

## The Effect of Caffeine Supplementation on Blood Lactate and Glucose after 1 and 4 km Cycling

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**Abstract:** The purpose of this study was to examine the effect of caffeine consumption on blood lactate and glucose levels after 1 and 4-km cycling. 15 time trial cyclist from Shiraz province participated in this research. In the first stage, subjects received placebos at three intervals (30 minutes before, 5 minutes before and immediately after the 1 and 4-km cycling). In the second and third stages (with a 5-day interval between each two stages), all the subjects received caffeine gum with two different doses (180 and 300 mg) at three intervals, like the first stage. The participants were instructed to chew the gum for 5 minutes. Blood glucose and lactate of the subjects were measured in all three stages, 5 minutes before and immediately after performing the tests. Repeated measure ANOVA and Tukey's post hoc test were used for data analysis ( $P \leq 0.05$ ). The results indicated that none of the doses of caffeine had a significant effect on blood lactate and glucose levels both before and after the 1 and 4-km cycling. Moreover, results did not show any significant difference between 1 and 4-km cycling. In conclusion, based on the results of the research, any judgment regarding consumption of caffeine by time trial cyclists, especially in the form of gums, requires further investigations.

**Key words:** Caffeine Gum • Time Trail Cycling • Blood Glucose • Blood Lactate

### INTRODUCTION

Caffeine is an alkaloid compound which occurs naturally in the seeds, leaves and fruits of many plants such as coffee beans, tea leaves, cocoa beans [1-3] and it also exists in a number of foods and drinks [3, 4]. Caffeine is readily distributed throughout the body after ingestion. The hydrophobic property of caffeine allows it to pass through all the biological membranes [5, 6]. Human studies have shown that there are no physiological barriers hindering the passage of caffeine through tissues [7, 8]. Understanding the ergogenic effects of caffeine requires an insight into the mechanisms of its function at the cellular level. Three major cellular mechanisms have been proposed to explain the ergogenic potential of caffeine during exercises: (1) increased myofilament affinity for calcium and/or increased release of calcium from the sarcoplasmic reticulum in skeletal muscle, (2) cellular actions caused by accumulation of cyclic adenosine monophosphate (cAMP) in various tissues including skeletal muscle and adipocytes; and (3)

cellular actions mediated by competitive inhibition of adenosine receptors in the central nervous system and somatic cells. Based on these three cellular mechanisms, caffeine has become prevalent among athletes as a nutritional supplement [9, 10].

Studies carried on caffeine show that its consumption stimulates the central nervous system and lead to the release of free fatty acids from adipose tissues. This is thought to increase the absorption of free fatty acids by the muscle and its oxidation in support of energy production; further, it is believed that muscle glycogen utilization is reduced through this mechanism. However, recent studies have cast a doubt on the validity of this hypothesis, especially in trained athletes [11]. Because caffeine has a stimulating effect on the central nervous system, it may improve performance through influencing the processes that determine the stimulation of the neuromotor system. Research has shown that caffeine has positive effects on exercises such as 1500-meter swimming, one-hour time trial cycling and on the capacity to perform a task during a two-hour pedaling test [12].

Some studies carried out have focused on the effect of caffeine on brief performance with high intensity. The results of these studies are not as consistent as those studying endurance exercises [13-15].

It has been showed that during anaerobic exercises, caffeine increases the production of lactate by the muscle [9, 16]. This phenomenon can reflect the increased production of muscle glycogenolysis by caffeine or increased release of lactate which does not necessarily reflect lactate production [16].

The focus of previous studies has been mainly on comparing different forms and doses of caffeine (capsule, oral solution, gum) to identify which of these forms is healthier, more secure and more quickly absorbable. Novumand colleagues [17] came to the conclusion that the rate of caffeine absorption was faster when consumed as chewing gums in comparison with a standard pill. Moreover, research has shown that almost 85% of caffeine is released by 5 minutes of chewing gum [17]. This will lead to a faster onset of the stimulating effects of caffeine [12]. The results showed that the maximum caffeine concentration was similar to the study that compared gum and capsule formulations. Moreover, the rate of absorption from the gum formulation was similar to the previous study signifying that the level and rate of absorption is constant when a certain dose is taken [18].

