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Unlocking muscle health: The synergistic impact of robusta coffee and exercise on myostatin regulation

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Abstract

Myostatin is a protein in the human body that inhibits muscle growth and is implicated in age-related muscle-wasting disorders like sarcopenia. Recent studies suggest that Robusta coffee, known for its high antioxidant content, and exercise may influence myostatin levels, potentially offering therapeutic benefits for muscle health. The purpose of this literature review is to explore the effects of Robusta coffee consumption and exercise on myostatin levels and assess their potential as strategies for enhancing muscle health and managing muscle-wasting conditions. A total of 46 research papers published between the years 2019 to 2024 were accessed and used for this review that met the criteria. This review highlights that coffee consumption and exercise may show promise in lowering myostatin levels and improving muscle health.

Keywords: Myostatin; Exercise; Robusta Coffee; Muscle Health; Lifestyle

1. Introduction

Myostatin is a protein known for regulating skeletal muscle growth and metabolism. It exhibits its function as a potent inhibitor of skeletal muscle growth, in which its deficiency can increase muscle mass [1]. Myostatin contains a complex autocrine and paracrine signaling process which influences muscle mass [2]. The presence of myostatin also influences bone metabolism. In musculoskeletal disorders, muscle and bone properties have shown improvements by inhibiting the gene myostatin, which would decrease myostatin levels [3]. Such age-related musculoskeletal disorders that are related to myostatin's function include sarcopenia and cachexia [4]. Natural compounds and inhibitory peptides have been explored to inhibit myostatin, highlighting its potential as a therapeutic target for muscle-related disorders [5]. The key to understanding myostatin's structure and mechanism is vital to developing practical therapeutic approaches for managing muscle and bone-related conditions to improve overall health.

Musculoskeletal disorders such as sarcopenia are a global health concern, as seen more in older adults. It is indicated by decreased skeletal muscle mass and body function, leading to a higher risk of functional decline, falls, and mortality [6,7]. In musculoskeletal disorders, there is an imbalance between protein synthesis and degradation resulting from this disorder, which is influenced by various signaling pathways. Myostatin is crucial in sarcopenia by inhibiting muscle growth and promoting atrophy [8]. Nationwide surveys conducted in Indonesia found that the prevalence of sarcopenia varies across different studies, ranging from 17.6% to 50.25% among older adults [9,10,11]. Factors such as female sex, dependent functional capacity, fragility, and history of falls are risk factors for sarcopenia [9]. While most studies focus on elderly adults, one study established a cut-off point value for appendicular skeletal muscle mass, hand grip strength,

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and gait speed based on young adult values to define sarcopenia in older adults. However, there is limited information on sarcopenia prevalence in young or productive-age adults in Indonesia from these studies [11]. Research has shown that an increase in myostatin levels is associated with sarcopenic subjects compared to those not [12]. Myostatin level holds promise as a potential biomarker for early detection and monitoring of the recovery process of sarcopenia [13]. However, the potential of myostatin to be used as a biomarker for sarcopenia is complicated by numerous factors such as age, gender, exercise, and other disorders [14].

Coffee consumption has garnered interest among researchers recently as fitness enthusiasts integrate this beverage into their pre-training regimens. The trend of coffee consumption as a pre-workout sparked a series of questions about the potential ergogenic benefits of coffee, especially concerning its influence on muscle functioning. Robusta coffee stands out among the various coffee types due to its unique chemical and higher antioxidant contents than other types [15]. Recent studies explored the potential benefits of coffee consumption on muscle mass and physical functioning. Frequent coffee consumption has been linked to lower muscle mass prevalence and better physical functioning outcomes [16,17]. The mechanism behind these outcomes is the ability of coffee to inhibit myostatin [18]. Robusta coffee, one of the main species consumed, contains more caffeine, chlorogenic acid, and antioxidant properties than Arabica coffee species, which inhibits myostatin more [19,20]. Modifying myostatin levels through dietary interventions like coffee consumption and exercise could offer promising therapeutic avenues and enhance muscle health.

This literature review aims to synthesize current research findings on the influence of Robusta coffee and exercise on myostatin regulation and muscle health. Specifically, this review addresses the mechanism of Robusta coffee consumption and exercise on myostatin levels and the potential of myostatin as a reliable diagnostic marker for muscle wasting disorders. By addressing these objectives, this review provides a comprehensive overview of the potential benefits of Robusta coffee and its implications for muscle health. It offers insights into preventive and therapeutic strategies for managing muscle-wasting conditions.

