Acute effect of ischemic preconditioning on physical performance and heart rate of young Soccer players during Soccer Match

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Abstract

Ischemic preconditioning (IPC) is defined as brief periods of ischemia, interspersed by reperfusion that precedes a period of sustained ischemia. Unlike what happens in the clinical area where the application of the maneuver has been extensively investigated but as for the association of IPC with sport there are still few studies. Although the data already known can provide important subsidies for its use in sports. The aim to analyze the acute effect of IPC in first half of a soccer match on young soccer players' physical performance and heart rate. The sample consisted of 10 male athletes from the sub-15 categories (64.5 ± 5.8 Kg; 1.79 ± 0.1 m; 20.2 ± 1.1 Kg/m^2). The volunteers were randomly divided with balanced input in following experimental sessions: a) IPC (4 x 5 minutes at 220 mmHg / 0 mmHg) + Soccer Match; b) SHAM (4 x 5 minutes at 20 mmHg / 0 mmHg) + Soccer Match and, c) Control + Soccer Match. The time-dependency was 60 to 75 minutes before the match, with an interval of seven days between the sessions. The first half of a soccer match was used for analysis. ANOVA was used to compare the number of sprints, total distance traveled, number of accelerations, and heart rate. There was no statistically significant difference between IPC vs. SHAM vs. Control Session in the first half of a soccer match for the number of sprints, total covered distance, number of accelerations, and the minimum, average and maximum heart rate ($p>0.05$). Our findings indicate that the IPC does not improve young soccer players' physical performance and heart rate in the first half of a soccer match.

Keywords: Ischemic; Reperfusion; Sport; Athletic performance; Effects cardiovascular.

Introduction

Soccer is a sport that requires various skills from athletes, including high cognitive efficiency, good tactical design of the game, high levels of concentration, and excellent physical condition[1]. It is characterized as an intermittent and acyclic modality[2]. The soccer game lasts for 90 minutes performed at very high intensity with random actions interspersed with moments of rest and low intensity efforts[3]. Thus, considering that the physical demands of a soccer match imposed on soccer players have increased in recent years, coaches and technical staff have been looking for ways to enhance athletes' performance[2].

Regarding the heart rate behavior during the game, it is possible to notice that it fluctuates all the time, demonstrating the intermittent character of the modality. The physiological demands during an intermittent activity do not depend solely on the duration and speed of the run but on the density of physical work, the proportion through the

rest times is of paramount importance for determining the physiological load[4].

Ischemic preconditioning (IPC) has been investigated as a method for improving sports performance since, in a competitive environment, the ultimate goal is victory. The IPC, in turn, is a simple and non-invasive method that aims to block blood flow in a specific body segment through a pneumatic device[5]. The primary speculations about the possible mechanisms involved in applying the IPC are related to the activation of adenosine receptors and the release of nitric oxide, causing more significant vasodilation and blood perfusion[6]. Thus, with increased oxygen extraction in muscle[7], there is an improvement in metabolic function, more efficient degradation of adenosine triphosphate (ATP), and less accumulation of lactate[8]. Therefore, its relationship with performance improvement has been the subject of studies in several sports, such as running[9], cycling[10], and swimming[11]. However, in modalities such as basketball[12], futsal[13], rugby[14], soccer[15], handball[16], athletics (sprinters)[17], ice skating[18], and recreational athletes from team sports[9], there was no improvement in sports performance.

This scenario suggests the need to investigate the effects of IPC in a real game situation, where soccer players are subjected to and required maximum physical, technical, tactical, and psychological performance during a soccer match. In the literature, there is only one study with IPC in soccer. However, performance has not improved significantly. But the authors used the IPC only in one test and not in a real game situation. Besides, no study was found in the literature that investigated the effect of the IPC on the number of accelerations in the field of team sports, a gap of paramount importance in the literature, since one more acceleration in a decisive moment of the match can decide the final result of the game. Therefore, the present study aimed to analyze the acute effect of IPC in the first half of a soccer match on young soccer players' physical performance and heart rate.

Methods

Subjects

The study included ten young male soccer players of the sub-15 category (age: 15 years; body mass index: 64.5 ± 5.8 kg; height: 179 ± 0.1 cm and BMI: 20.2 ± 1.1 kg / m²), belonging to the soccer extension project of the Faculty and Physical Education and Sports Federal University of Juiz de Fora, affiliated to the Minas Gerais Soccer Players Federation at Brazil. Throughout the research, there was a sample loss of 3 players, one due to injury and two dues to disciplinary suspension. It was totaling one sample loss per the protocol and seven players at the end of the study.

