The Influence of Caffeine and Genistein Ingestion on Plasma Triglycerides Status in Male Soccer Players

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Research article

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Abstract

Background

Scientific literature provides more and more information on compounds supporting fat metabolism. More research is needed to fully characterize the effects of compounds that increase concentration of triglycerides. The aim of our study was to test the influence of caffeine and genistein consumption on triglyceride status in athletes.

Methods

Fourteen Polish adult sub-elite soccer players (23.1 ± 2.1 years; 179.6 ± 8.5 cm; 74.1 ± 8.5 kg; 12.4 ± 3.8% body fat) were accepted for research. The athletes for this randomized, double-blind study were joining a fasted condition. After consuming a standardized milk meal, participants took caffeine (400 mg), genistein (120 mg), or placebo (400 mg of vitamin C). Athletes ate the compound if it saw a sequentially increase and decrease in triglyceride concentration after eating the test meal. Participants had their glucose levels measured every 15 minutes with a glucometer (Accu-Chek Active) and their triglyceride levels with CardioChek PA. The subject was terminating the study when he had sequentially increased and decreased triglyceride concentration after the compound. If no such reaction occurred, measurements were taken for up to 90 minutes. In order to determine statistically significant differences between the variables, non-parametric Kruskal-Wallis and U Mann-Whitney tests were used. The significance level of $\alpha = 0.05$ was adopted for both of these tests. The relationships between the variables were determined using the Spearman R correlation. The correlations were statistically significant at $p \leq 0.100$.

Results

A statistically significant difference was demonstrated between the initial and maximum triglyceride concentration after caffeine consumption compared to placebo ($p = 0.049$). After consuming caffeine, the athletes had a significant difference in triglyceride concentration at 30 min ($p = 0.018$) and 60 min ($p = 0.036$) compared to placebo. In the group taking genistein, only a statistically significant difference was noticed compared to placebo only in 60 min ($p = 0.029$).

Conclusion

Our research results show that after acute caffeine and genistein supplementation, triglyceride concentration increase in soccer players.

Background

The main energy substrates of athletes during exercise are carbohydrates and fats. In addition to the energy function, the right amount of these ingredients is designed to save the use of body proteins as an energy source. In the case of an insufficient amount of carbohydrates, free fatty acids (FFA) become the main energy substrate. They are released from fat cells and enter the plasma through the lipolysis
process. Lipolysis is defined as the process of enzymatic hydrolysis of triacylglycerols contained in fat cells [1]. Adipose tissue lipolysis takes place in order to maintain the supply of energy substrates in the state of energy deficit. This process is preceded by many biochemical reactions regulated by functional proteins [2]. The lipolysis reaction takes place in several stages. The first part of this process is the detachment of the fatty acid from the α position. The next step is to remove another acid molecule from the α’ position. At the very end of the hydrolysis, the last fatty acid residue from monoacylglycerol is separated from the β position [3]. The entire process is stimulated by enzymes. The activity of these fatty enzymes (lipases) is stimulated, inter alia, by glucagon, adrenaline and glucocorticosteroids. These compounds regulate adenylate cyclase. Its content in adipocytes directly affects the concentration of cyclic adenosine monophosphate (cAMP), which affects protein kinase (PKA). Thus, increasing or decreasing the level of cAMP regulates the lipolysis process [4,5]. There are many active chemical compounds in food that may affect adipose tissue by inducing, for example, lipolysis, or completely affect the apoptosis of adipocytes [6]. The results of scientific studies show the effect of given lipotropic factors based on in vitro studies conducted on murine models of adipose tissue [5,7–9] as well as in vivo studies [7,10–13]. Regulation of lipolysis occurs at many levels in response to changing metabolic conditions and nutrient intake. A relationship has been found between the rate of lipolysis and the body weight and size of fat cells [14, 15]. Chronic exposure to extreme physiological conditions such as obesity or starvation also induces metabolic adaptations that include changes in lipolysis. There is increasing evidence in the scientific literature that indicates that certain metabolically active nutrients in the diet can regulate lipolysis [16, 17]. There is a need to confirm the action of lipotropic agents in vivo and to provide information on the dose of a given component that produces a biological effect. More research is needed to fully characterize the effects of caffeine and genistein on the plasma triglyceride status of athletes. Therefore, the aim of this study was to examine the effects of caffeine and genistein consumption on changes in triglyceride concentrations.