2. Material and methods

To review the impact of Robusta coffee on myostatin levels and its implications for muscle health, Google Scholar was used to conduct the systematic literature, a web-based search engine that provides a quick and easy way to search and access published literature from articles, journals, and books. Thematic search terms in one sentence, “coffee, exercise, myostatin,” were used in the search. Another search evaluated the ergogenic contents and effects of Robusta coffee using the key terms “Robusta coffee profile, antioxidants, contents, health benefits, chemical composition.” Publications between the years 2019 and 2024 were acquired for this review. The results of the systematic review search yielded different results. Some articles had all the thematic keywords, and some were obtained that were specific to either coffee and myostatin, exercise and myostatin, or even only myostatin. By synthesizing the relevant studies, this literature review aims to provide a comprehensive overview of the influence of Robusta coffee consumption and exercise on myostatin levels and muscle health, highlighting the potential diagnostic and therapeutic implications.

3. Results

The result search at Google Scholar for information on the impact of Robusta coffee consumption and exercise on myostatin levels, a total of 5,975 results were retrieved from both thematic searches: 645 from the “coffee, exercise, myostatin” and 5330 from the “Robusta coffee profile, antioxidants, contents, health benefits, chemical composition.” Among the results obtained from the search, 3,818 were published within the years 2019-2024. Publications that reviewed the impact of Robusta coffee and exercise on myostatin levels showed 620 publications between 2019 and 2024.

However, only a total 46 articles are taken for this literature review based on the search criteria that have been mentioned above. Some of the articles retrieved for this research focused specifically on the combined impact of coffee consumption and exercise on myostatin levels. While some studies examined the individual effects of coffee or exercise on myostatin levels, others explored the broader health benefits of coffee, including its antioxidant and anti-inflammatory properties. This review also explains the health benefits of myostatin in muscle health and other fields of medicine.

4. Discussion

4.1. The potential benefits of coffee and myostatin

The potential benefits of coffee have been studied in various health contexts. One of the most consumed species of coffee is Robusta. The main contents of Robusta coffee include caffeine, chlorogenic acid, and other polyphenols, which display antioxidant properties [19]. Three major bioactive compounds in Robusta coffee have been identified as potent antioxidants: 5-CQA (caffeoylquinic acid), 4-CQA, and 3-CQA. The antioxidants have been linked with α-glucosidase inhibition and antiglycation activities, which suggests potential application in managing type 2 diabetes [21]. Other components include trigonelline, tryptophan alkaloids, and diterpenes such as cafestol and kahweol, which also influence myostatin negatively [22]. Regular coffee consumption also showed various health benefits in other aspects.

One such is that it has been proven to prevent neurodegenerative conditions such as Alzheimer's and Parkinson's disease [23]. Coffee consumption, especially from the Robusta species, in muscle health offers many benefits. Coffee silverskin extract has been proven to improve muscle mass and strength in mice by inhibiting myostatin activity [18]. A cross-sectional study of Japanese adults discovered that a higher coffee consumption rate was inversely related to low muscle prevalence. Groups that consumed more than 2 cups daily showed the lowest risk [16]. Extract of brewed Robusta coffee leaves demonstrated antioxidant effects in rats with diet-induced metabolic syndrome, thereby increasing total antioxidant status [24]. The anti-inflammatory effects can also improve skeletal muscle mass in middle-aged and older people through coffee consumption [25]. These findings suggest that coffee, particularly Robusta, may benefit muscle mass, metabolism, insulin sensitivity, and oxidative stress. Robusta coffee decreases myostatin activity, increases muscle mass, and protects it from atrophy.

4.2. Myostatin regulation

Myostatin is a protein from the TGF-β (transforming growth factor-β) superfamily that controls muscle growth and promotes muscle atrophy by activating Smad2 (Suppressor of Mothers against decapentaplegic homolog 2) and Smad3 [26]. The mechanism behind myostatin is through pathways that influence muscle cell proliferation and differentiation, muscle fiber type transformation, muscle physiology, and muscle protein synthesis and degradation [2]. It interacts with other pathways, eventually leading to the IGF-1-PI3K-Akt-mTOR (Insulin-like Growth Factor 1 - Phosphoinositide 3-Kinase - Protein Kinase B - Mechanistic Target of Rapamycin) pathway to control muscle mass. [27]. Myostatin induces muscle atrophy through the ubiquitin-proteasome system, which activates NF-κB (Nuclear Factor kappa-light-chain-enhancer of activated B cells) signaling [28]. On the other hand, muscle hypertrophy is promoted through IGF-1 signaling. It activates the Akt-mTOR pathway, which will then phosphorylate two proteins: protein ribosomal S6 kinase 1 (S6K1) is activated, and 4E-binding protein 1 (4E-BP1) is inhibited [27]. With this mechanism, myostatin inhibition has been seen as a promising therapeutic approach for muscle-wasting conditions such as sarcopenia [29]. There have been associations between myostatin levels and lean body mass, physical performance, and fratility status in elderly populations [30]. However, age, sex, physical activities, and comorbidities cause conflicting results in myostatin levels. These factors confound its use as a standalone biomarker [31]. A review has shown that muscle wasting is associated with abnormal myostatin levels in patients with rheumatoid arthritis [32]. While myostatin alone may not be a definitive marker, it can potentially become a proposed biomarker for muscle wasting disorder [31].

