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Effects of chocolate consumption on the health and performance of football players: A systematic review

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ABSTRACT

Purpose of the study: Chocolate, renowned for its abundance of bioactive flavonoid compounds, is recognized as a delectable food option with purported benefits for both athletes and general population. Nevertheless, there is no consolidated overview detailing the effects of chocolate consumption specifically among football players. This review aims to elucidate the diverse impacts of chocolate consumption on football players.

Methods: A systematic search adhering to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines studies that met the inclusion criteria was conducted in the databases of Google Scholar, PubMed (MEDLINE), Scopus, Embase, and Web of Science to April 01, 2024. Forthy-eight articles were retrieved, of which nine studies met the inclusion criteria.

Results: The findings of these studies indicate that chocolate consumption is associated with a decrease in diastolic blood pressure, mean blood pressure, plasma cholesterol, Low-density lipoprotein cholesterol, malondialdehyde, urate, platelet count, mean platelet volume, and platelet distribution width. It was found to reduce intestinal permeability as well as muscle damage biomarkers such as creatine kinase, lactate dehydrogenase. Furthermore, chocolate consumption was associated with an increase in vitamin E/cholesterol ratio, antioxidant power, mean daily exercise time, heart rate, time to fatigue, physical performance, and improvement in redox status.

Conclusion: Despite the limited number of studies in this area, small sample sizes, and the presence of limitations in each study, chocolate consumption has demonstrated the potential to enhance athletic performance and recovery in football players. However, further research is essential to fully understand the scope of these effects.

Keywords: chocolate, cocoa, cocoa powder, football, soccer

Conflict of interests: the authors declare no conflict of interest.

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Спортивная Медицина: наука и практика

Влияние потребления шоколада на здоровье и результативность футболистов: систематический обзор

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РЕЗЮМЕ

Цель исследования: Шоколад, известный своим обилием биоактивных флавоноидных соединений, обладает предполагаемой пользой как для спортсменов, так и для общей популяции. Тем не менее не существует систематического обзора литературы, подробно описывающего влияние потребления шоколада, особенно среди футболистов. Целью этого обзора было проанализировать эффекты потребления шоколада на футболистов.

Материалы и методы: систематический поиск исследований, соответствующих критериям включения, в соответствии с рекомендациями Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) проводился в базах данных Google Scholar, PubMed (MEDLINE), Scopus, Embase и Web of Science с момента их создания до 1 апреля 2024 г. Найдено 48 статей, 9 исследований из которых соответствовали критериям включения.

Результаты: Потребление шоколада связано со снижением диастолического артериального давления, среднего артериального давления, уровня холестерина в плазме, липопротеинов низкой плотности (ЛПНП-Х), малонового диальдегида, уратов, количества тромбоцитов, среднего объема тромбоцитов и ширины распределения тромбоцитов, а также снижением проницаемости кишечника. Было обнаружено снижение концентрации сывороточных маркеров повреждения мышц, таких как креатинкиназа, лактатдегидрогеназа. Кроме того, потребление шоколада было связано с увеличением антиоксидантной активности, среднего ежедневного времени упражнений, частоты сердечных сокращений, времени до утомления, физической работоспособности и улучшением окислительно-восстановительного статуса, соотношения витамина Е и холестерола.

Заключение: Несмотря на ограниченное количество исследований, небольшие размеры выборок и наличие ограничений в каждом исследовании потребление шоколада имеет потенциал для улучшения спортивных результатов и восстановления у футболистов. При этом необходимы дальнейшие исследования для полного понимания масштаба этих эффектов.

Ключевые слова: шоколад, какао, какао-порошок, футбол, соккер

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1. Introduction

Football (soccer) is the most globally renowned sport, characterized by athletes executing rapid mouvements, such as high-speed sprints, quick directional shifts, leaps, and numerous tackles [1]. Furthermore, players main focus is maintaining possession of the ball while strategically positioning it on the field to secure victories [2, 3]. After engaging in these activities, football players require active recovery periods or passive rest to restore energy during competitive periods [4]. One crucial aspect of athletes' training and recovery periods, particularly for football players, involves adhering to a suitable diet and consuming appropriate foods. Proper nutrition enhances physical performance and supports the achievement of athletic goals [5, 6, 7].