**Study Methods**

**Participants**

The study in question was a randomized, double-blind study involving 14 Polish adult sub-elite soccer players (23.1 ± 2.1 years, 179.6 ± 8.5 cm, 74.1 ± 8.5 kg) from different teams. Anyone could participate in this study twice. A total of 23 trials were performed, of which 9 people took 400 mg of caffeine and 8 people took 120 mg of genistein. The placebo group (400 mg vitamin C) consisted of 6 men. Criteria for inclusion in the study:

- male gender,
- age ranging from 18 to 30 years,
- physically active soccer players,
- low or optimal level of adipose tissue for health (5 - 22% [18]).
Certain anthropometric features of the studied participants increased the homogeneity of the group. The characteristics of the group are presented in Table 1.

**Study design**

The study was conducted at the Department of Human Nutrition, Faculty of Biotechnology and Food Sciences at the University of Life Sciences in Wrocław. At each stage, the test was carried out in a sterile, closed room and in accordance with Good Hygiene Practice. Participants were informed about the purpose of the research and the possibility of opting out of the experiment at any stage. Consent to participate in the clinical trial was declared by a handwritten signature on the declaration. Laboratory tests were carried out in the period from May 14 to June 6, 2019.

**Procedures**

The study started after receiving the approval of the Bioethics Committee at the Medical University of Piastów Śląskich in Wrocław - 239/2019 of March 18, 2019.

**Anthropometric measurements**

The men were informed about the necessity to come on an empty stomach. Using the Accuniq BC380 analyzer, basic anthropometric measures and body composition were determined, including: Total Fat Mass (PB), Viscellular Fat Area (VFA), Muscle Mass (SSM), Total Body Water (TBW).

**24-hour dietary interview**

On the day of the measurements, the participants were interviewed regarding food consumption in the last 24 hours. The analysis of 24-hour nutritional interviews took into account: energy value, protein content, carbohydrates, total fat, monounsaturated fatty acids, saturated fatty acids, polyunsaturated fatty acids, dietary fiber, vitamins B1, B2, B6, magnesium and calcium.

**Consumption of a standardized milk meal**

Studies [19–21] have shown that saturated fatty acids (SFA) have different effects on postprandial lipemia compared to monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). The effect of increasing the concentration of triglycerides in the blood is influenced not only by the amount and type of dietary fat, but also by other dietary components, such as: fiber, glucose, starch and alcohol [22–24]. A standardized milk meal was prepared for the participants (based on the data from the literature) [19–21,23,24]. After initial measurements, the examined participants consumed a dairy product - 70 ml of cream, 18% UHT. It did not contain fiber, protein, carbohydrates or other ingredients, so that the effect was noticeable as soon as possible. The increase in fatty acid concentration after consuming the test meal was supposed to take place in a short time. Before eating meals, the concentration of glucose and triglycerides in the capillary blood of the athletes was measured.
The CardioChek PA device was used to test blood triglyceride concentrations. An Accu-Chek Active glucometer was used to measure glucose concentrations. Thereafter, the concentration of these two biochemical markers was monitored every 15 minutes. The participant was qualified to the next stage, compound consumption, if the athlete had been observed to have had, respectively, an increase and a decrease in triglyceride concentration. If the triglyceride concentration fluctuated, measurements were taken up to a maximum of 90 minutes.

**Active Compound Ingestion**

Study participants consumed one compound: caffeine, genistein, or placebo. Due to the small differences in body weight, the men took the same dose of the active compounds. In the case of caffeine, it was 400 mg, and in the case of genistein, 120 mg. The placebo was vitamin C at a dose of 400 mg. The concentration of glucose and triglycerides in the capillary blood was measured every 15 minutes. The study scheme is presented in Fig. 1. The participant finished the study when an increase and a decrease in triglyceride concentration, respectively, had been observed. If no such reaction occurred, measurements were taken up to 105 minutes.

**Analysis of results**

In the created database, the exact values of the concentrations of selected blood chemistry indicators were included and the percentage increase in relation to the initial values was calculated. This made it possible to test the effectiveness of these compounds depending on their type and the time during which this effect is noticeable.

