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Systematic Review

The Combined Effect of the Mediterranean Diet and Physical Activity on the Components of Metabolic Syndrome in Adults: A Systematic Review of Randomised Controlled Trials

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Abstract

Metabolic syndrome (MetS) is a global public health challenge, characterized by the coexistence of cardiometabolic risk factors such as abdominal obesity, dyslipidaemia, hypertension, and insulin resistance. Non-pharmacological strategies, including the Mediterranean diet (MD) and physical activity (PA), have been widely studied for their potential to prevent and manage MetS. This systematic review aimed to synthesize the evidence on the combined effect of MD and PA on MetS components in adults, based on randomized controlled trials (RCTs). Twenty-two RCTs published between 2018 and 2024 were included, involving 11,478 participants. The interventions ranged from 8 weeks to 3 years and combined adapted or hypocaloric MDs with moderate-to-high-intensity PA, typically including walking, aerobic exercise, or high-intensity interval training (HIIT), performed 3 to 7 times per week. The combined interventions resulted in reductions in body weight (−2.5 to −7.2 kg), body mass index (−0.7 to −2.2 kg/m^2), waist circumference (−5.1 to −7.8 cm), and blood pressure (up to −9.0 mmHg systolic and −6.7 mmHg diastolic). Improvements in HDL cholesterol, triglyceride levels, and insulin sensitivity were also observed. These findings suggest that integrated interventions based on the Mediterranean lifestyle are effective in reducing MetS components and may support future public health strategies.

Keywords: mediterranean diet; physical activity; metabolic syndrome; cardiometabolic risk; insulin resistance; abdominal obesity; randomized controlled trials; systematic review

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1. Introduction

1.1. Physical Activity

Physical activity (PA) is defined as any bodily movement produced by the skeletal muscles that results in energy expenditure above resting levels. This practice can take place in a variety of contexts, such as leisure, work, commuting and household chores, and is widely recognized for its beneficial effects on physical and mental health. As well as improving cardiorespiratory capacity and body composition, regular PA is associated with a reduced risk of chronic diseases, including the components of Metabolic syndrome (MetS) [1,2].

Adopting lifestyle changes, such as regular PA, is widely recognized as the main non-pharmacological approach to controlling MetS [3]. According to the World Health Organization (WHO) guidelines [1,2], it is recommended that all adults perform between

150 and 300 min of moderate-intensity PA per week, 75 to 150 min of vigorous-intensity PA, or an equivalent combination of moderate- and vigorous-intensity aerobic exercise to promote health benefits. However, insufficient PA remains a significant global problem, and identifying effective exercise protocols that are enjoyable and optimize time can be a powerful strategy to encourage uptake and adherence to physical practice, which in turn can reduce the negative health consequences of MetS and promote a healthier and more sustainable lifestyle [4].

1.2. Mediterranean Diet

The Mediterranean Diet (MD) is a dietary pattern inspired by the traditional foods and drinks of the countries around the Mediterranean Sea [5]. The common features that characterize the MedDiet are defined as (a) daily consumption of unrefined cereals and other products (e.g., wholemeal bread, wholemeal pasta and brown rice), fresh fruit, vegetables, nuts and low-fat dairy products; (b) olive oil as the main source of lipids; (c) moderate intake of alcohol, preferably red wine, with meals; (d) moderate consumption of fish, poultry, potatoes, eggs and sweets; (e) monthly consumption of red meat; and (f) regular PA.

In recent decades, this dietary pattern has been widely documented in scientific literature as one of the healthiest diets and is consistently associated with the prevention of chronic diseases and increased longevity [6]. UNESCO considers MedDiet to be an intangible cultural heritage, given the responsible interactions between agricultural and food practices and the environment [7].

DM is widely recognized not just as a healthy eating pattern, but as an integrated lifestyle that encompasses both a balanced diet and regular PA. Adherence to this model is strongly associated with reduced risk of chronic diseases and increased longevity. The MedDiet, characterized by high consumption of fresh, natural and minimally processed foods, is accompanied by daily habits that include regular PA, such as walking and manual labour, which are common in traditional Mediterranean culture. These habits promote additional benefits for metabolic and cardiovascular health, reflecting the positive interaction between diet and PA as essential components of this lifestyle [8].

Lifestyle interventions, including changes in diet and PA, play a crucial role in the prevention of MetS. In fact, the NCEP ATP III has already suggested a dietary intervention to prevent this epidemic [9]. Diets rich in whole grains, fruit and vegetables and low in animal fats seem to help prevent cardiovascular disease risk factors such as hypertension, hypercholesterolemia and obesity [10].

1.3. Metabolic Syndrome

MetS is a complex, multifactorial condition characterized by the presence of cardiometabolic risk factors, including hyperglycemia, high blood pressure (BP), dyslipidemia (high triglycerides, low levels of high-density lipoprotein (HDL) cholesterol) and central obesity [11].

The prevalence of MetS has increased globally, representing a significant public health challenge due to its association with an increased risk of serious chronic diseases, which are the world's leading causes of morbidity and mortality [12]. The high prevalence of MS is also linked to the global increase in obesity rates and sedentary lifestyles, contributing to a higher incidence of metabolic complications, loss of quality of life and reduced productivity [13].

Although the exact cause of MS is not yet fully known, it is believed to result from a complex interaction between genetic and behavioural factors [14]. Aspects such as an unbalanced diet and physical inactivity play important roles, contributing to the development of obesity, which is widely recognized as a central element in the pathophysiology of MetS [15].