Chocolate is widely regarded as a popular dietary choice among athletes, including football players due to its favorable taste and perceived benefits. These benefits include improving the recovery process, enhancing aerobic, anaerobic, and strength metrics [8–10] with improving follistatin/myostatin ratio, leptin level, body fat percentage, body fat composition [11], as well as decreased muscle soreness and intestinal permeability [12]. Pieterse et al [13] discovered that Ironman athletes experienced reductions in heart rate (HR), systolic blood pressure, and pH after consuming low-fat chocolate-flavored milk. highlighting its potential as an oral recovery solution for extreme endurance athletes. Similarly, Kocakulak et al demonstrated that consuming dark chocolate mitigated oxidative stress markers among high-intensity kickboxing athletes [14].

Furthermore, several studies conducted on non-have also revealed favorable effects of chocolate consumption. These effects include improvements in mitochondrial COX activity (cytochrome c oxidase), capillary density, leg muscle perfusion, central nucleus [15], cognitive performance and endurance in hypoxic conduitions [16], body mass, waist-to-hip ratio, fat mass, high-sensitivity C-reactive protein (hs-CRP), Tumor necrosis factor-alpha (TNF-α), Interleukin-6 (IL-6), leptin, resistin, Retinol-binding protein-4 (RBP-4), Monocyte chemoattractant protein-1 (MCP-1), irisin, adiponectin concentrations [17], and total antioxidant capacity (TAC) [18].

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Despite numerous studies elucidating the diverse effects of chocolate intake among athletes and general population, a comprehensive synthesis of its specific influence on football players remains lacking. Thus, the objective of this systematic review is to analyze the existing evidence on the varied effects of chocolate consumption among football players.

2. Materials and methods

2.1. Protocol and registration

The systematic review adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [19, 20] and ethical guidelines in sports and exercise science research [21]. Furthermore, the systematic review was registered in the international prospective systematic review database under the registration number CRD42024539612.

2.2. Data Sources and Search Strategies

This research was conducted on April 1, 2024, by searching international databases, including Google Scholar, PubMed (MEDLINE), Scopus, Embase, and Web of Science. Following the use of the keywords ("Football" OR "soccer" OR "American Football") and ("Chocolate*" OR "Cocoa Powder*"), without applying language and publication year restrictions, finally, 48 articles were obtained for review. For example, the Scopus search strategy is presented in Table 1.

2.3. Study selection

Initially, all retrieved titles and abstracts were evaluated. Duplicates were identified and manually removed. Subsequently, the remaining articles were screened based on their titles and abstracts, and relevant articles were selected. The search for published studies was then independently conducted by two authors (MMK and FA), and any discrepancies were resolved through discussion among the remaining researchers.

2.4. Data extraction and quality assessment

Following the screening process, relevant data were extracted from eligible studies using a predefined extraction template. This template included information such as author names, titles, publication years, participant demographics, intervention details, study design, and research findings. The quality of the study was evaluated for potential biases related

Table 1

Scopus search strategy

Таблица 1

Стратегия поиска в Scopus

Database	Search strategy
Scopus	(TITLE-ABS ("football" OR "American Football" OR "soccer")) AND (TITLE-ABS ("Chocolate*" OR "Cocoa Powder*")).

