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CAPILLARY GLUCOSE BEHAVIOR AFTER ACUTE CONCURRENT EXERCISE SESSION IN TYPE 2 DIABETES MELLITUS

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Abstract: Physical exercise is an important non-pharmacological tool in glycemic control in patients with DM2, however little is known about the effect of an acute session of concurrent exercise on the behavior of capillary glycemia in recovery. The objective of the present study was to analyze the behavior of capillary blood glucose after an acute session of concurrent exercise in DM2. 8 women and 5 men, diagnosed with DM2, 62,6± 6,7 years, years, 78.2±8.6Kg, 27.9±2.4 Kg/m2, underwent an acute session lasting 60 minutes, with a prescription of concurrent exercise, with 50% aerobic exercises and 50% resistance exercises (emphasis on whole body muscle recruitment), at an intensity of <77% HRmax. (moderate) and collection of blood samples to analyze capillary blood glucose at rest and at 15, 30, 45 and 60 minutes of recovery. He advised all volunteers to observe medical recommendations regarding nutrition, use of drugs and physical activity. The results demonstrated a reduction in capillary blood glucose values at all moments of analysis during recovery compared to that observed at rest (190.3mg/dl). In R15' capillary blood glucose was 154.4mg/dl (reduction of 32.8mg/dl), in R30' it was 166.4mg/dl (reduction of 23.8mg/dl), in R45' it was 157.0mg/dl (reduction of 33.2mg/dl) and at R60' it was 151.3mg/dl (reduction of 38.7mg/dl). A significant difference was observed when comparing rest and R60' ($P<0.05$). It is concluded that a single session of concurrent exercise induces physiological adjustments that promote reductions in capillary blood glucose during recovery.

Keywords: type 2 diabetes, concurrent exercise, capillary blood glucose, acute effect, training session

INTRODUCTION

Type 2 diabetes (DM2) is a loss of metabolic regulation, both of carbohydrates, lipids and proteins, which results in inefficiency in the secretion of the pancreatic hormone insulin, due to peripheral resistance to this hormone or the combination of both (Defronzo and collaborators, 2015). Data from the International Diabetes Federation (IDF, 2019) reveal that cases rose to 74 million (16%), totaling a population of 537 million adults in the world in 2021. In Brazil, recent estimates add up to 16.8 million carriers of DM2, represents around 7% of the population (Brazilian Diabetes Society, 2019).

Its main cause is a progressive deficiency in insulin secretion by pancreatic beta cells related to the resistance of this hormone pre-existing in skeletal muscle, liver and adipose tissues (Defronzo et al, 2015). The risk increases constantly due to increased body weight, and when associated with a sedentary lifestyle and overnutrition results in the accumulation of fat, mainly in the abdomen and visceral tissues (Yumuk and collaborators, 2016, Pappachan, Viswanath, 2017).

Its treatment aims to maintain metabolic control through drug and non-drug therapy. The latter is associated with changes in lifestyle by adopting regular physical activity, healthy eating and stopping smoking (Cannata and collaborators, 2020). Participation in a physical activity program is an important mechanism in the treatment and control of DM2 (Kanaley and collaborators, 2022) as it provides physiological adaptations that promote glycemic control.

Studies have investigated the adaptations and their respective physiological effects of different training programs with aerobic and resistance physical exercise models (Garber and collaborators, 2011). Aerobic training improves glycemic control by increasing insulin-mediated diffusion of glucose to tissues, suppressing hepatic glucose synthesis (Kirwan et al., 2009), improving insulin signaling steps (Mann et al., 2022); modulates the expression and release of adipokines (Molnár and collaborators, 2022) and reduces the size of adipose tissue, mainly visceral (Lee-Ødegard and collaborators, 2022).

Resistance training also induces important physiological effects on glycemic control in patients with DM2, such as improvement in muscle strength, lipid profile, control of blood glucose levels and reduction of insulin dose (Ramalho et al, 2006). It also improves blood pressure, increases muscle mass and strength, which can positively impact the response to insulin and metabolic control (Strasser and collaborators, 2010). However, the combination of both training models, characterized by concurrent training (combination of aerobic and resistance training in a single session), appears to be more effective than aerobic and resistance training separately (Zhao and collaborators, 2021) and provides significant glycemic reductions at rest. and post-exercise, as well as medication dosage (Silva Júnior, Gomes, 2019).

Although the benefits of a physical training program for DM2 are known, the acute effect of a single session still requires investigation. The possible benefits are reducing post-exercise blood pressure, increasing post-exercise carbohydrate and fat oxidation and increasing insulin sensitivity with a reduction in capillary blood glucose within a period of 2 hours to 72 hours depending on the intensity and duration.