The sample's inclusion criteria were: a) the athlete belongs to the under-15 team of the soccer project and, b) to be the starter in the matches in which the collection took place and to play the first half of soccer matches. The exclusion criteria were: a) using ergogenic resources; b) have some osteoarticular impediment; c) be hypertensive. The collections took place in the matches held in the city of Juiz de Fora in Brazil. This research met the standards of the National Health Council (466/12, 2012) for researching human beings. This study was approved by the Human Research Ethics Committee of the Federal University of Juiz de Fora, number 3.236.436.

Study Design

The present study was carried out on five non-consecutive days. On the first visit, the volunteers signed the Free and Informed Consent Form and the Term of Assent to be signed by those responsible. On the second visit, the athletes underwent an anthropometric assessment and familiarized with the method. On the third visit, the volunteers were divided, in a randomized way with balanced entry, in the following experimental sessions: a) IPC (4 x 5 minutes at 220 mmHg / 0 mmHg) + Soccer Match; b) SHAM (4 x 5 minutes at 20 mmHg / 0 mmHg) + Soccer Match and, c) CON +

Soccer Match.

To familiarize themselves with the IPC session, the athletes were instructed to remain seated in a chair, with their shorts folded to place the sphygmomanometer. Ischemia was performed using a calibrated sphygmomanometer (Nylon Premium), with 51 x 14.5 cm cuffs (WCS®, Brazil) positioned in the athletes' proximal part thigh, in the inguinal region. The equipment inflated to a pressure of 220 mmHg, following the suggested protocol. The blood flow blocked in the tibial artery was confirmed by a vascular Doppler (DV-600).

In the SHAM session, the procedure performed was similar; however, the pressure was 20 mmHg. The IPC and SHAM maneuvers had a total time of 40 minutes. The Control session remained seated for 40 minutes without undergoing any intervention. On the day of the match, athletes were submitted to the experimental protocols with the time-dependence of 60 to 75 minutes until the game's start. All athletes were instructed to arrive 15 minutes before the protocols' beginning and remained seated throughout the collection.

Evaluation of Physical Performance and Anthropometric Measures

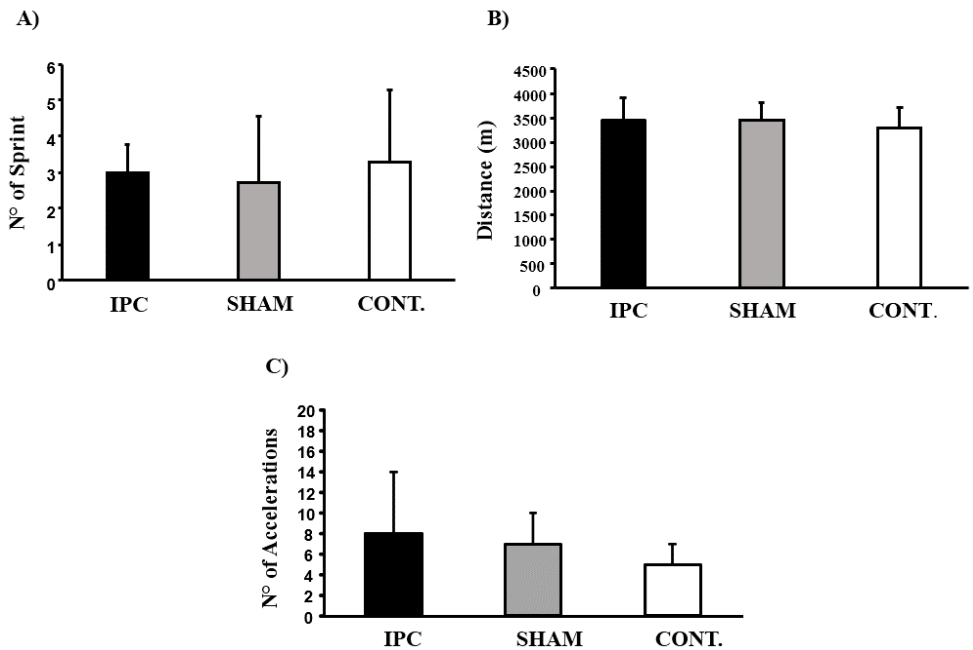
Height and body mass were measured using a stadiometer and a scale (FILIZOLA®). These measures were used to obtain the body mass index (BMI) in kg/m² After applying the experimental protocols. Upon returning to the locker room, the players attached the 10Hz Polar Team Pro Global Position System (GPS) device to their chest moments before the match. When connecting this device, via satellites, it establishes the location of the individual. The physical performance variables analyzed by the Global Position System (GPS) and used in this study were the number of sprints, number of accelerations, total distance covered, and the minimum, average and maximum HR. After the match, the GPS device that was attached to the tape next to the athlete's chest was collected and placed on the base for data download.". The number of sprints (> 25.2 Km/h), number of accelerations (> 0,5 m/s^2), total distance covered and the minimum, average and maximum HR were analyzed in the first half of the soccer match. The IPC and SHAM maneuvers had a total time of 40 minutes. The Control session remained seated for 40 minutes without undergoing any intervention. Immediately after the IPC, SHAM or Control session, the athlete's warm-up, which lasted 15 minutes. They returned to the locker room, attached the 10Hz Polar Team Pro Global Position System (GPS) device strap to their chest moments before departure. When connecting this device via satellites, it establishes the location of the individual. The Global Position System (GPS) analyzed the physical performance variables used in this study were the number of sprints, number of accelerations, total distance covered, and the minimum, average and maximum HR. After the match, the GPS device attached to the tape next to the athlete's chest was collected and placed on the base for data download.

