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Effect of Fatigue Mitigation on Kicking Precision during Penalty Shootout in Soccer

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Abstract
This study investigated the effects of fatigue mitigation on the kicking performance (KP)—specifically kicking precision (KP)—of soccer players during penalty shootouts after playing soccer for 120 minutes. This experiment was executed due to a gap in the concept and method in the literature. Therefore, this research filled the Research Knowledge gap, also known as the Knowledge void, in both concept and method. The fatigue indicator examined was general fatigue (GF). Employing a two-group pretest-post-test quasi-experimental design, the research involved 20 elite male field soccer players (mean age = 19.17 ± 2.68 years; mean weight = 66.09 ± 7.74 kg; mean height = 1.74 ± 0.065m; mean playing experience = 8.93 ± 2.57years), who were randomly assigned to either an experimental (EX) or control (CO) group. To mitigate fatigue, participants received a traditional Ghanaian meal comprising steamed rice (62%), oil, tomato stew (25%), and fish (13%), providing 4 $g \cdot kg^{-1}$ of body mass (BM) and totalling 1470 kJ of energy, alongside a glucose-fructose electrolyte supplement administered at 1.2 g · kg ¹ BM, which is all grounded in the literature. Significant differences were observed in post-test Blood Glucose levels between the experimental and control groups ($p = .038$). Additionally, within the control group, a significant change was observed between pre-test and post-test Blood Glucose levels ($p < .001$), and when considering both groups combined ($p < .001$). The experimental group also demonstrated a significant difference between pre-test and post-test Blood Glucose levels ($p = .015$). Further analysis revealed statistically significant differences in General Fatigue levels between the post-test experimental and control groups ($p < .001$), between pre-test and post-test General Fatigue within the control group ($p = .002$), and between the pre-test experimental and post-test control groups ($p = .001$). Regarding Kicking Precision, significant differences were identified between the pre-test experimental group and post-test control group ($p < .001$), between pre-test and post-test measures within the control group ($p < .001$), and between the post-test Kicking Precision of the experimental and control groups ($p = .004$). In terms of penalty kicks, statistically significant differences were found between the control group post-test and experimental group pre-test ($p = .004$), between the post-test measures of the control and experimental groups ($p = .002$), and between pre-test and post-test measures within the control group ($p = .002$). These findings suggest that attenuating fatigue contributes to maintaining Kicking Precision during penalty shootouts, potentially attributable to the restoration of Blood Glucose levels and the

consequent reduction in fatigue. It is therefore recommended that coaches and support staff administer glucose-fructose electrolyte supplements at a dosage of 1.2 $g \cdot kg^{-1}$ body mass during tournaments to alleviate fatigue and sustain optimal performance in penalty shootouts.

Keywords: Kicking Precision, General Fatigue, Glucose-Fructose Electrolyte.

Introduction

It is well documented that playing football, also known as soccer, imposes substantial physical and cognitive demands on players throughout the course of the game. These demands are closely associated with the onset of fatigue, which is proportional to the decrease in the Blood Glucose (BG) levels of players as workload intensifies, amidst the long duration of the inherent activities (Feldman & Barshi, 2013); thereby influencing the players' ability to sustain optimal performance (Mohr et al., 2005). Enoka and Duchateau (2016) and Hockey (2013) posited that the fatigue so developed is a physiological phenomenon that is characterised by complex functional alterations in the body that adversely affect athletic performance. This is usually noticeable as diminished energy and decreased motivation among players to engage in further physical exertion. The fatigue that manifests in the players tends to limit their subsequent performance, i.e., kicking, running, and even processing, etc., in soccer (Bangsbo, Iaia & Krustrup, 2007).

Despite numerous scientific advancements and breakthroughs on this subject matter, which has been extensively documented in the literature and utilised by both coaches and players to effectively manage and maintain the outputs of players during matches, relatively few studies and many football stakeholders have overlooked its influence resulting from playing for 120 minutes on the outcomes of penalty shootouts. Furthermore, a substantial body of research has predominantly ascribed players' failures in these shootouts to psychological factors such as pressure, stress, and anxiety, and often neglects the consideration of players' physiological status.

