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ACUTE EFFECT OF RESISTANCE EXERCISE ON ANAEROBIC THRESHOLD IN TYPE 2 DIABETIC INDIVIDUALS

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ABSTRACT

Introduction: Type 2 Diabetes Mellituscan promote changes in the cardiac autonomic nervous system, during exercise and even in the recovery period, and can alter the lactic metabolism of individuals with this pathology. One way to assess these changes is through blood lactate collection. **Objective:** to investigate the acute effect of resistance exercise on lactic metabolism in diabetic individuals. **Methods:** The sample consisted of 14 diabetic individuals and 10 apparently healthy individuals, of both sexes. The anaerobic threshold was determined during the knee extension exercise (Roman table) and two tests were applied: one with 10% below and the other with 10% above the LA, each lasting one minute, maintaining spontaneous breathing. and without apnea. **Results:** The results of our study showed that there were more significant changes in lactate measured by blood from 30% of 1RM for the CG as well as for the DM2 group, the latter with more expressive changes when also compared with the loads of 40 and 50% of 1RM. **Conclusion:** Diabetic individuals tend to suffer greater and lesser metabolic stress when compared to apparently healthy individuals.

INTRODUCTION

Gradual increases in blood glucose in response to the decline in insulin secretion and decreased hepatic and muscle metabolism is a mechanism for the development of diabetes. If glucose levels remain high, they generate damage to peripheral nerve fibers, causing an increase in sympathetic activity and vagal decrease, causing a deficient transport of glucose from the blood to muscle cells, causing changes in various body systems in diabetic individuals (KRAUS *et al* , 2002; MUST, 1999). The gold standard method for investigating metabolic stress during exercise (ie identification of anaerobiosis threshold), and even in the recovery period, is the measurement of blood lactate. About LA and aerobic exercise, there is already a vast literature covering this area and investigating its acute and chronic effects (GUGLIELMO E DENADAI, 2001; COEN*et al*, 2001; BACON and KERN, 1999). In 2004, with Barros *et al*, studies related to LA and resistance exercise in healthy trained and untrained individuals started. In this research, a comparison was made between relative and absolute values of the LA, in exercises for upper and ower limbs. The results found suggested that the relative values of LA are similar both in legpress and in exercises for upper limbs.

Another research involving resistance exercise and LA was carried out by Azevedo *et al* (2005), in which the sample was composed of young, healthy and trained individuals whoperformed 20 repetitions within 1 minute, with a repetition every 3 seconds and a 2-minute pause between each stage. This protocol was performed on the flexing table and the biceps curl. What was found was that, in relative values, the LA is approximately 28% of 1RM regardless of the exercise performed and the muscle group involved the metabolic response was similar. Oliveira *et al.* (2006) studied the LA and glycemic threshold (LG) in healthy young people and correlated it with the RE performed also in the upper and lower limbs. The results showed that both LA and LG could be identified during the exercise method incremental. The thresholds occurred at intensities between 31% and 36% of 1RM. In 2008 Moreira *et al.* also studied these indexes and found the presence of a threshold during incremental ER, by analyzing the behavior of lactate and glucose in subjects with DM2. LA occurred on average at 31.0% 1RM and LG at 32.1%, both for the legpress exercise. The study by Rafo *et al.* (2008) showed that the LA occurred at 40% of a 1RM during the performance of the bench press in trained young people, whereas Nasser (2010) using an incremental protocol, also in the bench press, found the LA in 29, 9%. However,

in diabetic individuals, the presence of this and other risk factors for cardiovascular disease such as obesity and hypertension can influence the absolute and relative intensities of occurrence of LA (MATTERN *et al.,* 2003). Thus, the metabolic, cardiovascular and respiratory adjustments involved in the LA process can present changes in their response patterns at lower levels of effort due to weakened health (PASCHOAL & FONTANA, 2011). It is known that physical exercises are recommended for the diabetic population since, according to Brazilian Diabetes Society (SBD 2020), physical activity is able to promote increased insulin sensitivity causing glycemic indexes to be adjusted in these individuals, however due to the changes resulting from this pathology in the body, the responses to exercise may be altered and, with regard to resistance exercise (RE), there is a scarcity of studies carried out in this population. Therefore, the aim of this study was to investigate the acute effect of ER on lactic metabolism in diabetic individuals.