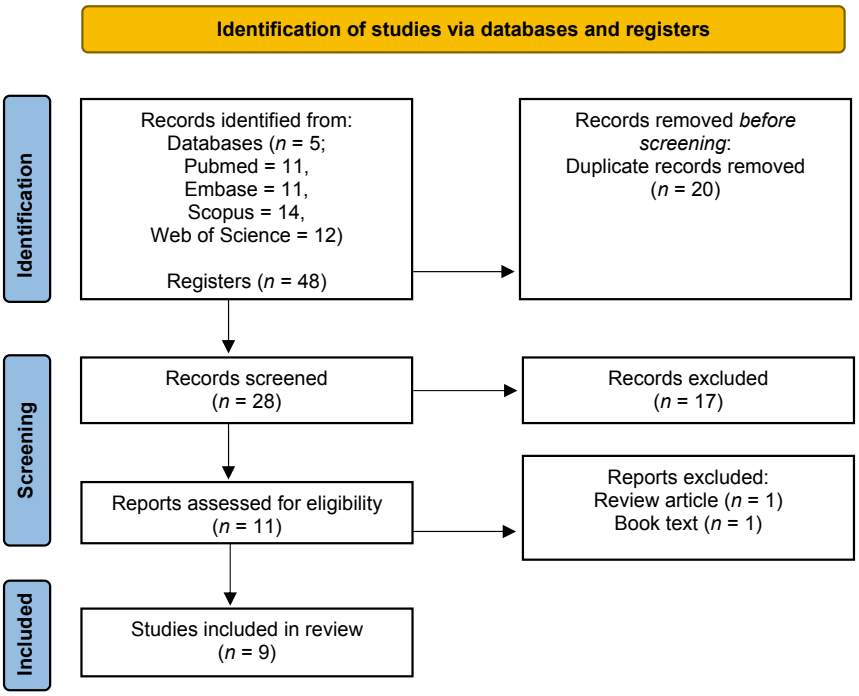

Fig. 1. Study Selection Flowchart for Inclusion in Systematic Review
Рис. 1. Схема отбора исследований для включения в систематический обзор

to randomization, blinding, and outcome assessment, utilizing the NIH Study Quality Assessment Tool for Controlled Intervention Studies [22].

3. Results

3.1. Search Selection and Inclusion of Publications

A total of 48 articles were identified through searches across five electronic databases. Upon transfer to the bibliography management software (Endnote), duplicates were automatically removed, resulting in 20 articles being eliminated. Subsequently, the titles, abstracts, and full texts of the remaining 28 articles were evaluated, leading to the exclusion of 19 articles that did not align with the research objectives, were review articles, or were part of a book. Finally, the remaining nine articles underwent comprehensive analysis and were included in this study (fig. 1). The process of article selection from the databases is illustrated in a flowchart following the PRISMA diagram.

3.2. Characterization of Studies

A total of 160 football players (8 women and 152 men) were included in this study. Eight studies only included men [12, 23–29], and one study [30] included both men and women. Three studies were conducted across European countries: Italy [12, 27] and Spain [26]; Five studies were conducted in the Americas: USA [24, 28, 30], Argentina [23], and Brazil [29]; and one article was also conducted in Asia (Iran) [25] (Table 2).

The articles were published in various academic journals, including the Journal of the International Society of Sports Nutrition (2 articles) [24, 29], Journal of Immunology Research [23], The Journal of Strength and Conditioning Research [30], British Journal of Sports Medicine [25], The Journal of Sports Medicine and Physical Fitness [26], Oxidative Medicine and Cellular Longevity [27], Nutrition [28], and Nutrients [12] (one article each).

Chocolate was consumed in different forms: chocolate milk [23, 24, 28–30], chocolate butter [23], chocolate solution [25, 26], and dark chocolate [12, 27] (Table 2).

3.3. Outcome Measurement

Studies have examined the impact of chocolate consumption on various factors associated with the risk of vascular disease, oxidative stress, and physical activity (including systolic, diastolic, mean blood pressure, plasma cholesterol levels, Low-density lipoprotein cholesterol (LDL-C) levels, malondialdehyde levels, urate activity, lactate dehydrogenase (LDH) levels and the ratio of vitamin E to cholesterol) [23]. Other parameters studied include serum creatine kinase (CK) levels, myoglobin (Mb) levels, muscle pain, fatigue rating, and isometric quadriceps strength, Maximal Voluntary Contraction (MVC) [24]. In addition, research has explored the effects on body recovery level [28, 30]; Platelet factors (platelet count (Plt), mean platelet volume (MPV), and platelet distribution width (PDW)) [25]; markers of muscle damage, oxidative stress and, physical fitness [26–28]; Sensory acceptance and digestive complaints [29]; and the rate of intestinal permeability and use [12].

