
ORIGINAL ARTICLES. SPORT

The effect of caffeine on running performance in performance triathletesKristián Bako^{1ABCDE}, Michal Hlávek^{1ABCDE}, Ivana Burská^{1ABCDE}, Ratko Pavlović^{2CDE*}¹Matej Bel University, Department of Physical Education and Sports, Banská Bystrica, Slovakia²Faculty of Physical Education and Sport, University of East Sarajevo, Bosnia and Herzegovina

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Abstract

Background and purpose	In an endurance sport such as triathlon, coaches at the elite level strive to select an appropriate nutritional strategy prior to performance in addition to optimizing the training process. Based on this, the research in question was designed with the aim to verify the effect of caffeine on the running performance of performance triathletes during the preparation period. Purpose is to determine the effect of caffeine on running performance in triathletes.
Material and methods	The study sample consisted of 8 performance triathletes from the TRIAN club of ŠK UMB Banská Bystrica, whose age was 16.7 ± 0.67 years. Diagnostics were run on InSPORTline Condi T6000i treadmill with the aim of detecting lactate and blood sugar levels (mmol/l) before the performance and within 10 seconds after the performance. The blood lactate level was detected with the portable device Lactate Scout+ and the blood glucose level was measured with the Wellion CALLA light glucose meter. The running pace at which the participants performed the test was at anaerobic threshold and they attempted to cover a distance of 1,500 m at a constant incline of 3%. The testing took place 1 time per week in the morning hours (08:00-08:30). On the second day after the initial testing from 01.03.2023 to 14.03.2023, the participants started taking placebo (magnesium lactate) on a daily basis in form of capsules. The participants took 2 capsules (200 mg magnesium) which they consumed with 200 mL of water 45 to 60 minutes before each morning workout/test. This was followed by the administration of caffeine capsules, which they consumed for an additional 2 weeks from 03.15.2023 to 03.28.2023. The participants consumed caffeine capsules at 5 mg/kg body weight 45 to 60 minutes before each morning workout/test. The intervention programme lasted 5 weeks
Results	When administering caffeine capsules at a dose of 5 mg/kg body weight, there was a significant reduction of approximately 26% in the average blood lactate level of the participants after the 1,500 m run. The participants' mean blood glucose levels increased by approximately 4.9% after the 1500 m run.
Conclusions	Based on the results we can claim that for ergogenic effects on performance we recommend supplementing with 5mg/kg body weight of caffeine approximately 45 to 60 minutes before training.
Keywords	caffeine, endurance, performance, running, triathlon

Анотація

Крістіан Бако, Міхал Главек, Івана Бурска, Ратко Павлович. Вплив кофеїну на ефективність бігу у професійних триатлоністів