Generally, a review of the results of research studies indicated that caffeine consumption in different doses and forms has different effects on the performance of athletes in different sports. Since caffeine is more quickly absorbed in the form of chewing gums and so far the effect of caffeine consumption on time trial cycling has not been studied, the aim of present research was to study the effect of caffeine gum consumption with different doses on blood glucose and lactate after a 1 and 4-km cycling as well as the time of this exercise in time trial cyclists.

## MATERIALS AND METHODS

The present research is quasi-experimental in which 15 time trial cyclistsmen participated with a mean and standard deviation of  $25.2 \pm 2.7$  years of age,  $170.5 \pm 5.9$  cm of height,  $68.3 \pm 4.5$  kg of weight and  $13 \pm 2.7\%$  body fat. The subjects appeared at the place of testing and explanations were provided regarding the purpose of the research and test procedures and they filled out the consent forms.

First, using Harpenden caliper the subcutaneous fat thickness of the chest, abdomen and thigh of the subjects was measured and the sum of it was replaced in Jackson-Pollock formula (1978) in order to calculate the density; then, the body fact percentage was estimated by replacing the obtained density in Siri equation ( $S = \text{Chest} + \text{Abdomen} + \text{Thigh}$ ).

$$\begin{aligned} d(\text{Body Density}) &= 1.10938 - 0.0008267(s) \\ &+ (0.0000016(s)^2) - (0.0002574(\text{age})) \text{g/cm}^2 \end{aligned}$$

$$\text{Body Fat Percentage} = \frac{4.95}{d} - 4.50 \times 100$$

A glucometer device (Bioneme GM300, made in Sweden with a precision of  $\pm 5$  mg/dl) was used for measuring blood glucose. Further, Lactate Scout (made in Canada with a precision of  $\pm 2$  mm/l; SN: 1-800-462-2876) was used for measuring blood lactate and Robic Stopwatch with an error level of 0.06 seconds was used for recording the time of 1-km cycling.

In the first stage, all the subjects received placeboes at three intervals (30 minutes before, 5 minutes before and immediately after the 1 and 4-km cycling). In the second and third levels (with a 5-day interval between each two stages), all the subjects received caffeine gum with three different doses (180 and 300 mg) at three intervals (30 minutes before, 5 minutes before and immediately after the 1 and 4-km cycling). The participants were asked to chew the gum for 5 minutes. Gum and placebo were given to the participants in a double-blind fashion. Blood glucose and lactate of the subjects were measured in all four stages, 5 minutes before and immediately after performing the 1 and 4-km cycling. Descriptive statistics and repeated measure ANOVA and Tukey's post hoc test (for determining the effect of different doses of caffeine on blood glucose and lactate as well as the time of the 1 and 4-km cycling) were used for data analysis. All the data analyses were done using SPSS 16 and EXCEL.

## RESULTS

The results of repeated measures ANOVA (Table 1) indicate the significant ( $P \leq 0.05$ ) effect of different measurement stages on blood lactate. Moreover, Tukey's post hoc test indicated a significant ( $P \leq 0.05$ ) difference between the levels of blood lactate before and after performing the 1 and 4-km cycling, after taking placeboes

Table 1: Mean and standard deviation of the level of blood lactate before and after performing the 1 and 4-km cycling and after consumption of different doses of caffeine and placebo and the results of the post hoc test

	Placebo	180 mg of Caffeine	300 mg of Caffeine
Before 4-km cycling	3.8±1.45*	4.73±2.55*	4.20±2.18*
After 4-km cycling	14.83±3.63	15.42±3.10	13.51±3.77
Before 1-km cycling	3.7±2.46†	4.2±2.20†	4.21±2.34†
After 1-km cycling	17.39±3.93	16.69±3.10	16.73±2.39

Notes: \*significant difference before and after the 4-km run, †significant difference before and after the 1-km cycling (±)

Table 2: Mean and standard deviation of the level of blood glucose before and after performing the 1 and 4-km cycling and after consumption of different doses of caffeine and placebo and the results of the post hoc test

	Placebo	180 mg of Caffeine	300 mg of Caffeine
Before 4-km cycling	90.24±14.19	120.77±14.12	116.23±11.46
After 4-km cycling	95.11±10.34	115.71±13.93	119.70±13.46
Before 1-km cycling	116.21±19.15	117.31±17.39	114.99±16.46
After 1-km cycling	122.19±17.60	127.50±14.06	120.13±14.06

Table 3: Mean and standard deviation of the time of 1 and 4-km cycling after consumption of different doses of caffeine and placebo

		Placebo	180 mg of Caffeine	300 mg of Caffeine
Time (min)	1 km cycling	1.10±0.23	1.09±0.18	1.09±0.20
	4 km cycling	5.43±0.25	5.36±0.19	5.30±0.19

and after taking 180 mg and 300 mg of caffeine, while no significant difference was observed between the levels of blood lactate between consumption of different doses of caffeine and placebo before and after performing the 4-km cycling ( $F = 86.35$ ,  $P \leq 0.05$ ) and after performing the 1-km cycling.