The rate of increase in triglyceride concentration is a physical quantity representing the change in triglyceride concentration per unit time \([(mg / dL) / min]\). The triglyceride concentrations of all participants after consuming the cream and the compound are presented in Tables 2 and 3 consecutively. The following scheme was followed for each participant (example based on data obtained for 1 participant):

- Two graphs of the change in triglyceride concentration over time after consuming the test meal and after administration of the active compound (Figures 1 and 2).
- A trend line was drawn and described with a polynomial so that the curve fitting coefficient \(R^2\) was close to 1. The more the polynomial plot fits the points marked on the coordinate system, the closer the \(R\) value is to 1.
- The tangent to the polynomial was determined at the point from which a rapid increase in triglyceride concentration was observed. A tangent is a geometric interpretation of the derivative of a polynomial function. In the graph, 1 tangent was assigned to the point \(x\), equal to 0 min, and in the second graph to the point \(x\), equal to 15 min.
- The rate of increase in triglyceride concentration was calculated. The rate of increase in triglyceride concentration was measured using the tangent tangent, i.e., the angle of its inclination to the \(x\) axis.
**Statistical analysis**

The research results were collected in an Excel spreadsheet. The statistical analysis of the results was performed in Statistica 13.1 PL. In order to test the compliance of the data with the normal distribution, the Shapiro-Wilk test was used. The mean, standard deviation for parametric data, median and lower quartile (Q1) and upper quartile (Q3) for non-parametric data were calculated. In order to determine statistically significant differences between the variables, non-parametric Kruskal-Wallis and U Mann-Whitney tests were used. The significance level of $\alpha = 0.05$ was adopted for both of these tests. The relationships between the variables were determined using the Spearman R correlation. The correlations were statistically significant at $p \leq 0.100$.

**Results**

There were no statistically significant differences in the blood triglyceride growth rate ($p = 0.282$) or the difference in triglyceride concentrations after ingestion of genistein compared to placebo ($p = 0.228$). It was noticed in the study that there was a statistically significant difference in glucose concentration after the consumption of the compound ($p = 0.043$) (Table 2).

The difference in triglyceride concentrations after caffeine consumption compared to placebo was statistically significant ($p = 0.049$). No difference in rate was found concerning increase in triglycerides after caffeine consumption compared to placebo ($p = 0.775$) (Table 3).

In this study, it was shown that the physiological effect after ingestion of the compound is time dependent. Table 4 shows a comparison of caffeine and placebo with respect to the time in which the increase in triglyceride concentrations was observed after the consumption of compounds. It was observed that a statistically significant difference in the increase in triglycerides after caffeine consumption compared to placebo occurred at 30 ($p = 0.018$) and 60 ($p = 0.036$) minutes. On the other hand, ingestion of genistein resulted in a statistically significantly greater increase in triglyceride concentrations after consuming the compound at 60 minutes compared to the consumption of placebo ($p = 0.029$). In the remaining time values, no differences between these groups were observed (Table 5).

There was a statistically significant negative correlation between the amount of carbohydrates consumed on the day before the study and the time when the increase in triglyceride concentrations was observed after consuming the compound in the genistein group ($r = -0.912$) and placebo ($r = -0.626$).

Moreover, in the group taking genistein, it was shown that the consumption of polyunsaturated fatty acids the day before the study was statistically significantly correlated with the time during which the increase in triglyceride concentration was observed after the consumption of compounds ($r = -0.758$). The present study also showed a statistically significant difference in triglyceride concentrations after consumption of the test meal before genistein administration compared to caffeine ($p = 0.036$). In the group taking caffeine, the body weight of the participants was statistically significantly correlated with the rate of increase in blood triglyceride concentration after consuming the test meal (-0.683).
Discussion

The main factor influencing postprandial lipemia is the amount of fat present in a meal. Other variables such as the presence and type of carbohydrates, alcohol and other nutrients are widely described in the scientific literature [25–29]. The triglyceride response after a fatty meal is also influenced by gender, physiological status, and several other causes, the details of which are not yet fully understood [30]. In the author's own study, people taking caffeine showed a negative correlation between body weight and the rate of increase in triglyceride concentration after consuming a test meal. Similar conclusions were shown in the work of Tiihonen et al. [31]. The authors of this study showed that the concentration of triglycerides after a standardized meal was statistically significantly lower in the normolipidemic group compared to the obese or hyperlipidemic groups. In addition, the maximum concentration of free fatty acids in the blood was found much earlier in people with normolipidemia than in the other two groups.