Обґрунтування і мета	<p>У такому виді спорту на витривалість, як триатлон, тренери елітного рівня прагнуть вибрати відповідну стратегію харчування перед виступом на додаток до оптимізації тренувального процесу. Виходячи з цього, дослідження, про яке йдеться, було розроблено з метою перевірити вплив кофеїну на бігову продуктивність триатлоністів під час підготовчого періоду.</p> <p>Мета полягає в тому, щоб визначити вплив кофеїну на ефективність бігу у триатлоністів.</p>
Матеріал і методи	<p>Вибірка дослідження складалася з 8 спортсменів-триатлоністів із клубу TRIAN ŠK UMB Banská Bystrica, вік яких становив $16,7 \pm 0,67$ років. Діагностику проводили на біговій доріжці InSPORTline Condi T6000i з метою визначення рівня лактату та цукру в крові (ммоль/л) до виконання та протягом 10 секунд після виконання. Рівень лактату крові визначали портативним приладом Lactate Scout+, а рівень глюкози крові вимірювали глюкометром Wellion CALLA light. Темп бігу, з яким учасники виконували тест, був на рівні анаеробного порогу, і вони намагалися подолати дистанцію 1500 м з постійним нахилом 3%. Тестування проходило 1 раз на тиждень у ранкові години (08:00-08:30). На другий день після початкового тестування з 01.03.2023 по 14.03.2023 учасники почали щодня приймати плацебо (магnezію лактат) у формі капсул. Учасники приймали 2 капсули (200 мг магнію), які запивають 200 мл води за 45-60 хвилин до кожного ранкового тренування/тесту. Після цього було введено капсули кофеїну, які вони вживали ще 2 тижні з 15.03.2023 по 28.03.2023. Учасники вживали капсули кофеїну в дозі 5 мг/кг маси тіла за 45-60 хвилин до кожного ранкового тренування/тесту. Програма інтервенції тривала 5 тижнів</p>
Результати	<p>При введенні кофеїну в капсулах у дозі 5 мг/кг маси тіла спостерігалось значне зниження приблизно на 26% середнього рівня лактату в крові учасників після бігу на 1500 м. Середній рівень глюкози в крові учасників підвищився приблизно на 4,9% після бігу на 1500 м.</p>
Висновки	<p>На основі результатів ми можемо стверджувати, що для ергогенного впливу на продуктивність ми рекомендуємо додавати 5 мг/кг маси тіла кофеїну приблизно за 45-60 хвилин до тренування.</p>
Ключові слова	<p>кофеїн, витривалість, продуктивність, біг, триатлон</p>

Introduction

The triathlon is an endurance contest in which we must compete in 3 consecutive events [1]. In elite and high-performance triathlon, every detail is crucial to the outcome. Therefore, it is essential to optimize not only the methods of triathlon performance development but also the improvement of cycling and running equipment, nutrition, and sports nutrition [2]. Optimal endurance performance requires careful consideration of nutrient intake. Endurance athletes rarely compete fasted because it can compromise their performance. The timing and composition of the pre-training meal is an important factor involved in their subsequent endurance performance [3]. Authors [4, 5, 6] say that we cannot expect to perform at our best in the triathlon if we do not strategically optimise our diet as well as our pre-exercise sports nutrition. Šindelář and Roubík [7] recommend that other aspects of sports nutrition such as energy balance, macronutrients, micronutrients and meal timing should also be observed for ergogenic effects caused by dietary supplements. One of the most widespread and widely used psychoactive substances that positively effects the functions of the nervous, cardiovascular and respiratory systems is caffeine. In addition to health benefits, it also has significant stimulatory effects on athletic performance. The ideal timing of caffeine administration prior to exercise also depends on the form in which the caffeine is consumed. Caffeine chewing gum is ideally consumed 5 to 15 minutes before exercise, coffee 40 minutes, and caffeine capsules approximately 60 minutes before exercise.

Caffeine in endurance sports shows positive effects on aerobic performance, as confirmed in a field study by [8]. A systematic review and meta-analysis by [9] summarises 44 studies, suggesting that caffeine supplementation has the greatest effect on endurance performance when taken at 3-6 mg/kg body weight. Authors [7], who report that taking this amount of caffeine reduces the time taken to complete an endurance event by approximately 2%, share this view. This 2% can also determine the top position for an elite triathlete at the performance level. Caffeine also has a positive effect on mental exhaustion. A study by [10] physically tested eight mentally exhausted participants on a bicycle. The results indicated an increase in endurance performance of approximately 14%. Based on this research, we can assume that the higher the amount of caffeine consumed, the more significant the improvement may be. Desbrow et al. [11] addressed

the issue of the amount of caffeine consumed in their study, which showed that there were no significant differences in endurance performance when 3 mg/kg or 6 mg/kg were consumed, therefore the previous claim can be rejected. Higher doses of caffeine can have rather negative effects such as headache, restlessness, nervousness, which will be reflected in sport performance. Additionally, an athlete's individual profile, i.e. their genetic make-up in terms of caffeine metabolism, has to be taken into account when consuming caffeine. Caffeine is metabolized in the liver, causing an increase in lipolysis, which increases the concentration of fatty acids in the blood and subsequently uses them as a source of energy from intra and extra muscular stores, thus allowing to reduce glycogen consumption and to increase endurance performance.