However, few studies relate the acute effect of a concurrent exercise session on capillary blood glucose during recovery. Given this, the objective of the present study was to analyze the behavior of capillary glycemia after an acute session of concurrent exercise in type 2 diabetics.

MATERIALS AND METHODS

KIND OF STUDY

Considering that DM2 has a higher prevalence and its clinical characteristics, as well as its care needs, the present study will be aimed at people with DM2. It will be an intervention study, with a quantitative approach, with a single comparison group for the analysis of "before and after" results, referring to the concurrent training program (Polit, Beck, 2011).

DESIGN AND ETHICAL ASPECTS

The study consisted of 4 meetings, the first of which included the reception of volunteers at the Exercise Physiology Laboratory (LABEFEX) of the Center for Applied Sciences in Education and Health (CeCAES) of the Federal Institute of Education, Science and Technology of the South of Minas Gerais, Muzambinho campus (IFSULDEMINAS), where the study was described, all questions were resolved and the informed consent form (TCLE) and image were signed. In the second meeting, anthropometric assessments were carried out and in the last meeting (3rd meeting), there was a single session of resistance exercise with blood sample collection to measure capillary blood glucose levels before and during recovery. The study was approved by the Research Ethics Committee of the Federal Institute of Education, Science and Technology of the South of Minas Gerais (IFSULDEMINAS), opinion no. 6,127,650, of June 19, 2023.

LOCATION AND PERIOD OF STUDY

The research was developed in the Exercise Physiology (LABIFEX) and Physical Conditioning (LACONF) Laboratories of CeCAES/IFSULDEMINAS, in 3 meetings that lasted 21 days.

SAMPLE

The sample initially consisted of 13 volunteers, 3 of whom dropped out, which resulted in a final sample of 10 volunteers diagnosed with DM2.

DATA COLLECTION ANTHROPOMETRIC ASSESSMENT

An octapolar multifrequency balance - InBody 720 (BIOSPACE, South Korea) was used. The results obtained with this equipment present a relationship of 0.88 with DEXA (Gibson et al., 2008) to determine the percentage of total body fat. This technology uses eight contact electrodes, four are positioned under the palms of the hands and thumbs and the others must be located under the front of the feet and heels. The following variables related to body composition were analyzed: body weight (BW), body mass index (BMI), fat percentage (%BF), body fat mass (MGC), skeletal muscle mass (SMM) and waist ratio and hip (WHR) through frequencies of 1, 5, 50, 250, 500 and 1000 kHz, following the procedures proposed by the manufacturer. Total height was assessed using the Caumak stadiometer.

CAPILLARY BLOOD GLUCOSE MEASUREMENT

The evaluation consisted of biochemical tests of capillary blood glucose measured using a portable Accu-chek active kit Roche glucometer, lasting 30 minutes, carried out at LABFEX and followed the protocol:

Capillary blood glucose measurement protocol using a portable glucometer:

1st. Sterilization of the lateral area of the second or third finger using cotton soaked in alcohol;

2nd. Bring the lancing device closer to the sterilized area to collect the blood sample;

3rd. Insert a test strip from the portable glucometer device;

4th. Touch the test strip of the portable glucometer device to the 1st drop of blood until it fills the deposit found on the test strip within a maximum period of 15 seconds and 5º. In a few seconds, the portable glucometer device will display the glucose concentration in the collected blood sample in mg/dl on the monitor. (Santos et al, 2008).

The assessment of capillary blood glucose was carried out before the concurrent exercise session and at 15', 30', 45' and 60' of recovery.

CONCURRENT EXERCISE SESSION METHODOLOGY

The concurrent exercise session lasted 80 minutes, held at LACONF and consisted of aerobic and resistance exercises.

Aerobic Exercise: lasted 30 minutes, performed on ergometers (treadmill and exercise bike) and walking on the sports court, classifying intensity as moderate and intense according to Howley's methodology (2001).

Resistance Exercise: lasted 30 minutes, on weight training machines, 2 sets with 15 repetitions, 1-minute interval between sets and exercises, recruitment of large muscle groups and intensity between 03 and 07 on the OMINI scale (Robertson and collaborators, 2003).

STATISTICAL PROCEDURES

The numerical data relating to the studied parameters are arranged in standard deviation and were subjected to the Komolgorow-Smirnov and Levene tests to verify, respectively, the normal distribution and homogeneity of variances. For comparisons between dependent samples, the paired t-test will be used for parametric data or the Wilcoxon test for non-parametric data. All statistical analyzes will be performed using the GraphPad Instat program and differences will be considered significant when the significance level (p) is less than 0.05.

