Original Article

# Effects of Acute Exercise on Postprandial Lipemia in Sedentary Men

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## Objective

To examine the effects of a single session of isometric physical exercise on postprandial triglyceridemia in sedentary male individuals with fasting triglycerides values $< 150$ mg/dl (NTG) or $\geq 150$ mg/dl ($TG_{ALT}$).

## Methods

Twenty-seven individuals (10 NTG and 17 $TG_{ALT}$), aged between 30-55 years were assessed in the study. Triglycerides were determined in the beginning, and at two, four and six hours after the oral ingestion of a solution with 50g/m$^2$ of fat in two occasions: at rest and after treadmill isometric exercise.

## Results

Acute exercise did not affect the levels of postprandial triglycerides or the area under the curve (AUC) of triglycerides. However, the abnormal pattern of postprandial lipemia curve was associated with higher basal triglyceridemia with exercise (basal TG: 147 ± 90 vs. 238 ± 89 mg/dl, p = 0.02) and without exercise (basal TG: 168 ± 93 vs. 265 ± 140 mg/dl, p = 0.04). Analysis of the receiver operating characteristics (ROC) curves showed cut-off values for basal triglycerides with exercise of 166.5 mg/dl (sensitivity: 0.78; specificity: 0.72) and AUC of 0.772 [CI 95%: 0.588-0.955], and without exercise of 172 mg/dl (sensitivity: 0.78; specificity: 0.61) and AUC: 0.722 [CI 95%: 0.530-0.914].

## Conclusion

Acute exercise did not affect postprandial triglyceridemia in sedentary male individuals, and basal triglyceride levels are predictors of an abnormal response of postprandialtriglycerides.

## Key words

Acute exercise, triglycerides, postprandial lipemia.

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The concept that the atherosclerotic process is a postprandial phenomenon was evidenced more than twenty years ago by Zilversmit[1], who demonstrated, in animals and in human subjects, that remnants of chylomicrons and low-density lipoproteins (LDL) are captured by endothelial cells.

Clinical studies have shown that the magnitude of postprandial lipemia or even increased postprandial triglyceride (TG) levels can predict symptomatic or asymptomatic atherosclerosis, regardless of risk factors assessed in the fasting state[2-5].

Postprandial lipemia reflects an integrated measure of the individual's capacity to remove triglycerides. Diets or treatments which reduce the fasting levels of triglyceride-rich lipoproteins may improve the postprandial levels of triglyceride-rich lipoproteins. Therefore, aerobic exercise, the reduction of body weight and certain medicines reduce postprandial triglyceridemia and can also reduce remnant lipoprotein levels[6].

Postprandial lipemia is characterized by transient hypertriglyceridemia, but fasting triglyceride concentrations are related to the size of the LDL particle[7]. This response may be conditioned to the higher mobilization of fatty acids, increase of the synthesis and delay in the removal of VLDL, thus allowing greater interaction between lipoproteins which contribute to the formation of small and dense LDL particles which are extremely atherogenic[7-10].

The magnitude of postprandial response is determined by several factors. Postprandial response is greater in men[11,12], tends to increase with age[13], is different between normo- and hypertriglyceridemic individuals[1,14] according to fasting serum lipid levels.

Regular exercise is associated with the reduction of the prevalence of coronary artery disease, diabetes mellitus and obesity[15-18]. Most of our life is spent in the postprandial state, and therefore interventions which may mitigate the atherogenic effects of postprandial hyperlipemia are specially important[19].

Although exercise may cause favorable changes in postprandial lipid profile, the acute effects of exercise are less known, especially when individuals with normal or altered fasting triglycerides levels are compared[20-22].

In view of the considerable increase in the prevalence of sedentary lifestyle, obesity and insulin resistance in modern society, this study was designed to examine the effects of a single session of physical exercise on postprandial triglyceridemia, in sedentary individuals with or without fasting hypertriglyceridemia.

## Methods

The study was approved by the Research Ethics Committee of the Federal University of São Paulo – Paulista School of Medicina, and all participants gave their written informed consent.

