

Effects of Water-Based Active Recovery on Physiological Responses and Skill Performance in Elite Futsal Players during an Intensive Training Program

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Abstract Introduction: Futsal is a rapidly growing sport with high-intensity demands and limited recovery time, placing significant strain on players' physical systems. Active water-based recovery (AWBR) has been suggested to enhance physiological recovery and technical performance, but its effectiveness in futsal is not yet well studied. **Purpose:** The present study aimed to investigate the potential effects of bi-weekly aquatic-based recovery (AWBR) incorporated into an intensive-training block on physiological adaptations and skill performance indices in elite futsal players. **Design:** Twenty-four professional futsal players were purposefully categorized into two matched groups based on anthropometric and fitness characteristics. Both groups performed a six-week high-intensity training block (5 days/week; 85--90% HRmax). The AWBR group completed two sessions of recovery-based aquatics per week (low-intensity aquatic-based exercise; 30--40% HRmax), while the control group passively participated in recovery activities. Physiological measures (VO₂max, VO₂, HR, RQ, LA_{max}) were quantified using a modified Bruce treadmill test with a COSMED K5 analyzer, while skill performance (speed, accuracy, and total execution) was quantified from a common futsal skill test. **Results:** The AWBR group

showed significant ($p < 0.05$) improvements in aerobic capacity (VO₂max), recovery kinetics (VO₂, HR, RQ), speed, accuracy, and total execution compared to the control group. Additionally, the intriguingly high lactate levels (LA_{max}) noticed immediately following the exercise provided further evidence that the AWBR group relied heavily on anaerobic energy sources. **Conclusions:** Including AWBR in training sessions may aid elite futsal players' physical recovery and ability to retain skills throughout intense training sessions. To refine the application of AWBR and test its efficacy in the real world, more rigorous controlled trials with larger groups of players are needed.

Keywords Active Recovery, Futsal, VO₂max, Water Immersion, Heart Rate, Skill Performance

1. Introduction

The popularity of futsal has skyrocketed in the past few years, making it one of the most rapidly expanding team sports in the world. The specific physiological and physical

demands of the sport distinguish it from traditional football. Futsal is a fast-paced indoor sport that demands players to constantly sprint, make explosive maneuvers, and change directions with little time to recuperate. The courts are smaller and the game times are shorter [1], [2]. Because of the heavy load on the neuromuscular and cardiovascular systems caused by these strenuous physical difficulties, players must recover well in between games and training sessions if they want to keep performing at a high level and avoid injuries [3].

Scientific evidence is mounting that futsal players can suffer from cumulative exhaustion, worse neuromuscular coordination, and a decline in technical abilities throughout the competitive season if they do not recover adequately from high-intensity workouts, contradicting the traditional training programs' emphasis on aerobic and anaerobic fitness [4, 5]. In addition, new research shows that high-intensity training programs have a number of negative physiological effects, including microtraumas, inflammation, depleted energy storage, oxidative stress, and central weariness, all of which impair neuronal drive and motor control. Failure to address and resolve these problems will significantly impair an athlete's ability to adjust training loads and their long-term performance [6, 7].

Absolute rest, electrical muscle stimulation, and hydrotherapy were first shown to have no significant effect on the hormone levels or anaerobic performance of relatively young futsal players, according to a study. However, the athletes were unanimous in their belief that electrical stimulation and water workouts were the best ways to rehabilitate. Furthermore, before the season begins, players should play a couple of friendly matches to acclimate to the extremely demanding training loads, according to the researchers [8]. Another study [9] reached a similar finding, highlighting the high levels of physical stress experienced by soccer players during training and games and emphasizing the need of adequate recovery for maintaining performance and minimizing weariness.

Among these recovery methods, water-based interventions have attracted considerable research attention. Cold-water immersion (CWI) is widely adopted to alleviate muscle soreness and inflammation [10] [11], yet passive immersion may limit circulatory activation and metabolic waste clearance. To overcome such limitations, active water-based recovery (AWBR)—involving low-intensity exercise in water—has been proposed as a promising strategy that combines hydrostatic and thermal benefits with gentle muscular activation. AWBR has demonstrated positive effects in accelerating lactate clearance, enhancing peripheral circulation, and promoting neuromuscular recovery without imposing additional mechanical stress on fatigued tissues [12], [13], [14]. There is currently no conclusive scientific evidence for the effectiveness of active healing therapies, despite the widespread recommendation of such practices. Particularly in fast-paced, high-intensity games like futsal, this is true.

