

A large purple circle containing a stylized illustration of a muscular man from the back, flexing his arms. To the left of the man is a chemical structure of caffeine, showing a purine ring system with labels for H₂C, O, N, and CH₃. At the bottom right of the circle, a black container labeled 'FULL' is tipped over, spilling dark capsules onto the ground.

Caffeine in Sport and Exercise: All in the Mind?

Key Stage 5 Sport and
Exercise

Model Answers

2019



Resource One Model Answers



- Answers**
- 1) Can you list three sources of caffeine that contain equivalent to or more than 80 mg of caffeine per serving? – Check table 1, column 3 enlisted “approximate caffeine dosage (milligrams (mg))”
 - 2) What percentage of the adult western population DOES NOT consume at least one caffeinated food source/drink per day? – 10%
 - 3) What is the most well recognised source of caffeine and from which two plants is this typically cultivated from? – Coffee bean, which is typically cultivated from *Coffea Arabica* and *Coffea Canephora*
 - 4) List 5 sources of caffeine cultivation? – *Coffea Arabica*, *coffea Canephora*, South American holly yerba mate and yaupon, kola nuts and seeds from Amazonian maple guarana berries.
 - 5) Analyse table 1 and suggest how many bars of dark chocolate a healthy adult would need to consume before risking caffeine toxicity? 13 – 16
 - 6) What is caffeine’s medical name? – 1,3,7-trimethylxanthine
 - 7) What is caffeine’s main mechanism of action? – Adenosine receptor antagonism/central nervous stimulation
 - 8) Using table 1. Estimate how much caffeine you consume per day? – Subjective, however a calculation based on items enlisted in table 1 should be provided
 - 9) Using the image depicting caffeine’s chemical structure, rearrange the below table to display how many of each atom caffeine contains. See answer to question 10

Carbon	10
Nitrogen	8
Oxygen	4
Hydrogen	2

Resource One Model Answers



Answers

- 10) Fill in the blank spaces below to complete caffeine's chemical structure C8H10N4O2
- 11) List 5 negative symptoms associated with caffeine toxicity? – migraines, anxiety, confusion, irritability, restlessness (see image depicting caffeine symptoms, within main text)
- 12) Create a comic strip depicting the cultivation, preparation and consumption of caffeine in a food/drink source of your choice:
- 13) Cultivation: Some reference to one of the following beans/plants of cultivation: Coffea Arabica, Coffea Canephora, South American holly yerba mate and yaupon. Caffeine is also commonly extracted from kola nuts and seeds from Amazonian maple guarana berries.
- 14) Preparation: Some reference to the infusion and steeping process
- 15) Caffeine consumption: Some reference to how the cultivation and preparation process assist in preparation of more commonly consumed, caffeinated food sources/beverages.
- 16) Create a diet log of food/drink items you have eaten over the last 3 days and identify which sources contain caffeine (extension task – estimate the content of caffeine per item and then explore the absolute value to compare against).
– Subjective, however estimations should be provided in line with table 1.

Resource Two

Model Answers



Answers 1. Multiple Choice

	A	B	C	D
What is caffeine's primary mechanism of action?	Adenosine receptor antagonism	Glycogen sparing	Central nervous stimulation	Free fatty acid oxidation
What does an adenosine receptor agonist cause?	Central nervous stimulation	Central nervous downregulation	Free fatty acid oxidation	Production of β -endorphins
What effect may caffeine have on the central nervous system?	Glycogen sparing	Central nervous stimulation	Reduced potential	downregulation
What effect may caffeine have on muscular force production?	Augmented	Decreased	No effect	Elongation of each contraction
Can you identify the negative health effect associated with an overly stimulated central nervous system?	Increased heart rate	Drowsiness	Worrying	Too much energy
What are β -endorphins?	Brain neurotransmitters	Lipids	Nerve cells	Adenosine receptor antagonists
By what order does an electrical impulse stimulate a muscular motor unit?	Brain, spinal cord, muscular motor unit	Spinal cord, brain, muscular motor unit	Brain, bone cells, muscular motor unit	Adenosine receptor, brain, muscular motor unit, spinal cord
What negative health effect may the production of β -endorphins cause?	Increased heart rate	Reduced pain perception	Reductions in oxygen consumption	increased fat metabolism
What may caffeine's thermogenic impetus cause?	Reductions in arousal and a better sleep.	Reduced pain perception, aggression and greater fine motor control.	Increased arousal, energy, motivation and aggression	Increased protein metabolism.

Resource Two

Model Answers



Answers

2.) Without referring back to the data source, can you recreate the mechanisms associated with adenosine and caffeine, and adenosine receptors? Some reference to adenosine receptor antagonism and subsequent central nervous stimulation. Additional credit should be provided for potential enhanced muscular force production.

