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REVIEW ARTICLE

Effects of the *Withania somnifera* supplementation on sports performance: a systematic review and meta-analysis

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Abstract

Background: *Withania somnifera* has been used as an ergogenic resource in recent years. In this scenario, a systematic literature review is justified to compile the findings in the scientific literature and to evaluate the methodological quality of these investigations. **Aims:** Our objective with this review was to evaluate the effects of *Withania somnifera* supplementation on sports performance in physical exercise practitioners. **Material and Methods:** This systematic literature review with meta-analysis addresses the effects of *Withania somnifera* supplementation on sports performance. **Results:** Of the parameters evaluated in the articles, the maximum oxygen uptake was shown to improve significantly in the three studies in which it was evaluated. Maximum strength was not influenced by the supplementation. **Conclusions:** The results of the present systematic literature review showed evidence that the supplementation of *Withania somnifera* over 500 mg to 1,250 mg before or after exercise can improve physical performance.

Keywords: *Withania*, Sports, Dietary Supplements, Athletic Performance.

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1 Introduction

Withania somnifera, popularly known as Ashwagandha or Indian Ginseng is a plant native to India, used for centuries in traditional oriental Ayurvedic medicine for a variety of uses [1]. Traditional uses of *Withania somnifera* are generally aimed at increasing energy, stamina, endurance, strength [2], treating chronic diseases [3], anxiety and sleep improvement [4], reduce stress [5], among other effects [2]. *Withania somnifera* root is used as an adaptogenic, diuretic, sedative, antioxidant [6] and aphrodisiac [7]. Other parts of the plant, such as leaves and fruits, have been used as an analgesic, memory stimulant, antineoplastic agent, antimicrobial agent and anti-inflammatory agent [8]. A number of studies have tested the supplementation of *Withania somnifera* intending to increase sports performance [9-11]. Research evidences its effects, as well as pre-hormonal effects about testosterone levels, muscle hypertrophy, increased strength [12]. Maximum oxygen capacity and endurance [10], induced better performance and consequent improvement in sports practice.

Ergogenic substances have been used for centuries by athletes and athletes seeking to improve their performance within sport [13]. Used as ergogenic resources, food supplements based on macronutrients and/or micronutrients to complement the diet with a sufficient supply of them to obtain the expected results concerning sports practice, as well as pharmacological formulas, also derived from plant strata aimed at pre-existing hormonal effects that benefit exercise performance.

The interest in the use of ergogenic medicines and supplements based on natural substances such as herbal extracts has increased during the last decade [14]. In sports, most herbal or plant supplements are used to improve muscle growth and reduce body fat. In this review, we discuss the effects of *Withania somnifera* evaluated in the studies, which cover the benefits proposed by these herbs mentioned above, as a consequence of a better yield and quality of sports performance, influenced by the supplementation of *Withania somnifera*.

With the growing interest in the use of natural substances to increase sports performance [15], it is essential that health professionals know the effects already evaluated, the effectiveness of the treatment on sports performance, as well as possible side effects expected from the use of *Withania somnifera* as a food supplement. In this scenario, it is justified to prepare a systematic literature review and meta-analysis to compile the findings present in the scientific literature and assess the methodological quality of these investigations. Our objective with this review was to evaluate the effects of *Withania somnifera* supplementation on sports performance in physical exercise practitioners.

2 Material and Methods

This systematic literature review addresses the effects of *Withania somnifera* supplementation on sports performance. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method was used as a basis, to enhance the quality of the assessment of possible bias risks existing in the studies used in the research [16]. Shortly, the PRISMA statement aims to provide a robust structure for systematically and transparently reviewing studies of the desired subject matter. The PRISMA statement comprises 27 items that must be methodically followed to ensure

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the highest possible quality and in a transparent manner. The items to ensure a good quality systematic review involve a thorough introduction, method, results and supporting information of competing interests and data availability of the researchers.

The collection of information in the databases was carried out by two researchers independently, afterwards, there was a crossover to ensure greater quality in the search for scientific articles. This work was registered on the platform PROSPERO (https://www.crd.york.ac.uk/prospero/) in 2020 by ID 148861.

2.1 Population Intervention Comparator and Outcomes (PICO)

Population

The population includes active and inactive adults submitted to exercise training interventions.

