# The effect of sodium bicarbonate drink consumption on fatigue index, anaerobic capacity, and lactic acid level after high-intensity exercise in advanced basketball players

*El efecto del consumo de bebidas con bicarbonato de sodio sobre el índice de fatiga, la capacidad anaeróbica y el nivel de ácido láctico después del ejercicio de alta intensidad en jugadores de baloncesto avanzados*

## Authors

Ahmed Hassan Yas [1]
Fatmah Abd-Alredah Hatam [2]

[1, 2] Al-Mustansiriya University

Corresponding author:
Ahmed Hassan Yas
yasahmedhasan@uomustansiriyah.edu.iq

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## Abstract

Introduction: This study investigated the effect of ingesting a sodium bicarbonate drink on specific physiological indicators following high-intensity exercise in advanced basketball players.
Objective: The research aimed to assess the drink's impact on the fatigue index, anaerobic capacity, and blood lactate levels after intensive exercise.
Methodology: The sample comprised sixteen players aged 19 to 27 years, divided into two groups. The experimental group received the sodium bicarbonate drink, whilst the control group received a placebo. All participants underwent standard pre- and post-tests for the measured variables.
Results: The results demonstrated a notable improvement in the fatigue index and anaerobic capacity, alongside a significant decrease in lactate levels within the experimental group compared to the control group.
Discussion: These findings align with several previous studies which indicated the potential role of external alkalising agents in enhancing high-intensity exercise performance by improving acid-base balance.
Conclusions: The study concluded that a sodium bicarbonate drink reduces anaerobic fatigue and improves energy utilisation efficiency in athletes. Future research should focus on determining optimal dosages and timing for consumption.

## Keywords

Anaerobic capacity; fatigue index; high-intensity exercise; lactate; sodium bicarbonate.

## Resumen

Introducción: Este estudio investigó el efecto de la ingestión de una bebida de bicarbonato de sodio sobre indicadores fisiológicos específicos tras ejercicios de alta intensidad en jugadores de baloncesto de nivel avanzado.
Objetivo: La investigación tuvo como objetivo evaluar el impacto de la bebida en el índice de fatiga, la capacidad anaeróbica y los niveles de lactato en sangre tras el esfuerzo intenso.
Metodología: La muestra estuvo compuesta por dieciséis jugadores de 19 a 27 años, divididos en dos grupos. El grupo experimental recibió la bebida de bicarbonato de sodio, mientras que el grupo de control recibió un placebo. Todos los participantes se sometieron a pruebas estándar previas y posteriores para las variables medidas.
Resultados: Los resultados demostraron una mejora notable en el índice de fatiga y la capacidad anaeróbica, junto con una disminución significativa de los niveles de lactato en el grupo experimental en comparación con el grupo de control.
Discusión: Estos hallazgos concuerdan con varios estudios previos que indicaron el papel potencial de los agentes alcalinizantes externos para mejorar el rendimiento en ejercicios de alta intensidad mediante la mejora del equilibrio ácido-base.
Conclusiones: El estudio concluyó que una bebida de bicarbonato de sodio reduce la fatiga anaeróbica y mejora la eficiencia en la utilización de energía en atletas. Investigaciones futuras deberían centrarse en determinar las dosis y el momento óptimo de consumo.

## Palabras clave

Capacidad anaeróbica; ejercicio de alta intensidad; fatiga; índice de fatiga; lactato; bicarbonato de sodio.

## Introduction

Basketball is considered a sport that requires high levels of endurance and anaerobic strength, and demands short, repeated efforts at maximum or near-maximum intensity. It involves quick sprints, performing continuous jumps during the execution of various skills, and sudden changes in direction and speed during matches and training sessions. The physiological demands of basketball are characterised by significant contributions from both the aerobic and anaerobic energy systems, with the anaerobic system dominating for most of the match period, particularly for the high-intensity explosive movements that characterise play.

As a result of this high intensity, lactic acid accumulates in the muscles, leading to fatigue and decreased performance during matches, especially in the final quarter. The "lactate threshold" or "anaerobic threshold" refers to the exercise intensity at which lactic acid begins to accumulate in the blood at a faster rate than the body can remove it. Exercising above this threshold is closely associated with the earlier onset of fatigue. The speed at which an athlete reaches the lactate threshold is a strong indicator of endurance performance. Therefore, many studies resort to investigating nutritional strategies to counter this fatigue and improve athletic performance.