3.) Can you predict what would happen if the central nervous system was stimulated through a caffeine overdose? – Effectively, cardiac failure and hypertension

4.) Evaluate the pro's and con's of using caffeine to study the night before an important exam?

Pros: Enhanced alertness, awareness and feelings of wakefulness would help improve the quality of exam revision

Cons: Due to excessive wakefulness, the individual may struggle to sleep (insomnia like symptoms)

Resource Three

Model Answers



- Answers**
- 1.) What is the main mechanism that is associated with caffeine’s beneficial effects on sport and exercise performance? **Central nervous stimulation through adenosine receptor antagonism**
- 2.) With regards to table 1. Can you calculate the mean change between caffeine and placebo trials? (Note: we must add all individual scores and divide this number by the total amount of individual scores to calculate the mean) – **Mean change = 11.8 – 12.0 = -0.2 s**

Table 1. 100 m sprint times in seconds following caffeine and placebo consumption

Participant	Caffeine	Placebo	Individual change (s)
1	11.6	11.4	0.2
2	11.7	11.3	0.4
3	12.1	12.2	-0.1
4	12.4	13	-0.6
5	12.3	12.3	0
6	11.3	11.8	-0.5
7	10.6	10.4	0.2
8	12.3	12.3	0
9	12.6	12.7	-0.1
10	11.5	12.2	-0.7
Mean change	11.8	12.0	

Resource Three

Model Answers



Answers 3.) Can you calculate the difference between caffeine and placebo trials for each individual?

Participant	Caffeine	Placebo	Individual change (s)
1	11.6	11.4	0.2
2	11.7	11.3	0.4
3	12.1	12.2	-0.1
4	12.4	13	-0.6
5	12.3	12.3	0
6	11.3	11.8	-0.5
7	10.6	10.4	0.2
8	12.3	12.3	0
9	12.6	12.7	-0.1
10	11.5	12.2	-0.7
Average	11.8	12.0	

4.) How many individuals performed greater during the caffeine trial? **4**

5.) Can you explain how caffeine may have improved sprint performance? **Caffeine may have increased muscular force production and therefore running acceleration through its ability to induce central nervous stimulation**

6.)For those individuals who displayed no difference/performed worse during the caffeine trial, can you evaluate why this may have occurred?

Individuals may have been caffeine tolerant, and/or the dosage used may have proven ineffective (too low) or caused debilitating effects (usually associated with too high a dosage).

7.) What is the prevalence of caffeine use across British athletes (can you also provide this as a %)? **Three out of four British athletes, or 75%**

Resource Three

Model Answers



- Answers**
- 8.) During the study by Del Coso et al. (2012), what factors do you feel were important in observing the performance benefit they perceived?
- Dosage of caffeine used was within the ergogenic range (3 mg/kg/body mass)
 - Optimum ingestion period was used (1-hour)
- 9.) How long do caffeine's effects typically last in healthy individuals? 1.5 – 9.5 hours
- 10.) What is the recommended range of caffeine dosages to improve sport and exercise performance? 3 – 9 mg/kg/body mass
- 11.) What may occur if somebody who is not used to using caffeine, consumes a higher end dosage? – for some individuals too great a dose may impair performance through negative side effects including nausea, headaches, jittering, blurred vision, insomnia.
- 12.) Create a comic strip outlining what dosage, how long before and for what benefit you would recommend caffeine to improve a soccer players performance.
- 3 – 9 mg/kg/body mass
 - 1-hour ingestion period to optimise caffeine bioavailability
 - Caffeine may effectively enhance central nervous stimulation and therefore improve: endurance capacity and soccer skill performance (as outlined by Del Coso et al. (2012)).

Resource Four

Model Answers



- Answers**
- 1.) What percentage of British athletes consume caffeine on a daily basis? – 75%
 - 2.) What percentage of the general population consume caffeine on a daily basis? – 90%
 - 3.) List 3 benefits associated with caffeine use? – central nervous stimulation, enhanced muscular force production, increased alertness, concentration and perceptions of energy
 - 4.) According to the US food and drug administration, how much caffeine would you be required to consume as an adult for it to be considered toxic? – 400 – 500 mg
 - 5.) Polymorphisms in which gene may result in increased rates of caffeine metabolism? – CYP1A2
 - 6.) Explain why extended periods of caffeine metabolism may prove detrimental to health? – Extended periods of increased heart rate, blood pressure, potentially negative psychological effects (if individual has pre-existing health concerns).
 - 7.) Are the risks associated with caffeine consumption the same for all populations? Explain your answer. – No, individuals who are relatively healthy are at a significantly lower risk. Individuals displaying polymorphisms in CYP1A2 and/or pre-existing debilitating health effects (increased blood pressure, heart rate etc.) are at an increased risk.
 - 8.) What percentage of caffeine is metabolised to theobromine, paraxanthine and theophylline? Paraxanthine (84%), theobromine (12%), and theophylline (4%)
 - 9.) What is the typical plasma half-life of caffeine? – 1.5 – 9.5 hours
 - 10.) What are catecholamines? – Neurotransmitters

Resource Four

Model Answers



Answers

11.) What are the three main catecholamines? – Epinephrine, norepinephrine and adrenaline

12.) What is the purpose of catecholamines? – Induce flight or fight response/increased energy production.