Intervention

Withania somnifera supplementation. The supplementation form is determined in aqueous root extract.

Comparator

The comparator was a placebo, such as rice flour or starch capsules.

Outcomes

The outcomes of interest were observed in maximum oxygen uptake (VO_{2max}) and maximum strength (1RM test).

2.2 Eligibility Criteria

Articles published in English and Portuguese between 2009 and 2019, available on the *PubMed/Medline* (Medical Literature Analysis and Retrieval System online), *Web of Knowledge*, *SciElo* and Academic *Google* search platforms were classified as eligible. Studies with the design of clinical trials and randomized clinical trials were chosen. Case-control studies or studies that contained other actives or substances from other supplements were excluded from the search. Studies that used *Withania somnifera* in patients with any chronic disease were excluded from the analysis. Additionally, literature reviews or animal studies were excluded from the systematic review.

2.3 Search Strategy

The articles were selected after using the following isolated and combined search terms: "*Withania*", "*Withania somnifera*", "*Withania somniferas*", "*Withanias*", "*somniferas*, *Withania*", "Ashwagandha", "Dietary Supplements", "Dietary Supplement", "Supplements, Dietary", "Dietary Supplementations", "Supplementations, Dietary", "Food Supplementations", "Food Supplements", "Food Supplement", "Supplement, Food", "Supplements, Food", "Nutraceuticals", "Nutraceutical", "Nutriceuticals", "Nutriceutical", "Neutraceuticals", "Neutraceutical", "HerbalSupplements", "HerbalSupplement", "Supplement, Herbal", "Supplements, Herbal", "Supplementation", "Sports", "Sport", "Athletics", "Athletic", "Athletic Performance", "Athletic Performances", "Performance, Athletic", "Performances, Athletic", "Sports Performance", "Performance, Sports", "Performances, Sports", "Sports Performances", "MuscleStrength", "Strength, Muscle", "Exercise", "Exercises", "PhysicalActivity", "Activities, Physical", "Activity, Physical", "PhysicalActivities", "Exercise, Physical", "Exercises, Physical", "PhysicalExercise", "PhysicalExercises", "AcuteExercise", "AcuteExercises", "Exercise, Acute", "Exercises, Acute", "Exercise, Isometric", "Exercises, Isometric", "IsometricExercises","IsometricExercise", "Exercise, Aerobic", "AerobicExercise", "AerobicExercises", "Exercises, Aerobic", "Exercise Training", "Exercise Trainings", "Training, Exercise", "Trainings, Exercise", "Athletes", "Athlete", "Testosterone".

2.4 Assessment of Risk of Bias of Included Studies

Two independent researchers (F.P.D. and A.R.D.) performed a risk of bias analysis. The following categories were listed for the evaluation: random sequence generation (selection bias), selection concealment (selection bias), blinding of participants and professionals (performance bias), blinding of outcome evaluators (detection bias), incomplete outcomes (attrition bias), selective outcome reporting (reporting bias) and other relevant biases. Any difference of opinion between reviewers was taken for analysis to a third reviewer (G.P.S.).

2.5 Data Extraction

The study selection process was conducted by two reviewers independently, firstly considering the title and abstract, and then the full paper. Disagreements between reviewers were solved by discussion among four researchers. We included only full-text papers, and there will be no restriction for the date of publication and language. A customized data extraction sheet was used to extract relevant information from each included study, such as general information (first author surname, title of the study, year of publication, journal name), article study methods for measuring outcomes.

2.6 Data Synthesis

Meta-analysis was performed using a random-effect model with *Review Manager 5.4*. For these analyses, only continuous data were used, which contained mean, standard deviation and sample size. A random-effect model was used due to no studies were identical in all included investigations. Additionally, since the population varied from inactive adults to elite athletes it was decided that it could have a significant impact on the intervention effect [17].

It was considered two or more eligible studies for an outcome to generate weighted mean difference (WMD), 95% confidence interval (CI), weight percentage, heterogeneity chi-squared, *I*-squared (I^2) for variation in WMD attributable to heterogeneity, Tau-squared to estimate between-study variance and forest plot.

3 Results

3.1 Study Selection

In the pre-established databases for search, the selection of articles was carried out, considering first the title and they corresponded to the theme of this review. From 1,182 articles found, and after removing duplicate articles found in more than one database, where the number of 1,182 articles remained, the eligibility screening was performed.