Sodium bicarbonate (NaHCO3) is considered a dietary supplement believed to help neutralise the acidity resulting from lactic acid accumulation, thereby delaying fatigue and improving performance capacity in anaerobic activities. "Sodium bicarbonate is known for its ability to act as a buffer, helping to neutralise accumulated acids in the muscles and blood, thus delaying the onset of fatigue and improving sports performance (Burke, 2013)."

Numerous researchers have investigated sodium bicarbonate supplementation, including a study by Saunders et al., which confirmed that "sodium bicarbonate supplementation significantly improves performance in high-intensity exercises lasting from 45 seconds to 10 minutes. The primary mechanism is increasing the blood's capacity to remove lactic acid (hydrogen ions) that accumulate in the muscles during exercise," thereby delaying the onset of muscular fatigue (Saunders et al., 2021).

"Furthermore, the long-term use of sodium bicarbonate (for example, prior to every exercise training session) may enhance training adaptations, such as increased time to exhaustion and increased power output" (Grgic et al., 2021).

Hence, the importance of this study lies in identifying the effect of consuming a sodium bicarbonate drink on the anaerobic fatigue index and post-exercise lactic acid level following high-intensity exercise among advanced basketball players.

This study aims to achieve three main and interconnected objectives. The primary objective focuses on determining the effect of ingesting a sodium bicarbonate beverage on the fatigue index following high-intensity exercise among the research sample. This is to measure the extent of this supplement's ability to extend the period of effective performance before the athlete reaches exhaustion. The second objective centres on determining the effect of the same beverage on anaerobic capacity, which is the primary driver for explosive sprints and repeated powerful movements in basketball. As for the third objective, it completes the picture by determining the beverage's effect on blood lactate levels after high-intensity exercise, thereby providing a direct physiological explanation for the mechanisms underlying any potential improvement observed in the fatigue index or anaerobic capacity.

The researchers formulated three hypotheses that naturally stem from the stated objectives. The first hypothesis posits a statistically significant relationship between the consumption of a sodium bicarbonate drink and the rate of perceived exertion after high-intensity exercise, anticipating a marked decrease in this rate. The second hypothesis proposes a statistically significant relationship between the drink and an improvement in anaerobic capacity. Meanwhile, the third hypothesis suggests a statistically significant relationship between the consumption of the drink and a reduction in lactic acid levels compared to the control group, supporting the hypothesis that the mechanism of action occurs through enhancing the body's acid-balance system. To ensure accuracy and objectivity, this research has clearly defined its scope. In terms of the human dimension, the study will focus on the players of Al-Mustansiriyah University's senior basketball team, to ensure sample homogeneity in terms of technical and physical level and the nature of the activity. Temporally, the experiment will extend from 23 September 2024 to 12 December 2024, providing sufficient time for experimental applications and data collection. Spatially, all measurements and practical applications will be conducted in the indoor sports hall of the College of Physical Education and Sport Sciences at Al-Mustansiriyah University, to ensure the stability of the surrounding environmental conditions.

## Method

### *Method of Preparation and Consumption*

Dose: 0.2 to 0.3 grams per kilogram of body weight, dissolved in 250-500 ml of water.

Example: If your weight is 70 kg, the dose will be between 14 to 21 grams.

Timing of Consumption (Sodium Bicarbonate): 60 minutes before exercise, its effect peaks after approximately one hour.

### *Research Methodology and Field Procedures*

#### *Research Methodology*

The researcher used the experimental scientific method in the current study. The experimental method is considered one of the most accurate and reliable methods in scientific research, as it contributes to enhancing the credibility of the results and their scientific application. This method helps in identifying causal relationships between variables, making it an ideal choice for research that seeks to test hypotheses accurately.

#### *Research Population and Sample*

The research population consisted of advanced basketball players. A random sample of 16 players, aged between 19 and 27 years, with 5 years of experience in basketball, was selected. The sample was randomly divided into two equal groups (8 players per group):

- First Experimental Group (Control): Received a placebo drink.
- Second Experimental Group (Experimental): Received a sodium bicarbonate drink.

Sample Homogeneity: Ensuring sample homogeneity ensures that each part of it reflects the characteristics of the overall sample, which reduces bias in the results.