This study aims to elucidate data that may clarify the physiological impact of fatigue alterations on the success of penalty shooting in soccer, with a particular focus on strategies for mitigating player fatigue and subsequent performance outcomes. Specifically, the investigation employs General Fatigue as a stressor to examine its effects on penalty shooting variables, such as Kicking Precision or Accuracy.

It is important to highlight that muscle glycogen reserves, which serve as the primary energy substrate for athletic performance, are metabolised into glucose to satisfy the energy requirements of players. These glycogen levels have been observed to decline by approximately 40% to 90% after a standard high-class 90-minute soccer match (Bangsbo et al., 2007). This observation suggests a substantial accumulation of fatigue by the conclusion of the matches. Consequently, it is reasonable to anticipate that an additional 30 minutes of play—extending the total duration to 120 minutes, as often occurs during tied matches in national and international tournaments (Russell et al., 2011; Quinones, 2016; IFAB, 2023)—would exacerbate fatigue levels to an extreme degree.

Under these severe fatigue conditions, the rules of soccer further challenge players' anaerobic performance, notably during penalty shootouts, which serve as a decisive test of skill and endurance that determines competitive outcomes (Mensah, Moses & Hagan, 2025). Surprisingly, an uncountable number of players have not succeeded in this assessment, although they have all the advantages over the goalkeepers (Leela & Comissiong, 2009).

Thus, this scientific investigation was designed to ascertain the role of physiological alterations in this phenomenon and to significantly increase practitioners' understanding of enhancing player load management to sustain performance during 120 minutes of soccer play, and the impact on their penalty-shooting performance thereafter (Thorpe et al., 2015).
In soccer, kicks—whether a short pass, a long-distance kick, or a scoring attempt— as demonstrated by Radman et al. (2016a, b) and stated in Mensah et al. (2025), are characterised by three dimensions, i.e., Kicking Precision (KP), Kicking Velocity (KV), and Kicking Quality (KQ). Although extreme fatigue, especially General Fatigue (GF) as categorised by Smets et al. (1995), affects every aspect of soccer players' performance, it is uncertain whether the fatigue experienced during the full 120 minutes of play impacts their Kicking Performance (KP = KP, KV and/or KQ) in a penalty shootout. But for this project, only the KP was assessed. These unresolved issues concerning the multifaceted nature of fatigue and its associated impairment of gross motor performance, particularly in relation to failures during penalty shooting, prompted this investigation into the potential deficiencies in the quality of soccer players' penalty kicks during shootouts.

Purpose of the Study

The purpose of the project was to ascertain whether physiologically, accurate kicks made during penalty shootouts at the beginning of a 120-minute match would be similar to those made at the end, with or without an intervention.

Hypotheses

The authors tested the underlisted hypotheses to guide the research:

1. The Blood Glucose levels of the soccer players in the Experimental group will significantly differ from those of their counterparts in the control group after playing for 120 minutes.
2. After playing soccer for 120 minutes, there will be no significant difference in the players' degrees of General fatigue between the control and experimental groups.
3. The Kicking Precision of the soccer players in the control group would significantly differ from that of the Experimental group after exposing the players to 120 minutes of intensive soccer play.

Materials and Methods

Research Design

This study employed a two-group pre-test-post-test quasi-experimental design, recognised as a robust framework for examining cause-and-effect relationships (Neuman, 2014).

Participants

The participants in this study comprised male soccer players competing in Ghana's national tier-one league. Amongst them, 25 players were consistently chosen to represent either the national teams or clubs participating in national tier-one tournaments. For this study, the sample comprised 20 male field soccer players, which facilitated the formation of two teams of 10 players each, designated as the experimental and control groups. The players were purposively selected according to specific criteria, including being physically fit and capable of playing for 120 minutes, having no injuries, being non-diabetic, and abstaining from smoking (Russell et al., 2011). This ensured the non-dilution of the data collected.