2. Method

2.1. Methodology of the Study

In order to get the best possible results from their research, the researchers decided to perform experiments. From start to finish, the experiment followed all of the guidelines laid out by CONSORT, the Consolidated Standards of Reporting Trials. Following these guidelines, which are intended for RCTs, ensured that the study was open, reproducible, and based on best practices.

2.2. Ethical Approval

All of the study's ethical guidelines were followed to the letter. Approval Number: 3035, dated 22/11/2024, officially authorizes the University of Mosul in Iraq's College of Physical Education and Sports Sciences. Finally, informed consent forms were signed by every single participant. Prior to the participants signing the consent forms, they were informed about the study's goals, the advantages (such as better recovery management, less fatigue, and enhanced future training readiness), and the disadvantages (such as muscle soreness, dizziness, discomfort from the water exercises, and in extremely rare instances, slipping, excessive heat/cold, and other issues).

Every exercise session was overseen by trained professionals to ensure the participants' safety. The water depth was 1.5 meters, the deck was marked with non-slip materials, and the temperature ranged from 30 to 32 degrees Celsius. In the event that any participants experienced extreme symptoms like a racing heart, dizziness, or pain, they were instructed to immediately discontinue all exercises. No one reported any bad events throughout the whole trial period.

2.3. Sample of the Study

In all, twenty-four members of Al-Hadbaa Sports Club's futsal team from the Iraqi Premier Futsal League participated in the study. A predetermined allocation approach was used to divide these players into two equal-sized groups. By using crucial variables such as age, length of training, height, and weight, this method matched participants evenly in the beginning groups. Homogeneity between the groups was confirmed using Levene's test (Table 1).

The two groups followed the following protocols:

1. **Intervention (AWBR) group:** Followed an intensive training program consisting of five training days per week, incorporating low-intensity water-based exercises in a swimming pool for two days as a form of active recovery.
2. **Control Group (Passive Recovery):** Followed the same intensive training program with five training days per week but used passive rest for two days as a means of passive recovery.

Table 1. The means, standard deviations, and calculated Levene's Statistics for the variables (chronological age, training age, height, and body weight) between the two groups

Variables	Unit	Intervention (AWBR) Group	Control (Passive Recovery) Group	Levene Statistic	Significance
Chronological Age	Years	19.25 ± 0.82	19.17 ± 0.98	0.97	0.402
Training Age	Months	49.33 ± 4.84	50.00 ± 4.73	0.30	0.749
Height	cm	173.33 ± 5.61	171.67 ± 4.97	1.55	0.245
Body Mass	kg	63.50 ± 4.64	64.33 ± 6.19	0.19	0.833

The results in Table 1 indicate that the significance values for the variables (chronological age, training age, height, and body weight) were greater than 0.05. This suggests that there were no statistically significant differences between the two groups, confirming that the experimental groups were homogeneous and equivalent in these variables prior to starting the experiment

2.4. Instruments and Equipment

- Electronic Scale: Detecto™ scale used for measuring weight and height.
- Treadmill: TMX425 Trackmaster 2004™ treadmill for conducting Bruce protocol tests.
- Metabolic Analyzer: K5™ system used to measure physiological variables.
- Stopwatches: Kenko™ brand for accurate timing during tests and training.
- Additional Equipment: 30-meter measuring tape, cones, balls, agility ladders, and obstacle tools for skill and agility drills.

2.5. Data Collection Methods

2.5.1. Measurement of Physiological Variables

The Bruce Protocol Treadmill Test [15] was conducted using a treadmill to assess the following:

1. Test Duration: The total time each participant lasted during the Bruce test.
2. Direct Measurement: VO₂max, METs, heart rate (HR), and respiratory quotient (RQ) were directly measured using the K5 metabolic analyzer.
3. Recovery Measurement: VO₂, HR, and RQ were recorded 10 minutes post-exercise while the participant remained seated comfortably wearing the K5 device throughout the recovery period.
4. Skill Performance Assessment: Speed and accuracy of players' technical abilities were evaluated using the Composite Skill Performance Test [16].