Table 1. Sample Homogeneity in Variables of Height, Mass, Age, Training Age

| Skewness Coefficient | Standard Deviation | Mean | Unit of Measurement | Variables |
|---|---|---|---|---|
| -0.12 | 2.5 | 22.8 | Cm | Age |
| 0.05 | 6.8 | 182 | Kg | Height |
| 0.18 | 5.2 | 78 | Year | Weight |
| 0.22 | 1.8 | 4.6 | Year | Training Age |

The skewness coefficient values fall within the range (-3, 3) , indicating that the data distribution in the studied variables approximates a normal distribution, which signifies sample homogeneity.

### *Equipment Used and Data Collection Methods*

#### *Data Collection Methods*

Accurate data collection in experimental research is crucial to ensure the validity of results. Several data collection methods include:

- Observation (direct, indirect, structured, unstructured)
- Questionnaires
- Personal interviews with specialists and experts in physical education
- Scientific references and sources
- Books and scientific articles published in peer-reviewed journals

- Specialized electronic databases in the field of study
- Personal interviews with experts and specialists
- Laboratory results forms
- Reliable websites related to the study topic

*Equipment Used in the Study*

In the context of the study, the researcher used a set of essential equipment and tools to fulfill the study requirements:

- Multi-functional digital medical scale (Chinese made) for weight measurement.
- Lactic acid measuring device.
- Essential medical supplies (medical cotton and high-quality sterilization materials).

*Field Research Procedures*

Before starting the research tests and measurements, written consent was obtained from all players after explaining the study objectives and the field procedures followed. All players underwent a medical examination to ensure there were no health contraindications for consuming sodium bicarbonate or performing high-intensity exercises.

*Dietary supplement - sodium bicarbonate drink*

- Placebo Drink: Contained water and artificial flavor without any active ingredients.
- Sodium Bicarbonate Drink: Sodium bicarbonate was given at a dose of 0.3 grams per kilogram of body weight, dissolved in 400 ml of water, 60 minutes before performing high-intensity tests (Arbello et al., 2020).

*Determination of Tests and Measurements Used*

- Anaerobic Power Test: Wingate test to measure anaerobic power and mean anaerobic power (Hoffman, 2012).
  - Wingate Test: A common test used to measure anaerobic power and anaerobic capacity.
  - Purpose of the Test:
    - Measuring peak anaerobic power.
    - Measuring anaerobic capacity.
  - Test Procedure:
- Required Equipment: Ergometer bicycle (equipped with a power measurement system) and a system for calculating bike resistance (usually a percentage of body weight).
- Stopwatch.
- Test Steps:
    - Warm-up: 5-10 minutes on the bike at low to moderate intensity.
    - Resistance Adjustment: Bike resistance is calculated based on body weight:
    - For men: 7.5% of weight (kg) x 9.81 (to determine force in Newtons).
    - For women: 7.5% of weight (kg) x 8.82.
    - Starting the Test: The subject (player) is asked to start at maximum possible speed from a stationary position. The determined resistance is applied immediately after the movement begins. The effort continues at maximum speed for 30 seconds.
    - Cool-down: 2-3 minutes of reduced effort to restore heart rate.
  - Method of Calculating Results:

- Peak Anaerobic Power: Highest power recorded during the first 5 seconds (measured in Watts/kg).
- Mean Power: Average performance during the full 30 seconds.
- Fatigue Index: Calculated as the percentage decrease in power from peak to end:
- FatigueIndex=PeakPower(PeakPower−LowestPower)×100

- Blood Lactate Level Test: Blood lactate level is measured using a Lactate Analyzer by taking blood samples from the subjects (5 minutes after exercise) (McArdle et al., 2015).

*Pilot Experiment*

A pilot experiment was conducted on Monday, September 23, 2024, by the assistant team under the supervision of the researcher to ensure the following:

- Validity of tests and measurements.
- Duration of exercises used.
- Safety of equipment used.
- Understanding of proposed exercises by the subjects.

*Test Design*

Both groups underwent the following tests:

- Pre-tests: Pre-tests for the research sample were conducted on Wednesday, September 25, 2024, before consuming the drinks (placebo or sodium bicarbonate) and before starting the experimental training program. The anaerobic capacity test and fatigue index test were performed, followed by lactic acid measurement using a Lactate Analyzer.
- Experimental Program: The experimental program was applied to the subjects on Sunday, September 29, 2024. The second experimental group was given the sodium bicarbonate drink 60 minutes before the training unit. The dose was 0.2 to 0.3 grams per kilogram of body weight, dissolved in 250-500 ml of water. The first experimental group (control) was given a placebo drink at the same time (60 minutes before the training unit). The training unit included a set of high-intensity anaerobic physical exercises, with 3 training units per week over 10 weeks, ending on Sunday, December 8, 2024.
- Post-tests: Post-tests and measurements were conducted on Monday, December 9, 2024. The same conditions as the pre-tests and measurements were observed to evaluate the sodium bicarbonate drink combined with a high-intensity training program on the studied variables.