Statistical Analyses

A descriptive statistic was performed to analyze the general characteristics of the sample. To verify data distribution and homogeneity of variance, Shapiro Wilk and Levene tests were performed, respectively. To test the possible differences between comparing the sessions IPC vs. SHAM vs. Control (CON) between groups (interaction effect) regarding the number of sprints, total distance covered, number of accelerations and heart rate during the execution of the protocol, a repeated-measures analysis of variance (Two-way ANOVA) followed by the Bonferroni post hoc were carried out. Values presented using the mean and standard deviation. All analyses performed using the GraphPad Prism 8 software (PRISM®). A significance level of 5% ($p < 0.05$) was adopted.

Results

The number of sprints did not show any effect of group interaction and a statistically significant difference between IPC vs. SHAM; IPC vs. CON and SHAM vs. CON in the first half of a soccer match (F = 0.150; p = 0.861) (FIGURE 1A). The total covered distance did not show any effect of group interaction and statistically significant difference between IPC vs. SHAM, IPC vs. CON and SHAM vs. CON in the first half of a soccer match (F = 0.254; p = 0.777) (FIGURE 1B). The number of accelerations did not show any effect of group interaction and statistically significant difference between IPC vs. SHAM, IPC vs. CON and SHAM vs. CON in the first half of a soccer match (F = 0.320; p = 0.729) (FIGURE 1C).



IPC = ischemic preconditioning (220 mm Hg);
SHAM = cuff administration with lower pressure (20 mm Hg);
CONT = control (0 mm Hg);
m = meters.

FIGURE 1 - A) Number of Sprints. B) Total Covered Distance. C) Number of Accelerations.

The IPC does not change the minimum, average and maximum heart rate of young soccer players in the first half of a soccer match (TABLE 1).

TABLE 1 - Minimum, average and maximum heart rate in the first half of a soccer match.

HR	IPC	SHAM	CONT.	F	p
MINIMUM HR (bpm)	136 ± 13	136 ± 21	132 ± 14	0,800	0,923
AVERAGE HR (bpm)	186 ± 22	176 ± 10	173 ± 9	1,30	0,291
MAXIMUM HR (bpm)	199 ± 8	201 ± 8	199 ± 8	0,141	0,869

Heart rate.
HR = heart rate;
bpm = beats per minute;
IPC = ischemic preconditioning (220 mm Hg);
SHAM = cuff administration with lower pressure (20 mm Hg;
CONT. = control (0 mm Hg).

The data obtained by GPS, number of sprints, distance covered, minimum, average and maximum heart according to the protocol, position of each player in each of the three matches are shown below in TABLE 2.

TABLE 2A - Match 1.