2.5.2. Skill Performance Assessment

The players' technical performance was evaluated using the Composite Skill Performance Test for Futsal, which measures the speed and accuracy of combined technical skills under game-like conditions. The test was conducted on a normal 8×12 meter surface and included passing to

rebound boards with color-coded penalty zones, dribbling through cones, and controlled shooting into goal areas. When technical mistakes like improper passes or missed shots are added to the total performance time, a penalty is calculated.

For futsal-specific abilities, this exam has demonstrated excellent content validity, and in repeated measures, it has demonstrated excellent reliability (ICC > 0.85) [16]. Therefore, it is a reliable instrument for gauging futsal players' intricate technical competence. (As seen in Figure 1)

2.5.3. Training Program

- Program Duration: This rigorous six-week program prepares players to compete in the Iraqi Premier Futsal League with 30 intensive training units, or 5 sessions each week.
- Content of the program: The program included high-intensity anaerobic workouts, technical practice, tactical drills, and aerobic conditioning, which were all methodically distributed throughout the training units.
- Training intensity is approximately 85-90% of maximum heart rate (HR_{max}).
- Session Duration: Training sessions lasted 90 to 140 minutes.
- Program Uniformity: The first (experimental) and second (control) groups went through the identical rigorous training regimen.

2.5.4. Recovery Units

Players were given two recuperation days every week to minimize overtraining, as detailed below:

- The Intervention (AWBR) Group engaged in low-intensity pool workouts twice a week (on Tuesdays and Fridays).
- The control group followed a passive recovery strategy with no physical activity on the same days (Tuesdays and Fridays).
- During the study, the Intervention (AWBR) group had 12 active recovery periods, while the control group only had 12 passive rest sessions. The Intervention (AWBR) Group's active recovery sessions lasted 30 to 40 minutes and concentrated on modest water exercises designed to aid recovery without causing further physical stress.

- The aquatic recovery sessions comprised activities at 30-40% of HRmax in a 1.5-meter-deep swimming pool, and included the following parts:
 - Walking in 1.5-meter-deep water for ten minutes.
 - Ten minutes of pool stretching exercises (flexibility drills). Light swimming for 10 minutes.
- On the other hand, the control group rigorously followed passive recovery and did not do any physical activity on their rest days.

Table 2 presents the weekly training load distribution and total training volume for the Active Water-Based Recovery (AWBR) group across six weeks, showing the planned variation in session duration and the inclusion of structured recovery days.

2.6. Main Research Procedures – Pre-Test Measurements

1. Warm-up: 5 to 7 km/h on the treadmill at 4 to 6% incline for 7 to 10 minutes.
2. Rest Phase: Physiological variables were allowed to stabilize for 5 to 7 minutes.
3. K5 Setup: Fitting the K5 mask for the metabolic analyzer to record baseline data.
4. Bruce Test: Performed to assess physiological variables until the participant reached exhaustion.
5. Composite Skill Performance Test: Administered to assess variables related to skill which included speed, accuracy, and overall execution.

2.6.1. Instrument Validity and Reliability


Validity and reliability of the measurement tools and tests used in the study were established and consistent with previous studies. The K5 metabolic analyzer has established validation for accurate measurement of VO₂max and other metabolic variables [17]. The Composite Skill Performance Test for evaluating technical futsal players showed excellent test-retest reliability (ICC > 0.85), and strong content validity [16].

Confounding Variables were controlled:

To reduce the likelihood of confounding variables, the following strategies were put into practice:

- Similar dietary recommendations were given to all participants and their sleep schedules were also similar throughout the study period.
- The training sessions were held at the same time of day which helped to eliminate the effects of circadian variations.
- The same environmental conditions (e.g., temperature, humidity) were maintained during both the testing and training sessions.
- The experimental and control groups were subjected to similar training programs with the only difference being the recovery modality.
- In the case of the experimental group, water temperature during active recovery sessions was strictly controlled at 30°C to 32°C, which is referred to as a thermoneutral range that provides comfort, and encourages muscle relaxation and at the same time prevents additional thermal stress during aquatic exercises.