### ***Statistical Analysis***

The researchers used the Statistical Package for the Social Sciences (SPSS) program to analyze the data.

An Independent Samples T-test was applied to compare the means of the two groups (first and second experimental) in the post-tests to determine if the differences were statistically significant.

A Paired Samples T-test was used to compare pre- and post-tests within each of the first and second experimental groups.

## Results

### ***Presentation, Analysis, and Discussion of Results***

*Presentation and Analysis of Pre- and Post-test Results for the First Experimental* Group

Table 2. Pre- and Post-test Results for the First Experimental Group

| Significance Level | T-value | Post-Standard Deviation | Post-Mean | Pre-Standard Deviation | Pre-Mean | Tests and Measurements |
|---|---|---|---|---|---|---|
| 0.04 | -2.35 | 2.5 | 31.98 | 2.3 | 29.9 | Anaerobic Fatigue Index (%) |
| 0.001 | -3.80 | 1.1 | 9.12 | 0.89 | 7.9 | Lactic Acid Level (mmol/L) |
| 0.05 | 2.10 | 0.7 | 10.06 | 0.98 | 11.23 | Anaerobic Capacity (Watts/kg) |

*p<0.05 indicates statistically significant differences.

From Table (2), the results of the pre- and post-tests for the three studied indicators of the first experimental group show statistically significant differences. The results indicate that the changes that occurred after the post-test were statistically significant for most measured indicators, with an increase in anaerobic fatigue index and lactic acid level, and a decrease in anaerobic capacity.

Regarding the anaerobic fatigue index (%): The results show an increase in the index from 29.9% before exercise to 31.98% after it, with a T-value of -2.35 and a significance level of p=0.04, which is less than 0.05. This indicates a statistically significant difference between the pre- and post-measurements, and this increase in anaerobic fatigue index may indicate an increased ability of the body to tolerate fatigue during anaerobic exercises and activities.

As for the measurement of lactic acid level after exercise, the results showed that the average lactic acid level increased significantly from 7.9 mmol/L before exercise to 9.12 mmol/L after it. The calculated T-value was -3.80 with a low significance level (p=0.001). This difference is highly statistically significant, as the increase in lactic acid level is due to an increase in the intensity of anaerobic exercise.

For the anaerobic capacity test (Watts/kg): The results showed that the pre-mean was 11.23 Watts/kg, while the post-mean was 10.06 Watts/kg. The T-value was 2.10, and the significance level was p=0.05. This indicates that this decrease can be considered statistically significant and may indicate fatigue, exhaustion, and a decrease in performance after a period of anaerobic training or exercise.

*Presentation and Analysis of Pre- and Post-test Results for the Second Experimental Group*

Table 3. Pre- and Post-test Results for the Second Experimental Group

| Significance Level (p) | T-value | Post-Standard Deviation | Post-Mean | Pre-Standard Deviation | Pre-Mean | Tests and Measurements |
|---|---|---|---|---|---|---|
| 0.003 | 4.56 | 1.39 | 24.89 | 2.02 | 30.10 | Anaerobic Fatigue Index (%) |
| 0.000 | 5.22 | 0.9 | 6.02 | 1.2 | 8.12 | Lactic Acid Level (mmol/L) |
| 0.002 | -3.93 | 0.99 | 12.6 | 0.8 | 11.32 | Anaerobic Capacity (Watts/kg) |

*p<0.05 indicates statistically significant differences.

From Table (3), the results for the second experimental group (after administering the sodium bicarbonate supplement) showed a significant improvement in all three tests and measurements when comparing pre- and post-tests. The significance level (p) being less than 0.05 in all tests indicates that these improvements are not due to chance, but rather a result of the supplement's (sodium bicarbonate drink) effect in conjunction with high-intensity anaerobic exercises.

Regarding the anaerobic fatigue index (%): The pre-mean was 30.10 with a standard deviation of 2.02, while the post-mean was 24.89 with a standard deviation of 1.39. The T-value was 4.56 with a significance level of 0.003. The results indicate a significant decrease in the anaerobic fatigue index from 30.10 to 24.89. This indicates an improvement in the ability of the subjects (second experimental group) to resist fatigue during anaerobic exercises and activities.