In this case, we have decided to use the dosage according to the aforementioned authors, at a level of 5 mg/kg body weight, in the form of caffeine capsules, 45-60 minutes before the start of the test. The purpose is to determine the effect of caffeine on running performance in triathletes

Material and Methods

Participants

The study of the effect of caffeine on running performance was carried out on 8 performance triathletes from the club TRIAN ŠK UMB Banská Bystrica, whose age during the initial measurements was 16.7 ± 0.67 years. The research was conducted from 21.3.2023 to 28.3.2023 during the triathletes' preparation period. The entire testing process took place in the premises of the Sports School in Banská Bystrica. The room temperature was 20 to 22 °C.

Experimental study design

The intervention program consisted of 5 weeks, during which the triathletes completed the 1,500 m running test 5 times (at weekly intervals). Every Tuesday morning (08:00-08:30), the triathletes completed a 1500m treadmill running test using four InSPORTline Condi T6000i treadmills. The speed at which the triathletes performed the test was determined by individual performance. Triathletes were instructed to cover a distance of 1 500 m at an anaerobic threshold level at a constant incline of 3%. Blood lactate (mmol/l) and blood glucose (mmol/l) levels were recorded for each participant before

each test. The participants' lactate and blood glucose levels were also measured immediately after the test (within 10 seconds). The blood lactate level was measured with the portable device Lactate Scout+ and the blood glucose level was measured with the Wellion CALLA light glucose meter. The test was accompanied by a warm-up consisting of a 10-minute run on the treadmill on which the test was carried out. The warm-up consisted of dynamic stretching focused on the lower limbs. The test was performed in groups of four with one-minute intervals between each group to ensure accurate data output (lactate and glucose).

Procedures

The participants consumed caffeine on a regular basis in the form of coffee or energy drink and therefore they were informed on 21.02.2023 to cut out any form of caffeine (energy drinks, green/black teas, coffee, caffeine capsules...) from their diet one week before to the first testing, so that the ergogenic effects of caffeine were avoided at the initial testing (28.02.2023).

On the second day after the initial testing, the participants began taking a placebo on a daily basis. Placebo as the control variable was magnesium lactas and was administered in capsule form. The participants consumed 2 magnesium capsules 45 to 60 minutes before each morning training or testing. In terms of nutritional data, 2 magnesium capsules represent 200 mg of magnesium. Placebo was taken by the participants with 200 ml of water and taken from 01.03.2023 to 14.03.2023. The experimental variable in this research was caffeine. The participants also consumed caffeine in the form of capsules, but the dosage was adjusted according to body weight (5 mg/kg). They started taking the capsules from 15. 03. 2023 until 28. 03. 2023, when the final tests were carried out. The participants also consumed the caffeine capsules with 200 ml of water 45 to 60 minutes before each morning practice or test. The caffeine dosing method was based on the findings of [7, 9], who recommend supplementing caffeine 3 to 6 mg/kg within 60 minutes (capsule form) before each training session for ergogenic effects. The placebo together with the caffeine was in unmarked packets and both types of capsules were white in colour. The participants reported the consumption of each dietary supplement (placebo/caffeine) to their head coach on a daily basis. They did not consume any energy drinks, green/black teas or coffee during the

entire research period.

Statistical analysis

In this study, we used Microsoft Excel 2016 to process the data and to calculate arithmetic means, standard deviations and percentage differences of each variable in the research.

When developing the theoretical background, we used the methods of logical analysis, induction and deduction, comparing the results of our research with previous knowledge, from which we drawn conclusions in the discussion of the study.

Results

In the following figures we illustrate and summarize the results of our research conducted on 8 performance triathletes aged 16.7 ± 0.67 years from the club TRIAN ŠK UMB Banská Bystrica.