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There were discussions between the participants and authors on the confidentiality of information to be obtained before the commencement of the tests. Participants were given instructions and adequate demonstrations of the measurements and procedures before the beginning of the tests. The nature, purpose, and expected outcomes during and after the administration of the tests were also explained to all participants. Those who showed interest signed consent forms.

Measurements

The protocol aimed to induce extreme exhaustion in the control group and to evaluate how the supplementation influenced the Blood Glucose of the experimental group, the corresponding fatigue levels, and their KPs under realistic competitive penalty shootout conditions.

Pre-test

A detailed account of the materials and methodologies employed in this study has been previously documented by Finnoff et al. (2002), Smets et al. (1995), Radman et al. (2016a), Wood and Wilson (2010), and Mensah et al. (2025).

The study utilised the Camry ISO 9001 digital portable scale to measure participants' weights, which informed the individualised bolus and intervention dosages. Participants consumed a standardised Ghanaian meal rich in carbohydrates, fats, and proteins three hours before testing to ensure proper digestion and uptake. The Experimental group (Ex-group) ingested a 50:50% prepared glucose-fructose electrolyte solution at 1.2g per kg of body mass in purified water as established by Andrade-Souza et al. (2015). The players were made to ingest a fifth of the electrolyte before the start of the protocol and during the 2 hydration breaks, as established by FIFA, in addition to the half-time and 90th-minute breaks. These were intended to aid in the stabilisation of the players' Blood Glucose levels and reduce fatigue, while the Control group (Co-group) consumed water as a placebo. All exercise protocols were conducted in the afternoon to ensure ecological validity (match conditions and circadian rhythms; under consistent environmental conditions averaging 33.1°C and low wind).

The study measured Blood Glucose levels, fatigue, and the KP of the soccer players before and after a 120-minute competitive match to assess the effects of the intervention versus a water placebo (the norm during these matches) on the outcomes of the kicks. Blood Glucose was monitored using a portable Glucose meter from fingertip capillary blood samples, while fatigue was evaluated through the Multidimensional Fatigue Inventory (MFI-20) from Smets et al. (1995), which assessed their General Fatigue via self-reported ratings.

The KP or KP were also tested using a standardised wooden target to assess shooting accuracy (Finnoff et al., 2002), and the penalty kicks were recorded on video with a goalkeeper present to ensure ecological validity. The recorded videos were analysed to extract the second part of the KP data. This was done by dividing the scoring areas of the goalpost into 75 zones—5 verticals and 15 horizontals—based on the 0.488 m × 0.488 m zones as established by Radman et al. (2016a). This helped to ascertain accurate ball entry positions within the goalpost. Players were asked where they intended to place the ball after they had kicked to compare with the actual point of entry. All shots, including those that missed the target and obstructed shots, were rated for accuracy based on their expected placement (Wood & Wilson, 2010).

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Post-Test

Following the completion of the first part of the protocol, the Blood Glucose measurements of the participants were re-taken without delay to ascertain the on-the-spot established levels as well as the fatigue status (MFI-20) of the players without recovery. This was then followed by the post-KP measurements as described in the pre-test.

Below is the schema of the tests as displayed in Mensah, Moses and Hagan (2025).