Table 2. Weekly Training Load Distribution for the Active Recovery Group (AWBR) showing the weekly variation (load undulation) and training volume (in minutes)

Day	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Training load ripple						
Saturday	90 min	90 min	100 min	100 min	110 min	90 min
Sunday	100 min	100 min	110 min	110 min	120 min	100 min
Monday	110 min	110 min	120 min	120 min	130 min	110 min
Tuesday (Recovery)	30 min	30 min	35 min	35 min	40 min	30 min
Wednesday	110 min	110 min	120 min	120 min	130 min	110 min
Thursday	120 min	120 min	130 min	130 min	140 min	120 min
Friday (Recovery)	30 min	30 min	35 min	35 min	40 min	30 min
Total Weekly Volume	590 min	590 min	650 min	650 min	710 min	590 min

2.6.2. Training Program Implementation

The training program was designed to get the team ready for competing in a national futsal championship. The program consisted of high-intensity training sessions that played a major role in getting the body and performance to a higher level. The utilization of low-intensity water-based activities as a means of recovery and adaptation was an incredibly innovative and brilliant notion.

- The AWBR Group engaged in five rigorous training sessions per week and two active recovery sessions with low-intensity aquatic activities.
- On the other hand, the control group underwent the same rigorous training program but took the same two days each week for passive recovery (rest).

2.6.3. Post-Test Measurements

Identical to pre-test measurement conditions.

2.6.4. Statistical Analysis

The analysis of the statistical data took place using SPSS version 26. Descriptive statistics were given as mean \pm standard deviation. For inferential statistics, Levene's test was applied to check the homogeneity of variance. A paired t-test was performed within groups to compare pre- and post-test measurements, while an independent samples t-test was used for the comparison of post-test results between experimental and control groups. Additionally, Cohen's d was calculated to determine the effect size for both within-group and between-group comparisons, providing insight into the magnitude of observed differences.

3. Results

3.1. Presentation of the Differences between the Pre-Test and Post-Test for the Control Group

The results in Table 3 show varying significance levels across the physiological and skill-related variables in the control group. Some variables exceeded the 0.05 significance level, indicating no statistically significant differences between pre- and post-tests, while others showed moderate improvements. Overall, these findings confirm that the changes observed in the control group reflect natural variation rather than the influence of any training intervention. The control group showed improvement in Bruce Test performance and VO₂max during the exertion phase (Bruce Test).

1. There were no statistically significant differences in LAm_{ax} values measured 5 minutes after exercise between the pre- and post-tests.

2. The control group showed improvement during the recovery phase (after 10 minutes post-exercise) in the VO₂ variable, while no significant differences were found in HR and RQ variables.
3. The control group did not show statistically significant improvements in skill performance variables including skill speed, skill accuracy, and total achievement in the skill performance test between the pre- and post-tests.
4. Effect size (Cohen's d) analysis showed large effects ($d \geq 0.8$) in Bruce Test, VO₂max, and skill speed; medium effects ($d \approx 0.4-0.7$) in HR; and small effects ($d \leq 0.2$) in RQ and skill accuracy, indicating notable physiological gains but limited improvements in skill precision.

3.2. Presentation of the Differences between the Pre-Test and Post-Test for the Intervention (AWBR) Group

Table 4 presents the pre- and post-test means, standard deviations, t-values, significance levels, and effect sizes for the physiological and skill-related variables of the experimental (AWBR) group, showing statistically significant improvements across all variables as a result of the intervention.

1. The Intervention (AWBR) Group showed improvement in Bruce Test performance and VO₂max during exertion (Bruce Test).
2. The Intervention (AWBR) Group demonstrated statistically significant differences in LAm_{ax} measured 5 minutes after exertion between the pre- and post-tests.
3. The Intervention (AWBR) Group exhibited improvements during the recovery phase (10 minutes post-exercise in the Bruce Test) in the variables VO₂, HR, and RQ.
4. The Intervention (AWBR) Group showed statistically significant improvements in skill performance variables, including skill speed, accuracy, and total achievement, between the pre- and post-tests.
5. Effect size (Cohen's d) analysis showed very large effects ($d \geq 0.8$) across all variables in the experimental group, including Bruce Test, VO₂max, VO₂, HR, RQ, and skill performance (speed, accuracy, and total achievement), indicating substantial physiological and technical improvements.