Figure 1 shows a comparison of the mean blood lactate levels of the 8 participants. The caffeine-free column represents the mean blood lactate level at the baseline measurement, which was 1.76 ± 0.4 mmol/L. The participants did not consume any form of caffeine during this period. The placebo column indicates the period when the participants took placebo (magnesium lactate). This column shows a slightly higher blood lactate level of 1.83 ± 0.56 mmol/l. The caffeine column defines the period of caffeine consumption. The mean blood lactate of the participants was 1.73 ± 0.35 mmol/l, which was the lowest value compared to weeks in which the participants were not given caffeine or had placebo (magnesium lactate) as substitute.

In Figure 2 we interpret the mean blood lactate level achieved by the 8 participants. This data was obtained after the 1,500 m run. The caffeine-free column shows that the mean blood lactate level of the participants was 5.7 ± 2.52 mmol/l after the performance. In the second, placebo, column, we can see that during the 2-week period when the participants supplemented with magnesium lactate, the mean blood lactate level after the test was lower at 4.65 ± 1.48 mmol/l. The caffeine column characterises the 2-week period during which the participants supplemented with caffeine. During this period, the blood lactate level was significantly lower after the 1,500 m run, at 4.2 ± 1.77 mmol/l. From the current results, we can assume that the consumption of caffeine before exercise can reduce the level of lactate in the blood, which is in accordance with the

findings of the study [12].

Figure 3 compares the 3 periods when participants were caffeine-free, took placebo (magnesium lactate) and caffeine, and their effect on blood glucose levels before the performance. The caffeine-free column represents the lowest blood glucose level of 5.32 ± 1.38 mmol/l. During the 2 weeks of magnesium lactate supplementation, the blood glucose level before the performance increased slightly to 5.48 ± 0.72 mmol/l. The highest blood glucose values were during the 2-week period of caffeine use. During this period, the participants had a mean blood glucose level of 5.54 ± 0.47 mmol/l before the 1500 m run.

Figure 4 shows the average blood glucose level achieved by the 8 participants. These data were obtained after the 1,500 m run. The caffeine-free column shows that the mean blood glucose

level of the participants after exercise was 5.43 ± 1.11 mmol/l. On the second, placebo column, we can see that over the 2-week period when the participants supplemented with magnesium lactate, the mean post-test blood glucose level was almost identical to that of the caffeine-free column, at 5.44 ± 0.44 mmol/l. The caffeine column characterises the 2-week period during which the participants supplemented with caffeine. During this period, blood glucose levels were significantly higher after the 1,500 m run compared to the caffeine-free and placebo measurements. The blood glucose level was 5.7 ± 0.65 mmol/l. From these results, we can assume that consuming caffeine before exercise may increase blood glucose levels. Graham et al. [13] also suggest that caffeine may be involved in the increase in blood glucose during exercise.

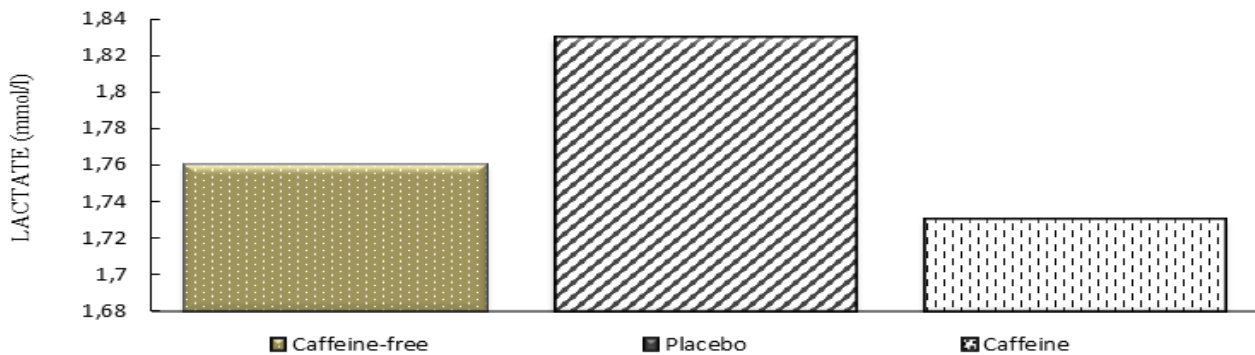


Fig. 1. Mean blood lactate levels (mmol/l) of the participants before performance

