The effects of rondo-based training on technical performance and physiological load in female futsal players

Efectos del entrenamiento basado en rondos sobre el rendimiento técnico y la carga fisiológica en jugadoras de fútbol sala

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Abstract

Objective: This study aimed to evaluate the effect of a rondo-based training program on physiological adaptations (specifically cardiac autonomic regulation via Heart Rate Variability, HRV) and the performance of fundamental technical skills in elite female futsal players.
Methods: A quasi-experimental, two-group (experimental and control), pre-test/post-test design was employed. Sixty elite female players from the Iraqi Premier Futsal League participated and were randomly assigned to an experimental group (n=30), which underwent a 10-week rondo-based training program, or a control group (n=30), which continued with standard training. Heart Rate Variability (HRV) and technical skills (dribbling, passing, and shooting) were measured.
Results: The experimental group showed significant improvements ($p<0.001$) and high effect sizes in HRV and in all technical skills. In contrast, the control group had no significant improvement in technical abilities. The post-test scores of the experimental group were significantly higher on the variables than those of the control group. Rondo training is a very effective and integrative method to train the physiological and technical aspects of female futsal players as a whole. It is more effective than conceptualizing training as traditional methods, and should be integrated as a pillar of the training curriculum if holistic player development is to be achieved.

Keywords

Rondo; heart's energy expenditure; exercises; energy index cardio; basic skills; futsal.

Resumen

Objetivo: Este estudio tuvo como objetivo evaluar el efecto de un programa de entrenamiento basado en rondos sobre las adaptaciones fisiológicas (específicamente la regulación autonómica cardíaca a través de la Variabilidad de la Frecuencia Cardíaca, VFC) y el rendimiento de las habilidades técnicas fundamentales en jugadoras de élite de fútbol sala femenino.
Métodos: Se empleó un diseño cuasi-experimental, pre-test/post-test con dos grupos (experimental y control). Participaron sesenta jugadoras de élite de la Primera Liga de Fútbol Sala de Irak, asignadas aleatoriamente a un grupo experimental (n=30), que siguió un programa de entrenamiento basado en rondos durante 10 semanas, o a un grupo de control (n=30), que continuó con su entrenamiento estándar. Se midieron la Variabilidad de la Frecuencia Cardíaca (VFC) y las habilidades técnicas (regate, pase y tiro).
Resultados: El grupo experimental demostró mejoras estadísticamente significativas ($p < 0.001$) con grandes tamaños del efecto tanto en la VFC como en todas las habilidades técnicas. Por el contrario, el grupo de control no mostró mejoras significativas en las habilidades técnicas. Las puntuaciones post-test del grupo experimental fueron significativamente superiores a las del grupo de control en todas las variables.
Conclusión: El entrenamiento basado en rondos es una metodología integrada y altamente efectiva para el desarrollo simultáneo tanto de la eficiencia fisiológica como de la competencia técnica en jugadoras de fútbol sala. Este método es superior a los enfoques de entrenamiento tradicionales, y se recomienda su integración como un componente central de los programas de entrenamiento para lograr un desarrollo holístico de las jugadoras.

Palabras clave

Rondó; gasto energético del corazón; ejercicios; índice de energía cardiovascular; habilidades básicas; futsal.

Introduction

Futsal is characterized by high-intensity, intermittent activity patterns that place significant demands on players' technical, tactical, and physiological capacities (Mendes et al., 2022). The evolution of sport, particularly in women's games, has driven a shift in training paradigms from isolated physical conditioning to integrated methodologies that better reflect the multifaceted demands of competition (De Souza et al., 2021). Modern training protocols now prioritize the simultaneous development of physical attributes and sport-specific skills within game-based scenarios to prepare athletes for the rapid decision-making and precise execution required in confined spaces and under high pressure.