4. Discussion

This review aimed to systematically evaluate studies examining the impact of chocolate consumption on oxidative stress, muscle damage, hemostatic, biochemical, hematological, and physiological changes in football players. Research indicates that the consumption of various forms of chocolate, such as chocolate milk, chocolate butter, chocolate drinks, and dark chocolate, can positively influence the physiological conditions of football players. Despite methodological differences among the studies, the results from all nine studies that met the inclusion criteria for this systematic review consistently showed that consuming chocolate in various doses can enhance muscle recovery, reduce oxidative stress, and improve athletic performance in football players.

Football is a demanding sport characterized by intense physical exercises and movements that engage various muscle groups, inevitably leading to oxidative stress and muscle damage [31]. Increased training or competition volume, when not paired with adequate recovery, can results in non-functional overreaching (NFOR). This condition is associated with reduced performance and a higher incidence of injuries, often accompanied by elevated inflammatory markers [32]. To mitigate these effects, appropriate nutritional strategies should be implemented to reduce the levels of these inflammatory markers.

Chocolate, which is rich in flavonoids and polyphenols, can effectively reduce oxidative stress and muscle damage induced by exercise because of its potent antioxidant properties [33, 34]. In this regard, studies conducted by Fraga et al. [23], Gilson et al. [24], González-Garrido et al. [26], and Cavarretta et al. [27] on football players have confirmed that chocolate consumption can enhance antioxidant capacity, thereby reducing muscle damage biomarkers such as CK and LDH, which subsequently leads to improved athletic performance. Increased endurance and heart rate observed in football players [24, 30] are additional effects of chocolate consumption. These effects are likely due to the role of antioxidants in preventing and accelerating recovery from exercise-induced fatigue [35].

Furthermore, it has been observed that following a match/training session, football athletes experience alterations in homeostatic, biochemical, and hematological parameters, which may arise from the intensity, duration, and stress associated with the exercise or competition [36, 37]. Consumption of various foods can also lead to similar changes in individuals. Studies have shown that chocolate consumption by football athletes can reduce diastolic blood pressure, mean blood pressure, plasma cholesterol, LDL cholesterol, malondialdehyde, urate activity, and LDH, as well as increase vitamin E/cholesterol [23, 25].

Milk and chocolate milk, which contain carbohydrates, protein, and other beneficial nutrients simultaneously, are popular among adults [30, 38] and adolescent athletes [40]

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Table 2

Summary of the included studies

Таблица 2

Резюме включенных исследований

Authors (year)	Population (age and sex)	Region	Study design	Supplementation protocol (type, dose, and duration)	Type of exercise	Main results
Fraga et al. (2005) [23]	28 young male soccer players (18–20 years)	Argentina	Randomized crossover study	A flavanol-containing milk chocolate (FCMC); 105 g (168 mg of flavanols)/day OR cocoa butter chocolate (CBC); 105 g (< 5 mg of flavanols)/day 14 days	Trained at least twice a week, at least for the past two years (before and during the study period, played in at least one 90-min-match per week)	Consumption of FCMC: decrease in diastolic blood pressure, mean blood pressure, plasma cholesterol, LDL-cholesterol, malondialdehyde, urate, and lactate dehydrogenase (LDH) activity, and an increase in vitamin E/cholesterol. No relevant changes in these variables were associated with CBC consumption. No changes in the plasma levels of (-)-epicatechin were observed following the analysis of fasting blood samples
Gilson et al. (2010) [24]	13 male soccer players (Mean age = 19.5 ± 0.3 years)	United States	Randomized crossover study	Isocaloric chocolate milk (CM) (504 kcal; 84 g CHO; 28 g Pro; 7 g Fat), after each ITD 4 days	One week of normal 'baseline' training followed by four days of increased training duration (ITD)	Increases in mean daily exercise time and heart rate (HR) between baseline exercise and ITD, with no difference between treatments. No treatment*time effects were observed for myoglobin (Mb), muscle soreness, fatigue rating, and Maximal Voluntary Contraction (MVC). Decreased serum creatine kinase (CK)
Spaccarotella and Andzel (2011) [30]	13 athletes (8 women, 5 men) (mean age = 19.5 ± 1.1 years)	United States	Randomized crossover study	Low-fat chocolate milk 1 g carbohydrate per kg or mean volume of 615 ± 101 ml On both days, the beverages were consumed immediately after the first practice and again 2 hours later	Preseason practice sessions for soccer	No significant differences in run time were reported for either group For men only, there was a trend of increased time to fatigue with chocolate milk compared with carbohydrate-electrolyte beverage
Soleimani et al. (2013) [25]	20 healthy male soccer players (Mean age = 22 ± 1 years)	Iran	Semi-experimental study	One dose of cocoa solution (18.75 g cocoa powder in 300 ml 4 % sucrose solution)	Bruse Test	Despite the significant increase in platelet count, MPV, and PDW after the Bruse test, cocoa consumption 2 h before the test decreased these values significantly
González-Garrido et al. (2017) [26]	15 professional male soccer players (15–18 years old)	Spain	Intervention study with pre/post-design	Cocoa (0.375 g/kg body mass in 300 mL water for 7 days [average, 25.1 g of cocoa per day])	Trained five days a week (before and during the study) and played at least one 90-min match per week in the Mexican Football Federation	Decreased muscle damage biomarkers of CK and LDH. Modified redox status by decreasing oxidative damage and increasing the total antioxidant capacity and GSH-Px activity. Increase in physical performance