MATERIAL AND METHODS

Sample: For the sample size calculations, the pilot study was carried out with 8 sample elements taking as reference the difference between the moments of rest and exercise for the RMSSD values. There was an average difference between the moments of exercise and rest of 5.65ms and standard deviation of 3.34ms. Considering a type I error of 1% (0.01) and a power of 90%, a sample of 8 sample elements was estimated. Considering a possible sample loss of up to 30%, a sample of 11 sample elements was considered. Sample size calculations were performed using Software Primer of Biostatistics verson 7 (Glantz, 2011). The sample consisted of 14 diabetic individuals, constituting the DM2 group and 10 apparently healthy individuals constituting the control group (CG).

Local: The research took place on the premises of the Center for Studies in Education and Health (CEES) of Universidade Estadual Paulista - UNESP in Marília - SP.

Ethical aspects: The project was submitted to the Research Ethics Committee Involving Humans, according to Resolution 466/2012 and its Complements of the National Health Council and was approved (opinion nº 083602/2016). All volunteers were informed about the experimental procedures, as well as the fact that they did not affect their health. They were also clarified about the confidentiality ofinformation and their identities. After reading and agreeing, they signed an informed consent form.

Selection criteria: Subjects with fasting blood glucose> 100mg / dL (pre-diabetics) and>126mg / dL (diabetics) (American Diabetes Association, 2018) and with optimized medication. Those with: diagnosis of diabetes before the age of 30 or gestational; heart, lung and neurological diseases; anemia; pacemaker; smokers; consume 30g / day or more of alcohol; motor limitations that compromise the execution of physical tests; pregnant women; ER practitioners in the last 6 months; menstrual irregularity.

Study Procedures: Blood samples were collected after 12 hours of fasting and analyzed for blood glucose, triglycerides (TG), total cholesterol (CT), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), in addition to addition, medications in use were investigated. The experiments were carried out in the same period of the day, to standardize the influences of circadian variations on the organism (BILAN *et al* 2005). The volunteers wore comfortable clothes the day before and on the day of the tests, were instructed not to drink alcoholic beverages and / or stimulants (tea, coffee, chocolate and others), did not perform strenuous physical activities and ate a light meal at least 2 hours before the tests. On the day of the tests, the conditions related to the volunteer's health status were observed, to verify the occurrence of a regular night's sleep and to confirm that the HR and BP variables were within normal limits. In order to reduce anxiety and expectation on the part of volunteers, familiarization with the test protocol, with the technical group of researchers and with equipment. The experimental room was monitored and maintained at a temperature of 23 ± 2oC and the relative humidity at $50 \pm 10\%$. After the interview

(personal data and physical activity level questionnaire), pilot tests were carried out with the participants so that they understand the data collection routine, familiarizing themselves previously with the environment and the resources used. The protocol for data collection was applied in 3 days with an interval between them from 48 to 72 hours. Following is the brief description of each assessment:

Day 1: Blood pressure measurement, anthropometry, HR record and RR intervals at rest and familiarization for the component tests of cardiac autonomic assessment.

Day 2: On this day, the participant will receive instructions and will be familiarized with the maximum load test (1RM). The maximum load obtained in this familiarization was a reference for the definitive test to determine the 1RM.

Day 3: Maximum load test (1RM): the volunteer performed the 1 RM test (described later in detail). After a 30-minute rest, the volunteer underwent blood lactate thresholds (described in detail later). The submaximal loads evaluated corresponded to 10, 20, 30, 40 and 50% of the obtained RM.