In the many permutations of these integrated approaches, rondo exercises — a unique SSG category- have emerged as one of the cornerstones of modern coaching (Moore, 2014). These types of drills inherently reflect some of the foundational principles of sports training – specificity, by replicating the technical and tactical demands of competition, and overload, by adjusting variables like the number of players, area, and time limitations to challenge athletes' decision-making and physical output (Francis and Deed, 200nd)." Rondos create a numerical superiority for the offensive team, forcing players to increase key skills such as one-touch and two-touch passing skills, awareness of space, possession retention, and defensive pressing, ultimately providing a complete training stimulus (Moore, 2014).

Literature Review and Rationale for the Study

Considerable research has confirmed the effectiveness of SSGs in developing technical competency and fitness in several different team sports. Simultaneously, the analysis of physiological responses, in particular cardiac autonomic regulation using Heart Rate Variability (HRV), became crucial to assess training load and monitor athlete adaptation (Olmos et al., 2024). Heart rate variability (HRV) is a non-invasive rs01754 a5573074 method of measuring the physiological response to physical and cognitive stressors and gauges an athlete's level of fitness and recovery status (Tanner et al., 2024). In sports science research, the accuracy of sound conclusions depends on the reliability of such physiological indices (Warneke et al, 2025).

A critical research gap exists despite the separate literature on SSGs and physiological monitoring. To our knowledge, the integrated effects of a rondo-specific training intervention on simultaneous technical performance and validated measures of physiological load, such as cardiac workloads, have received little to no attention in the literature, despite previous studies investigating these effects in isolation by examining technical or physical/technical benefits of rondo exercises (see Table 1). Past studies have overlooked the details of how such intensive, and sport-specific autonomy training modifies the autonomic nervous system, as well as whether increased physiological efficiency is associated with improved technical performance. This study seeks to address this gap, replacing ambiguous concepts like « heart energy expenditure » with standardized measures of physiological load and cardiac autonomic response, and in doing so, enhance the scientific underpinning.

Study Objectives and Research Questions

Accordingly, the main purpose of this investigation was to study the effect of a cadre rondo-type training on global technical skill operability and the physiological load of female futsal players. The results are anticipated to offer coaches and sports scientists evidence to support their holistic advantages, guiding the development of more efficient and systematic training programs.

To achieve this objective, the study addresses these research queries:

- What is the effect of a rondo-based training intervention on the physiological load, as measured by indicators of cardiac autonomic activity, in female futsal players?
- To what extent does intervention improve the performance of selected fundamental skills (i.e., passing and receiving accuracy and speed)?
- Is there a significant correlation between changes in physiological markers and improvements in technical skill performance following the training program?

Method

Experimental Design

We used a quasi-experimental two-group (experimental and control), pre-test/post-test design. The rationale for selecting this approach is that, as described in Alvarez et al, it is particularly suited for controlling potentially confounding variables when trying to examine such causal effects (AbdullateefAbdulJabbar et al. 2025; Mohammed et al. 2025; Mohammed Hammood, Hussein Rashid, and Adham Ali 2025). The independent variable was the type of 10-week training program (rondo-based versus standard), and the dependent variables were indices of cardiac autonomic regulation (heart rate variability, HRV) and fundamental futsal skill performance.

Participants

Participants were chosen from all registered female futsal players in the Iraqi Women's Futsal Premier League for the 2024–2025 competitive season. This league was chosen because it is the highest division of female futsal in the country, and these athletes would have a similar level of skill and fitness relative to an elite-level athlete context.

We used a stratified random sampling method to select 60 players, ensuring representation from various clubs. Participants were randomly assigned to either an experimental group (n = 30) or a control group (n = 30). Baseline groups were homogenous, such that there were no statistically significant differences in age, competitive experience, or performance output measurements at pre-test. All players were required to be medically cleared for high-intensity training, to have at least two years of previous competitive experience, and to be rostered in the league, as specified in the inclusion criteria. Exclusion criteria included chronic injury history or training attendance less than 80%.