Schema of the test/ data collection

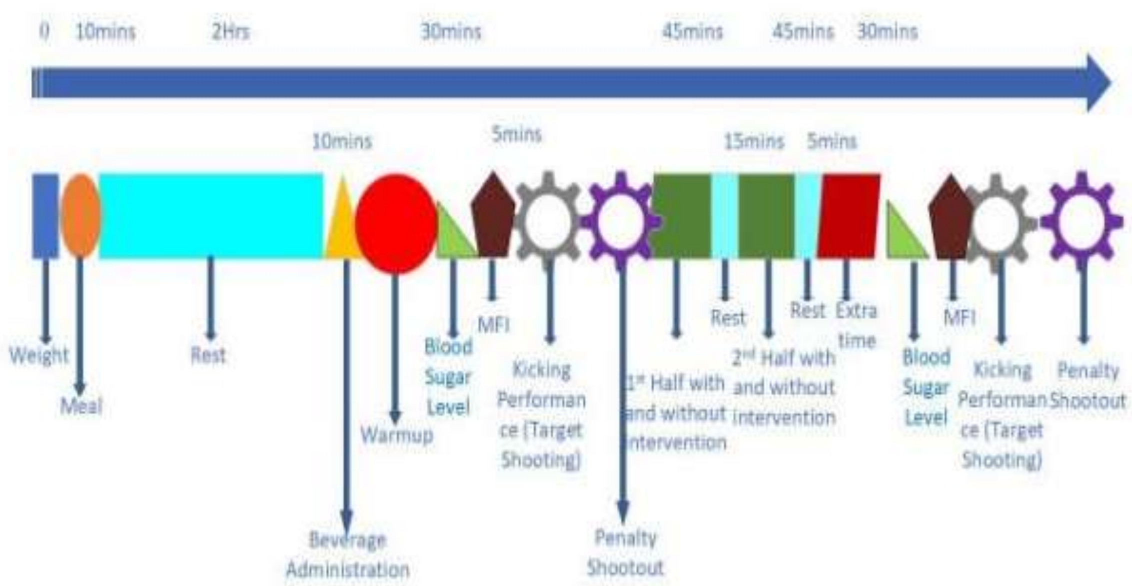

Figure 1. Detailed plan of the test.

Statistical Analysis

The 27th edition of the SPSS application was used to analyse the data collected. Both descriptive and inferential statistics were used to compute the data obtained for this study. Friedman's Two-Way Analysis of Variance was employed to compare the pretest and post-test glucose levels, fatigue status, and the KP of the players due to its capacity to accommodate non-parametric data and its adaptability within repeated measures experimental designs, and its appropriate use for non-normal distribution data, as determined by the Shapiro-Wilk test for normality. The data obtained from this study had all the above properties; thus, the use of Friedman's Two-Way Analysis of Variance. The alpha level was set at 0.05.

Results

Table 1- Demographic data of participants

Demographic Characteristic	N	Min.	Max.	Mean	Standard Deviation
Age (yrs)	20	16.00	27.00	19.17	2.68
Weight (kg)		55.10	86.20	66.09	7.74
Height (m)		1.53	1.85	1.74	.065
Experience (yrs)		4.00	15.00	8.93	2.57

Descriptive Statistics of the players

Table 1 presents comprehensive data on the anthropometric characteristics, ages, and playing experience of the participants. The study involved a diverse cohort of 20 male soccer players, aged between 16 and 27 years, as outlined in Table 1. Participants' body weights ranged from 55.10 kg to 86.20 kg, with a mean of 66.09± 7.74. In terms of height, the players measured between 1.53 m and 1.85 m, with an average height of 1.74± 0.065.

The sample demonstrated considerable playing experience, averaging 8.93±2.57 years. While the majority of players had approximately 9 years of experience, there was significant variability within the group. The minimum and maximum durations of playing experience were 4 and 15 years, respectively, indicating a wide range of expertise among the participants.

Table 2: Friedman's Two-Way Analysis of Variance of Pre- and Post-test comparisons of Blood Glucose levels of the players

Sample 1-Sample 2	Std. Error	Std. Test Stats	p-value
PTGluC-PTBGluE	.577	2.078	.038
PTGluC-PrTBGluC		3.811	.000
PTGluC-PrTBGluE		4.503	.000
PTBGluE-PrTBGluC		-1.732	.083
PTBGluE-PrTBGluE		2.425	.015
PrTBGluC-PrTBGluE		.693	.488

Pairwise comparisons of the players' BG levels pre- and post-120-minute game

Table 2 presents a series of pairwise comparisons between Pre-Test and Post-Test Blood Glucose levels within the Experimental (PrTBGluE and PTBGluE) and Control (PrTBGluC and PTBGluC) groups. Significant differences were identified between the Post-Test Blood Glucose levels of the Experimental and Control groups ($p = .038$), between Post-Test and Pre-Test Blood Glucose levels within the Control group ($p < .001$), between Post-Test and Pre-Test Blood Glucose levels across both Control and Experimental groups ($p < .001$), and between Post-Test and Pre-Test Blood Glucose levels within the Experimental group ($p = .015$). No statistically significant differences were observed in the comparisons of Post-Test Experimental versus Pre-Test Control ($p = .083$) and Pre-Test Control versus Pre-Test Experimental ($p = .488$) Blood Glucose levels.