Table 2. Continuation

Таблица 2. Продолжение

Authors (year)	Population (age and sex)	Region	Study design	Supplementation protocol (type, dose, and duration)	Type of exercise	Main results
Cavarretta et al. (2018) [27]	24 male elite football players (mean age = 17.2 ± 0.7 years)	Italy	Randomized Controlled Study, double-blind	Dark Chocolate/day (40 g; 20 g every 12 h) 30 days	Intensive physical exercise	Increased antioxidant power Reduction in muscle damage markers (CK and LDH)
de Carvalho et al. (2019) [28]	13 male collegiate rugby players (18–26 years)	United States	Randomized Controlled Study, double-blind	Chocolate milk (CHOC) or chocolate milk with additional cocoa flavanols (CocoaCHOC) (1 g/carbohydrate/kg/day; immediately post- and 2-h after rugby practice) 7 days	Drop jump protocol on day 5 of the intervention	No changes were observed between the groups over time for isometric torque, vertical jump performance, and yo-yo testing between trials. No interaction was found in Urinary markers of oxidative stress (isoprostanes) levels between the trials. No main effect (treatment × time) was observed for Urinary markers of oxidative stress (isoprostanes). Although not significant, the Cocoa-CHOC group ran 97 m further than the CHOC group in the yo-yo test
da Silva et al. (2021) [29]	10 male football players (mean age = 23 ± 2 years)	Brazil	Randomized Controlled Study	Low-fat, lactose-free, and leucine-enriched chocolate cow milk prototype (CML) (~ 630 mL) in aliquots at three separate moments: 50% at time 0, 30% at 45 min, and 20% at 75 min. (drink the entire offered volume quota in 5 min)	A 90-min football match simulation protocol (FMP)	Improvement in Product Acceptability Index and sensorial acceptability
Nocella et al. (2023) [12]	24 young elite male football players (Mean age = 17.2 ± 0.7 years)	Italy	Randomized Controlled Study	Dark chocolate (40 g; 20 g every 12 h) 30 days	Intensive physical exercise	Decreased intestinal permeability. Levels of LPS, zonulin, and occludin did not change

Abbreviations: FCMC: A flavanol-containing milk chocolate; **CBC:** Cocoa butter chocolate; **m:** meter; **min:** minute; **h:** hour; **g:** Gram; **mg:** Milligram; **ml:** milliliter; **kg:** Kilogram; **LDL:** Low-density lipoprotein; **LDH:** Lactate dehydrogenase; **CM:** Chocolate milk; **ITD:** Increased training duration; **HR:** Heart rate; **Mb:** Myoglobin; **MVC:** Maximal Voluntary Contraction; **CK:** Creatine kinase; **MPV:** Mean platelet volume; **PDW:** Platelet distribution width; **CHOC:** Chocolate milk; **CocoaCHOC:** Chocolate milk with additional cocoa flavanols; **CML:** Leucine-enriched chocolate cow milk prototype; **FMP:** Football match simulation protocol; **LPS:** Lipopolysaccharide.

are likely due to their combination of taste and convenience. However, lactose intolerance, gastrointestinal discomfort, and reduced appetite resulting from high-intensity training can prevent some athletes from benefiting from these valuable beverages [29, 39]. In their study, da Silva et, al. [29] found that football players who consumed chocolate as a sports drink exhibited improved product acceptance and favorable sensory acceptance. This outcome appears to be attributed to the variety of chocolate flavors [40] and the minimal occurrence of gastrointestinal discomfort reported with this supplement [41].