1,176 articles were excluded for not meeting the parameters of interest for this review, as well as studies that used other substances in combination with *Withania somnifera*, studies with individuals with chronic diseases and studies with animals. In the end, the remaining six articles, meeting all pre-established criteria for this systematic review. The search flowchart can be seen in Figure 1.

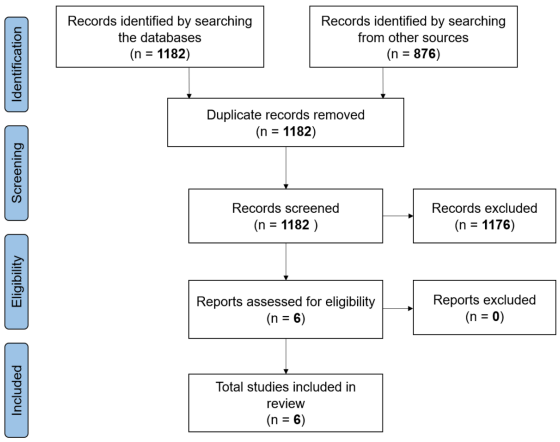

Figure 1: Search and study selection flowchart for this systematic review (PRISMA model)

3.2 Study Characteristics

An overview of the characteristics of the studies and main results are presented in Table 1. All studies used as eligibility criteria that participants were healthy and able to exercise. Of the six articles included in this review, five are randomized clinical trials. In four articles the sample is composed of both sexes and in the other two only men. Of the six articles, four were with physically active individuals, one of these four works with trained individuals (athletes and practitioners of physical exercise), and two with physically inactive individuals.

The total number of participants in this systematic review according to the sample number of all selected studies was 245 participants. The intervention with the supplement ranged from four to twelve weeks (mean 8.6 weeks). All studies used the supplementation of *Withania somnifera* in the form of an aqueous root layer. Doses ranged from 500 mg/day to 1,250 mg/day (mean 700 mg/day). The types of exercises most used during the interventions to test the effects of the herb supplementation were strength training with bench press and squats, and aerobic endurance training with treadmill running. Of the parameters evaluated in the articles, the maximum oxygen uptake (VO_{2max}) was shown to improve significantly in the three studies in which it was evaluated. The maximum strength was not influenced significantly in the two articles in which it was evaluated.

3.3 Risk of bias

In this review, of the six articles evaluated, five (83.3%) followed the randomization criteria, avoiding possible risks of bias in most studies. However, one article (16.6%) did not generate the participants' allocation sequence, and two others (33.3%) did not cover the participants' allocation, which could lead to selection biases.

In three articles (50.0%), the blinding of the participants and professional staff involved in the study was not performed or reported, and four (66.6%) did not report whether the outcome evaluators were blinded, which may result in a performance bias. In the six articles reviewed, there was no significant number of participant dropouts to the point of influencing an imbalance between the groups or significant data loss, thus, with a low risk of attrition bias. All parameters that were evaluated in each article had their outcomes reported, considering a low risk of reporting bias.

In most articles, the existence of other biases was observed, such as the lack of information on the description of the participants in one of the articles, and others with sponsorship from a supplement company and sample variability. The summary of the risk of bias analysis can be seen in Figure 2.

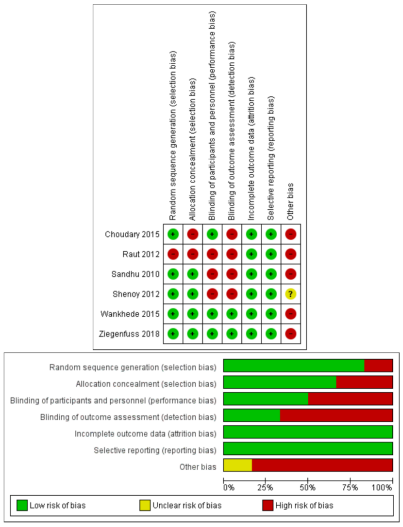

Figure 2: Risk of bias analysis of the studies selected for the systematic review. A) Risk of bias summary. B) Risk of bias graph