Anthropometry and Body Composition: Anthropometric measurements were performed with bare feet, men in shorts and women in shorts and top. The following conditions were respected for the assessment of fat percentage and body composition: minimum interval of three hours after waking up; not having consumed alcohol in the last 24 hours; not having practiced physical exercises;not having eaten food or caffeine in the last 4 hours; having ingested 2 to 4 glasses of water in the last 2 hours before the test. Body mass was measured using an anthropometric scale (Welmy, São Paulo, Brazil), which has an accuracy class 3. To check height, a stadiometer was used and the participants were barefoot and with their heads in an orthostatic position. From these data, the Body Mass Index (BMI) was calculated using the formula: body mass (kg) / height2 (m) (WHO, 2000). Measurements of waist and hip circumference were performed with the individual standing with a relaxed abdomen and relaxed arms beside the body. A measuring tape with a precision of 1 mm was used, which was placed horizontally on the skin, positioned at half the distance between the last ribs and the iliac crest, for the measurement of the waist circumference, and in the region with the largest protuberance of the buttocks for the measurement of the hip circumference (TAYLOR *et al.,* 2000). From these measurements, the ratio between them to obtain the waist-to-hip ratio was calculated. A bioimpedance body composition analyzer was used. (BIODYNAMICS, 450 CLASS I TBW, São Paulo, Brazil) The volunteer remained on the stretcher in the supine position and the electrodes were positioned as follows: on the right foot, distal electrode at the base of the middle finger and the proximal electrode between the medial and lateral malleoli; in the right hand, distal electrode at the base of the middle finger and the proximal electrode coinciding with the styloid process and the percentage of fat was analyzed.

Maximum load test and LA determination: Previously, a warm-up was performed as follows: a) 5 minutes of cardiorespiratory exercise on a cycle ergometer with an intensity of 50% of the reserve HR [(220 - age - rest) x 0.5) + rest)]; b) 2 sets of 15 seconds of stretching for each of the muscle groups to be tested. c) 10 repetitions of the exercise with the weight of the device, without adding load. Tests for determination of MR were started five minutes after heating. Then, a maximum load test (1-RM) of knee extension (Roman table) was performed, where the volunteer remained seated as hips and knees at 90º of flexion, with the back resting on the back of the machine, foam pads on the arm lever supported on the front of the legs, two centimeters above the lateral malleoli of the ankles. To determine the maximum load, the weight obtained in the familiarization of the test was the initial one. The resistance was progressively increased every 5 kg until the volunteer was unable to complete the subsequent attempt, and when this occurred, 50% of the added load was subtracted in the last attempt. A maximum of five attempts were made, with three-minute retreat intervals between attempts, if it was not possible to verify the maximum load for one repetition in the five

attempts, the individual should return after 48 hours to perform the test again (ACSM, 2010). The LA determination test was performed after thirty minutes of determining the 1RM load. The individuals performed 20 repetitions during one minute with 10, 20, 30, 40 and 50% of the load obtained in the 1RM test with a 3-minute recovery interval between them. Right after the completion of each submaximal load, in the first minute, asepsis was performed with alcohol in the ear lobe and, using a lancet and disposable procedure gloves, the first drop of blood was discarded and quantified (mMol.L) of the lactate using an analyzer (ACCUTREND PLUS - ROCHE, USA). The object of study with this procedure is to observe the loss of linearity with an abrupt and exponential increase in the lactatemia curve, which will be considered to be the LA (BARROS *et al*, 2004).

Data analysis: The variables are described by the distribution of absolute (f) and relative (%) frequency for qualitative variables, and by the mean and standard deviation for quantitative variables. The normality distribution was verified by the Shapiro-Wilk test with Liliefors correction. An Anova of Repeated Measures was carried out to analyze the effect of the group (diabetic and control), the moment (rest and overload) and the interaction. When the interaction effect was significant, the Bonferroni multiple comparison test will be performed to find the differences. The level of confidence adopted was 5%. The data were analyzed using SPSS software version 24.0 for Windows.

RESULTS

Sample: 114 individuals were screened, of these 98 were not included and 16 were excluded from the study according to our previously mentioned criteria.