As for the lactic acid level after exercise (mmol/L): The pre-mean was 8.12 mmol/L with a standard deviation of 1.2, while the post-mean was 6.02 mmol/L with a standard deviation of 0.9. The calculated T-value was 5.22, and the significance level (p) was 0.000. A decrease in lactate accumulation after high-intensity exercise is a positive sign of improved lactate threshold, allowing subjects to exert higher effort before lactate levels accumulate.

Regarding anaerobic capacity (Watts/kg): For the second experimental group, the pre-test mean was 11.32 Watts/kg with a standard deviation of 0.8, while the post-test mean was 12.6 Watts/kg with a standard deviation of 0.99. The tabulated T-value was -3.93 with a significance level (p) of 0.002. The increase in anaerobic capacity indicates an improvement in the body's ability to rapidly produce energy for short, intense bursts of activity. This is attributed to the sodium carbonate drink supplement combined with high-intensity exercises.

*Presentation and Analysis of Post-test Results Between the First Experimental Group (Control) and the Second Experimental Group*

Table 4. Post-test Results Between the First Experimental Group (Control) and the Second Experimental Group

| Significance Level (p) | T-value | Experimental Group 2 (M/Experimental 2) | | Control Group (M/Experimental 1) | | Tests and Measurements |
|---|---|---|---|---|---|---|
| | | Post-Standard Deviation | Post-Mean | Post-Standard Deviation | Post-Mean | |
| 0.000 | 5.63 | 1.39 | 24.89 | 2.5 | 31.98 | Anaerobic Fatigue Index (%) |
| 0.000 | 6.13 | 0.9 | 6.02 | 1.1 | 9.12 | Lactic Acid Level (mmol/L) |
| 0.000 | 4.34 | 0.99 | 12.6 | 0.7 | 10.06 | Anaerobic Capacity (Watts/kg) |

*$p<0.05$ indicates statistically significant differences.

From Table (4), it is clear that there are highly statistically significant differences in all three tests between the post-measurements of the first experimental group (control) and the second experimental group. This indicates a significant and clear effect of the dietary supplement (sodium bicarbonate drink) on the measured variables. All results indicate a positive, clear, and tangible improvement in the anaerobic performance of the subjects in the second experimental group, whether in terms of reducing fatigue, improving lactic acid clearance, or increasing energy production capacity.

Regarding the anaerobic fatigue index (%): The post-mean for the first experimental group (control) was 31.98 with a standard deviation of 2.5, while the post-mean for the second experimental group was 24.89 with a standard deviation of 1.39. The tabulated T-value was 5.63, which is a positive and large value, confirming this significant decrease in the fatigue index value. This decrease in the fatigue index indicates a significant improvement in the players' ability to resist anaerobic fatigue during exercise. This means they became more efficient in anaerobic performance for a longer period or at higher intensity.

As for the lactic acid level after high-intensity exercise: The post-mean for the first experimental group (control) was 9.12 with a standard deviation of 1.1, and the post-mean for the second experimental group was 6.02 with a standard deviation of 0.9. The T-value was 6.13, which is also a positive and large value. This indicates a significant decrease in lactic acid concentration for the research sample.

Regarding the anaerobic capacity test (Watts/kg): For the post-tests of the first and second experimental groups, the post-mean for the first experimental group (control) was 10.06 with a standard deviation of 0.7, while the post-mean for the second experimental group was 12.6 with a standard deviation of 0.99. The T-value was -4.34, which is a negative value. In T-tests, a negative value indicates that the mean of the second group (post-test) is greater than the mean of the first group (pre-test) when the pre-mean is subtracted from the post-mean, which indicates statistically significant differences. This increase in anaerobic capacity indicates a clear increase in the ability to produce energy rapidly in the absence of oxygen, due to sodium bicarbonate drink, meaning there is a significant improvement in maximum strength and speed during anaerobic activities for the subjects (basketball players).

## Discussion

From Tables (3) and (4), the results showed that consuming sodium bicarbonate drink before high-intensity exercise had a positive and significant effect on the studied variables, particularly the anaerobic fatigue index, as well as on lactic acid level and anaerobic capacity in the subjects (second experimental group).