Twenty-seven sedentary individuals participated in the study, with ages between 30 and 55, of whom ten were normotriglyceridemic NTG (basal TG < 150 mg/dl) and seventeen had altered basal triglyceride values $TG_{ALT}$ (TG ≥ 150)[23,24]. Individuals with TG > 400 mg/dl were excluded from the study.

We also excluded from the study those individuals with body mass index ≥ 30 kg/m$^2$, with symptomatic coronary disease, assessed by means of clinical and electrocardiographic criteria, recorded at rest or during the treadmill exercise test. Additionally we excluded individuals with severe liver, severe kidney disease, diabetes, patients with infections or cancer.

*Design of the study* - The protocol comprised medical assessments, laboratory tests, ergospirometry, nutritional assessment and study of postprandial lipemia (fig. 1). Exercise prescription followed the ergospirometric test.

Nutritional assessment comprised two stages. We obtained the anthropometric data of the selected individuals in basal conditions, in addition to a 3-day feeding record[25]. Based on the data informed, we calculated the usual diet. The ingestion of each nutrient in the usual diet was calculated with the Nutrition Support Software Program of the Center of Computers applied to Health – EPM/ UNIFESP – version 2.5[26].

The study of postprandial lipemia was carried out in two periods, with patients submitted to thirty minutes of exercise on the treadmill, right after the ingestion of the diet. The study was repeated two weeks later, without the treadmill exercise.

We collected blood samples after a twelve to fourteen hour fast and at two, four and six hours following the ingestion of the standardized diet for analysis of the triglycerides (fig. 1).

*Laboratory analysis* - Total cholesterol and triglycerides were measured using an automated enzymatic method (Opera, Bayer, Germany), the HDL-C fraction being quantified in the supernatant, after the precipitation of lipoproteins containing apo B; LDL-C was estimated using Friedewald's formula[27]. Biochemical analyses were carried out in an Advia 120 device (Bayer, Germany).

*Ergospirometric assessment and physical exercise* - The ergospirometric test was carried out on a treadmill with a continuous protocol of increasing loads[28].

The exercise proposed was walking on the treadmill, with no slope, for thirty minutes at constant speed, according to the result of the ergospirometric test (anaerobic threshold). The exercise phase followed a 3-minute warm up phase, which was repeated at the end of each period.

*Postprandial lipemia* - The individuals were submitted to two tests for postprandial lipemia. As preparation prior to postprandial lipemia, they were asked to suspend

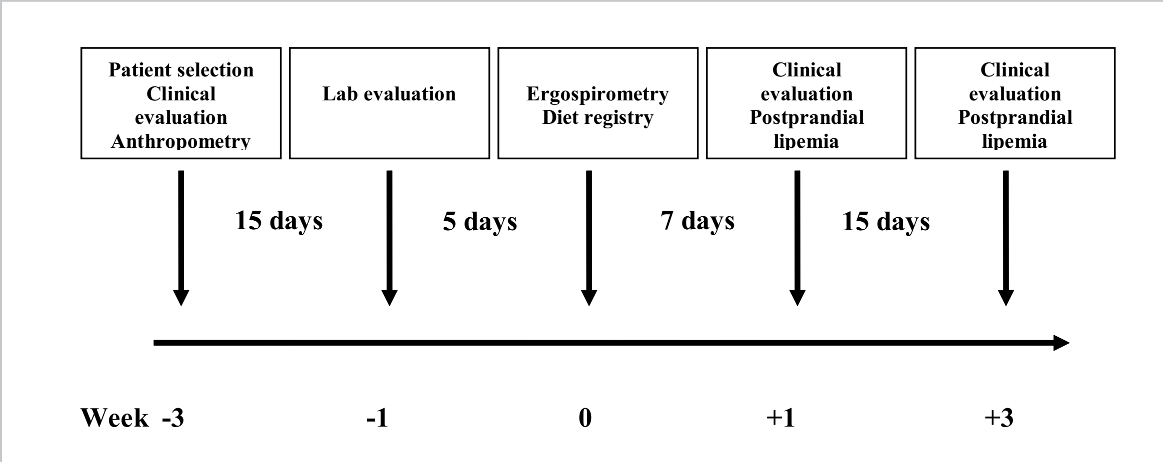


***Fig. 1*** *– Design of study.*

physical activity for 48 hours, to refrain from drinking alcohol and caffeine for a period of 24 hours, and to follow the diet prescribed for dinner in the evening before the test[29-33].