PLAYER	POSITION	PROTOCOL	N° SPRINT	DISTANCE COVERED (*m*)	MIHR (*bpm*)	MAHR (*bpm*)	MAHR (*bpm*)	N° ACEL
1	DEFENDER	IPC	3	3310	144	187	205	2
2	MIDFIELDER	SHAM	4	3480	133	163	185	4
3	MIDFIELDER	IPC	3	4257	135	174	198	20
4	MIDFIELDER	SHAM	4	3906	154	183	207	4
5	ATTACKER	CONTROL	5	3248	146	175	194	10
6	ATTACKER	CONTROL	0	3984	170	193	206	5
7	ATTACKER	IPC	3	2985	149	176	198	11

N° SPRINT = number of sprints;
MIHR = minimum heart rate;
AHR = average heart rate;
MAHR = maximum heart rate;
N° ACEL = number of accelerations;
bpm = beats per minute;
IPC = ischemic preconditioning (220 mm Hg);
SHAM = cuff administration with lower pressure (20 mm Hg);
CONT = control (0 mm Hg);
m = meters.

TABLE 2B - Match 2.

PLAYER	POSITION	PROTOCOL	N° SPRINT	DISTANCE COVERED (*m*)	MIHR (*bpm*)	MAHR (*bpm*)	MAHR (*bpm*)	N° ACEL
1	DEFENDER	CONTROL	1	3288	146	183	203	3
2	MIDFIELDER	IPC	4	3567	130	137	186	5
3	MIDFIELDER	SHAM	0	3283	107	163	203	2
4	MIDFIELDER	CONTROL	4	3672	138	180	209	4
5	ATTACKER	SHAM	3	3049	131	168	192	6
6	ATTACKER	IPC	2	3772	157	189	204	6
7	ATTACKER	CONTROL	5	2734	133	171	196	8

N° SPRINT = number of sprints;
MIHR = minimum heart rate;
AHR = average heart rate;
MAHR = maximum heart rate;
N° ACEL = number of accelerations;
bpm = beats per minute;
IPC = ischemic preconditioning (220 mm Hg);
SHAM = cuff administration with lower pressure (20 mm Hg);
CONT = control (0 mm Hg);
m = meters.

TABLE 2C - Match 3.

PLAYER	POSITION	PROTOCOL	N° SPRINT	DISTANCE COVERED (*m*)	MIHR (*bpm*)	MAHR (*bpm*)	MAHR (*bpm*)	N° ACEL
1	DEFENDER	SHAM	1	3267	139	180	205	6
2	MIDFIELDER	CONTROL	2	3455	118	165	187	7
3	MIDFIELDER	CONTROL	2	3754	98	162	209	8
4	MIDFIELDER	IPC	4	3438	120	177	211	5
5	ATTACKER	IPC	2	2772	119	161	190	4
6	ATTACKER	SHAM	5	3561	140	186	207	7
7	ATTACKER	SHAM	6	2484	118	167	196	6

N° SPRINT = number of sprints;
MIHR = minimum heart rate;
AHR = average heart rate;
MAHR = maximum heart rate;
N° ACEL = number of accelerations;
bpm = beats per minute;
IPC = ischemic preconditioning (220 mm Hg);
SHAM = cuff administration with lower pressure (20 mm Hg);
CONT = control (0 mm Hg);
m = meters.

Discussion

The present study aimed to analyze the acute effect of IPC in the first half of a soccer match on the physical performance and heart rate of young soccer players, being the first study to date to carry out this type of intervention in a real match and analyze the number of accelerations in a team sport with this type of intervention. Our results showed that the IPC application did not improve performance in the variables number of sprints, total distance covered, number of accelerations and the minimum, average and maximum heart rate in the first half of a soccer match. According to Bush et al.[2], soccer has evolved a lot in recent years, making match soccer more intense. The analysis of the number of sprints and the total distance covered can be used to analyze physical performance evolution in a soccer match.

Our findings corroborate with some team sports studies that verified the effects of IPC on the sprint's variable, as in athletes from various team sports[9,19], handball[20] and soccer[21]. The study by Gibson et al.[19] corroborates the findings of this research, they verified the effect of the IPC on the performance of maximum sprints of 10m, 20m, and 30m found no significant difference in sprint performance between the three IPC, SHAM, and control groups. Gurses et al.[21] observed the effects of IPC on 13 soccer players in the Wingate test. Participants made three visits to the laboratory, with a minimum of 72 hours between visits. After 50 minutes of applying the IPC, the volunteers performed the Wingate test. The results showed no significant improvement in the fatigue index, peak power, and average power.

