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REVIEW

Acute effect of caffeine consumption on isotonic muscular strength and endurance: A systematic review and meta-analysis

Effets aigus de la consommation de caféine sur la force musculaire isotonique et l'endurance : revue systématique et méta-analyse

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KEYWORDS
Nutrition;
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Data analyses

Summary
Objectives. — The aim of the present study was to perform a systematic review and meta-analysis of the acute effects of caffeine ingestion on maximal strength and muscular endurance in isotonic resistance exercises.
Equipment and methods. — Up until March 2015, 17 studies which met the inclusion criteria, 42 trials related to muscular endurance and 5 trials related to muscular strength, were found from a search in the following databases: PubMed, ISI Web of Knowledge, SportDiscus, Scielo, Lilacs, Medcarib, Ibecs and ProQuest Dissertations & Theses. The effect sizes were calculated as the standardized mean difference and meta-analysis were completed using a random-effects model.
Results. — No significant effects were identified for gender, muscle location, muscle size, dosage of caffeine or form or timing of pre-exercise caffeine consumption on performance at maximum strength. For muscular endurance, all moderators were related to improve performance after caffeine intake ($P < 0.01$). The between groups analysis showed no differences with regard to the effect sizes in the comparisons for muscle location ($P = 0.09$); muscle size ($P = 0.12$);

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caffeine dosage ($P = 0.08$); and form of intake ($P = 0.24$). Effect size related to time of consumption pre-exercise was significant only for 60 min, with significant differences vs. 45 min and 90 min ($P = 0.04$). Comparisons between gender groups were not possible, since only one trial investigated females.

MOTS CLÉS
Nutrition ;
Entraînement contre résistance ;
Système nerveux central ;
Psychostimulants ;
Analyses de données

Résumé
Objectifs. — L'objectif de cette étude était de réaliser un examen systématique et une méta-analyse des effets aigus de l'ingestion de caféine sur la force maximale et l'endurance musculaire au cours d'exercices contre résistance de type isotonique.
Matériel et méthodes. — Jusqu'en mars 2015, 17 études qui répondaient aux critères d'inclusion, 42 expérimentations mesurant l'endurance musculaire et 5 centrés sur la force musculaire, ont été retrouvées lors d'une recherche dans les bases de données suivantes : PubMed, ISI Web of Knowledge, SportDiscus, Scielo, Lilas, MEDCARIB, Ibecs et ProQuest Dissertations & thèses. Les tailles d'effet ont été calculées comme la différence moyenne normalisée et une méta-analyse a été effectuée en utilisant un modèle à effets aléatoires.
Résultats. — L'analyse globale n'a montré aucun effet significatif du sexe, du type de muscle, du volume musculaire, de la dose de caféine consommée, de sa forme d'apport ou de l'heure de consommation avant l'exercice sur la force maximale développée. Par contre, tous les facteurs de modulation étudiés influent positivement sur l'endurance musculaire ($p < 0,01$). La comparaison entre groupes n'a montré aucune influence de la localisation musculaire ($p = 0,09$), de la taille du muscle ($p = 0,12$), de la quantité de caféine consommée ($p = 0,08$), ou de la forme de l'apport ($p = 0,24$). L'heure de consommation de la caféine influe sur l'endurance musculaire, avec une amélioration de l'endurance uniquement observée lorsque l'apport est programmé 60 min avant l'exercice, comparativement aux apports à 45 et 90 min ($p = 0,04$). L'effet spécifique du sexe n'a pas pu être évalué dans la mesure où un seul essai a été réalisé chez les femmes.

1. Introduction

Caffeine is an ergogenic substance and may enhance physical performance due to peripheral and central effects [1]. For instance, there is evidence that caffeine can potentialize the propagation of neural signals between the brain and neuromuscular junction and increasing the calcium release from the sarcoplasmic reticulum, which facilitates muscle contraction [2]. Caffeine can also act upon the nervous system, blocking afferent peripheral sensory pathways A2A and central adenosine A2B receptors, which can alter pain [3] and perceived exertion thresholds [4].

The literature about the ergogenic effects of caffeine concerning strength exercises is mixed. Davis and Green [1] suggested in a previous review that endurance strength exercises could have the performance enhanced by caffeine ingestion, but that this effect would not occur for maximum strength. On the other hand, a meta-analysis by Warren et al. [5] suggested that ergogenic effects of caffeine could be present in both endurance and maximum strength exercises.

It must be noted, however, that Warren et al. [5] included in their analysis trials involving different types of contraction (i.e., isotonic, isometric and isokinetic). Despite the similarities with regard to physiological mechanisms of muscle contraction, it is well accepted that different types of contraction have also distinct characteristics, which ultimately determine the specificity of muscle action [6]. Therefore, it is reasonable to assume that ergogenic effects of caffeine might be different, depending on the type of contraction performed during strength exercises.

In practical terms, exercises with isotonic contraction (i.e. exercise performed with dynamic constant external resistance) [7] are most frequently used in resistance training [7,8]. Hence, it would be of particular interest to analyze the impact of ergogenic agents upon the performance of exercises with this type of contraction. However, specific information regarding the effects of caffeine on resistance exercises involving exclusively isotonic contractions are limited and mixed. Moreover, the methods applied by available studies are very heterogeneous, which precludes the identification of common trends from their findings. For example, the dosage of caffeine may range from 3 mg/kg [9] to 6 mg/kg [10]; the interval between caffeine ingestion and exercise bouts range from 45 min [11] to 90 min [12]; and the measure of muscle performance has been made using either 1 repetition maximum (RM) [13] or repetitions until fatigue [14].

It would be useful in practical terms to analyze the effect of caffeine on the performance of exercises focusing on maximum muscular strength and endurance performed with isotonic contractions, as well as to investigate the relative role of potential moderators of this effect. The meta-analytical approach allows integrating the results of several studies, providing an overview of their effect sizes and respective moderators. Thus, the present study investigated