From Table (2) for the first experimental group (control), which consumed the placebo drink, the results showed an increase in anaerobic fatigue index and an increase in lactic acid level after high-intensity exercise, and a decrease in anaerobic capacity. The researcher believes that these results are normal and expected, as high-intensity exercises lead to the accumulation of hydrogen ions (

H+) and lactic acid, which causes a decrease in pH within the working muscles and blood, thus leading to fatigue and reduced muscle performance . These results are consistent with recent research on the physiology of exercise, as shown by Šimenko, J., & Hadžić, V. (2021). “High-intensity exercise leads to a significant increase in blood lactate concentration and a concurrent decrease in anaerobic power performance, primarily due to acid-base disturbance resulting from hydrogen ion accumulation.”

The second experimental group, which consumed sodium bicarbonate drink before high-intensity exercises, showed a clear and significant improvement in the studied variables. Regarding the anaerobic fatigue index, it decreased significantly, indicating that sodium bicarbonate contributed to delaying the onset of fatigue and increasing anaerobic endurance in the subjects This result is consistent with the results of a study (Saunders et al., 2024), which confirmed that supplementing with sodium bicarbonate improves high-intensity exercise performance through its mechanism as an external buffer. . The researcher attributes this effect to the role of sodium bicarbonate as an extracellular buffer, "as it works to absorb hydrogen ions accumulated in the blood resulting from anaerobic metabolism, thereby maintaining blood pH within the normal range" (Matz-Petersen et al., 2021).

As for the lactic acid level after high-intensity exercise in the second experimental group, the results from Table (3) showed a significant decrease in the acid level. This confirms the effectiveness of sodium bicarbonate in neutralizing acidity, and "when a higher pH is maintained, muscles can work more efficiently for longer periods, leading to improved performance during high-intensity anaerobic exercises" (Carr et al., 2011). This aligns with the good improvement in anaerobic capacity in the players of the second experimental group after high-intensity exercises, as the body's ability to clear acidity allows muscles to produce more energy more efficiently.

From Table (4), the post-test results for the first experimental group (control) and the second experimental group, using the T-test for differences between means, showed statistically significant differences at the $p<0.05$ level in all studied indicators (tests). This indicates the effectiveness of the dietary supplement (sodium bicarbonate drink) combined with high-intensity exercises applied to the second group. A significant decrease in the anaerobic fatigue index was observed in the experimental group. This is due to the effectiveness of the dietary supplement (sodium bicarbonate drink) combined with high-intensity exercises, which is consistent with the study by Al-Khawaldeh and Al-Qatawneh (2020) , which indicated that high-intensity interval training (HIIT) reduces anaerobic fatigue by improving energy consumption efficiency. These results also align with previous studies that showed the benefits of sodium bicarbonate intake in improving athletic performance in activities requiring high (anaerobic) effort lasting from 30 seconds to 10 minutes (Grgic et al., 2021). This effect is attributed to the ability of sodium bicarbonate to increase the alkaline buffering capacity of the blood, allowing for greater accumulation of fatigue receptors before reaching the threshold that impedes muscle performance.

The researcher observes from the results that there is an improvement in the muscles' ability to deal with anaerobic lactate accumulation. The researcher attributes this to the effectiveness of sodium bicarbonate in neutralizing acidity and also supports the hypothesis of the body's adaptation to training loads. The study by Al-Otaibi (2018) confirms that integrated aerobic training reduces lactate accumulation by increasing the efficiency of oxidative metabolism. Sodium bicarbonate acts as a buffer for pH in the working muscles, reducing blood acidity resulting from the accumulation of hydrogen ions

H+) and lactic acid during high-intensity anaerobic exercises (Peart et al., 2012). This explains the significant decrease in lactic acid levels and the reduction in feelings of exhaustion and fatigue.

The results from Table (4) indicate a clear and significant improvement in the anaerobic capacity (Watts/kg) of the second experimental group. This result is consistent with Al-Zubaidi's (2019) study, which found that high-intensity exercises enhance anaerobic capacity by stimulating enzymes responsible for glucose breakdown. Other studies have also shown the importance of consuming sodium bicarbonate before high-intensity exercises in improving the anaerobic capacity of players. Abdullah and Al-Mousawi (2019) indicated that consuming sodium bicarbonate before high-intensity exercises led to a 10-15% improvement in performance in speed and anaerobic capacity tests. Saad El-Din (2018) also confirmed that bicarbonate enhances performance in anaerobic exercises such as sprinting and weightlifting, as bicarbonate improves the efficiency of energy production in the absence of oxygen.

