¿DOES CPY1A2 AFFECT THE ERGOGENIC EFFECT PRODUCED BY CAFFEINE IN ATHLETES' PERFORMANCE? A REVIEW.

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RESUMEN

Este Trabajo de Fin de Grado (TFG) examina la influencia del genotipo CYP1A2 en el efecto ergogénico de la cafeína sobre el rendimiento deportivo. Las sustancias ergogénicas son estimulantes que mejoran el rendimiento deportivo, aumentando la fuerza muscular y la resistencia, a la vez que reducen la fatiga y el tiempo de reacción.

Este estudio se centra en la mediación de este efecto por un polimorfismo de nucleótido único en el gen CYP1A2, que clasifica a los individuos como metabolizadores rápidos (genotipo AA) o lentos (genotipos AC o CC) de cafeína.

Se incluye una búsqueda exhaustiva en dos bases de datos científicas: PubMed y Scopus, así como artículos encontrados como referencias dentro de otros, sumando un total de 62 artículos. Tras varias cribas, finalmente se analizaron 16 documentos.

Los hallazgos clave indican que los metabolizadores rápidos (AA) tienden a beneficiarse más del consumo de cafeína, especialmente en ejercicios de resistencia como el ciclismo de media/larga distancia y entrenamientos de fuerza prolongados, mientras que los metabolizadores más lentos (CC) pueden llegar a ver penalizado su rendimiento tras la ingesta de cafeína previa al ejercicio. En cuanto a deportes más explosivos como baloncesto, balonmano y CrossFit no se encontraron beneficios ni desventajas adicionales asociados con los genotipos AA, AC o CC.

Esta revisión proporciona una visión general de la investigación existente, enfatizando la importancia de considerar la genética individual al evaluar el impacto de la cafeína en el rendimiento deportivo, y subraya la necesidad de estudios más detallados para optimizar el uso de la cafeína en deportes, asegurando tanto la efectividad como la seguridad adaptadas a los perfiles genéticos.

Palabras clave: Cafeína, CYP1A2, Efecto ergogénico, Rendimiento deportivo, Polimorfismo genético, Ciclismo.

ABSTRACT

This Final Degree Project (TFG) explores the influence of the CYP1A2 genotype on the ergogenic effects of caffeine in athletic performance. Ergogenic substances are stimulants that enhance athletic performance by increasing muscle strength and endurance while reducing fatigue and reaction time.

This study focuses on how a single nucleotide polymorphism in the CYP1A2 gene mediates this effect, classifying individuals as either fast (AA genotype) or slow (AC or CC genotypes) caffeine metabolizers.

The research involved a thorough search in two scientific databases: PubMed and Scopus, along with articles referenced within other studies, resulting in a total of 62 articles. After several screening stages, 16 relevant documents were analyzed.

Key findings suggest that fast metabolizers (AA) tend to benefit more from caffeine consumption, particularly in endurance activities like medium/long-distance cycling and prolonged strength training. In contrast, slow metabolizers (CC) may experience a decline in performance following caffeine intake before exercise. For more explosive sports such as basketball, handball, and CrossFit, no significant advantages or disadvantages were associated with the AA, AC, or CC genotypes.

This review provides an overview of current research, highlighting the importance of considering individual genetic profiles when evaluating the impact of caffeine on sports performance. It also underscores the need for more detailed studies to optimize caffeine use in athletics, ensuring both effectiveness and safety tailored to genetic variations.

Keywords: CYP1A2, Caffeine, Ergogenic effect, Athletic performance, Genetic polymorphisms, Cycling.

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INTRODUCTION

Caffeine (CAF) usage among elite athletes has been remarkable since its removal from the World Anti-Doping Agency's list of prohibited substances (Del Coso et al. 2011).

This is largely due to CAF being an **ergogenic aid**: a performance-enhancing substance that promotes athletic performance, improving muscle strength and endurance while decreasing reaction time and fatigue (Liddle and Connor, 2013).