Table 3: Friedman's Two-Way Analysis of Variance of Pre- and Post-test comparisons of *General Fatigue levels of the players*

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	p-value
PTGFE-PrTGFC	-.200	.577	-.346	.729
PTGFE-PrTGFE	.500		.866	.386
PTGFE-PTGFC	-2.150		-3.724	.000
PrTGFC-PrTGFE	.250		.433	.665
PrTGFC-PTGFC	-1.800		-3.118	.002
PrTGFE-PTGFC	-1.900		-3.291	.001

Pairwise comparisons of the players' GF levels pre- and post-120-minute game

The data presented in Table 3 represent pairwise comparisons of General Fatigue levels measured before (pre-test) and after (post-test) the intervention for both the Experimental group (PrTGFE and PTGFE) and the Control group (PrTGFC and PTGFC). The analysis revealed that statistically significant differences existed in General Fatigue levels between the Post-test Experimental and Control groups ($p < .001$), as well as between the Pre-test and Post-test General Fatigue in the Control group ($p = .002$) and the Pre-test Experimental and Post-test Control groups ($p=.001$). No significant differences were observed in the remaining comparisons, including PTGFE versus PTGFC ($p = .729$), PTGFE versus PrTGFE ($p = .386$), and PrTGFC versus PrTGFE ($p = .665$).

Table 4: Friedman's Two-Way Analysis of Variance of Pre- and Post-test comparisons of *Kicking precision of the players*

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	p-value
PrTKPE-PrTKPC	-.100	.577	-.173	.862
PrTKPE-PTKPE	-.400		-.894	.371
PrTKPE-PTKPC	-2.300		-3.984	.000
PrTKPC-PTKPE	1.100		1.905	.057
PrTKPC-PTKPC	-2.200		-3.811	.000
PTKPE-PTKPC	-1.300		-2.907	.004

Pairwise comparisons of the players' KP/KP pre- and post-120-minute game

Table 4 presents a pairwise analysis comparing the pre-test and post-test Kicking Precision between the Experimental group (PrTKPE and PTKPE) and the Control group (PrTKPC and PTKPC). Significant differences were observed between the Pre-test Experimental group and Post-test Control group Kicking Precision ($p < .001$), the Pre-test and Post-test Kicking Precision within the Control group ($p < .001$), and between the Post-test Kicking Precision of the Experimental and Control groups ($p = .004$). No significant differences were found in the comparisons of Pre-test Kicking Precision between the Experimental and Control groups (PrTKPE vs. PrTKPC, $p = .862$), between the Pre-test and Post-test Kicking Precision of the Experimental group (PrTKPC vs. PTKPE, $p = .371$), and between the Pre-test Control group and Post-test Experimental group (PrTKPC vs. PTKPE, $p = .057$).

Table 5: Friedman's Two-Way Analysis of Variance of Pre- and Post-test comparisons of *Penalty Kicks of the players*

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	p-value
PTPENKICKC-PrTPENKICKE	1.300	.577	2.907	.004
PTPENKICKC-PTPENKICKE	1.400		3.130	.002
PTPENKICKC-PrTPENKICKC	1.800		3.118	.002
PrTPENKICKE-PTPENKICKE	-.400		-.693	.488
PrTPENKICKE-PTPENKICKC	-1.100		-1.905	.057
PTPENKICKE-PrTPENKICKC	-.700		-1.212	.225

Pairwise comparisons of the players' Penalty Kick Precision pre- and post-120-minute game

Table 5 presents a pairwise analysis comparing Pre- and Post-test Penalty Kick Precisions within the Experimental (PrTPenKickE and PTPenKickE) and Control (PrTPenKickC and PTPenKickC) groups. A statistically significant difference was observed between the Control group Post-test and Experimental group Pre-test Penalty Kicks ($p = .004$), between the Control and Experimental groups Post-test Penalty

Kicks ($p = .002$), and between the Control group Post-test and Pre-test Penalty Kicks ($p = .002$). No significant differences were detected in the other comparisons, including PrTPenKickE versus PTPenKickE ($p = .488$), PrTPenKickE versus PrTPenKickC ($p = .057$), and PTPenKickE versus PrTPenKickC ($p = .225$).