Blood samples were collected using a plastic catheter (Vialon® n. 20, Becton Dickinson), and 5 ml of blood were discarded at each new sample collection to guarantee the precision of the test results. Four blood samples were collected (fasting, two, four and six hours). After the basal collection, the participants ingested a solution with a high concentration of fats, in fifteen minutes.

The solution was made up of: one liter of whole milk, one can of milk cream, 50 grams of dehydrated hen egg, 100 grams of powder chocolate, one tablespoon of saltless butter, six Brazil nuts, two dwarf bananas, 150 ml of coconut milk. The total nutritional value of the recipe was 2,655 calories, with 81 g of proteins (11.6%), 151 g of carbohydrates (21.4%) and 209 g of lipids (67.0%).

Each participant received the equivalent to 50 grams of fat per square meter of body surface. The yield of this recipe relative to 50 grams of fat was 365 ml which, multiplied by the body surface, resulted in the ingested quantity of the solution.

*Statistical analysis* - Numerical variables of the basal period are presented as means and standard deviation relative to the means and were compared across the NTG and $TG_{ALT}$ groups using Student's t test, for unrelated samples. For the analysis of triglycerides in fasting, and then at two, four and six hours, we used the repeated measures analysis of variances. The area under the curve was calculated using the trapezoidal rule. We used Student's t test for related samples to compare the areas under the curves with and without physical activity. We built ROC curves to assess the efficiency of triglyceride basal values in the prediction of alterations in the response of postprandial triglyceridemia. Values of $p < 0.05$ were considered significant.

## Results

The basal characteristics of the participants are presented in Table 1. There was no difference in demographic variables and anthropometric parameters between NTG and $TG_{ALT}$ participants, with the exception of waist circumference, which was larger in $TG_{ALT}$ individuals. In addition to higher TG basal values, $TG_{ALT}$ individuals presented lower HDL-C values when compared with NTG individuals, with no difference as regards glycemia values.

There was no difference across the groups as regards the total calorie consumption of the diet, the content of proteins, carbohydrates, and lipids; however, NTG individuals presented greater consumption of polyunsaturated fatty acids than $TG_{ALT}$ individuals (Table 2).

*Postprandial lipemia and the effect of acute exercise* - Postprandial triglyceridemia peaked within four hours, with no difference as regards the prescription of acute exercise or not ($p = 0.098$), with a ratio between the values of triglycerides at peak of 0.95 (CI 95%: 0.74;1.15) (fig. 2). Mean values obtained for the areas under the triglyceride curve (six hours) did not differ (AUC: 632 ± 422 vs. 751 ± 427 mg/dl, with and without physical activity, respectively; $p = 0.133$, Student's *t* test for related samples), with the ratio of the areas under the curve being 0.97 (CI 95%:0.75;1.19) (fig. 3).

Postprandial triglyceride curves are presented in Table 3 and in figure 4. There was no effect of acute exercise on the postprandial triglyceride curve ($p = 0.40$; ANOVA with repeated measures). However, there was an association of the basal triglyceride values with the behavior of the triglyceride curve of individuals in time ($p = 0.026$).

Analyzing the behavior of the postprandial triglyceride curve of the participants of the study we observed that eighteen individuals presented a behavior which was typical of a normal curve, i.e., at hour six after the

**Table 1 – Demographic and anthropometric characteristics and basal biochemical variables of NTG and $TG_{ALT}$ participants**

| Variables | NTG N = 10 | SD | $TG_{ALT}$ N = 17 | SD | P |
|---|---|---|---|---|---|
| Age (median, years) | 41 | - | 42 | - | 0.990 |
| BMI (Kg/$m^2$) | 25 | 2 | 25 | 3 | 0.670 |
| Waist circumference (cm)* | 82 | 7 | 91 | 7 | 0.006 |
| Total cholesterol (mg/dl) | 204 | 29 | 227 | 37 | 0.110 |
| HDL-C (mg/dl)* | 52 | 12 | 38 | 11 | 0.007 |
| LDL-C (mg/dl) | 134 | 28 | 145 | 41 | 0.430 |
| Triglycerides (mg/dl)** | 110 | 18 | 259 | 68 | < 0.0001 |
| Glycemia (mg/dl) | 93 | 8 | 96 | 11 | 0.430 |