RESULTS

The study consisted of 10 volunteers of both sexes, 5 women and 5 men, mean age ±SD of 62.6 ± 6.7 years and body composition parameters are expressed in table 1.

Figure 1 represents the behavior of capillary blood glucose at rest and at 15 minutes (R15'), 30 minutes (R30'), 45 minutes (45') and 60 minutes (R60') of recovery in a single concurrent exercise session.

An intense reduction in the value of capillary blood glucose can be observed at time R15' (15 minutes of recovery). From this moment to R30', capillary blood glucose tends to a slight increase (9mg/dl, 5.7%), at moments R45' and R60', it reduces again to 157.0 mg/dl and 151.3mg/dl, respectively, being 5.7mg/dl (4%).

Figure 2 shows the average capillary glycemia values obtained at the moments analyzed, the comparison of the reduction in capillary glycemia between recovery and rest and the respective percentages. When comparing rest with R15', we have a reduction of 32.9mg/dl in capillary blood glucose, which corresponds to a 17% reduction. When comparing R30' with rest, the reduction reduces to 23.9mg/dl (13%). The difference rises again to 33.3md/dl at R45' and when compared at R60', the difference with resting values rises to 39.0mg/dl (21%), being the biggest difference between the comparisons.

DISCUSSION

The study aimed to analyze the behavior of capillary blood glucose after an acute session of concurrent exercise in DM2. The hypothesis would be that capillary blood glucose would tend to reduce its values during recovery compared to the value obtained at rest or before an exercise session. The results demonstrated a constant, but not significant,

Volunteer	PC(Kg)	IMC (Kg.m^2)	%G(%)	MGC (Kg)	MME(Kg)	RCQ
10	77,8±8,6	28,5±2,4	36,8±9,9Kg	28,8±7,7	26,8±3,9	1,02±0,6

Table 01 – Body composition parameters of volunteers

Figure 01 below shows the behavior of capillary blood glucose during the rest period and during recovery, at moments 15, 30, 45 and 60 minutes.

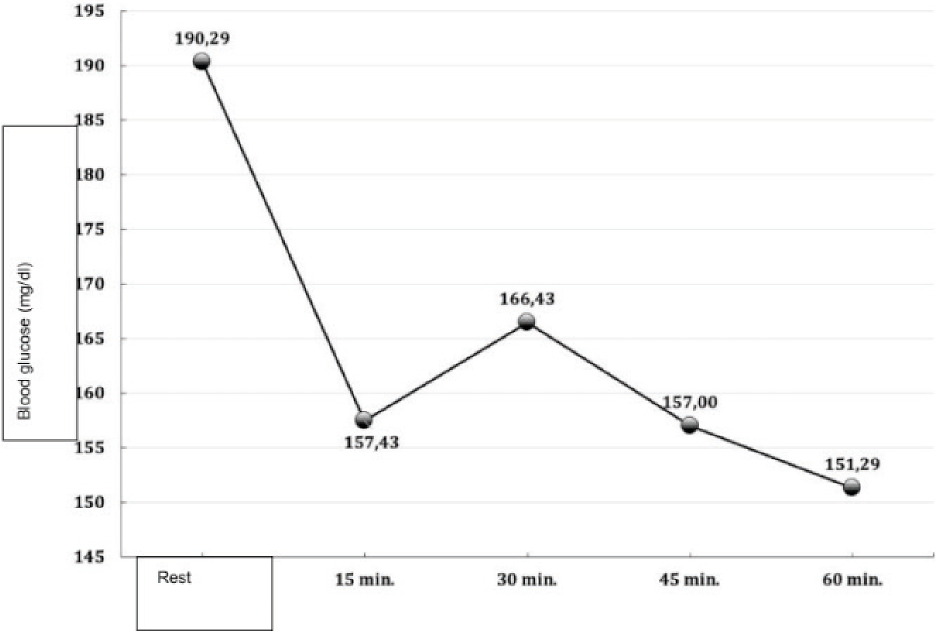

Figure 01 – Behavior of capillary blood glucose at rest and during the recovery period