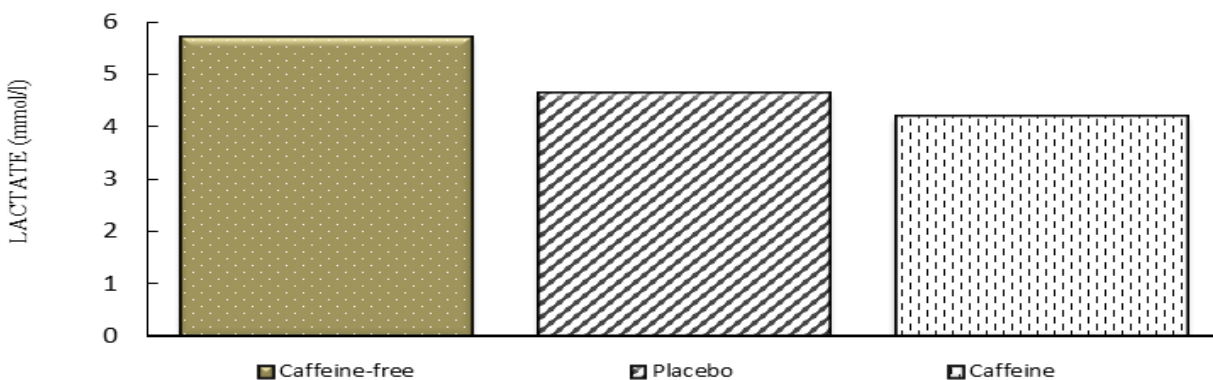


Fig. 2. Mean blood lactate levels (mmol/l) of participants after the 1,500 m run

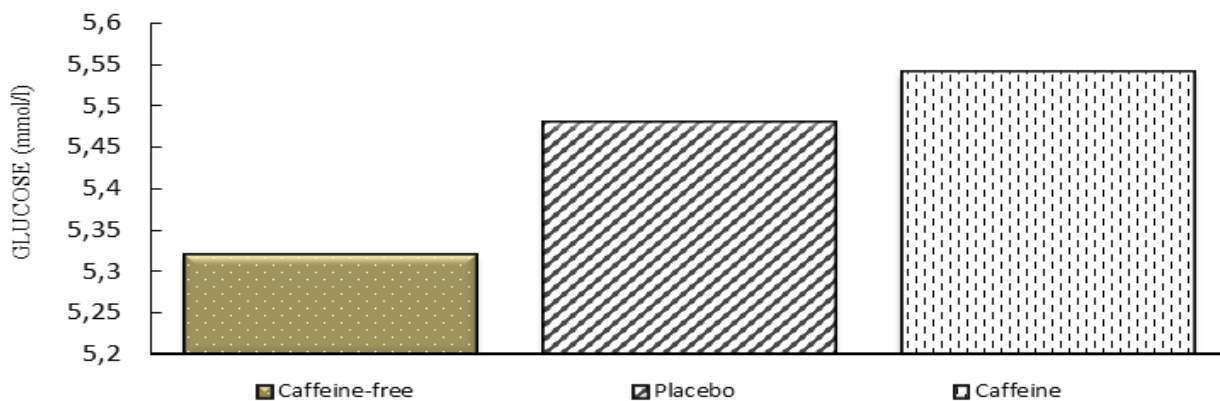


Fig. 3. Mean blood glucose levels (mmol/l) of participants before exercise

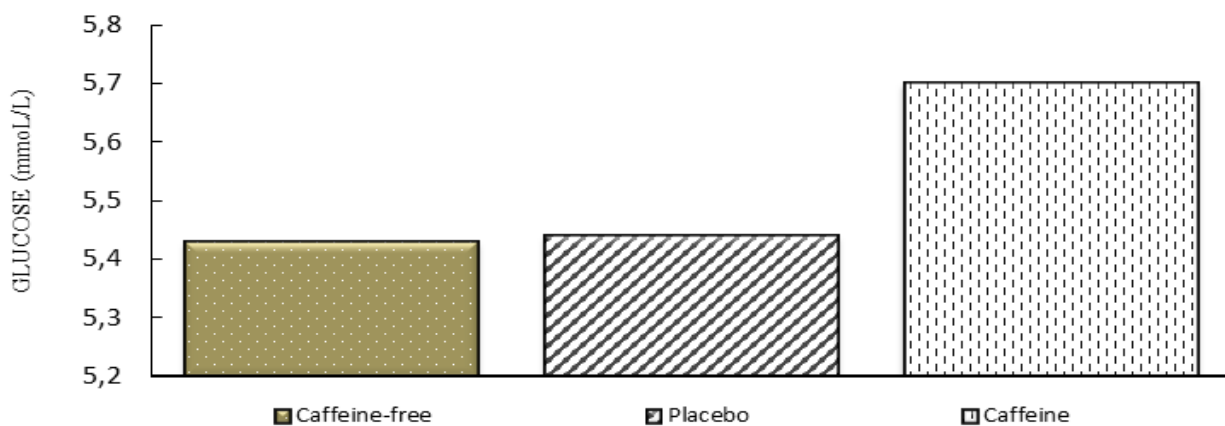


Fig. 4. Mean blood glucose levels (mmol/l) of participants after the 1,500 m run

Discussion

The aim of this study was to verify the effect of caffeine on the running performance of high performance triathletes during the preparation period, which we were able to do.

On average, 8 performance triathletes showed minimal differences in pre-exercise blood lactate and blood glucose levels compared to results obtained after the 1500 m run. Pre-exercise blood lactate levels were nearly identical when compared to baseline, but pre-exercise blood glucose levels were slightly elevated.

There was a reduction of approximately 26% when comparing the participants' average blood lactate levels after a 1500m run. The participants' mean blood glucose levels increased by approximately 4.9% after the run.

Our claim that caffeine contributes to lowering blood lactate levels, which may ultimately positively affect running performance, can be supported by the research of [12]. In that research, a reduction in blood

lactate levels occurred with an identical amount of caffeine intake (5 mg/kg body weight). Gaesser & Rich [14] also support this claim. According to them, blood lactate levels can be significantly affected by caffeine consumption. A slower onset or lower blood lactate level allows us to reach exhaustion later, which can prolong endurance performance. This is supported by [7], who say that consuming this amount of caffeine reduces the time needed to complete an