Table 1. Demographic, anthropometric and physiological data at rest

Variables	DM2	CG
Age (years)	61.08 ± 9.18	56.57 ± 7.74
Body Mass (Kg)	71.62 ± 13.66	69.60 ± 8.65
Height (m)	1.60 ± 0.07	1.60 ± 0.08
Body massindex	27.97 ± 4.47	27.31 ± 2.67
Waistcircumference (cm)	92.68 ± 16.34	94.31 ± 7.39
Waist / Hip Ratio	0.95 ± 0.11	0.91 ± 0.07
Fatpercentage	32.66 ± 4.80	35.48 ± 6.90
Systolic Blood Pressure (mmHg)	129.92 ± 13.59	113.71 ± 9.76
Diastolic Blood Pressure (mmHg)	79.85 ± 9.65	77.43 ± 11.53

Note: Kg = kilograms; m = meters; Kg / m² = kilograms per square meter; cm = centimeters; mmHg =millimeters of mercury.

The demographic, anthropometric and physiological data at rest of the individuals are shown in Table 1. The prevalence data for the risk factors and current medications in the sample are shown in Table 2.

Table 2. Prevalence data for risk factors and medications in force in the sample

Variables	AbsolutePrevalence (%)	
	DM2 (n14)	*CG (n10)*
Riskfactors (%)		
Dyslipidemia	7 (50%)	2 (20%)
Increased WHR	12 (85.7%)	10 (100%)
Increased WC	11 (78.5%)	10 (100%)
Systemic arterial hypertension	11 (78.5%)	0 (0%)
Diabetes	14 (100%)	0 (0%)
Obesity (BMI)	5 (35.7%)	2 (20%)
Currentdrug classes (%)		
Hypocholesterolemic	2 (14.2%)	0 (0%)
PlateletBlocker	4 (28.5%)	0 (0%)
Beta blocker	2 (14.2%)	0 (0%)
Hypoglycemic	12 85.7%)	0 (0%)
Diuretics	3 (21.4%)	0 (0%)
Calcium Channel Blocker	3 (21.4%)	0 (0%)
Convertingenzymeinhibitor Angiotensin	7 (50%)	0 (0%)
Selective serotonina reuptake inhibitor	2 (14.2%)	1 (10%)
Antacid	0 (0%)	1 (10%)
Hormone Replacement	1 (7.1%)	1 (10%)

Note: WHR = Waist / Hip ratio; WC = waist circumference; BMI = body mass index.

Table 3. Values of mean and standard deviation of blood lactate at rest and during loads of 10 to 50% of 1RM for Diabetics (DM2) and non-diabetic control

	DM2 (n14)		CG (n10)		The new (p-value)		
Variables	Average	PD	Average	PD	Group	Time	Interaction
La_REP	2.6	0.6	2.3	0.9	0.018	0.0001	0.716
La_10	3.0^{†,c,d}	0.6	2.1^{c}	0.4	*	*	
La_20	3.4^{†,c,d}	1.3	2.2^{c}	0.6			
La_30	3.8 ^{†,r,c,d}	1.1	2.7^{c}	0.9			
La_40	5.0 ^{r}	1.7	3.5	1.7			
La_50	5.6 ^{r}	2.1	4.2	1.8			

Note: * p≤0.05 significant effect of the group; c significant difference within the group in relation to the 50% load by the Bonferroni Post-Hoc test; d significant difference within the group in relation to the 40% load by the Bonferroni Post-Hoc test; r significant difference within the group in relation to rest by the Bonferroni Post-Hoc test. † significant difference in relation to the Control group by the Bonferroni Post-Hoc test.

DISCUSSION

Factors such as age, gender, anthropometric characteristics, physical conditioning and factors linked to environmental conditions influence physiological responses both at rest and during physical exercise (GALLO JR *et al.,* 1995; BARBOSA, BARBOSA FILHO, DE SA, 1996; RIBEIRO *et al.,* 2000; CATAI *et al.,* 2002), for this reason we tried to maintain the standardization and homogeneity of the sample in this study, as shown in table 1. Since the CG was composed of apparently healthy volunteers, they presented associated risk factors such as WHR and WC increased in 100% of the sample; dyslipidemia and obesity (BMI) by 20%. In the DM group, WHR was recurrent in 85.7% of the sample, increased WC and SAH in 78.5%, dyslipidemia in 50% of the sample and 35.7% had obesity (BMI). Both groups presented individuals with increased RQC and obesity, Hawley and Hourmand (2004) affirm that 50 to 80% of those with type 2 diabetics are obese and that this pathology is one of the greatest endocrine complications of recent times. Regarding current drugs, it is known that they influence cardiovascular and metabolic variables and can alter cardiac autonomic modulation (ALBANESI FILHO, 1998), the CG has a low incidence of drugs in the sample, which, in turn, is not capable of influence the results of the present study. In the DM2 group, on the other hand, there is a greater variety of drugs in use in the sample, since these individuals have risk factors for cardiovascular disease, however the study of each one of them and their implications for HRV was not the objective of this research. As shown in Table 3, it was found in our study that, on average, blood lactate, in the control group, maintained stability up to a load of 30%, with loads of 10, 20 and 30% significantly different from 50% of 1RM.