*SD = standard deviation relative to mean. *$TG_{ALT}$ < NTG; $p < 0.05$; **$TG_{ALT}$ > NTG; $p < 0.05$; Student's t test for independent samples.*

**Table 2 – Distribution of NTG and $TG_{ALT}$ participants according to food consumption**

| Dietary variable | NTG | SD | $TG_{ALT}$ | SD | p |
|---|---|---|---|---|---|
| Total calories (Kcal/d) | 2195 | 590 | 1980 | 735 | 0.44 |
| Proteins (%) | 20 | 2 | 22 | 5 | 0.10 |
| Carbohydrates (%) | 44 | 10 | 48 | 8 | 0.26 |
| Lipids (%) | 35 | 8 | 30 | 6 | 0.06 |
| Saturated fatty acids (%) | 12 | 4 | 10 | 3 | 0.28 |
| Polyunsaturated fatty acids (%)* | 5 | 2 | 3 | 1 | 0.01 |
| Monounsaturated fatty acids (%) | 9 | 4 | 6 | 3 | 0.06 |
| Cholesterol (mg) | 331 | 109 | 285 | 103 | 0.29 |

*SD = standard deviation relative to mean. *NTG > $TG_{ALT}$; $p<0.05$; Student's t test for independent samples.*

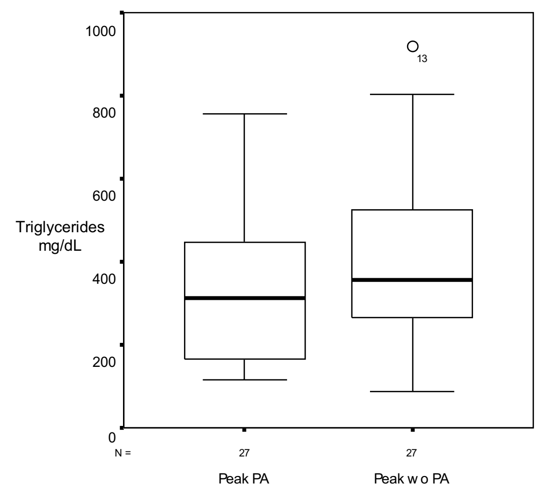


***Fig. 2** – Boxplots of peak triglyceride values (4 hours) with and without physical activity (PA). PA = physical activity. With PA = Without PA; p = 0.098; Student's t test for related samples. Ratio between the values obtained in the peak = 0.95 (CI 95%: 0.74;1.15).*

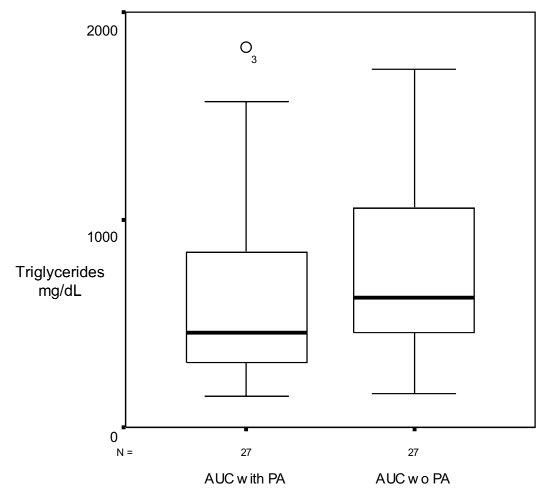


***Fig. 3** – Boxplots of areas under curve of triglycerides values with and without physical activity. PA = physical activity. With PA = Without PA; p = 0.133; Student's t test for related samples. Ratio between the values obtained for the areas under the curves = 0.97 (CI 95%: 0.75; 1.19).*

ingestion of the lipid solution triglyceridemia returned to near basal values, whereas nine subjects presented abnormal curves. Individual profiles of postprandial lipemia response with and without physical activity are presented in figures 5 and 6, respectively. Basal triglyceride values were then compared according to the behavior of the normal or abnormal postprandial triglyceride curve, with and without physical activity, with higher basal triglyceride values for individuals who had an abnormal postprandial lipemia curve with physical activity (basal TG: 147 ± 90 *vs* 238 ± 89 mg/dl, p = 0.02, Student's *t* test) and without physical activity (basal TG: 168 ± 93 *vs* 265 ± 140 mg/dl, p = 0.04, Student's *t* test) (fig. 7 and 8). There was agreement in the response of postprandial triglyceridemia in seventeen individuals with and without acute exercise (thirteen normal with and without physical activity and four abnormal individuals with and without physical activity).