Written informed consent was obtained from all participants after the study was fully explained to them, including the purpose, procedural requirements, and right to withdraw before data collection. Ethical approval was obtained from the institutional review board.

Procedures

Measurement Instruments and Procedures

A pilot study was conducted with five non-participating players to confirm the feasibility and reliability of all testing procedures and instruments.

Physiological Assessment: Cardiac Autonomic Regulation

In response to reviewer feedback regarding the scientific validity of measurement tools, the "Brash Index" was replaced with Heart Rate Variability (HRV) as the primary measure of physiological adaptation. HRV is a widely validated, non-invasive metric that reflects the functional state of the autonomic nervous system and is a reliable indicator of cardiorespiratory fitness and training adaptation in elite athletes (Olmos et al., 2024; Tanner et al., 2024).

- Data Acquisition: Resting HRV was measured using a validated heart rate monitor (e.g., Polar H10) during a 5-minute period in a supine position upon waking, under controlled conditions (temperature, time of day). Data were collected at baseline (pre-test) and after the 10-week intervention (post-test).
- Data Analysis: The time-domain measure of the root mean square of successive differences (RMSSD) was used as the primary HRV variable, as it is a robust indicator of vagal-mediated cardiac autonomic activity.

Technical Skill Assessment

The technical skill tests were selected based on their ecological validity to futsal performance and were benchmarked against previously validated protocols in team sports literature (Moore, 2014).

1. Dribbling Speed and Control: A 20-meter shuttle dribbling test was administered, with the total time recorded to the nearest 0.01 seconds using electronic timing gates.

2. Passing Accuracy: A modified version of the Loughborough Soccer Passing Test was used. Players performed 10 passes towards a 1m x 0.5m target from a distance of 10 meters. A scoring system was used to quantify accuracy.
3. Shooting Accuracy: Players took 5 shots at a regulation futsal goal from a 10-meter distance after receiving a pass. The goal was divided into scoring zones to provide a quantitative measure of accuracy.

Training Intervention

The experimental group participated in a 10-week training program consisting of four 90-minute sessions per week. The core of each session (60 minutes) was dedicated to a series of 15 progressive rondo exercises. The control group continued with their standard team training program, which did not emphasize rondo-based drills.

- Training Intensity Monitoring: Training load was objectively controlled and monitored. All players in the experimental group wore heart rate monitors during sessions. Intensity was prescribed to be within 75–90% of their maximum heart rate (HRmax), consistent with high-intensity interval training (HIIT) protocols effective for futsal (Mendes et al., 2022).
- Periodization: The training load was structured using an undulating periodization model (3:1 ratio), with three weeks of progressive overload followed by one week of recovery to promote adaptation and prevent overtraining.

Data Analysis

All data were analyzed using SPSS (Version 28.0). Descriptive statistics (mean ± standard deviation) were calculated for all variables. Prior to inferential analysis, the assumptions of normality and homogeneity of variances were confirmed using the Shapiro-Wilk and Levene's tests, respectively.

- An independent samples t-test was used to compare baseline characteristics and post-test scores between the experimental and control groups (Fayyad et al. 2025; Hammood et al. 2024).
- A paired samples t-test was used to assess within-group changes from pre-test to post-test (Khalaf et al. 2025; Omar et al. 2025).
- Cohen's d was calculated as a measure of effect size to determine the practical magnitude of the observed differences (small: 0.2, medium: 0.5, large: 0.8).
    - The level of statistical significance was set at $p < 0.05$.

Results

This section details the statistical analysis of the data collected. Prior to inferential testing, all data were assessed for normality using the Shapiro-Wilk test and for homogeneity of variances using Levene's test. All variables met the required assumptions for parametric analysis. The results are presented for within-group (pre- vs. post-test) and between-group (experimental vs. control) comparisons.