Being the CYP1A2 enzyme the one in charge of the 95% of the metabolization of CAF, a particular single nucleotide polymorphism on the homonymous gene has been used to categorize individuals as "fast" (AA genotype), or "slow" (AC or CC genotype) metabolizers of CAF (Guest et. al 2021).

With that in mind, the **objective** of the present review is to examine the impact of CPY1A2 genotypes on the ergogenic effect that CAF provides for athletes.

METHOD

PubMed n=38

From other articles n=4

Scopus n=20

Total articles found n=62

Articles after 1st exclusion (non-open access) n=32

Articles after 2nd exclusion (duplicates) n=22

Articles after 3rd, and **final** exclusion (off-topic) n=16

RESULTS

ENDURANCE/ AEROBIC SPORTS

Womack et al. 2012. (n=35)	
40-km cycling 6 mg/kg	- 4.9% time on AA. + 1.8% time on CC.

Wang et al. 2023. (Review)	
2 new cycling studies. 2; 4 mg/kg	Completion time -1.7min for participants with AA. (2mg/kg)

Carswell et al. 2020. (n=18)	
15-min cycling 3 mg/kg	CYP1A2 did not affect the ergogenic effect of a 3mg/kg dose of caffeine.

Guest et al. 2018. (n=101)	
10-km cycling 4 mg/kg	-4.8/-6.8% time on AA. +13.8% time on CC.

Rahimi, 2021. (n=30)
Bench/Leg/Shoulder Press & Seated CableRow (3 sets) 6 mg/kg

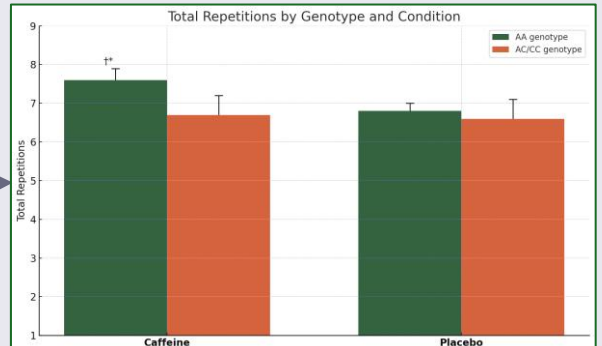
EXPLOSIVE/ ANAEROBIC SPORTS

Muñoz et al. 2020. (n=31)	
CMJ, Sprint, Grip & Shot Speed. 3mg/kg	Improvement of shot speed from 7m on AA genotype . No other interaction was found.

Puente et al. 2018. (n=19)	
Abalakov Jump 3mg/kg	No differences were found between CYP1A2 genotypes.

Grgic et al. 2020. (n=22)	
CMJ, Sprint & Bench Press 3 mg/kg	No significant differences between AA and AC/CC genotypes.

Główka et al. 2024. (n=26)	
Fight Gone Bad test 3, 6, 9 mg/kg	No interaction between genotype and performance.



CONCLUSIONS

Even though caffeine is highly proven to enhance any type of sport/exercise performance, there is some evidence that shows a tendency to improve that condition even more for "fast" caffeine metabolizers; especially on endurance exercise, like mid/long distance cycling, or extended strength training. Likewise, those with the "slow" CYP1A2 genotype might find a substantial penalty on consuming any dose of CAF from 2 to 6mg/kg prior to endurance-like competitions.

On the other hand, explosive or intermittent sports such as basketball, handball, cross fit, and any form of strength training (involving fewer than three sets to muscle failure at 85% of 1RM) show no additional benefits or disadvantages associated with AA, AC, or CC genotype.

LIMITATIONS/ FUTURE RESEARCH

1. Time appears to play a significant role on studies that demonstrate no interaction between genotype and performance, particularly in shorter tests where this interaction has not been fully studied.
2. More research on specific doses, and effects of polymorphisms in athletes would be useful to establish personalized ergogenic guidelines.
3. There's few studies focusing on the side effects of higher CAF consumption, and its potential impact on athletes depending on their genotype. Future research is needed on prevention, and risk factors to assist athletes.

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