**Table 3 – Distribution of triglyceride values throughout the postprandial lipemia curve with and without physical activity**

| | Beginning | SD | 2h | SD | 4h | SD | 6h | SD |
|---|---|---|---|---|---|---|---|---|
| **Without PA** | 201 | 23 | 289 | 27 | 406 | 41 | 372 | 55 |
| **With PA** | 177 | 19 | 258 | 24 | 340 | 36 | 325 | 48 |

*PA = physical activity; SD = standard deviation relative to mean. With PA = without PA; p = 0.400; ANOVA with repeated measures. Beginning < 2h, 4h and 6h; p = 0.026, ANOVA with repeated measures.*

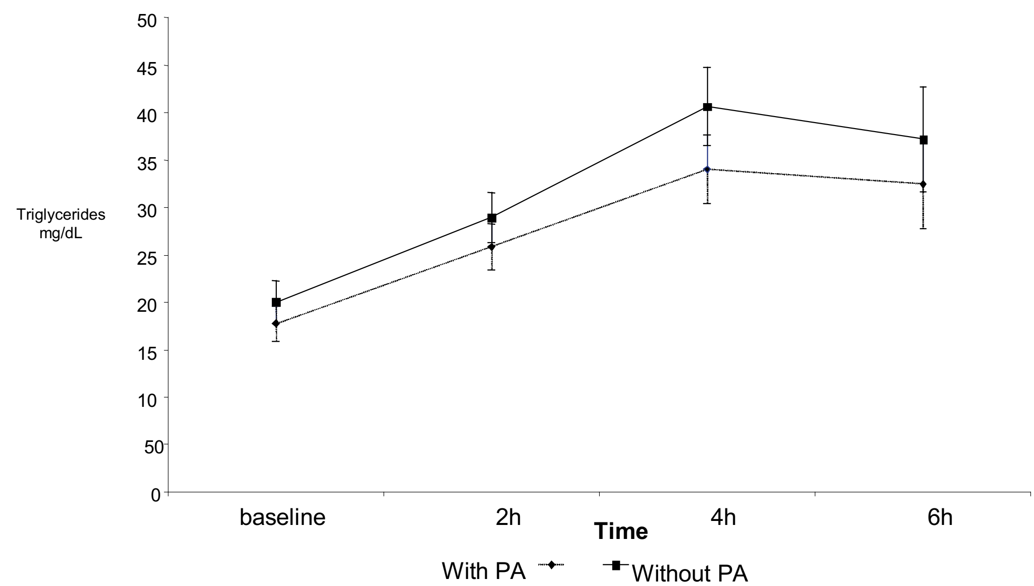


***Fig. 4*** *– Mean values of the responses of triglycerides in postprandial lipemia with and without physical activity. PA = physical activity. With PA = Without PA; p = 0.400; ANOVA with repeated measures.*