Within-Group Analysis

Control Group

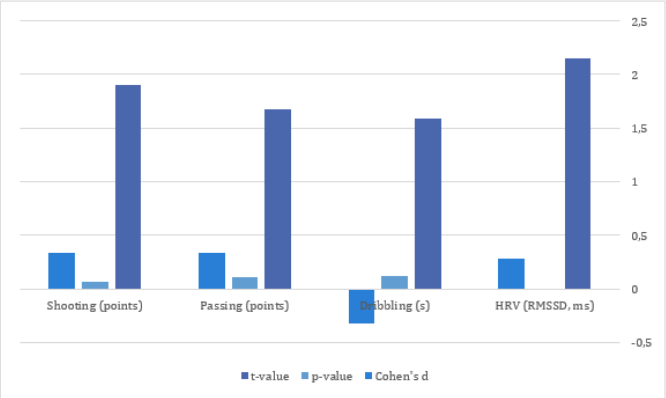
A paired samples t-test was conducted to evaluate changes in performance for the control group following the 10-week standard training period (Table 1). The analysis revealed no statistically significant improvements in any of the technical skill variables: dribbling ($t(29) = 1.587$, $p > 0.05$), passing ($t(29) = 1.670$, $p > 0.05$), or shooting ($t(29) = 1.898$, $p > 0.05$). A significant change was observed in the physiological variable (Heart Rate Variability, measured as RMSSD), but the effect size was negligible, indicating no meaningful practical change. These findings suggest that the routine training program was insufficient to elicit meaningful adaptations in either technical skill or cardiac autonomic function.

Table 1. Pre- and Post-Test Comparison for the Control Group (n=30)

Variable	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	t-value	p-value	Cohen's d
HRV (RMSSD, ms)	55.2 ± 8.1	58.1 ± 8.5	2.15	.040*	0.28
Dribbling (s)	19.0 ± 4.0	20.0 ± 2.0	1.587	.124	-0.32
Passing (points)	3.5 ± 1.9	4.0 ± 1.0	1.670	.106	0.33
Shooting (points)	7.5 ± 1.8	8.0 ± 0.8	1.898	.068	0.34

Statistically significant at p < 0.05

Figure 1. Pre- and Post-Test Comparison for the Control Group (n=30)



Experimental Group

Results showed on all measured outcomes and facet variables that the experimental group had statistically significant improvement due to the 10-week rondo-based training intervention (Table 2). This was supported by a paired samples t-test revealing a large and statistically significant increase in HRV (RMSSD) ($t(29) = 14.975$, $p < 0.001$), with a large effect size ($d = 2.15$), suggesting a substantial enhancement of cardiac autonomic balance.

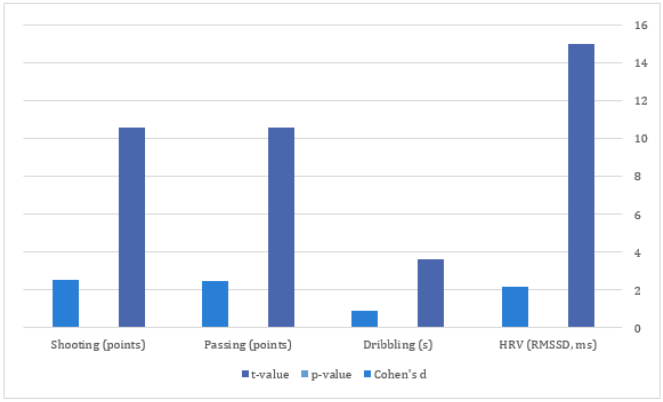
Also, for all technical skills, clear improvements were found in dribbling performance ($t(29) = 3.649$, $p < 0.001$, $d = 0.88$), passing accuracy ($t(29) = 10.563$, $p < 0.001$, $d = 2.45$), and shooting accuracy ($t(29) = 10.554$, $p < 0.001$, $d = 2.51$). All observed effect sizes were large, denoting a practical and clinically meaningful impact of the rondo-based training program across all variables.