Based on these results, it can be concluded that sodium bicarbonate after high-intensity exercise is a good and promising dietary supplement for reducing fatigue (exhaustion), which in turn reflects on improving performance in basketball players (the research sample), especially for activities requiring high anaerobic capacity.

## Conclusions

Consuming a sodium bicarbonate drink after high-intensity exercise had a positive and significant effect on the anaerobic fatigue index in the second experimental group .The sodium bicarbonate drink after high-intensity exercise also significantly reduced lactic acid levels .The sodium bicarbonate drink also improved anaerobic capacity in advanced basketball players after high-intensity exercise, thereby improving individual performance.

The researchers recommended several recommendations, including conducting similar studies on various sports activities using sodium bicarbonate after high-intensity exercise .The researchers recommend that basketball coaches and specialists include sodium bicarbonate in the diet of basketball players during periods of high-intensity training and competition, after consulting with nutritionists to determine the appropriate dosage.

Further studies should also be conducted to determine the optimal dosage and timing of sodium bicarbonate intake, and to identify its side effects.

Finally, the researchers recommended conducting studies on different samples to determine the effect of sodium bicarbonate on other indicators, such as recovery speed.

### *Appendices*

#### *Sample Training Units*

Training Unit One: – Week One

- Unit Goal: Developing anaerobic capacity and speed
- Intensity: High
- Unit Duration: 45-60 minutes

Warm-up (10-15 minutes before each unit)

Includes light jogging, flexibility and stretching exercises, and basketball-specific cool-down exercises.

Table 5. Sample Training Units

| Notes | Number of Sets | Rest Duration (between repetitions/sets) | Exercise Duration (per set) | Type of Exercise |
|---|---|---|---|---|
| Quickly touch the finish line, with rapid change of direction. | 5 | 90 seconds | 30 seconds | Zig-zag running |
| Jump onto a suitable height box, landing on the balls of your feet. | 4 | 90 seconds | 4-8 jumps | Plyometric exercise - Box jumps |
| Run as fast as possible. | 6 | 60 seconds | 20-30 meters | Short sprints |
| High jumps in place, bringing knees to chest. | 4 | 90 seconds | 10-12 repetitions | Plyometrics exercises |

#### *Cool-down (5-10 minutes after each unit)*

Includes cool-down exercises, stretching exercises, and light free play with the ball.

Training Unit Two – Week One

- Unit Objective: Develop speed endurance and anaerobic capacity
- Intensity: Sub-maximal
- Unit Duration: 45-60 minutes

Warm-up (10-15 minutes before each unit): Includes light jogging, flexibility and stretching exercises, and basketball-specific cool-down exercises.

Table 6.

| Notes | Number of Sets | Rest Duration (between repetitions/sets) | Exercise Duration (per set) | Exercise Type |
|---|---|---|---|---|
| Fast running with changes to moderate speed | 6 | 45 sec | 45 sec | Intermittent Running Exercise |
| Focus on precision and speed during foot movements | 4 | 60 sec | 45 sec | Agility Ladder Exercise |
| Quick penetration of defense followed by lay-up shooting | 5 | 60 sec | 45 sec | Defense Penetration& Shooting Drills |
| Use a resistance band to develop starting and explosive power | 5 | 45 sec | 15-30 sec | Resistance Band Exercises |

*Cool-down (5-10 minutes after each unit)*

Includes cool-down exercises, stretching exercises, and light free play with the ball.

Third Training Unit – First Week

- Unit Goal: Developing Lactate Endurance
- Intensity: Moderate
- Unit Duration: 45-60 minutes

Warm-up (10-15 minutes before each unit):

Includes light jogging, flexibility and stretching exercises, and basketball-specific cool-down drills.

Table 7.

| Notes | Rest (between reps/sets) | Number of Sets | Exercise Duration (per set) | Exercise Type |
|---|---|---|---|---|
| Sprinting at maximum speed. | 90 seconds | 4-6 | 30-45 seconds | Full-court sprints (back and forth) |
| Running at 90% of maximum speed. | 90-120 seconds | 4-6 | 30-45 seconds | Intermittent running (sprint) |
| Performed as fast as possible by the player. | 75 seconds | 4-5 | 45 seconds | Jump rope exercise |
| Ascend stairs as fast as possible, light jog descent. | 90 seconds | 4 | 60 seconds | Stair climbing exercise |

*Cool-down (5-10 minutes after each unit)*

Includes cool-down exercises, stretching exercises, and light free play with the ball.