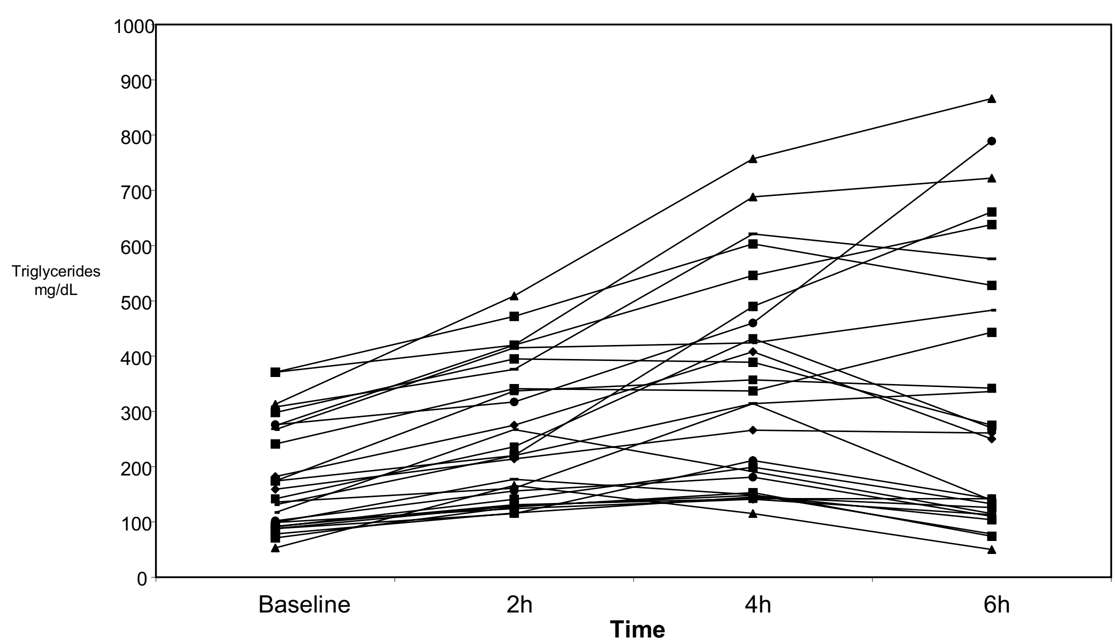


***Fig. 5*** *– Individual profiles in the response of postprandial triglyceridemia with physical activity.*

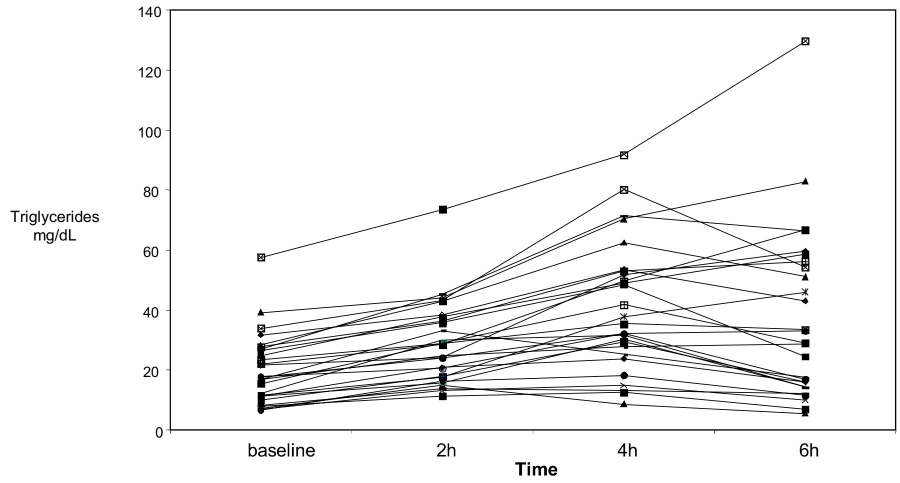


*Fig. 6 – Individual profiles in the response of postprandial triglyceridemia without physical activity.*

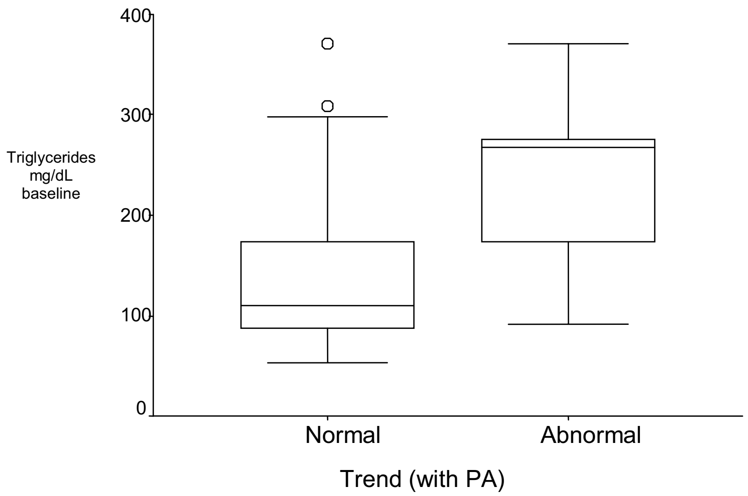


*Fig. 7 – Boxplots of basal triglyceride values with physical activity according to the behavior of individuals in the postprandial triglyceride curve. PA = physical activity. Abnormal > Normal; p = 0.020; Student's t test for unrelated samples.*