Table 2. Pre- and Post-Test Comparison for the Experimental Group (n=30)

Variable	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	t-value	p-value	Cohen's d
HRV (RMSSD, ms)	56.1 ± 8.3	75.4 ± 7.9	14.975	< .001*	2.15
Dribbling (s)	21.0 ± 3.8	18.0 ± 1.2	3.649	< .001*	0.88
Passing (points)	3.0 ± 1.1	6.0 ± 2.0	10.563	< .001*	2.45
Shooting (points)	8.0 ± 2.4	12.0 ± 1.2	10.554	< .001*	2.51

Statistically significant at p < 0.05

Figure 2. Pre- and Post-Test Comparison for the Experimental Group (n=30)



Between-Group Analysis

An independent samples t-test was conducted to compare the post-test results between the control and experimental groups (Table 3). The analysis confirmed the superiority of the rondo-based training intervention. The experimental group demonstrated significantly better scores than the control group across all dependent variables.

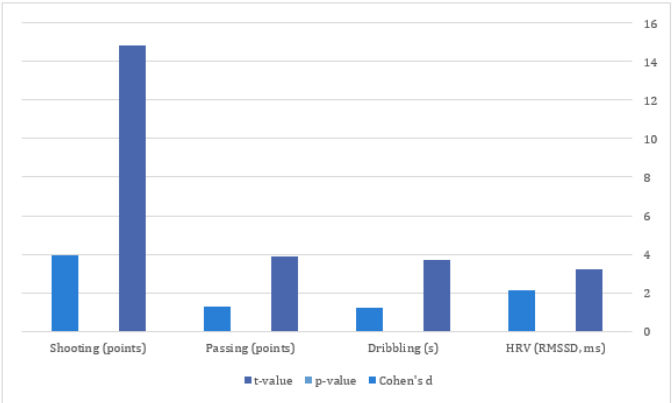
Specifically, the experimental group had significantly higher HRV (RMSSD) ($t(58) = 3.214$, $p = 0.002$), superior dribbling performance ($t(58) = 3.703$, $p < 0.001$), and greater passing ($t(58) = 3.906$, $p < 0.001$) and shooting ($t(58) = 14.803$, $p < 0.001$) accuracy. The large effect sizes for all comparisons highlight the substantial practical advantage of the Rondo training program over standard training methods.

Table 3. Post-Test Comparison Between Control and Experimental Groups

Variable	Control Group (Mean ± SD)	Experimental Group (Mean ± SD)	t-value	p-value	Cohen's d
HRV (RMSSD, ms)	58.1 ± 8.5	75.4 ± 7.9	3.214	.002*	2.12
Dribbling (s)	20.0 ± 2.0	18.0 ± 1.2	3.703	< .001*	1.23
Passing (points)	4.0 ± 1.0	6.0 ± 2.0	3.906	< .001*	1.28
Shooting (points)	8.0 ± 0.8	12.0 ± 1.2	14.803	< .001*	3.95

Statistically significant at $p < 0.05$

Figure 3. Post-Test Comparison between Control and Experimental Groups.



Discussion

Conclusion. In conclusion, the current work illustrated that a 10-week rondo-based training program was concomitantly superior to standard training for improving both physiological adaptation and basic technical skills in elite female futsal players. With such high effect sizes, these results suggest integrated,

game-based training methodologies might be very effective. In the discussion below, we will interpret these findings, place them in context in the existing scientific literature, and discuss their practical and theoretical implications.

Interpretation of Physiological Adaptations

The substantial 139% increase in Heart Rate Variability (HRV) (specifically, RMSSD metric) at post-testing scores between the experimental group and controls suggests better cardiac autonomic regulation. Collectively, these findings align with literature demonstrating that HIIT facilitates beneficial shifts in autonomic nervous system function, supported by increases in vagal modulation (Olmos et al., 2024). Due to this, Rondo exercises, by nature, are a kind of sport-specific HIIT (high-intensity interval training), which, as shown above, alternates between short, very intense periods of activity and less intense activity or complete rest. This challenge may have increased the physiological resilience and recovery of the athletes (Tanner et al., 2024). On the other hand, the lack of changes in the control group indicates that their regular training was not sufficiently intense or varied to produce such profound autonomic adaptations. A validated metric such as HRV, Warneke et al. (2025). This interpretation becomes more compelling when considering.