## References

Abdullah, A.,&Al-Mousawi, M. (2019). The effect of sodium bicarbonate on athletic performance. *Journal of Sports Sciences, 12*(3), 22–30.

Al-Khawaldeh, A.,&Al- Qatawneh, M. (2020). The effect of high-intensity interval training on anaerobic fatigue. *Journal of Sports Sciences*.

Al-Khoury, N. (2017). *Functional nutrition for athletes*. Damascus University.

Al-Otaibi, K. (2018). *Aerobic training and its effect on lactic acid*. Scientific Publishing House.

Al-Zubaidi, N. (2019). Anaerobic capacity and explosive exercises. In *Proceedings of the Arab Conference of Sports Sciences* (p. 65).

Arbello, E., Stenger, D., & Reiser, R. F. (2020). The effects of sodium bicarbonate ingestion on exercise performance: A systematic review and meta-analysis. *Journal of Strength and Conditioning Research, 34*(1), 271–285.

Burke, L. M. (2013). Sports nutrition: A review of the latest evidence. In *Clinical Sports Nutrition* (5th ed., pp. 1-25). McGraw-Hill.

Carr, A. J., Hopkins, W. G.,&Gore, C. J. (2011). Effects of acute bicarbonate ingestion on exercise performance: a meta-analysis. *Sports Medicine, 41*(8), 679–694.

Grgic, J., Grgic, I.,&Pickering, C. (2021). Sodium bicarbonate supplementation and exercise performance: An umbrella review. *Journal of the International Society of Sports Nutrition, 18*, 61.

Hoffman, J. R. (2012). *NSCA's guide to tests and assessments*. Human Kinetics.

Matz-Petersen, D., Rønnow, D., & Schiermer, A. (2021). The effect of sodium bicarbonate on exercise performance in short-duration, high-intensity exercise: a systematic review and meta-analysis. *Journal of Sports Sciences, 39*(20), 2296–2309.

McArdle, W. D., Katch, F. I., & Katch, V. L. (2015). *Exercise physiology: Nutrition, energy, and human performance* (8th ed.). Lippincott Williams& Wilkins.

Mujica-Johnson, F. N., Concha López, R., Peralta Ferroni, M., & Burgos Henríquez, S. (2024). Gender Perspective in Physical Education Teacher and School Training. Critical analysis in terms of the Chilean context. *Challenges, 55*, 339–345.

Robergs, R. A., Ghiasvand, F.,& Parker, D. (2004). Biochemistry of exercise-induced metabolic acidosis. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology, 287*(3), R502–R516.

Rosemann, T., & Wirnitzer, K. (2018). Comparison of sodium bicarbonate and sodium citrate for ergogenic effects. *Journal of the International Society of Sports Nutrition, 15*, 33. https://doi.org/10.1186/s12970-018-0238-7

Saad El-Din, K. (2018). Anaerobic exercises and the effect of alkaline minerals. In *Proceedings of the Scientific Conference of Sports Medicine, Cairo* (pp. 112–125).

Saunders, B., Elliott-Sale, K., Artioli, G. G., Swinton, P. A., Dolan, E., Roschel, H., Sale, C., & Gualano, B. (2021). The effects of sodium bicarbonate supplementation on exercise performance: An umbrella review. *International Journal of Sport Nutrition and Exercise Metabolism, 31*(3), 285–294.

Saunders, B., Elliott-Sale, K., Artioli, G. G., Swinton, P. A., Dolan, E., Roschel, H., Sale, C., & Gualano, B. (2024). β-alanine and sodium bicarbonate supplementation for high-intensity exercise: a systematic review and meta-analysis. *European Journal of Sport Science, 24*(4), 431–447. https://doi.org/10.1002/ejsc.12115

Šimenko, J., & Hadžić, V. (2021). The Effect of High-Intensity Interval Training on Blood Lactate Levels and Anaerobic Performance in Athletes. *Journal of Human Kinetics, 80*(1), 189–198.

## Authors and translators' details:


| | | |
|---|---|---|
| Author | yasahmedhasan@uomustansiriyah.edu.iq | Asst. Prof. Dr. Ahmed Hassan Yas |
| Author | fatimah-redhaH@uomustansiriyah.edu.iq | Fatmah abd-alredah hatam |
| Translator | qabas.gmil@imamaladham.edu.iq | Asst. prof Qabas Jameel Rashid |