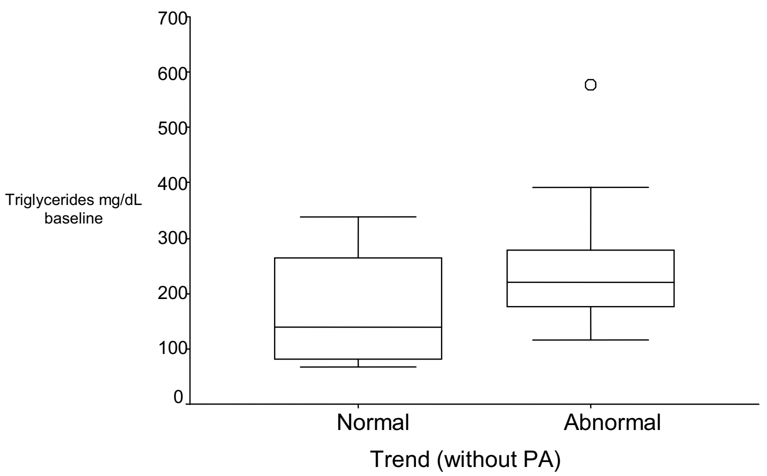


*Fig. 8 – Boxplots of basal triglyceride values without physical activity according to the behavior of individuals in the postprandial triglyceride curve. PA = physical activity. Abnormal > Normal; p = 0.040; Student's t test for unrelated samples.*

ROC curves showed that triglyceride basal values were predictors of an altered response of postprandial triglyceridemia with and without physical activity (fig. 9 and 10). The efficiency of basal triglycerides in predicting an altered response of postprandial triglycerides was 0.793 (CI 95%: 0.622-0.964), with physical activity and 0.722 (CI 95%: 0.530-0.914) without physical activity.

The cut-off point of triglyceride basal values for predicting an abnormal response of postprandial triglyceridemia was 166.5 mg/dl (sensitivity = 0.77 and specificity = 0.72) with physical activity and 172 mg/dl (sensitivity = 0.78 and specificity = 0.61) without physical activity.

## Discussion

The major contribution of this study was to show that acute physical exercise was unable to modify postprandial triglyceridemia in sedentary men, and especially of valuing fasting triglyceride serum levels as predictors of postprandial lipemia. Additionally, it identified which triglyceride basal values are associated with abnormal postprandial triglyceridemia.

The study has also shown that sedentary individuals with altered fasting triglyceride levels ($TG_{ALT}$) presented larger waist circumference and lower HDL-C, although their mean BMI was similar to the BMI of normotriglyceridemic individuals.

Although the postprandial assessment of triglycerides did not evidence the effect of physical exercise on postprandial lipemia, we observed that a group of individuals showed an abnormal pattern of response of postprandial triglyceride, with or without physical activity, which characterized an abnormal behavior of the curve, and that this pattern could be predicted based on basal triglyceride values. Basal triglyceride values above 166.5 and 172.0 mg/dl, with and without physical activity,

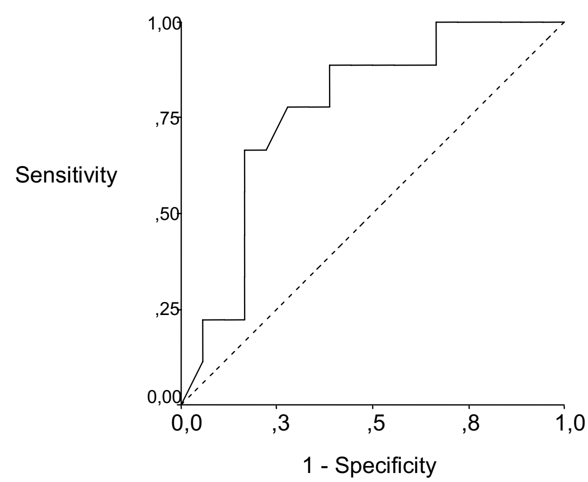


*Fig. 9 – ROC curve of basal triglyceride values with physical activity. Area under the curve: 0.772 (CI 95%: 0.588; 0.955). Basal triglyceride cut-off value: 166.5 mg/dl. Sensitivity: 0.78; Specificity: 0.72.*