13.) Explain why individuals considered 'slow caffeine metabolisers' may be at an increased risk of catecholamines? – The effects of catecholamines (e.g. increased blood pressure, heart rate etc.) are extended for a longer period of time putting the individual's cardiovascular system under increased strain.

14.) With regards to catecholamines, why would individuals who consume caffeine prior to sport and exercise performance be at an increased risk versus those who do not? – Catecholamines and caffeine both have a stimulatory effect. Additionally, exercise has been observed to augment catecholamine production as has caffeine.

15.) Create a flyer outlining how caffeine may cause potential health concerns in individuals who display genetic polymorphisms versus those who do not? – Students should outline: individuals who display polymorphisms in gene CYP1A2 are at a greater risk of caffeine's adverse effects due to a prolonged caffeine half-life (effectively this increases the amount of time an individual will perceive symptoms and sensations (e.g. increased heart rate and blood pressure) associated with caffeine, which may often prove debilitating to health). This can last up to 16 hours.

Resource Five

Model Answers



- Answers**
- 1.) Can you differentiate between a placebo and the placebo effect? – Placebos are inert interventions that carry no pharmacological influence. The placebo effect is considered a procedure or substance that is administered with expectations that it will modify a symptom or sensation but unbeknown is just a placebo.
 - 2.) What are expectancies? – Expectancies are thoughts and beliefs an individual has about a treatment (in our instance caffeine).
 - 3.) List 3 factors that may influence an individual's expectancies? – Habitual caffeine consumption, verbal persuasion (what we hear on the radio or from friends), observational learning (visual advertisement campaigns), conditioning effects, pre-existing perceptions.
 - 4.) What type of individuals may be least responsive to placebos? – Individuals who do not believe that the treatment administered is effective or hold negative perceptions regarding the treatment administered.
 - 5.) Using evidence from the data source explain how expectancies may be best modulated? – Using salient techniques like watching caffeinated coffee being brewed, or being provided scientific literature to emphasise a point. Also, through stimulation of various senses.
 - 6.) List 3 psychological constructs that are likely influenced by expectancies? – Confidence, motivation, determination, beliefs, anxiety, optimism.
 - 7.) Provide your opinion on why expectancies are generally unaccounted for across the broader caffeine literature? – The answer here will likely be subjective; however, students should show an appreciation for overreliance on caffeine's pharmacological mechanisms (e.g. adenosine receptor antagonism and central nervous stimulation).

Resource Five

Model Answers



Answers 8.) Can you think of any ethical concerns when administering placebos? – Students should consider whether it is ethically right to lie/deceive an individual (as this is relevant to induce expectancies) even if it is to induce a positive performance effect.

9.) Explain the double-dissociation design? The double-dissociation design ultimately involves four groups, these are: given placebo/told placebo, given placebo/told caffeine, given caffeine/told placebo and given caffeine/told caffeine. This helps distinguish caffeine's psychological (given placebo/told caffeine) versus pharmacological (given caffeine/told placebo) effect.

10.) What methods should be considered to most effectively utilise the double-dissociation design? – How well individuals are made to believe the group they are part of

11.) What is the nocebo effect? – A negative effect following administration of a placebo.

12.) Differentiate between quantitative versus qualitative analysis? – Quantitative analysis is interested in quantifying numbers (e.g. how much faster does A run 100m versus B), whereas qualitative analysis explores subjective perceptions (e.g. interview procedures, questionnaires etc.) that are likely to be different from person to person and experience to experience.

13.) Why is qualitative analysis important when exploring the placebo effect? – The mechanisms behind the placebo effect are likely subjective and associated with beliefs and expectancies, therefore qualitative analysis is required to explore these.

Resource Five

Model Answers



Answers 14.) Describe one way of collecting qualitative data? — Interviews and/or questionnaires.