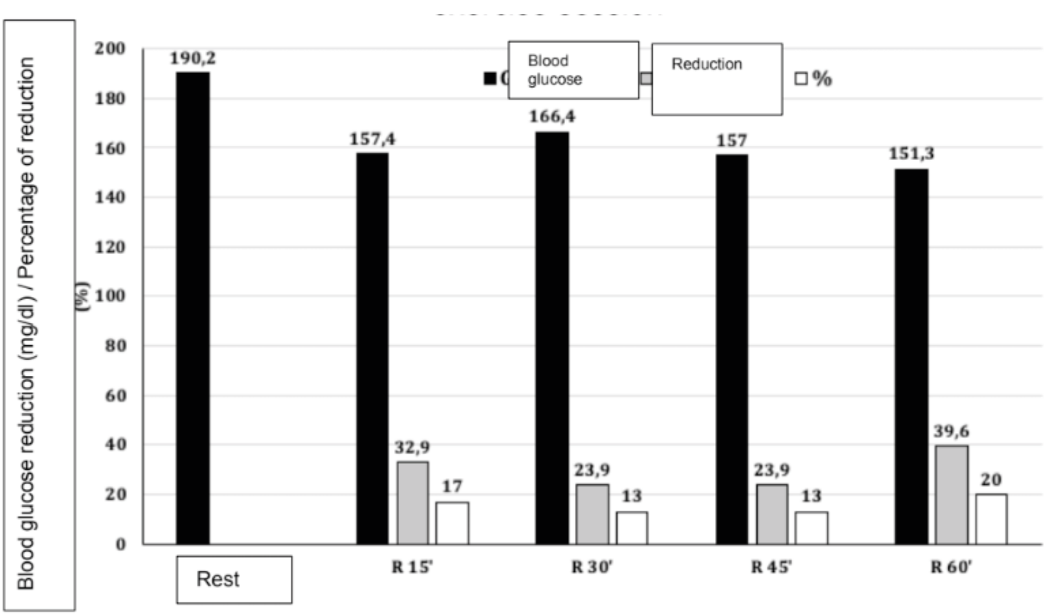

Figure 02 – Comparison of capillary blood glucose behavior, reduction and respective percentage between rest and recovery moments in a single concurrent exercise session

Rep.= rest, Glic. = capillary blood glucose (ng/dl), reduction: reduction (comparison between values during recovery and rest), %: percentage of reduction.

reduction in moments R15', R30', R45' and R60' when compared to the resting value.

The behavior of capillary glycemia during recovery was studied in elderly rats after two swimming sessions lasting 90 minutes, interspersed with a 45-minute break. The authors observed that there was a reduction in the rate of glucose disappearance, but this was restored after 16 hours of the exercise protocol. They concluded that a single exercise session has the ability to attenuate signaling pathway modulators that promote improved sensitivity and reverse insulin resistance promoted by obesity during recovery (Pauli and colleagues, 2010). The present study adopted different methodologies for both the volunteers and the physical exercise session. However, despite these differences and the fact that we did not analyze the behavior of modulators of the signaling pathway, capillary glycemia reduced during the recovery period.

Performing 2 concurrent physical exercise sessions interspersed for 72 hours also showed a reduction in capillary blood glucose during the recovery period. In the study, 20 male volunteers, with an average age of 21.80 ± 2.90 years, BMI ≥ 23 kg/m2, 24.83 ± 3.68% fat. The order of execution of the exercises was, strength then resistance and resistance after strength. Capillary blood glucose was obtained before, immediately at the end of each exercise session and during recovery, at 30, 60 and 90 minutes. The results demonstrated a significant reduction in capillary blood glucose during recovery in both exercise models.

However, the concurrent exercise carried out initially with a predominance of strength and then aerobic, was more efficient in reducing capillary blood glucose values (Silva Júnior and collaborators, 2021). When comparing the studies, it is observed that the age of the volunteers and the methodology are different. Also, in the present study, the volunteers were diabetic. Despite these differences, the behavior of capillary glycemia was similar between both studies, reducing the recovery period in relation to resting values.

In diabetic volunteers, he studied the effect of Pilates sessions on the behavior of capillary blood glucose during recovery. The study consisted of 8 volunteers, female, aged 62.4 ± 7.9 years, type 2 diabetics who performed a Pilates session in the water, Pilates on the ground and did not perform physical activity. The session lasted 30 minutes and capillary blood glucose was measured at rest, before and during the session and after 15 minutes of recovery. The results demonstrated reductions in capillary blood glucose during recovery in both models of physical exercise, significantly in water Pilates. The authors suggest that this difference is due to the type and intensity of the exercise (Macêdo and collaborators, 2017). This study used diabetic volunteers and observed a reduction in capillary blood glucose at rest. These data corroborate our study, we observed a reduction at moment R15', however the biggest drop occurred at the end of the analysis, R60 minutes. We believe that this difference may be due to the methodology adopted in our study, prescription of concurrent exercises, session duration and analysis of capillary blood glucose during recovery. Regarding exercise prescription, resistance exercises were prescribed that present greater intensity and recruitment of muscle fibers, which may induce greater metabolization of muscle glycogen and greater diffusion of glucose to these muscle fibers (Silva Júnior and collaborators, 2021). Also, the physical exercise session lasted 60 minutes, which is twice as long as the study mentioned, so with a longer duration, we will have greater metabolic consumption and, probable diffusion of glucose to the muscle fibers. We observed the greatest reduction in capillary blood glucose in 60 minutes of recovery, but if we had only analyzed it in 15 minutes, we would also have the same result as in the Pilates session.