endurance event by about 2%. Also [8, 9] are inclined to suggest that caffeine has positive effects on endurance performance. According to [7], the approximately 4.9% increase in blood glucose levels in our participants may be due to an increase in lipolysis, which increases the concentration of fatty acids in the blood and uses them as an energy source from intra- and extra muscular stores, causing a decrease in glycogen consumption. The result of this process is an increase in endurance performance. According to [13], glycogen levels increase after the initial few minutes of the performance following caffeine consumption.

The research was limited by the number of

participants who completed it. The reason for this limitation is a low representation of participants at the performance level in the club TRIAN ŠK UMB.

A further limitation of the study may be the individual profile of athletes and their reaction to caffeine in terms of their genetic make-up of caffeine metabolism [7]. For this reason, it may not suit everyone to consume capsules 45-60 minutes before exercise. Another alternative we would like to test in the future is caffeine chewing gums. Baretoet al. [15-20] conducted an interesting meta-analysis based on 14 studies showing that caffeine chewing gum supplementation is significant in competitive endurance athletes who ingested caffeine via caffeine

chewing gum at ≥ 3 mg/kg body weight within 15 min before the start of exercise.

Conclusion

Based on our findings regarding ergogenic effects, we recommend supplementing with 5 mg/kg body weight of caffeine approximately 45 to 60 minutes before training.

Conflict of interest

The author declares no conflict of interest.

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