In the present study, the time between the end of the application of the IPC and the start of the match was 1 hour. The literature speculates between 40 and 60 minutes for the beginning of sports practice, despite having waited for the suggested time for the intervention, the results did not show significant differences. In addition, it is possible that other intervening factors may have contributed to not finding positive results. Differently from other studies, the effect on the IPC maneuver was tested in a real environment, that is, in an official soccer match for the base Minas Gerais Football Championship. In this way, it is believed that the results found are more applicable to the context of football sport. However, it is also true that intervening factors such as temperature, level of the opposing team, importance of the game, tactical factors, technical factors and psychological environment may have influenced the results.

The justification for respecting the time-dependency is that immediately after the IPC maneuver, the energy reserves are lower than before the procedure. However, over time the tendency is for energy stocks to be higher than the moment before the IPC maneuver, thus explaining the possible increase in performance. Previous studies[21,22] have evaluated muscle metabolism after IPC on the simultaneous consumption of ATP, PCr, and Pi and, consequently, pH and provided an insight into the tissue's energy status and its ability to undergo oxidative phosphorylation. These showed an overcompensation of PCr together with the increase in the ATP / ADP ratio over time.

The increase in PCr formation was observed during reperfusion four hours after IPC, indicating that energy metabolism improved during the post-ischemic period[23]. Likewise, this PCr overcompensation is dependent on the ATP/ADP ratio and the mitochondrial creatine kinase that causes an increase in the demand for oxygen in the muscle, followed by an increase in oxidative metabolism in the reperfused muscle tissue[23]. However, we can infer that in a real match situation for young soccer players, the mechanism associated with time-dependence did not cause an improvement in sprints. Thus, using IPC as a strategy to improve performance, focusing on the energy substrate necessary for a better response in sprints, has not been effective.

In the present study, the total distance covered did not show any statistically significant difference between IPC vs. SHAM, IPC vs. CON and SHAM vs. CON in the first half of a soccer match ($F = 0.254$; $p = 0.777$). The research by Paixão et al.[24] and Marocolo et al.[13] also dedicated themselves to investigating the effect of the IPC maneuver on the total distance covered in sports with characteristics similar to soccer. In these studies, no significant differences were found for the total distance covered variable,

corroborating this research's findings.

The present study did not show any statistically significant difference between the groups IPC vs. SHAM, IPC vs. CON and SHAM vs. CON in the first half of a soccer match for the variable number of accelerations (F = 0.320; p = 0.729). However, this was the first study that analyzed this variable for team sports with the intervention of the IPC and the first study to analyze this intervention in a real game environment. When analyzing figure 1C, it is noted that the players who perform IPC had, on average, three more accelerations than the control group. Ade et al.[24] through high-speed training, emphasize the importance of acceleration in the context of training and play since one more acceleration in a match can be decisive and define the final result of the game.

The mechanisms related to the IPC are still speculative and with greater consistency in animals. Thus, investigations into the possible effects of the IPC suggest not only local but systemic action. As a result, vasodilation is followed by better blood perfusion, better oxygen extraction occurs, and the opening of ATP-dependent K+ channels increase energy stores after applying the IPC, improving the fast contraction performance of muscle fibers[22]. It is believed that the release of endogenous substances, such as adenosine, bradykinin, reactive oxygen species, and opioids, may be linked to improved performance[4,25]. Besides, the IPC application is linked to neural aspects indicating a spontaneous inhibition in afferent fibers of type III and IV, increasing the central motor drive[26]. It was thus suggesting a possible decrease in fatigue, which can improve performance in a given task. This mechanism occurs through the release of opioids after applying the IPC[22] activating the receptors of type III and IV afferent fibers during exercise[26,27]. Therefore, the IPC can change the level of the activation threshold of the receptors, desensitizing the afferent fibers of groups III and IV. In turn, this phenomenon increases the neural drive and the number of motor units recruited, thus increasing anaerobic capacity and, consequently, the production of force[28].

The IPC does not change the minimum (F = 0.800; p = 0.923), average (F = 1.30; p = 0.291) and maximum (F = 0.141; p = 0.869) heart rate of young soccer players in the first half of a soccer match. The heart rate monitoring method has been widely used for its practicality and for respecting the activity's specificity to be assessed. This method provides a complete record of the physiological process, which reflects the amount and intensity of physical activity[33]. Oliveira[29] compared the effect of IPC on the minimum, average and maximum HR between two IPC sessions: one of 2 cycles of 5 min of occlusion for 5 min of reperfusion, and another of 5 cycles of 2 minutes of occlusion/reperfusion on 35 trained cyclists. Only the 2x5 IPC group decreased the mean of the fastest heart rate compared to baseline. At the end of the exercise, HR deceleration occurs through a coordinated interaction of parasympathetic reactivation and sympathetic withdrawal[30], with the parasympathetic branch being the main influence in the first 60 seconds[31]. Evidence indicates that increases in parasympathetic activity[32] accompanied the application of the IPC maneuver. Therefore, the author believes that after the application of the IPC there was a more effective vagal reactivation, accelerating the recovery of HR in the first 60 seconds.