Table 3. The means, standard deviations of the physiological and skill-related variables, calculated t-values, and significance levels between the pre- and post-tests for the control group

Variables		X	S.D	t	sig.	Cohen's d	Effect Size
(Bruce) (min)	Pre	17.542	1.154	-2.469	0.039	0.71	(Medium)
	Post	18.052	0.868				
(VO₂max) (ml.min-1)	Pre	4471.253	381.425	-2.703	0.027	0.78	(Medium)
	Post	4668.97	339.825				
(Lamax) (mlg)	Pre	13.589	2.331	-1.894	0.095	0.55	(Medium)
	Post	14.344	1.561				
VO₂ (ml.min-1)	Pre	488.066	64.92	3.871	0.005	1.12	(Very Large)
	Post	430.479	38.289				
(HR) (bpm)	Pre	104.441	9.039	2.22	0.057	0.64	(Medium)
	Post	100.689	7.34				
(RQ)	Pre	0.953	0.084	0.122	0.906	0.04	(Trivial)
	Post	0.95	0.126				
(Speed) (second)	Pre	71.333	5.874	2.035	0.076	0.59	(Medium)
	Post	65.444	5.102				
Accuracy) (second)	Pre	7.778	1.093	0.71	0.498	0.20	(Small)
	Post	7.333	1.118				
(Achievement in the Skill Performance Test) (second)	Pre	79.111	6.66	1.85	0.102	0.53	(Medium)
	Post	72.778	5.911				

Table 4. The means, standard deviations of the physiological and skill-related variables, calculated t-values, and significance levels between the pre- and post-tests for the experimental group

Variables		x	Cv	t value	sig.	Cohen's d	Effect Size
(Bruce) (min)	Pre	18.06	1.225	6.224	< 0.001	1.80	(Very Large)
	Post	19.077	1.147				
(VO₂max) (ml.min-1)	Pre	4467.108	543.667	3.963	0.004	1.14	(Large)
	Post	5078.056	443.038				
(Lamax) (mlg)	Pre	14.756	2.111	2.975	0.018	0.86	(Large)
	Post	16.626	2.927				
VO₂ (ml.min-1)	Pre	521.369	71.214	4.735	0.001	1.37	(Very Large)
	Post	448.796	69.646				
(HR) (bpm)	Pre	109.494	10.117	2.834	0.022	0.82	(Large)
	Post	105.172	7.499				
(RQ)	Pre	0.967	0.073	4.992	0.001	1.44	(Very Large)
	Post	0.907	0.061				
(Speed) (second)	Pre	70.333	6.325	4.672	0.002	1.35	(Very Large)
	Post	63.556	4.72				
Accuracy) (second)	Pre	7.222	1.716	3.25	0.012	0.94	(Large)
	Post	5.778	1.202				
(Achievement in the Skill Performance Test) (second)	Pre	77.556	7.299	5.015	0.001	1.45	(Very Large)
	Post	69.333	5.477				

Table 5. The means, standard deviations of the physiological and skill-related variables, calculated t-values, and significance levels between the experimental and control groups in the post-test

Variables		x	cv	t value	sig.
(Bruce) (min)	Pre	18.06	1.225	-6.224	< 0.001
	Post	19.077	1.147		
(VO ₂ max) (ml.min-1)	Pre	4467.108	543.667	-3.963	0.004
	Post	5078.056	443.038		
(Lamax) (mlg)	Pre	14.756	2.111	-3.257	0.012
	Post	16.848	2.724		
VO ₂ (ml.min-1)	Pre	521.369	71.214	5.781	< 0.001
	Post	396.573	19.364		
(HR) (bpm)	Pre	109.494	10.117	2.941	0.019
	Post	100.728	3.814		
(RQ)	Pre	0.967	0.073	5.047	0.001
	Post	0.843	0.051		
(Speed) (second)	Pre	70.333	6.325	5.192	0.001
	Post	60.889	3.18		
Accuracy) (second)	Pre	7.222	1.716	3.25	0.012
	Post	5.778	1.202		
(Achievement in the Skill Performance Test) (second)	Pre	77.556	7.299	5.699	< 0.001
	Post	66.667	4.062		