Studies conducted among women showed a less intense postprandial lipid response than in men [32]. This proves that men are characterized by an increased ability to remove triglycerides from the cardiovascular system. Tolerance of fatty meals usually decreases with age but can also be related to weight gain or the phase of the menopause. Peddie et al. suggest that increased physical activity, such as running or cycling, and even walking, can significantly reduce fasting triglycerides and the postprandial triglyceride response [32]. In our study, people who consumed caffeine showed a 4-fold higher rate of triglyceride growth after consuming cream compared to placebo. Men in this group were characterized by a greater lipid response after consuming a fatty product. However, this result was not statistically significant (p = 0.113). It was observed that the amount of carbohydrate consumed the day before the study statistically significantly correlated with the increase in triglyceride concentration after consuming the compound in the placebo group (-0.626) and genistein (-0.912). After the results obtained, it can be suggested that a high intake of carbohydrates, possibly including fiber, may extend the time when genistein becomes active. Our study also showed that the consumption of polyunsaturated fatty acids influenced the time in which the increase in triglyceride concentration was observed after ingestion of genistein. In addition, no more statistically significant relationships were observed between the intake of macronutrients on the day before the study and the difference in triglyceride concentrations.

The lipolytic effects of caffeine and other tea- and coffee-derived methylxanthines are well recognized and reported in the scientific literature. These compounds stimulate lipolysis by increasing the concentration of cAMP in cells due to two main mechanisms. The first is the antagonism of A1-adenosine receptors [33]. These receptors dominate in differentiated mature adipocytes, where they inhibit the activity of adenylate cyclase and the lipolysis process [34]. Antagonism of A1 receptors results in inactivation of adenylate cyclase activity and increased lipolysis. Methylxanthines inhibit phosphodiesterase activity, preventing the breakdown of cAMP, and stimulate lipolysis in fat cells [35]. Caffeine is a widely used stimulant that has well-established benefits for athletic performance. Its ergogenic effect is attributed to the increased release of endorphins, improved neuromuscular function, improved alertness, and decreased perception of fatigue during exercise [36]. In recommendations for athletes, information on the consumption of caffeine in the amount of 3-6 mg of the compound for each
kilogram of body weight can be found. The concentration of caffeine increases within 15-45 minutes of being absorbed into the body. The maximum concentration is approximately 60 minutes after ingestion [37]. In experiments involving humans, it has been shown that caffeine increases lipid turnover and the concentration of non-esterified free fatty acids in the blood serum [7, 10, 11, 38]. Consumption of methylxanthines may also contribute to weight loss or maintenance [39]. In the work of Kobayashi-Hattori et al. [9] it was shown that administering caffeine to rats in a dose of 5 mg / kg for 21 days gradually decreased the weight and the percentage of adipose tissue in Sprague-Dawley rats. Based on the results obtained in this study, it can be suggested that in the case of a high-fat diet, caffeine consumption enhanced lipolysis mediated by catecholamines. In a study by Benowitz et al. [40], caffeine was administered in various doses to 12 healthy volunteers, 6 men and 6 women. Benowitz et al. Proved that the consumption of caffeine compared to placebo increased the amount of free fatty acids in a significant way. However, the authors of the same study did not show any statistically significant differences between doses of 2 mg / kg and 4 mg / kg of body weight. Another study showed an age difference in increasing the concentration of FFA in the blood plasma. Younger men were more susceptible to caffeine and significantly increased the concentration of FFA compared to the elderly [38]. Two studies have shown that the time when the increase in FFA concentration was observed after caffeine consumption was 30-60 minutes [11,40]. These data confirm the results obtained during our study. It is impossible to compare the results of our work with the results of the work of Benowitz et al. [40]. In this study, the concentration of FFA was monitored every 30 minutes.