15.) Create a comic strip outlining how you would administer caffeine placebos to help individuals perform better during sport and exercise. *Subjective, provide students credit for consideration of techniques used to enhance the deception associated with expectancies. For example, administering decaffeinated coffee (coffee placebo) but having individuals watch this being brewed to augment beliefs. Additionally, students may explain they would explore an individuals' pre-perceptions and administer caffeine placebos based on what is considered more efficacious (e.g. placebo capsules vs placebo coffee) to the individual (this would enhance expectancies and beliefs)*

Resource Six

Model Answers



- Answers**
- 1.) Can you explain what caffeine placebos are? – Inert treatments that resemble caffeine modes of ingestion (and therefore induce expectation of caffeine consumption)
 - 2.) List 3 health concerns associated with caffeine? – Increased heart rate, blood pressure, potential increments in anxiety, depression and insomnia
 - 3.) Are all populations at the same health risks of caffeine, explain your answer? No, individuals with pre-existing health concerns (e.g. increased heart rate, blood pressure, anxiety, etc.) are at an increased risk, as are individuals who suffer from polymorphisms in gene CYP1A2 due to an increased plasma half-life.
 - 4.) What techniques can be used to increase caffeine placebo efficacy? – Verbal information (e.g. verbally explaining the benefits of caffeine) and/or observational learning (e.g. watching a video displaying how caffeine improves sport and exercise performance) with more salient techniques usually of greater significance here (e.g. using the findings of scientific research when verbally explaining the benefits of caffeine and/or having individual watch decaffeinated coffee being made, whilst under the false assumption it is caffeinated coffee).
 - 5.) What habitual factors will influence the effectiveness of caffeine placebos? – Whether an individual is a habitual caffeine user, habituated expectancies (e.g. the pre-existing belief an individual has in a treatment), whether they have been predisposed to any conditioning effects.
 - 6.) How may caffeine placebos reduce the health concerns associated with caffeine? Caffeine placebos do not contain pharmacologically active caffeine (theoretically the ingredient which causes caffeine's stimulatory effects) therefore the health concerns are significantly reduced.
 - 7.) Based on the findings of Shabir et al. (2018), why may expectations for caffeine use help improve active caffeine efficacy? – If we combine the pharmacological effect of caffeine with belief in its use, then we maximise the psychological potential which may improve active caffeine's efficacy.

Resource Six

Model Answers



- Answers**
- 8.) Describe what Figure 1 is telling us about caffeine expectancies? One of the mechanisms by which caffeine expectancies may induce a performance effect is through enhanced confidence. However, overconfidence may result in impaired performance due to reductions in effort. Therefore, an optimum point of confidence is theorised and this may differ from individual to individual.
- 9.) Describe 3 factors which may prevent an individual from experiencing a beneficial placebo effect? Negative habituated expectancies, and/or negative perceptions regarding the administered treatment (these may be induced acutely or chronically).
- 10.) What is a nocebo effect? – A negative effect following consumption of an inert intervention, often due to negative beliefs regarding the administered treatment.
- 11.) What ethical issues may be presented when administering placebos? – Students should consider whether it is ethically right to lie/deceive an individual (as this is relevant to induce expectancies) even if it is to induce a positive performance effect.
- 12.) What are the differences between expectancies and conditioning effects? Conditioning effects are considered learned responses over a longer period of time, these can often be conscious or sub-conscious, whereas expectancies or cognitive processes usually consciously driven
- 13.) List and describe 3 mechanisms associated with caffeine placebos? – Increments in psychosomatic sensations, some examples include: confidence, motivation, determination, perceptual arousal, fatigue and energy.

Resource Six

Model Answers



Answers 14.) Create a poster highlighting the benefits of using caffeine placebos as opposed to active caffeine for ALL populations – Students should highlight, that caffeine placebos do not contain active caffeine and therefore should not increase blood pressure, heart rate and or psychological concerns (e.g. anxiety, depression, insomnia) to the same severity. Moreover, caffeine placebos may represent an alternate to active caffeine for populations who are unable to consume caffeine (e.g. those who suffer of pre-existing health concerns and/or genetic polymorphisms (CYP1A2)).

Final Reflection Model Answers



Guidance Task – Design a poster or PowerPoint presentation (approximately 10 minutes) explaining why caffeine expectancies and the placebo effect is an important area of research. When designing this try to outline the benefits associated with placebo caffeine versus physiologically active caffeine (and perhaps use evidence from real life research projects as per Shabir et al. (2018) and Del Coso et al. (2012)). In your final slides you should aim to design an experimental study that you feel might add something interesting to this area of practice.

Students should make specific reference to the ergogenic nature of caffeine being somewhat psychologically stimulated. Moreover, reference should be made to some individuals suffering from health concerns (e.g. hypertension, heart failure, irregular heart beat, anxiety, depression etc.) that may be augmented by pharmacologically active caffeine, and how placebos may be used as an alternate. Students should present the findings of at least one research study (see shabir et al. (2018) for an overview of all studies pertaining caffeine expectancies and sport, exercise and cognitive performance.



www.researchbasedcurricula.com



www.access-ed.ngo



[@_AccessEd](https://twitter.com/_AccessEd)



hello@access-ed.ngo



100 Black Prince Road
London, SE1 7SJ



AccessEd is a non-profit company
registered in England (#10383890)