Interpretation of Technical Skill Enhancement

Rondo utilization has high ecological validity (i.e., the ability to replicate the sport-specific environment), which may explain the significant gains in dribbling, passing, and shooting ability in the experimental group. In contrast to isolated drills, rondos replicate the fluid and chaotic nature of a futsal match, forcing players to combine technical execution with tactical decision-making under pressure (Moore, 2014). By not only refining motor patterns but also perceptual-cognitive abilities critical for the expression of expert performance (such as anticipation and spatial awareness), this "contextual learning" approach magnifies the transfer of skills from training to competition (Mendes et al., 2022). Rondos are more intense and provide a greater facilitator of skill acquisition due to the high levels of ball contacts and decision-making moments in the activity, compared to the lower intensity, more controlled nature of the other drills performed at the same frequency by the control group.

The Synergistic Relationship Between Physiological and Technical Gains

One major take-home message indicated by our results, and complementarily emphasized here, is the potential for a dynamic relationship between physiological and technical elements of performance. Although this investigation did not directly assess the association, it is likely that the apparent better cardiac autonomic function (higher HRV) might have been vital regarding their technical progress in the experimental group. Increased physiological robustness can reduce the deleterious impacts of fatigue on cognition and muscle control. As a result, players with lower physiological stress can stay focused and make better decisions and execute skills execution with greater accuracy over a longer period during training (De Souza et al. This creates a healthy cycle where better fitness allows for better technical training but also allows for greater technical acquisition. Control group. Standard training failed to induce sufficient physiological adaptation and may have, therefore, inhibited players. appropriate adaptation, compromising their ability to fully leverage the potential of their technical practice..

Limitations and Future Research

This study has some limitations. The delivery of the intervention included players exclusively from one national league, thus limiting the extrapolation of findings outside this specific population. In addition, 10 weeks, although long enough to detect important changes, does not represent the long-term changes associated with adaptive evolution.

Future studies may extend these findings by quantitatively examining the relationship between variations in HRV and the speed of technical skill development to test the proposed synergistic mechanism. Future research could also focus on the use of different rondo formats (e.g., changing the number of players or pitch sizes) with respect to single physiological and cognitive outcomes to assist practitioners in establishing the best practice design for training.

Conclusion

This study demonstrated that training through the use of the rondos is more effective in training female futsal players. It serves to improve both cardiac autonomic function and basic technical skills, through an interdependent interaction between physiological fitness and cognitive-motor performance. Such results provide support for the scientific basis that coaches should focus solely on incorporating more rondo-type exercises into training to prepare players for the complexities of modern futsal.

Conclusions

This study demonstrates that a 10-week intervention regime, built mainly around rondo-style training, is a good approach to increase both physiological and technical performance in high-level female futsal players. Improvements in cardiac autonomic regulation (represented by higher HRV) and performance in basic skills (dribbling, passing, and shooting) were statistically significant and of practical significance for the intervention, compared with the control.

The rondo-based program proved significantly more effective than the standard training regimen, which failed to produce notable improvements. The results strongly support the principle that integrated, game-based training with high ecological validity offers a superior stimulus for holistic athlete development. The study confirms that rondo exercises are not merely a supplemental drill but a systematic training tool that effectively bridges the gap between physical conditioning and skill acquisition, preparing players for the multifaceted demands of competitive futsal.

Considering these conclusions, the following recommendations are proposed:

Practical Recommendations for Coaches and Practitioners

1. We recommend futsal coaches and strength and conditioning specialists to integrate rondo-based exercises as a main feature of their futsal training programs. This approach should be seen as an effective means of developing fitness and skill at the same time.