Discussion

The objective of this study was to determine whether physiologically accurate penalty kicks executed at the onset of a 120-minute match differ from those performed at its conclusion, both in the presence and absence of an intervention.

The study's participants were primarily comprised of young players with considerable experience in soccer. The diversity in their age, weight, height, and experience levels provided a robust dataset, facilitating a thorough examination of various factors affecting penalty kick performance during a shootout following 120 minutes of intense match play.

The Blood Glucose test was a guide from hypothesis 1, which stated that 'The Blood Glucose levels of the soccer players in the Experimental group will significantly differ from those of their counterparts in the Control group after playing for 120 minutes'. It was, thus, observed in the analysis in Table 2 that statistically significant differences existed between the post-test Blood Glucose levels of the Experimental and Control groups ($p = .038$), between Post-Test and Pre-Test Blood Glucose levels within the Control group ($p < .001$), between Post-Test and Pre-Test Blood Glucose levels across both Control and Experimental groups ($p < .001$), and between Post-Test and Pre-Test Blood Glucose levels within the Experimental group ($p = .015$).

The observed outcomes are likely attributable to the fact that the Blood Glucose levels of the participants in the Experimental group did not experience a significant decline following 120 minutes of gameplay with periodic administration of the glucose-fructose electrolyte intervention, in contrast to the Control group, which received a placebo. Hypothesis 1 is, therefore, upheld.

The findings of this aspect of the study indicate that while players effectively consume substantial amounts of carbohydrates in the days leading up to competition, these carbohydrate stores are significantly depleted during prolonged, high-intensity match play, as evidenced by the data from the Control group. Nevertheless, regular supplementation with a glucose-fructose electrolyte solution appears to mitigate this depletion by facilitating carbohydrate replenishment, as observed in the data from the Experimental group.

These findings also suggest the presence of fatigue in both groups, as said by Feldman and Barshi (2013), with a notably higher prevalence observed in the Control group. Furthermore, the results indicate that the low Blood Glucose levels and subsequent fatigue experienced by the Control group are likely to adversely affect their kicking performance during the penalty shootout compared to the Experimental group.

The 2nd hypothesis, which stated that 'After playing soccer for 120 minutes, there will be no significant difference in the players' degrees of General fatigue between the Control and Experimental groups', helped to elucidate data to analyse the levels of fatigue that accrued in the players during the test.

The data in Table 3 showed statistically significant differences in General Fatigue levels between the Experimental and Control groups in the post-test phase ($p < .001$). Additionally, notable differences were found between the pre-test and post-test measurements of General Fatigue within the Control group ($p = .002$), as well as between the Pre-test Experimental group and the Post-test Control group ($p =$

.001). While the comparisons among the remaining data sets (PTGFE versus PTGFC, $p = .729$; PTGFE versus PrTGFE, $p = .386$; and PrTGFC versus PrTGFE, $p = .665$) did not demonstrate statistically significant differences, the initial three comparisons did. This indicates the presence of varying levels of General Fatigue within the groups. Consequently, hypothesis 2 is rejected.

The observed prevalence of fatigue supports the Blood Glucose depletion identified in Table 2. It is plausible that the post-test General Fatigue experienced by the Control group may influence their KP/KP measurements following the 120-minute protocol.

A critical analysis of the results indicates that the intervention administered to the Experimental group effectively reduced their fatigue levels following 120 minutes of play, in contrast to the Control group. This finding suggests that the Experimental group may have retained sufficient strength to continue kicking the ball after the protocol compared to the Control group. Furthermore, their recovery rate may appear to be superior to that of the Control group. Consequently, it can also be inferred that the supplementation—comprising a 50:50 glucose-fructose electrolyte solution, administered at a dose of 1.2 g per kilogram of body mass of the players in purified water—and the mode of administration, specifically through modified FIFA hydration breaks, may have had a significant effect on the Experimental group players.