Genistein isoflavone is also a compound that influences the release of free fatty acids from adipocytes into the plasma. It has been proved in animal models that soy isoflavones can regulate many pathways in the body, including the influence of 5'AMP-activated kinase. Affecting this compound may facilitate the process of reducing body fat [41]. In this study it was determined that a dose of 20-200 μmol influences the condition of adipocytes leading to their apoptosis. This process is stimulated by inactivation of 5'AMP-activated kinase (AMPK). Mori et al. [42] proved that the consumption of soy isoflavones in a dose of 100 mg / day for nearly 6 months reduces body weight and reduces body fat. Weight loss has been observed in Asian people who consume fermented soy products. The participants of the study by Cha et al. and Cha et al. consumed two varieties of soybean paste: doenjang and kochujang for 3 months [43,44]. In vitro studies have shown that genistein also blocks adipogenesis by inactivating tyrosine kinase. The supply of genistein along with the diet may stimulate the lipolysis process in humans, potentially contributing to the reduction of adipose tissue mass [45]. Nogowski et al. [8] studied the effect of genistein on lipid metabolism in rats after ovariectomy. It was shown that genistein administered with feed increased the concentration of free fatty acids in the blood plasma. The effect was tested at a dose of 20-300 μmol / l for a period of 14 days. The severity of the reaction was observed after increasing to a dose of 100 μmol / l. The efficiency of genistein did not increase statistically significantly after the dose of 100 μmol / l was exceeded. There is no information in the scientific literature regarding the influence of genistein supplementation on the lipolysis process in vivo. In our own study, genistein supplementation in a dose of 120 mg was tested. There were no statistically significant differences in triglyceride concentrations after ingestion of genistein compared to placebo.
The in-house study suggests that genistein increases free fatty acid concentrations and potentially affects body fat at 60 minutes compared to placebo. In our study, a strong correlation (-0.905) was found between body weight and the rate of increase in triglyceride concentration after ingestion of genistein. The strong correlation obtained shows that as body weight increases, genistein activity occurs later. Tiidhonen et al. proved the correlation between body weight, fasting fatty acid concentration and postprandial lipemia similarly to this study [31].

In our own study, it was shown that there are no differences in the increase in triglyceride concentrations after caffeine consumption compared to genistein in each monitored sample. The lack of differences between caffeine and genistein consumption may be due to many factors affecting the postprandial lipid response. Our study showed a statistically significant difference in triglyceride concentrations after consuming a test meal before genistein administration compared to caffeine. A statistically significant difference in triglyceride concentrations after consumption of the test meal could have impaired the detection of differences in triglyceride concentrations after ingestion of the active compound.

Limitations

There are a few limitations of this study. The difficulty was that it was not possible to accurately estimate the ration of the meals consumed the day before the study. Another limitation in this study was the small sample size and the lack of diverse groups. Apart from methodological limitations, there were also difficulties for the participants. Participants had to consume a fatty test meal and endure about a 5-hour fast. More research is needed to include more people. Future studies should compare the effects of genistein, caffeine and placebo in each athlete separately. This study looked at the effect in a homogeneous group. Subsequent research should take into account other sports disciplines and the female gender.

Conclusion

In our own study, it was proved that caffeine and genistein influenced the process of increasing the concentration of triglycerides in the blood. These compounds increased the concentration of triglycerides in the capillary blood compared to placebo. Caffeine started its activity from 30 minutes. A significantly greater increase in the concentration of triglycerides in the blood plasma was observed at 30 and 60 minutes after the consumption of the compound compared to placebo. For genistein, the physiological effect was only noticed at 60 minutes compared to placebo. Based on the data from the nutritional history of consumption 24 hours before the study, it was proved that the amount of polyunsaturated fatty acids influenced the time in which the increase concentrations triglycerides was intensified. The amount of carbohydrates consumed on the day before the test had an influence on the increase in the concentration of free fatty acids after the consumption of the compound. In addition, a negative correlation was found between body weight and the rate of increase in the concentration of triglycerides in the blood plasma after consuming the test meal. More nutritional factors have not been associated
with the change in triglyceride concentrations and the lipid response following a meal with a specific fat content.