The IPC does not improve number of sprints, total distance covered, number of accelerations and the minimum, average and maximum heart rate of young soccer players in the first half of a soccer match. The present work is the only study so far carried out in a real match environment, so further studies in team sports in the real match environment are needed.

Resumo

Efeito agudo do pré-condicionamento isquêmico no desempenho físico e na frequência cardíaca de jovens futebolistas durante partida de futebol.

O pré-condicionamento isquêmico (PCI) é definido como breves períodos de isquemia, intercalados por reperfusão, que antecedem um período de isquemia sustentada. Sendo isquemia definida pela diminuição ou suspensão da irrigação sanguínea em alguma parte do organismo, resultante de uma obstrução arterial. Enquanto reperfusão é o retorno da irrigação sanguínea, como o resultado da desobstrução arterial. Diferente do que acontece na área clínica, em que a aplicação da manobra tem sido amplamente investigada, os estudos que relacionam PCI e desempenho esportivo ainda registram um número reduzido de informações. Embora os dados já conhecidos possam fornecer importantes subsídios à sua utilização no meio esportivo, é necessário ter cautela na interpretação e aplicação de tais conhecimentos, tendo em vista que cada tipo de exercício apresenta suas particularidades, como a via energética utilizada durante a prática, o que pode alterar as respostas de cada indivíduo ao procedimento de PCI. Alguns estudos tem mostrado que o PCI realizado antes do exercício pode afetar de forma positiva o desempenho físico em diversas modalidades esportivas, como ciclismo, natação, e mergulho em apneia. Contudo, outros estudos apontam nenhuma melhora ou até mesmo diminuição no desempenho esportivo, como no basquete e rúgbi. Sendo assim, o objetivo desse estudo foi analisar o efeito agudo do PCI no primeiro tempo de jogo de uma partida de futebol sobre o desempenho físico de jovens futebolistas. Participaram do estudo 10 jovens futebolistas do sexo masculino (idade: 15 anos, índice de massa corpórea: 64,5±5,8 kg, altura: 1,7±0,1 M e IMC: 20,2±1,1 kg/m2) da categoria sub-15, pertencentes ao projeto de extensão de futebol da Faculdade e Educação Física e Desportos (Faefid) da Universidade Federal de Juiz de Fora (UFJF), filiados à Federação Mineira de Futebol que treinam 5 vezes por semana, sendo o nível de competição estadual e com jogos aos finais de semana. Os indivíduos foram divididos de forma randomizada com entrada contrabalançada nos seguintes protocolos experimentais, com intervalo de 7 dias entre eles: PCI + Jogo (PCI), SHAM + Jogo (SHAM) e controle + Jogo (CONT). Durante cada um dos protocolos experimentais os 10 atletas foram divididos aleatoriamente em um rodízio da seguinte maneira: a) 4 atletas foram submetidos ao protocolo PCI, 3 atletas foram submetidos ao protocolo SHAM e 3 atletas ao protocolo jogo (CONT), b) 3 atletas foram submetidos ao protocolo PCI, 4 atletas foram submetidos ao protocolo SHAM e 3 atletas ao protocolo jogo (CONT), c) 3 atletas foram submetidos ao protocolo PCI, 3 atletas foram submetidos ao protocolo SHAM e 4 atletas ao protocolo controle jogo (CONT). A FC mínima nas condições PCI, SHAM e Controle foram (136±13, 136±21, 132 ±14 p>0,05 respectivamente). A FC média nas condições PCI, SHAM e Controle foram (186±22, 176±10, 173±9 p>0,05 respectivamente). A FC máxima nas condições PCI, SHAM e Controle foram (199±8, 201±8, 199±8 p>0,05 respectivamente). O número de acelerações nas condições PCI, SHAM e Controle foram (8±6, 7±3, 5±2 p>0,05 respectivamente). O PCI não melhora o número de acelerações e não modifica a FC mínima, média e máxima de jovens futebolistas no primeiro tempo de uma partida de futebol.

Palavras-chave: Pré-condicionamento isquêmico; Frequência cardíaca; Futebol; Acelerações; Jovem atleta.

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