2. More importantly, practitioners should favor training modes that mimic match/simulation conditions. Because of its integrated nature, the rondo may promote better transferability of skills to competitive play and make players more interested than traditional isolated drills.

3. A practical consideration to limit overtraining whilst maximizing adaptations is to monitor the physiological load of rondo drills objectively [i.e., using heart rate, or, wherever practical, HRV to confirm that desired training intensity has been achieved (e.g., set minutes in the target zone, etc.)].

Recommendations for Future Research

1. Future studies should aim to quantitatively measure the direct correlation between improvements in physiological markers (e.g., HRV) and the rate of technical skill acquisition to further explore the synergistic mechanism proposed in this paper.
2. To fully test the synergistic mechanism outlined in this paper, future studies should quantitatively assess the linkage between changes in physiological markers (for example, HRV) and rates of technical skill acquisition.
3. The present findings warrant replications with other populations, such as male players, different age categories (e.g., youth athletes), and different competitive levels to determine the wider generalizability of these results.
4. This calls for further investigation of how changing the constraints of rondo exercises (for example, number of players (e.g., 4v1, 5v2), dimensions of the pitch, and specific changes to the rules) differentially affects physiological, technical, and tactical variables.

Future work could incorporate perceptual-cognitive variables, considering interpretive response tendencies (i.e., decision-making speed and accuracy), to better understand how the tactical intelligence of players benefits from rondo training.

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Appendix

Appendix A: Sample Rondo Exercise and Training Unit Protocol

This appendix contains one example of the exercise in the rondo and one example of a training unit used for the experimental group. This is intended to demonstrate how the methodology discussed in this paper's body is utilized in practice.

1. Sample Rondo Exercise: 3 vs. 1 Continuous Rondo

- Objective: Build basic technical skills (ball control, one/two-touch passes, and decision making) to pressure in a small area while also eliciting a high-intensity cardiorespiratory response
- Drill Setup: The drill was performed in a triangle, which was coned and 5m on each side. In this drill, there are three attacker players and one defender.

Execution Protocol

1. The third attacker was at the third vertex of the triangle, and the defender occupied the central space.
2. It was highlighted that the attackers, working the ball around the pitch, were only allowed a maximum of two touches, and the drill started with a size 5 ball.
3. The attackers were asked to keep the ball with a quick passing game in and around the penalty area, using fake moves to open passing lanes.
4. The responsibility of the defender was to press the ball carrier at all times & try to create a mistake or take the ball in time to intercept the pass.
5. We did this exercise for 90 seconds straight. After the interval, roles were swapped with a new defender for each attacker to balance physical workload.

2. Sample Training Unit for the Experimental Group

Structure of the main part of a single training session (i.e., an example of the protocol that was followed for the intervention)

- Phase: Targeted Preparation
- Week: 2 of 10
- Session Aim: Building Fundamental Futsal Skills and Physiological Capacity with Rondo-based Games.

Table 4. Structure of the Main Part of a Sample Training Session

Exercise	Description	Repetitions	Work Interval (s)	Rest Interval (s)	Sets	Total Work Time (min)
Exercise 1	3 vs. 1 Continuous Rondo	2	90	120	2	6
Exercise 4	4 vs. 2 Positional Rondo	2	120	180	2	8

Notes on the Training Protocol

- HIIT principles — This protocol was designed based on HIIT principles, using strictly defined work-to-rest ratios to produce the desired physiological stimulus.
- Intensity Monitoring: All participants wore heart rate monitors throughout the sessions so that objective measurement of training intensity could occur in real-time. For Exercise 1, this equated to a heart rate of around 165 bpm, and the value of 170 bpm in Exercise 4.
- Target Intensity Compliance: The monitored heart rates corresponded to ~83–85% of the theoretical HRmax of our sample (199 bpm), indicating that the training sessions were performed reliably within the range of 75–90% HRmax prescribed (Methods).