3.3. Presentation of the Differences between the Experimental and Control Groups in the Post-Test

Table 5 presents the post-test means, standard deviations, t-values, and significance levels for the physiological and skill-related variables when comparing the experimental (AWBR) group with the control group, showing clear superiority of the experimental group across all measured variables:

1. The Intervention (AWBR) Group outperformed the control group in Bruce Test performance and VO₂max during exertion.
2. The Intervention (AWBR) Group showed superiority over the control group in LAm_{ax} values measured five minutes after exertion.
3. The Intervention (AWBR) Group achieved better recovery outcomes than the control group in VO₂, HR, and RQ measured 10 minutes after exertion.
4. The AWBR (Awareness-Based Relationship) Intervention Group performed better than the control group in all measured variables of skill performance which were speed of execution, accuracy, and total score in the skill performance test.

4. Discussion

4.1. The Effect of Intensive Training and Water-Based Active Recovery on Bruce Test Performance

The inclusion of water-based active recovery (WBAR) into the training program likely contributed, at least in part, to the intervention group's (AWBR) exceptional performance on the Bruce test (Tables 3-5). This recuperation method may have helped eliminate metabolic waste products like lactic acid more effectively, which would have reduced exhaustion during training.

A large body of research has shown that submersion in water reduces gravitational stress and increases peripheral circulation [14, 18]. It is believed that hydrostatic effects are the reason behind faster recovery, especially in sports like futsal which require both aerobic and anaerobic capacities. High-intensity training along with aquatic therapy has been reported to produce a synergistic effect according to previous studies [18, 19].

Moreover, Crowther's mixed-methods study found that water active recovery was a common recovery strategy for team sports players [20]. Even though the scientific community is still split regarding the technique's actual physical benefits, it seems that most athletes consider it as a physically and mentally beneficial exercise that makes them feel less tired and more ready for the coming sessions. This is in line with the gains made by the test subjects, indicating the multi-dimensional nature of WBAR's positive impacts on both the body and the mind.

4.2. Effect on Maximal Oxygen Uptake (VO_{2max})

The AWBR technique that incorporates intense training along with water-based active recovery brought about a significant increase in VO_{2max} in the subjects and the evidence can be derived from (Tables 3-5). This might indicate that intensive training accompanied by water recuperation is the most effective way to raise the levels of aerobic fitness and cardiovascular endurance. It could also be that the water recovery method played a role in reducing fatigue after the workout, thus making the body more receptive to the change through exercise.

Earlier studies have indicated active recovery methods, particularly water, can greatly assist in metabolic recovery, lessen post-exercise fatigue and eventually improve cardiac and vascular functions [21, 22]. However, we must be careful in drawing parallels between these results and those from previous studies that provided evidence since many studies were conducted under different conditions or for shorter durations.

Some of the unique properties of water like buoyancy and resistance might have played a part in the positive effects that were noticed. The properties may act to load the muscles and joints less and at the same time increase blood flow to the limbs. The athletes could have been able to train harder without becoming too fatigued if this had been done. Water exercises may hasten aerobic recovery by reducing cardiac strain and increasing blood flow to muscles, as pointed out by Wilcock et al. [10], who also showed comparable beneficial benefits.

Furthermore, it was suggested in the study of Mota et al. [23] that active recovery in water could improve oxygen delivery to working muscles, which in turn could assist in sustaining performance during aerobic and anaerobic workouts.

4.3. Post-Exercise Blood Lactate (LA_{max})

There was a statistically significant difference between the two groups in terms of the amount of lactate (LA_{max}) in the blood immediately following exercise, with the experimental group of players exhibiting this difference. This may indicate that the athletes in the AWBR group were able to exercise at a higher intensity for longer periods of time, which would indicate that their anaerobic energy efficiency had improved.

High lactate levels in these situations do not always indicate that the players were really exhausted, according to the "Lactate Shuttle" theory [24]. However, this can indicate that the athletes' bodies are responding positively to the training. According to this view, lactate is involved in more than simply the breakdown of muscle tissue; it's also crucial for the proper passage of energy between muscle fibers and for reestablishing metabolic equilibrium following strenuous exercise.