The reduction in capillary blood glucose behavior during recovery from a concurrent exercise session can be explained by the action of muscle contractions and not by the effects of insulin. This hormone has the ability to act on a wide range of body tissues, but mainly on skeletal muscles, liver and adipose tissue. Its physiological effect initially is to increase glucose uptake by skeletal muscles, subsequently promotes glycogenesis and inhibits hepatic glycogenolysis and gluconeogenesis and finally, storage of triglycerides in adipocytes of adipose tissue, resulting in a reduction in capillary glycemia (or capillary hypoglycemia effect) (Aronoff and collaborators, 2004). By binding to its receptor (insulin receptor – IR), insulin activates a sequence of key protein phosphorylations that will, at the end of the process, promote the translocation of glucose transporters (glucose transport – Glut) that allowed its diffusion from the interstitial environment to the intracellular environment (Richter, Hargreaves, 2012). The translocation of Glut4 to the sarcolemma of skeletal muscle fibers is mediated by the IP3K pathway, which is initiated by the phosphorylation of protein tyrosine kinase, the substrates of the insulin receptor (mainly IRS1), the substance phosphatidylinositol 3 kinase (IP3K); the protein kinase B (PKB or Akt) and finally the RabGDP protein in RabGTP. The translocation of Glut4 to the sarcolemma allows the diffusion of glucose into the intracellular environment (Silva Jr, 2017; Mann and collaborators, 2022).

The uptake of glucose by skeletal muscles does not occur solely through the action of insulin (Hullet and collaborators, 2022). Muscle contraction, which occurs during physical exercise, has the capacity to increase the uptake of this energy substrate. Studies in acute training models suggest that muscle contractions can increase energy demand by increasing the enzymatic processes of glycolysis and oxidative phosphorylation of adenosine triphosphate (Stanford, Goodyear, 2014). With the increase in oxidative phosphorylation of ATP, there will be a reduction in the ATP/AMP ratio, which activates protein kinase activity by adenosine monophosphate (AMPK), which increases the translocation of glucose transporters (Glut4) and consequently the uptake of glucose in skeletal muscles (Bonab, Dastah 2022; Hullet and collaborators, 2022). Studies indicate that in addition to the activation of the AMPK enzyme, other mechanisms act in the translocation of Glut4, including: activation via calcium/cammodulin, nitric oxide and actin cytoskeletons (Richter, Hargreaves, 2013).

In the present study, there was a reduction in capillary glycemia during the concurrent acute exercise session and during recovery, which is the main stimulus to also reduce insulin release (Aronoff and collaborators, 2004). Therefore, the most likely mechanism acting on the reduction of capillary glycemia may be skeletal muscle contractions during the session. It is worth mentioning that the session recommended in the present study includes resistance exercises that induce greater recruitment of muscle fibers with a predominance of glucose/glycogen metabolization, which may facilitate the diffusion of glucose into the intracellular environment (Hullet and collaborators, 2022). These physiological effects induced by concurrent physical exercise, even if it is acute, promote reductions in capillary glycemia during recovery and allow DM2 important glycemic control other than through pharmacological means, even if it lasts for a short time.

FINAL CONSIDERATIONS

The acute performance of a concurrent exercise session (combination of aerobic and resistance exercises in a single session) promotes reductions in capillary blood glucose during recovery, probably due to the action of muscle contractions and not due to the physiological effects of insulin. Important effect that characterizes physical exercise as an important non-pharmacological tool for glycemic control in patients with DM2. However, more studies are needed to better explain the relationships between the acute concurrent exercise session and glycemic control in recovery.

STUDY LIMITATIONS

The study had some limitations, including the small sample size and may have compromised a more accurate statistical analysis. Also, the time taken to analyze capillary blood glucose during the recovery period presents a great disparity, studies have analyzed it at just 15 minutes, 90 minutes and other moments, which makes a more careful analysis difficult. And finally, the methodological characteristics of physical exercise, which presents a wide variation in models of metabolic predominance, intensity, duration, muscle recruitment and intervals between sessions.

CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest related to the present study.

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