Table 1: Characteristics of the studies selected for the systematic review

Study	Sample	Country	Placebo	Supplement	Dosage (mg/day)	Duration (weeks)	Exercise	Parameters evaluated	Outcomes
Choudhary *et al.* (2015) [10]	(n=50) healthy active adults	India	Yes	Aqueous root extract	600	12	Shuttle-Run Test	VO_{2max} Aerobic resistance	↑ ↑
Raut *et al.* (2012) [26]	(n=18) healthy adults	India	No	Aqueous root extract	750 (10 days), 1.000 (10 days), 1.250 (10 days)	4	Resistance training	Muscle strength Exercise tolerance	↑ ↑
Sandhu *et al.* (2010) [9]	(n=40) inactive adults	India	Yes	Aqueous root extract	500	8	Running and vertical jumping	VO_{2max} Absolute potency Relative potency Maximum speed	↑ ↑ ↑ ↑
Shenoy *et al.* (2012) [8]	(n=40) adults elite athletes	India	Yes	Aqueous root extract	1.000	8	Maximum treadmill test	$\dot{V}O_{2max}$ Time to exhaustion	↑ ↑
Wankhede *et al.* (2015) [12]	(n=57) healthy active adults	India	Yes	Aqueous root extract	600	8	Resistance training	Maximum muscle strength	↑
Ziegenfuss *et al.* (2018) [11]	(n=40) active adults	United States	Yes	Aqueous root extract	500	12	Resistance training	Maximum muscle strength Muscle potency Aerobic resistance	↑ ↑ ↑

Abbreviations: ↑: increase / higher; ↓: reduced / lower; ↔: no alterations; mg: milligram; $\dot{V}O_{2max}$: maximum oxygen uptake; 1RM: One repetition maximum test.

3.4 Meta-analysis

A random-effect model of a meta-analysis of six studies was conducted to investigate the effectiveness of *Withania somnifera* supplementation on exercise performance. One study that did not have a control group was excluded from the meta-analysis.

3.5 Maximum Oxygen Uptake (VO_{2max})

Three studies investigated the outcome of VO_{2max} over the six eligible investigations. Overall, the supplementation of *Withania somnifera* appears to mildly increase VO_{2max} in adults (+ 3.45 ml/kg/min; CI = 0.30, 6.60; I^2 = 74%; *P* value = 0.03) compared to the control group (Figure 3A). The individual studies were all favorable to the intervention and their weight influence of the individual studies was similarly distributed.

3.6 One Repetition Maximum Test (1RM)

Two studies evaluated the outcome of maximum strength over the six eligible investigations. One study [26] had to be excluded from the meta-analysis for lacking a control group. Overall, the supplementation of *Withania somnifera* seems to not increase maximum strength in lower members (+ 4.95 kg; CI = 0.75, 9.15; I^2 = 0%; *P* value = 0.66) and upper members (+ 13.77 kg; CI = -0.44, 27.98; I^2 = 50%; *P* value = 0.16) in adults compared to the control group (Figure 3B and 3C).

Not all individual studies were equally favorable to the intervention and their weight influence of the individual studies was unevenly distributed.

4 Discussion

Withania somnifera is one of the main plants in traditional Indian medicine and its effects have been studied for centuries. Having evidenced activity as an aphrodisiac [18], anti-inflammatory [19], antioxidant [20] and immunomodulator [6]. However, currently, there are no literature reviews that seek to assess how plant extract supplementation impacts aerobic and anaerobic sports performance.