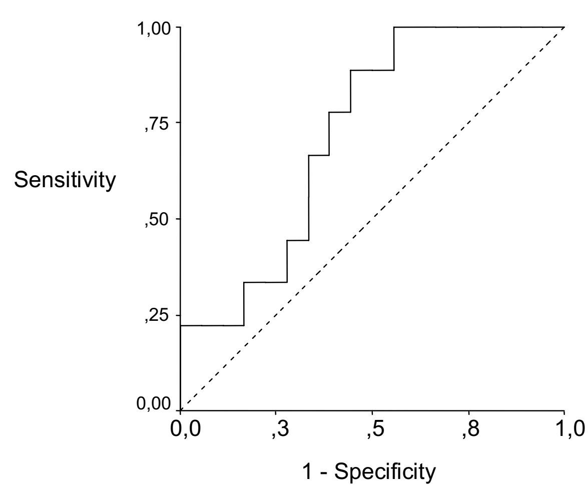


*Fig. 10 – ROC curve of basal triglyceride values without physical activity. Area under the curve: 0.722 (CI 95%: 0.530; 0.914). Basal triglyceride cut-off value: 172 mg/dl. Sensitivity: 0.78; Specificity: 0.61.*

respectively, efficiently predicted an altered response of postprandial triglycerides in sedentary individuals.

Triglyceride-rich lipoproteins from the intestine and liver contribute to the triglyceridemia found after the ingestion of a fat-rich solution[2,10]. The quantification of lipemia was based on triglyceride serum concentration, which reflects the balance between the rate of appearance in and disappearance from the circulation, of lipoproteins rich in this lipid[29], with the peak of the lipemia curve being obtained four hours after the ingestion of the fatty solution[14], and its normalization occurring as of the sixth hour[31].

It is well established that during prolonged and marked postprandial lipemia there is exchange of neutral lipids between triglyceride-rich particles, LDL and HDL, thus leading to the formation of small and dense LDL particles and to a lower concentration of HDL-C[34]. More recently, there were reports stating that endothelial function is altered in the postprandial state and is related to the increase of postprandial triglycerides[35]. Other studies have also shown that, in healthy individuals, serum concentrations of inflammatory cytokines and adherence molecules were elevated after the ingestion of diets rich in fat, but not in carbohydrates[36], which caused a transitory proinflammatory state. These mechanisms are involved in the atherogenic process and are associated with greater cardiovascular risk[37].

Athletes and individuals who exercise regularly present low levels of postprandial lipemia[38]. The effects of acute exercise in normotriglyceridemic individuals have been recently assessed, and no difference was observed in the response of postprandial triglycerides when the fat-rich diet was administered either before or after the exercise[39]. We assessed the effect of one week of detraining on the postprandial lipemia of trained individuals, and they presented increase in basal and postprandial triglycerides and of triglyceride-rich lipoproteins, with no change in the endothelial function in the short period without exercise[40].

In athletes, different degrees of acute exercise did not demonstrate changes in the area under the curves of postprandial triglycerides[41]. We did not find in the literature description of the effects of acute exercise on the postprandial response of triglycerides in hypertriglyceridemic individuals. In our study, with untrained normo- and hypertriglyceridemic individuals we did not observe any effect of a single session of exercise on postprandial triglyceridemia. However, basal triglyceride values were predictors of the postprandial response with or without acute exercise, thus reinforcing the orientation provided in current guidelines which emphasize the value of fasting lipid levels.

To conclude, our study evidenced that in untrained men, with normal or altered basal triglycerides values, acute exercise does not alter postprandial triglyceridemia. Basal triglyceride values above desirable ones are predictors of an abnormal response of postprandial triglycerides.

## Acknowledge

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### Potencial Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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