Hypothesis 3 posited that the Kicking Performance or Accuracy of the soccer players in the Control group would exhibit significant differences compared to those in the Experimental group following 120 minutes of intensive soccer play. This hypothesis guided the data collection process, as reflected in Tables 4 and 5, which present measures of Target Kicking Precision and Penalty Shooting performance, respectively.

Table 4 reveals statistically significant differences in Kicking precision between the pre-test Experimental group and the post-test Control group ($p < .001$), within the Control group when comparing pre-test and post-test measures ($p < .001$), and between the post-test Kicking precision of the Experimental and Control groups ($p = .004$). Conversely, no significant differences were identified in the comparisons of pre-test Kicking Precision between the Experimental and Control groups ($p = .862$), between pre-test and post-test Kicking Precision within the Experimental group ($p = .371$), nor between the Control group pre-test and the Experimental group post-test ($p = .057$). Given the notable differences identified in Table 4, Hypothesis 3 was upheld.

The findings clearly demonstrate that the Control group experienced fatigue-related declines following 120 minutes of play, which likely contributed to their diminished Kicking precision and consequently resulted in the observed performance disparity. Conversely, it can be inferred that the intervention administered to the Experimental group effectively maintained their energy reserves and physical strength throughout the 120-minute protocol, thereby preserving their subsequent performance levels.

Again, a statistically significant difference was identified between the Control group post-test and the Experimental group pre-test in Penalty Kicks ($p = .004$), as well as between the Control and Experimental groups post-tests in Penalty Kicks ($p = .002$). Additionally, a significant difference was found between the Control group post-test and pre-test Penalty Kicks ($p = .002$). Conversely, no significant differences were observed in the remaining comparisons, including Experimental group pre-test versus post-test Penalty Kicks ($p = .488$), Experimental group pre-test versus Control group pre-test Penalty Kicks ($p = .057$), and Experimental group post-test versus Control group pre-test Penalty Kicks ($p = .225$).

These findings further corroborate the validity of hypothesis 3, as statistically significant differences were identified between the kicks of the Experimental and Control group players, probably due to the intervention. Analysis of the raw data revealed a decline in the performance of players in the Control group, a pattern that was consistently associated with both fatigue and blood glucose levels. It was once again observed that the Experimental group players were in good shape, which probably may have been due to the intervention.

Conclusion

The results of this research indicate that providing adequate supplementation to soccer players during matches that can extend up to 120 minutes has the potential to significantly decrease fatigue and maintain their kicking performance, particularly accuracy or precision, during subsequent penalty shootouts. This finding underscores the importance of nutritional support in maintaining optimal physical condition and performance levels throughout the duration of a match, especially in high-stakes situations such as penalty shootouts where precision is critical.

Additionally, the findings revealed that the performance of players in penalty shootouts following 120 minutes of strenuous play is not only influenced by psychological factors as widely documented but also by the physiological changes that occur as a result of prolonged exertion, which produces fatigue in the players, diminishing their physical capabilities, leading to a decline in performance.

Consequently, it is essential for soccer stakeholders, particularly coaches and support staff, to proactively address the fatigue that may arise in their players during extended matches. This can be achieved through strategic planning that includes the provision of adequate nutritional supplementation to make the players fatigue-resilient. By doing so, they can significantly improve their players' chances of success in penalty shootouts that follow extended periods of play, ultimately contributing to better overall team performance and outcomes in competitive scenarios.

Recommendations

Soccer stakeholders, encompassing managers, coaches, and support personnel—particularly dietitians and nutritionists—should recognise the physiological impact of fatigue on players' penalty shooting performance following a 120-minute match. Consequently, it is advisable for these stakeholders to implement strategies aimed at mitigating player fatigue under such conditions. This includes the identification and administration of recommended supplements, such as the one utilised in the present study, at a dosage of 1.2 $g \cdot kg^{-1}$ body mass during tournaments, to alleviate fatigue and maintain optimal performance during penalty shootouts.

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