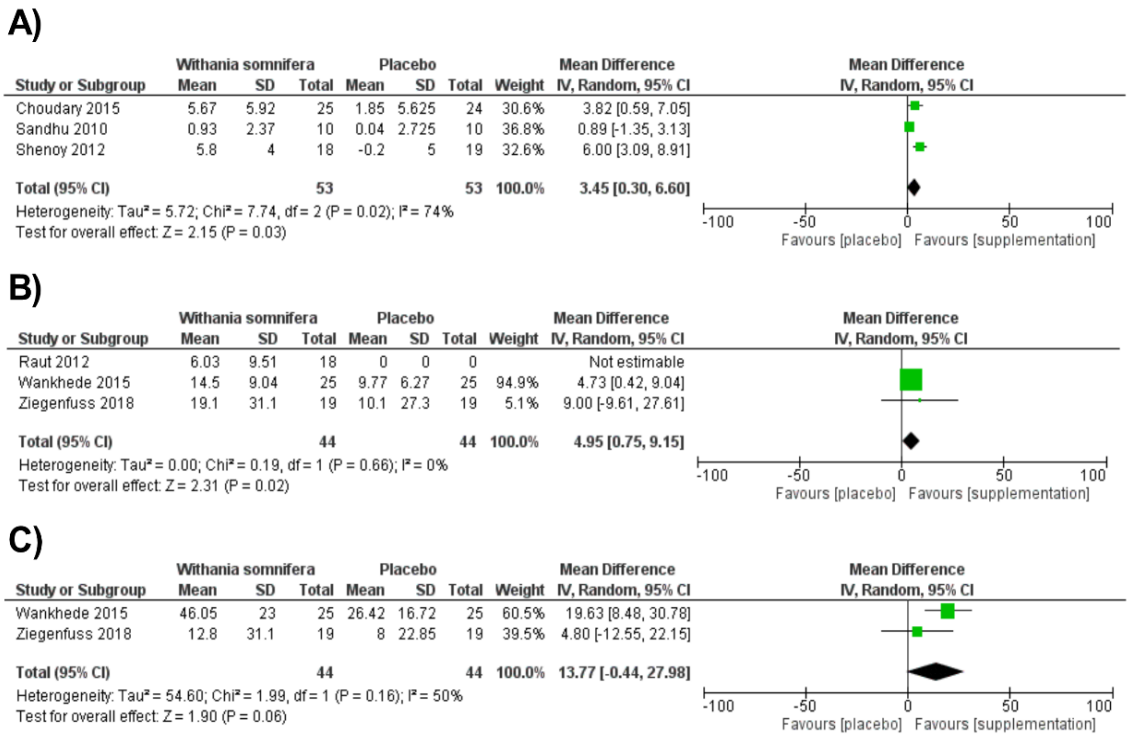

Figure 3: Meta-analysis of main outcomes. A) Effects of *Withania somnifera* supplementation on VO2max. B) Effects of *Withania somnifera* supplementation on 1RM (lower members). C) Effects of *Withania somnifera* supplementation on 1RM (upper members)

VO_{2max} is one of the most used indicators of cardiorespiratory endurance [21], determining the individual's ability to absorb, transport and use oxygen. It is a measure of long-term aerobic and cardiovascular endurance parameters [22, 23]. The use of a supplement of *Withania somnifera* in the form of an aqueous extract of the root is effective in cardiorespiratory endurance, with the VO_{2max} being increased in all the studies in which it was evaluated in this review. During a twelve-week intervention with active individuals, using doses of 600 mg/day, the VO_{2max} was estimated through a 20-meter running test, and, used as an indicator of cardiorespiratory endurance, it showed a greater increase than the group that received placebo [10].

An increase in VO_{2max} was also found in a study with inactive individuals who performed running tests and vertical jumps, after eight weeks of treatment with the supplement *Withania somnifera* (500 mg/day) [9]. Doses of 1000 mg/day of *Withania somnifera* supplementation in cycling athletes (40 male and female cyclists), measured through treadmill grade stress tests, also showed an increase in VO_{2max}, while athletes who received placebo showed no change in this parameter [9].

Strength training produces marked increases in muscle strength, attributed to a series of neurological and morphological adaptations [24]. Muscle strength measured by the 1RM test, "one-repetition maximum", refers to the maximum load that an individual can lift for an exercise cycle [25]. Exercises on machines for the chest (bench press) and lower limbs (knee extensor) were used to measure the maximum strength, through 1RM. In a study with active individuals, in which the group that supplemented *Withania somnifera* (600 mg/day) showed an increase in the maximum strength of upper limbs compared to the placebo group, in the upper and lower part of the body [12]. In another investigation [11] in which the maximum strength was also evaluated, the same exercise for the chest (vertical bench press) was used, varying in the exercise of the lower limbs (squat on the Smith machine), using the 1RM test. An increase in maximum strength in the upper and lower body was observed in the group that was supplemented with 500 mg/day doses of *Withania somnifera*.