This demonstrates a physiological response that occurred in this group, which can be explained according to Pretrofsky and Lind (1980), who explains in his study that the increase in intramuscular pressure, together with the increase in muscle tension, leads to the collapse of capillaries. oxygen supply to the muscle group being exercised and generates the accumulation of blood lactate. The study by Myers *et al* (1997) describes that there may be an increase in blood lactate levels during exercise due to the progressive recruitment of motor units, mainly type IIb fibers, where a decrease in intracellular pH interferes with the contraction- coupling and its ability to maintain strength and to compensate for this factor more oxidative fibers are recruited, resulting in increased glycogenolysis and lactate, we perceive this in the control group when we observe that from a load of 30% of 1RM the levels of lactic acid increase in blood. Simões *et al.* (2010) studied apparently healthy elderly men, submitting them to a resistance exercise protocol in legpress and found, similarly to our results in the control group, the anaerobic threshold at 30% of 1RM, possibly explaining this behavior due to the fact that from this load there is a significant hemodynamic modification of the exercised musculature due to the compression of blood capillaries, with a significant reduction in blood flow. When we observed the lactate responses of the DM2 group, compared to the exercise proposed in our protocol, we identified that there was also a

stability up to the load of 30% and a significant difference in the loads of 10, 20 and 30% of 1RM when compared with 40 and 50% of 1RM, the justification for these responses in this situation are the sameexplained to the CG, physiological responses to physical exercise. The study by Moreira *et al* (2008) corroborates our findings when he subjected diabetic individuals to an incremental resistance test of legpress and bench press and verified blood lactate by finding LA in both exercises at about 30% of 1RM. In relation to the other findings in our study, the significant difference between the loads of 40 and 50% of 1RM in relation to rest, as well as the difference between the groups in the respective loads of 10, 20 and 30% propose that diabetics tend to have greater metabolic stress compared to physical exercise when compared to apparently healthy individuals of the same age group. The study by Moreira *et al.,* (2007) compared different methods of identifying the anaerobic threshold, including blood lactate analysis, in sedentary diabetic, active diabetic and non-diabetic individuals. In this study, it was identified that during the aerobic protocol, the sedentary diabetic group had lower tolerance to exercise and higher blood lactate values than the other two groups, indicating that this sample tends to present greater metabolic stress more quickly, as shown in our sample during exercise resisted. Moreira justified this by claiming that in this population possible peripheral limitations may occur, alower recruitment of motor units, that trigger muscle fatigue more quickly, in addition, the study by Marin *et al.* (1994) showed that the composition of muscle fibers and capillary density in diabetics are different, in this population there is a low number of type I fibers, a high number of fibers type II and a low capillary density. Kawaji *et al.* (1989) also studied two groups, one with diabetic individuals and the other with healthy non-elderly individuals, and identified that in diabetics, the intensity of aerobic exercise at the time of the anaerobic threshold was lower than that of healthy individuals, showing one more Since in the diabetic population the metabolic stress is higher, when compared to healthy control groups and, they occur at lower intensities of physical exercise, showing similarity with the results of the present study.

CONCLUSION

Our results suggest that in both groups, LA occurred at 30% of 1RM, tending to stabilize after this load and that diabetic individuals tend to suffer greater metabolic stress and at lower intensities when compared with apparently healthy individuals.

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