**Abbreviations**

**cAMP**: cyclic adenosine monophosphate

**PKA**: protein kinase

**PB**: Total Fat Mass

**VFA**: Viscellular Fat Area

**SSM**: Muscle Mass

**TBW**: Total Body Water

**SFA**: saturated fatty acids

**MUFA**: monounsaturated fatty acids

**PUFA**: polyunsaturated fatty acids

**MAX**: the highest triglyceride concentration

**BEG**: initial triglyceride concentration

**FFA**: free fatty acids

**AMPK**: 5'AMP-activated kinase

**Declarations**

Ethics approval and consent to participate

The subjects provided written informed consent to participate in the present study. This study was approved by the Bioethics Committee at the Medical University of Piastów Śląskich in Wrocław - 239/2019 of March 18, 2019.

Consent for publication

Not applicable.

Availability of supporting data
Please contact corresponding author for additional data, by emailing the corresponding author (karoldanielik@gmail.com)

Competing interests

The authors have no conflict of interest.

Funding

The study has been carried out as part of university research activity and there are no financial reasons which may lead to a conflict of interest.

Author's Contributions

This experiment was performed at the University of Life Sciences in Wrocław. K. D. and K. Ł. were responsible for the conception and design of the experiment. M. B. corrected the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

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Tables

Table 1. Characteristics of the study group: anthropometric-training soccer players (n = 23).

<table>
<thead>
<tr>
<th>Variable</th>
<th>± SD</th>
<th>Me</th>
<th>(Q1; Q3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age [years]</td>
<td>23.1</td>
<td>2.1</td>
<td>-</td>
</tr>
<tr>
<td>Body weight [kg]</td>
<td>74.1</td>
<td>8.5</td>
<td>-</td>
</tr>
<tr>
<td>Body height [cm]</td>
<td>179.6</td>
<td>8.5</td>
<td>179</td>
</tr>
<tr>
<td>The level of adipose tissue [%]</td>
<td>-</td>
<td>-</td>
<td>12.1</td>
</tr>
<tr>
<td>Muscle tissue content [%]</td>
<td>-</td>
<td>-</td>
<td>48.99</td>
</tr>
<tr>
<td>Water content in the body [%]</td>
<td>-</td>
<td>-</td>
<td>64.23</td>
</tr>
</tbody>
</table>

Table 2. Comparison of genistein effectiveness versus placebo

<table>
<thead>
<tr>
<th>Variable</th>
<th>Genistein [median (Q1; Q3)]</th>
<th>Placebo [median (Q1; Q3)]</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of increase of triglycerides after cream consumption [(mg / dl) / min]</td>
<td>0.61 (0.31; 1.79)</td>
<td>1.28 (0.71; 1.86)</td>
<td>0.662</td>
</tr>
<tr>
<td>The rate of growth of triglycerides after ingestion of the chemical compound [(mg / dl) / min]</td>
<td>2.77 (1.40; 4.16)</td>
<td>2.21 (0.55; 3.08)</td>
<td>0.282</td>
</tr>
<tr>
<td>Difference in triglyceride concentration after consumption of the compound (MAX-BEG) [%]</td>
<td>29 (7; 60)</td>
<td>9 (6; 20)</td>
<td>0.228</td>
</tr>
<tr>
<td>Difference in triglyceride concentration after consumption of cream (MAX-BEG) [%]</td>
<td>8 (0; 19)</td>
<td>4 (0; 29)</td>
<td>0.852</td>
</tr>
<tr>
<td>Difference in glucose concentration after consumption of the compound (MAX-BEG) [%]</td>
<td>2 (0; 4)</td>
<td>6 (5; 9)</td>
<td>0.043</td>
</tr>
<tr>
<td>Difference in glucose concentration after consumption of cream (MAX-BEG) [%]</td>
<td>5 (3; 9)</td>
<td>6 (3; 13)</td>
<td>0.573</td>
</tr>
</tbody>
</table>

Mann-Whitney U test, p <0.050
Table 3. Comparison of the effectiveness of caffeine versus placebo