In addition, the athletes' other physiological metrics, along with the lactate result, may imply that they maintained their high-intensity performance despite the partial blood lactate levels. They can keep up almost the same levels of performance since their muscles and bodies have adapted to the lactate environment. The physiological alterations might have been caused by the body's improved acid buffering capabilities, which were likely enhanced during anaerobic glycolysis, the major source of acid. This method would make it possible to efficiently prolong the duration of the muscle contractions. It is believed that athletes might perform even better under anaerobic stress if they combine high-intensity training with Active Recovery strategies, such as swimming at a moderate intensity. Prior studies have provided evidence in favor of this, such as Bishop's arguments [10, 22].

Though one research by Monedero and Donne [25] suggests it could be an indirect strategy, active recovery in water has never been thought of as a direct way to facilitate lactate elimination. There may have been a more favorable ratio of fatigue to preparedness if the participants had access to water. It is quite probable that this is the reason why the players demonstrated improved lactate tolerance and activity endurance during the Bruce test.

This was supported by an additional study that showed lactate clearance was quicker following water-based cycling compared to conventional land-based rehabilitation [18]. This, according to the researchers, is because floating helps blood flow more freely and lessens the impact of gravity. Athletes in futsal and other mixed-effort sports benefited from water workouts in terms of both performance and recovery time, according to another study [14].

4.4. Physiological Recovery Indicators (VO_2 , HR, RQ)

The recovery results demonstrated that the AWBR group recovered more quickly than the control group, as shown by lower levels of VO_2 , HR, and RQ. Benefits of low-intensity water workouts include relaxation, improved blood circulation, stability of physiological variables, and a reduced heart rate. A quicker recuperation is in store for those who participate in water activities. The instance of futsal and similar games where anaerobic and aerobic power are equally important is a prime example of this. The author's confirmation of this (Brooks) theory lends credence to the idea that a drop in RQ can indicate an increase in fat oxidation during resting periods, relieving

stress on anaerobic pathways [24]. Active recovery in water would help the heart rate recover (and, by extension, restore physiological balance) after exercise, according to another [25]. In addition, research has shown that contrast water treatment can help alleviate post-workout muscle soreness and speed up the recovery of muscular strength [26]. These aspects are expected to contribute to a speedier recovery of total physical performance.

Consistent with Nemčić and Calleja-González [27], who indicated the quality of recovery by improvements in aerobic recovery indicators, the current data demonstrate a substantial physiological recovery in the experimental group. Reductions in heart rate (HR), oxygen consumption (VO_2), and respiratory quotient (RQ) during the recovery phase suggest that water-based active recovery and intense training have a synergistic effect on the body's ability to recover from exercise. Because water can support very light items, it eases the load on the muscles and tissues. The water works as a medium that somewhat tight, forceful motions can stimulate blood flow through, relieving further pressure on already-fatigued tissues [14]. The transport of oxygen and nutrients to the working muscles is accelerated by hydrotherapy, which involves dilating the blood vessels to a certain amount in water heated to 30-32 °C. After this, the injured muscles will begin to repair and the autonomic balance will be restored when the parasympathetic nervous system is activated [12, 28]. Since the heart and breathing rates decrease more rapidly as a result of the interaction between heat and blood circulation, this facilitates a more rapid and effective cardiorespiratory recovery following the high-intensity physical exercise [13, 29].

Athletes' heart rates decreased more rapidly and they recovered more effectively after drinking water, as shown in [19]. One possible mechanism by which submersion alleviates emotional and physical stress is that the body may take physiological measurements for the indications of improvement more rapidly.

On the other hand, the control group did exhibit evidence of recovery, albeit at a slower pace. These results might suggest that the recovery program that used water helped reduce heart strain and improve metabolic recovery. Another possible explanation for the lower RQ in the Intervention (AWBR) Group during recovery is that they use substrates (fat and carbohydrates) more efficiently. This is a characteristic typically seen in athletes who have adapted effectively to their environment. A beneficial physiological adaptation that can be achieved by appropriate training and recuperation methods is an improved capacity to oxidize fat as the primary energy source, as mentioned in [30].