One study evaluated upper and lower body muscle power, associating Smith machine bench press (1RM) and squat with bodyweight jump (1RM) along with *Withania somnifera* (500 mg) supplementation. The strength analyzer of strength exercises has already been shown to be a reliable means of assessing skeletal muscle power [11]. The study showed an increase in this parameter only in the supplemented group, both in the mean squat power and in the power peak during the bench press. This result reinforces the efficiency of *Withania somnifera* in improving muscle performance during resistance training, considering that

the placebo group did not demonstrate changes in muscle power. Aerobic endurance was assessed through a test in which all participants had to complete a seven-kilometer time trial on an ergometric cycle. Each participant was instructed to complete the test within the shortest possible time. The study demonstrated that the supplemented group performed better than the placebo group, by completing the test in less time [11].

Supplementation of *Withania somnifera* (500 mg) combined with vertical jumping exercises showed an increase in the parameters of the mean absolute and relative power of the lower limbs. The systematic measurement system was used to measure these parameters during physical exercise [9]. The same study used a similar systematic measurement system to measure maximum speed through running tests, resulting in an increase in this parameter in individuals who supplemented with *Withania somnifera*, after eight weeks of intervention. The balance parameter (contact with the floor and no contact time) was also evaluated, considered as an ability to maintain the center of gravity within the support base with minimal postural sway. However, in this last parameter, no increase in physical performance was observed.

The supplementation of 600 mg of the aqueous extract of *Withania somnifera* root, divided twice a day, combined with a strength training program caused an increase in the muscle area of the thigh, chest and biceps [11]. Participants in the supplemented group had 135% greater growth in the skeletal muscle domain of the pectoral than the placebo group, and the biceps muscle showed an approximately 70% greater increase in muscle area, compared to the placebo group.

Incremental doses of *Withania somnifera* were tested in healthy individuals, using three different portions (750 mg, 1,000 mg and 1,250 mg) of the root aqueous extract, over four weeks [26]. An increase in lean mass was observed in all visits, with an average increase of one kilogram of lean mass per week. Using the same method, it was concluded that there was a progressive reduction in body fat, with no change in total body mass. Constant doses also showed a significant result on the percentage of body fat, showing an average reduction of 3.4% in body fat mass over eight weeks, with the use of 600 mg of the supplement. The stress imposed on the muscle as a result of physical activities has been evaluated by measuring creatine kinase (CK) concentrations in the bloodstream [27].

Muscle recovery was assessed using this method in a study [12], in which, the researchers submitted the participants to a blood test and used as a reference the plasmatic concentrations of CK, analyzing the values 24 and 48 hours after the physical exercise imposed in the research, to monitor the muscular damage of the skeletal muscle. The main finding of the research was due to the increase in the level of CK circulating in the bloodstream of supplemented individuals compared to levels before the intervention. For this reason, the work raised the hypothesis that the supplemented individual would have faster skeletal muscle recovery after physical exercise than consuming a placebo.

The number of studies in the scientific literature on the effects of *Withania somnifera* on sports performance, so far, is still very scarce, limiting conclusions about its efficiency. The intervention times of the studies are limited to twelve weeks, limiting the supplement's effects within a short period. Most studies were carried out with active and inactive individuals, with little evidence with trained individuals and athletes, who experience the sport intensely for a long time. We imagine that training time could be a crucial factor and could make a difference in results with the use of the supplement. Another limitation is the gender and age of the participants, as most samples are composed of a young and male audience.

5 Conclusions and recommendations

The results of the present systematic review and meta-analysis showed evidence that the chronic use, for more than 30 days, of oral supplementation with *Withania somnifera*, with doses between 500 mg and 1,250 mg, before or after exercise, can improve physical performance in practitioners of physical exercise, especially concerning cardiorespiratory fitness. For muscle strength outcomes, there was no positive effect of supplementation with *Withania somnifera* in adults. However, the literary collection with studies evaluating the effects of *Withania somnifera* on physical activity is limited. Therefore, we believe that more studies are needed that seeks to explore the effect of supplementation with *Withania somnifera* in different populations and using different training programs.

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Author contribution: F.P.D., A.R.D., G.P.S. conceived and designed the study, and undertook the literature research. All authors participated in the experiment and data acquisition. F.P.D., A.R.D., G.P.S. performed the data analysis. G.P.S. carried out the statistical analysis, prepared, reviewed and drafted the manuscript. All authors approved the final version before submission. All authors have read and agreed to the published version of the manuscript.

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