4.3. Exercise and myostatin

There have been mixed results for the effects of exercise on myostatin levels. Patients with a chronic disease or morbidity tend to have increased myostatin levels after exercise. The study found that resistance training increases serum myostatin contents in chronic kidney disease patients. In contrast, endurance and resistance training can reduce myostatin levels in older rats through increased IGF-1 expression [33,34]. The mechanism behind myostatin inhibition is evidenced by the activation of NF-κB signaling seen in a mouse model of Parkinson's disease when given endurance exercise [35]. Exercise such as swimming has been found to decrease myostatin levels in the metabolic syndrome model [36]. The same changes can be found with aerobic exercise in type 1 diabetic rats, where myostatin decreases, possibly due to reduced inflammatory cytokines [37]. Interestingly, plasma myostatin has been positively associated with baseline muscle mass and physical performance in chronic kidney patients. However, this relationship weakened after 12 months of exercise [38]. A systematic review that involved 26 randomized studies found that resistance training in adults effectively decreases myostatin levels, which may benefit muscle mass outcomes [39]. Overall, the effects of exercise on myostatin levels appear to vary depending on the type and intensity of exercise, and it was mostly the population that was studied. Mainly without a chronic complication, exercise in any form reduces myostatin levels after being done for a specific duration.

4.4. The synergistic combination of coffee and exercise

The lifestyle of coffee consumption as a pre-workout is quite popular among gym enthusiasts and athletes. Little research has been investigated on the potential synergistic effects of combining coffee consumption with exercise and myostatin levels. Aerobic exercise combined with green coffee supplementation significantly increased serum myonectin and meteorin-like levels in obese women, thus improving insulin sensitivity [40]. Robusta coffee consumption reduces reactive oxygen species levels of F2-isoprostane due to excessive exercise. This result indicates that Robusta coffee has antioxidant effects that protect muscle tissue [41]. Coffee consumption may enhance physical performance, thermogenesis, lipolysis, and insulin sensitivity through various mechanisms, including adenosine receptor antagonism and increased catecholamine concentrations [42]. However, the effects of dietary supplements and exercise on myostatin levels are not consistent, with some studies showing increases, reductions, or neutral effects [43]. Supplementation of epicatechin, although not typically found in significant amounts in coffee, can be seen in dried coffee leaves combined with resistance training, significantly decreased myostatin levels, leading to improved muscle strength and function in older adults with sarcopenia [44,45]. Exercise, primarily resistance and endurance training, proper nutrition, and vitamin D intake, is crucial in preventing osteoporosis and sarcopenia [46]. While these findings suggest promising interactions between exercise and coffee consumption on muscle-related factors, further research is needed to fully understand their combined effects on myostatin levels and muscle health.

This literature review provides insight into how the synergistic consumption of Robusta coffee and exercise might influence myostatin levels, but several limitations must be noted. Few of the studies were small-scale, with some containing observational methods, which limits how widely we can apply the findings. Additionally, the coffee preparation method, such as brewing to extract the contents to reduce myostatin levels, is inconsistent with most research. This can lead to different rates of extractions of coffee compounds that are needed to affect myostatin levels. There are very few studies focused on exercise and coffee consumption intervention. Future research should focus on large, well-designed trials examining the long-term effects of regularly consuming Robusta coffee alongside different exercise routines.

5. Conclusion

In conclusion, this results of research in 46 previous articles highlights that there is a potential decrease change in myostatin levels of combining Robusta coffee consumption with exercise that will affect muscle health. The decrease of myostatin levels increases muscle mass, which prevents muscle-wasting conditions such as sarcopenia from occurring. It also stresses the need for further studies to explore these interventions' long-term effects and optimal conditions. Understanding both reactions could lead to developing new strategies for preventing and treating muscle-wasting disorders, eventually improving the quality of life for individuals at risk of these conditions.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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