4.5. Skill Performance

Table 5 demonstrates that all skill indicators revealed statistically significant differences between the control group and the Intervention (AWBR) Group, with the Intervention (AWBR) Group emerging as the top

performer. Following training, there were noticeable gains in performance for the Intervention (AWBR) Group. One indicator of successful program execution leading to improved skill competence among futsal players is a rise in the total composite score on the sport's skill test.

One possible explanation for this remarkable shift is the way water-based active recovery aids neuromuscular recovery in the time between workouts. Because of this, athletes kept their motor efficiency and gave the tasks a better shot. What has accelerated the motor response is likely the relaxation brought on by the extremely low-intensity underwater exercises and the enormous blood flow to the legs. Additionally, the skill's efficient execution may have been influenced by the central nervous system, which may have been mitigated by the calming effects of aqua-associated recovery, which in turn reduced mental weariness.

Active recuperation after futsal matches reduced tiredness and increased performance the following day, according to the results of Tessitore et al. [8], which lend credence to the suggested interpretations. Furthermore, as correctly pointed out by Nemčić and Calleja-González [27], technical success in sports involving extremely high intensity and intermittent training, such as futsal, is dictated by the quality of recuperation, not the amount. Therefore, quality, not number, should be the main focus of recovery efforts.

It appears that athletes at all levels of technical competence are utilizing active recovery in water to juggle rigorous training. Training hard may help athletes not only overcome emotional and physical exhaustion, but also return to their desired performance levels [11].

It appears that elite futsal players may achieve their physical and technical training goals while simultaneously improving their tactical game by combining high-intensity training with active water recovery sessions.

This agrees with the result given by Nemčić and Calleja-González [27]: futsal's technical aspect will be directly improved by active recuperation. This lines up with the findings in [13], which show that swimming or other forms of water recovery between games have significant physical advantages for all team sports.

Among the many benefits to coaches that Active Water-Based Recovery (AWBR) training provides is the enhancement of players' recovery and skill performance accuracy. When you incorporate AWBR into your hard exercise, it helps your body recover faster. It appears that AWBR helps the players concentrate better and get their abilities aligned more precisely, in addition to reducing mental tiredness and tension. Elite athletes make the connection between this finding and the increasingly studied topic of recovery perception [21, 27].

5. Conclusions

This study's results suggest that after including water

active recovery into their normal training program, futsal players improved their technical and physical performance in the areas where they were trained. The experimental group outperformed the control group on the Bruce test and had higher VO_2max values, indicating a beneficial impact on physical performance. The athletes' enhanced aerobic capacity and resilience to high-intensity sprints are likely the causes of these increases.

A higher lactate handling capacity (LAm_{ax}) was also noted in the water-based active recovery (AWBR) group, suggesting that they may be able to maintain their performance under demanding conditions. Furthermore, the respondents' decreased VO_2 , HR, and RQ values approximately ten minutes post-exercise suggest that water aids active recovery and speeds up the body's normalization process.

A skill test measuring overall performance, accuracy, and speed found that the AWBR group performed better than the control group. Incorporating recovery tactics into futsal players' high-intensity training routines is essential if we want them to get fitter and better players overall. These results point to the fact that physical recovery is crucial to a player's technical skill.

5.1. Recommendations

Considering the preliminary data described earlier, we propose the following recuperation approaches that can be evaluated for effectiveness and eventually used in the training of top futsal players:

1. **The Integration of Water Applications for Recovery:** One way to improve physiological recovery and reduce neuromuscular fatigue is to include low-intensity swimming (~30-40% HR_{max}) into training cycles gradually.
2. **Neuromuscular Efficiency Support:** Along with water-based recovery, investigate neuromuscular endurance and skill performance retention in high cumulative fatigue periods.
3. **Recovery Monitoring Individualization:** Post-exercise indicators (VO_2 , HR, RQ) can be used to monitor recovery efficiency and customize recovery strategies to the individual needs of the athlete.
2. Larger randomized controlled trials can be conducted to validate the effectiveness of water-based recovery protocols and to create evidence-based guidelines for their application in elite futsal training.

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