Although proper nutrition and dietary supplements can help prevent cell damage and increased intestinal permeability caused by exercise, the consumption of various supplements, such as antioxidants, has demonstrated ambiguous findings [42–44]. Furthermore, few studies have reported the effects of polyphenol supplements on exercise-induced intestinal dysfunction [45, 46]. Therefore, additional research is necessary to justify the incorporation of any supplement into an athlete's nutrition program. For instance, Nocella et al. demonstrated that chocolate consumption by soccer players reduced intestinal permeability

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[12]. This effect is likely due to the polyphenols in chocolate, which can modulate the intestinal microbiota, reduce oxidative stress, improve inflammatory status, and enhance intestinal barrier function [47].

Hence, it appears that various chocolate formats can enhance the physical fitness of football players by mitigating and averting muscle damage. Consequently, there is a need to underscore the significance of incorporating chocolate into prevailing sports supplement regimens to augment the performance caliber of football athletes. By enhancing players' physiological states, chocolate can amplify their athletic prowess and overall well-being during both training sessions and competitive events.

This study has certain limitations, including small sample sizes and variations in participant characteristics such as age and gender, as well as differences in the type, dosage, and duration of chocolate interventions and the outcome measures assessed in the included studies. These factors limit the generalizability of the findings. Therefore, future research should focus on standardizing participant demographics (with larger and more diverse samples), intervention types, dosages, durations, and performance, clinical, and body outcome measures, to achieve more robust and definitive results.

5. Conclusion

Based on the available evidence, this systematic review suggests that chocolate consumption can lead to favorable physiological changes during various phases of training and competition in football players. However, further research is recommended to explore the effects of chocolate consumption on different physiological conditions of football players and to uncover additional dimensions of this relationship.

Abbreviations

PRISMA: Preferred Reporting Items for Systematic Review and Meta-Analyses; **LDL-C:** Low-density lipoprotein cholesterol; **MPV:** Mean platelet volume; **PDW:** Platelet distribution width; **CK:** Creatine kinase; **LDH:** Lactate dehydrogenase; **HR:** Heart rate; **hs-CRP:** High-sensitivity C-reactive protein; **TNF-α:** Tumor necrosis factor-alpha; **IL-6:** Interleukin-6; **RBP-4:** Retinol-binding protein-4; **MCP-1:** Monocyte chemoattractant protein-1; **TAC:** Total antioxidant capacity; **Mb:** Myoglobin; **MVC:** Maximal Voluntary Contraction; **Plt:** Platelet count; **FCMC:** A flavanol-containing milk chocolate; **CBC:** Cocoa butter chocolate; **m:** meter; **min:** minute; **h:** hour; **g:** Gram; **mg:** Milligram; **ml:** milliliter; **kg:** Kilogram; **CM:** Chocolate milk; **ITD:** Increased training duration; **CHOC:** Chocolate milk; **CocoaCHOC:** Chocolate milk with additional cocoa flavanols; **CML:** Leucine-enriched chocolate cow milk prototype; **FMP:** Football match simulation protocol; **LPS:** Lipopolysaccharide; **NFOR:** Non-functional overreaching.

Authors' contribution

Mohammad Mehdi Khaleghi — conceptualization, methodology, investigation, data collection and interpretation, writing — original draft, writing — editing, visualization, project administration, and formal analysis.

Fatemeh Ahmadi — conceptualization, methodology, investigation, writing — original draft, writing — editing, visualization, project administration, and formal analysis.

Martin Hofmeister — conceptualization, methodology, investigation, writing — original draft, writing — editing, visualization, project administration, and formal analysis.

Вклад авторов:

Мохаммад Мехди Халеги — концептуализация, методология исследования, сбор и интерпретация данных, написание первой версии рукописи, редактирование, визуализация, администрирование проекта и формальный анализ.

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