The results of repeated measure ANOVA suggested the lack of a significant ( $p < 0.05$ ) effect of different measurement stages on blood glucose after 1 km ( $F = 7.253$ ,  $P = 0.288$ ) and after 4 km cycling.

The results of repeated measure ANOVA suggested the lack of a significant ( $P \leq 0.05$ ) effect of different doses of caffeine and placebo on the time of 1 and 4-km cycling (Table 3).

## DISCUSSION AND CONCLUSION

The purpose of the present research was to study the effect of caffeine consumption with different doses on the levels of blood glucose and lactate after a time trial cycling exercise (1 and 4-km cycling). The results showed that the level of blood glucose does not change with consumption of different doses of caffeine chewing gum. This finding is consistent with the results of Van Soeren and Graham [19], Bertram and colleagues [20] and Bangsbo and colleagues [10]. Van Soeren and Graham [19] studied six recreational athletes and came to the conclusion that caffeine has no effect on the levels of blood glucose during an exhausting exercise. In another study carried out by Batram and colleagues [20], they examined the effect of caffeine on glucose kinetics in 12

active men and found that caffeine has no effect on endogenous glucose production. Bangsbo and colleagues [10] studied the acute and chronic responses to caffeine and exercise in healthy adults. They found that the levels of blood glucose do not change with caffeine consumption. However, there are studies that have found caffeine to cause a rise in blood glucose [21-23]. Graham and Spriet [23] examined exercise responses to different doses of caffeine in endurance athletes and came to the conclusion that blood glucose concentration increases during exercise.

The reason why blood glucose did not increase with caffeine gums in the present research could be due to the nature of the sport. While Graham and Spriet [24] observed a rise in the level of blood glucose in endurance exercises, the present research studied mid-endurance exercises (1500 and 800-meter run). Another reason could be the low-dose caffeine ingestion by the participants of the present research. The doses used in the present research may have been insufficient for creating a significant change in the level of blood glucose during running, although the rate of absorption of caffeine in gum formulation is higher.

The results of the present research also showed a significant difference between the levels of blood lactate before and after performing the 1 and 4-km cycling, after consumption of placebo and 180, 240 and 300 mg of caffeine, while no significant difference was observed between the levels of blood lactate between consumption of different doses of caffeine and placebo before and after performing the 1 and 4-km cycling. The reason for

the significant difference in the level of blood lactate before and after performing the 1 and 4-km cycling and after taking placebo and three doses of caffeine is due to the mid-endurance nature of these exercises. However, the results showed that blood lactate does not change by taking different doses of caffeine. Research regarding the effect of caffeine on blood lactate during exercise has not been discussed much and in those few cases that do, the findings regarding the glycogen sparing property of caffeine are contradictory. Most researchers have shown that the concentration of blood lactate increases after caffeine consumption [23-26]. This increase in blood lactate can indicate lactate production by active muscles or decreased blood clearance [23]. Our findings are contrary to those of Van Soeren and Graham, Jackman and colleagues, Graham and Spriet and Sukman [23, 24, 26, 27]. Van Soeren observed the metabolic effects of caffeine after withdrawal and reported that blood lactate increases in response to physical activity and caffeine consumption [19]. Jackman and colleagues [26] also studied the effect of caffeine during short intense exercise and found that the concentration of blood lactate increases during the exercise and after caffeine consumption. Moreover, Graham and Spriet [23] found that blood lactate increase during exercise with caffeine ingestion. Studies that have reported an increase in blood lactate after caffeine consumption are inconsistent with the theory that caffeine is glycogen sparing. If glycogen sparing occurs, lactate concentration should not increase, since free fatty acids are the main source of fuel during exercise. Many factors can be the reasons behind the inconsistency of the results of the present research with those of other studies. The first reason is the low-dose caffeine consumption by the participants of the present research. The second is the fitness of the participants and the third is the type of exercise used in the research.

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