<table>
<thead>
<tr>
<th>Variable</th>
<th>Caffeine [median (Q1; Q3)]</th>
<th>Placebo [median (Q1; Q3)]</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of increase in triglycerides after cream consumption [(mg / dl) / min]</td>
<td>5.12 (1.12; 8.74)</td>
<td>1.28 (0.71; 1.86)</td>
<td>0.113</td>
</tr>
<tr>
<td>The rate of growth of triglycerides after ingestion of the chemical compound [(mg / dl) / min]</td>
<td>2.28 (0.43; 4.37)</td>
<td>2.21 (0.55; 3.08)</td>
<td>0.775</td>
</tr>
<tr>
<td>Difference in triglyceride concentrations after consuming the compound (MAX-BEG) [%]</td>
<td>36 (15; 94)</td>
<td>9 (6; 2)</td>
<td><strong>0.049</strong></td>
</tr>
<tr>
<td>Difference in triglyceride concentrations after consuming cream (MAX-EST) [%]</td>
<td>37 (18; 39)</td>
<td>4 (0; 29)</td>
<td>0.113</td>
</tr>
<tr>
<td>Difference in glucose concentration after consumption of the compound (MAX-EST) [%]</td>
<td>2 (0; 7)</td>
<td>6 (5; 9)</td>
<td>0.327</td>
</tr>
<tr>
<td>Difference in glucose concentration after consumption of cream (MAX-EST) [%]</td>
<td>8 (6; 9)</td>
<td>6 (3; 13)</td>
<td>0.688</td>
</tr>
</tbody>
</table>

Mann-Whitney U test, **p <0.050**

Table 4. Comparison of the effectiveness increase concentration by caffeine compared to placebo

<table>
<thead>
<tr>
<th>Increase in triglyceride concentration after consumption of the compound over time [%]</th>
<th>Caffeine [median (Q1; Q3)]</th>
<th>Placebo [median (Q1; Q3)]</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>15min</td>
<td>5 (-11; 8)</td>
<td>4 (0; 16)</td>
<td>0.864</td>
</tr>
<tr>
<td>30 min</td>
<td>28 (8; 46)</td>
<td>2 (-9; 10)</td>
<td><strong>0.018</strong></td>
</tr>
<tr>
<td>45 min</td>
<td>15 (0; 31)</td>
<td>-7 (-26; 19)</td>
<td>0.224</td>
</tr>
<tr>
<td>60 min</td>
<td>7 (6; 12)</td>
<td>-13 (-23; 3)</td>
<td><strong>0.036</strong></td>
</tr>
<tr>
<td>75 min</td>
<td>7 (-0.09; 26)</td>
<td>-6 (-18; 17)</td>
<td>0.388</td>
</tr>
<tr>
<td>90 min</td>
<td>7 (-9; 26)</td>
<td>-9 (-19; 7)</td>
<td>0.145</td>
</tr>
<tr>
<td>105 min</td>
<td>-2 (-15; 10)</td>
<td>-3 (-20; 14)</td>
<td>0.776</td>
</tr>
</tbody>
</table>

Mann-Whitney U test, **p <0.050**
Table 5. Comparison of the effectiveness increase concentration triglyceride by genistein compared to placebo

<table>
<thead>
<tr>
<th>Increase in triglyceride concentration after consumption of the compound over time [%]</th>
<th>Genistein [median (Q1; Q3)]</th>
<th>Placebo [median (Q1; Q3)]</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>15min</td>
<td>16 (4; 33)</td>
<td>4 (0; 16)</td>
<td>0.228</td>
</tr>
<tr>
<td>30min</td>
<td>23 (4; 52)</td>
<td>2 (-9; 10)</td>
<td>0.142</td>
</tr>
<tr>
<td>45min</td>
<td>2 (-2; 38)</td>
<td>-7 (-26; 19)</td>
<td>0.282</td>
</tr>
<tr>
<td>60 min</td>
<td>4 (-2; 29)</td>
<td>-13 (-23; 3)</td>
<td>0.029</td>
</tr>
<tr>
<td>75 min</td>
<td>6 (-1; 24)</td>
<td>-6 (-18; 17)</td>
<td>0.282</td>
</tr>
<tr>
<td>90 min</td>
<td>6 (-1; 24)</td>
<td>-9 (-19; 7)</td>
<td>0.081</td>
</tr>
<tr>
<td>105 min</td>
<td>4 (-3; 24)</td>
<td>-3 (-20; 14)</td>
<td>0.282</td>
</tr>
</tbody>
</table>

Mann-Whitney U test, p <0.050

Figures

Figure 1

Scheme of research.