These factors increase the economic impact on health systems and create inequalities in access to treatment and prevention, highlighting the urgent need for effective public health interventions [16]. This economic pressure on health systems is compounded by the high prevalence of MS, especially in populations with sedentary lifestyles and high rates of obesity, highlighting the need for effective prevention and management policies that reduce the costs and social impact of this condition [17–19].

1.4. Impact of Physical Activity and the Mediterranean Diet on Metabolic Syndrome

The combined impact of PA and DM on MetS has been widely investigated, demonstrating positive results in controlling and reducing its components. Regular PA, as indicated by the WHO [1,2], is fundamental in the prevention and control of MetS, helping to improve insulin sensitivity, reduce BP and cholesterol levels, and promote weight loss.

Studies show that combining physical exercise with a balanced diet, such as DM, can amplify the benefits for metabolic health. Guasch-Ferré and Willett [20] point out that integrating both practices results in significant improvements in cardiovascular risk factors, glycemic control and reduced inflammation, providing a synergistic effect in the prevention of chronic diseases. In addition, Castro-Barquero et al. [10] show that the combination of DM and PA can improve the lipid profile, reduce abdominal obesity and optimize glycemic control, which are fundamental factors in the management of MS. Martínez-González et al. [7] also reinforce that this integrated approach is associated with a significant reduction in the risk of cardiovascular disease and type 2 diabetes, proving that the combination of healthy eating and physical exercise offers a more effective impact on overall health than either factor alone.

The MedDiet, characterized by a high consumption of fresh and natural foods such as fruit, vegetables, whole grains and olive oil, has been associated with a reduction in cardiovascular risk factors and the prevention of metabolic diseases [5,7]. This diet has shown beneficial effects in reducing abdominal obesity, controlling glycaemia and improving lipid levels, crucial factors in the management of MetS [10,11]. Furthermore, when these interventions are combined, the evidence suggests a synergistic effect, providing an effective approach to combating MetS and its complications [20].

The inclusion of behavioural support, such as nutritional and motivational counselling, has also been shown to be an important factor in increasing adherence to these interventions, maximizing the benefits for metabolic health [4]. Strategies such as individualized nutritional counselling, health education sessions, setting realistic goals, continuous monitoring and positive reinforcement are often used to improve participant engagement and promote health self-management [21,22]. These approaches are key to facilitating sustained changes in health behaviour and have been associated with better results in interventions aimed at preventing and controlling MetS. Such behavioural approaches are key to overcoming common barriers such as lack of motivation, limited time or difficulty in changing ingrained habits. Studies indicate that interventions that include psychological and motivational support, using techniques based on behavioural theories such as Motivational Interviewing and Self-Determinism Theory, are more effective in reducing MetS risk factors [21,23].

Although the literature already has a systematic review on this topic, the rapid evolution of scientific evidence justifies a new analysis of the combined effects of DM and PA on the components of MetS. The continuous advance of scientific production in the area justifies the need for a new synthesis of the available evidence [24]. Since the publication of the previous review, new randomized clinical trials have been conducted, using different methodologies, populations and intervention protocols. In addition, this review proposes a more comprehensive approach by including interventions that, in addition to diet and PA, incorporate behavioural support strategies such as educational counselling and motivational support—components with the potential to increase adherence and the effectiveness of interventions.

The inclusion of Randomized Clinical Trials (RCTs) in this systematic review, together with the detailed analysis of the duration, frequency and intensity of the programmes, allows for a more robust assessment of the effects of DM and PA on the components of MetS. Randomized clinical trials are considered the gold standard in research due to their methodological rigour, which minimizes bias and allows for the most accurate comparison between interventions. The specific analysis of these variables—such as the duration of the programmes, which can influence the magnitude of the effects observed, and the intensity of PA, which is a determining factor for metabolic health benefits—offers a more precise view of the underlying mechanisms and long-term effects of this combined approach. This detailed approach allows for a more up-to-date and rigorous evaluation of interventions, offering more accurate data for clinical practice and for the development of public health policies that promote the prevention and control of MetS. Thus, this systematic review aims to update, especially regarding understanding the impact of the combination of diet and exercise on the prevention of metabolic diseases, and to provide more concrete guidelines for evidence-based interventions.

2. Materials and Methods

2.1. Information Sources and Search Strategies

A systematic search for articles was carried out between April 2018 and October 2024 in the following databases: PubMed, Web of Science and Scopus. The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO; CRD42024604823). The descriptors used were terms related to DM, PA or exercise, metabolic risk factors and randomized clinical trials. Table 1 shows the content of the research.

Table 1. Research strategy.

Search Number	Research Content
1	"Mediterranean diet" or "mediterranean lifestyle" or "meddiet score" or meddiet or "mediterranean style diet" or "mediterranean diet score" or "mediterranean diet index" or "mediterranean dietary pattern" AND Exercis* or training or physical activit* or sport* AND "metabolic risks" or "metabolic risk" or "metabolic markers" or "metabolic syndrome" or "cardiovascular disease" or CVD or "cardiovascular risk factors" or "cardiovascular disease risk" or "cardiovascular disease risks" or "vascular markers" or adiposity or overweight or obesity or obese or "body weight" or "body composition" or BMI or "body mass" or "fat mass" or "waist circumference" or weight or "blood pressure" or cholesterol or triglycerides AND Intervention* or "controlled trial" or "controlled trials" or rct* or "randomized controlled trial" or "randomized controlled trial"

*: wildcard character.

2.2. Eligibility Criteria

The following inclusion criteria were used to select the studies: (i) RCT-type studies; (ii) studies published between 1 April 2018 and October 2024; (iii) studies written in English, Portuguese or Spanish; (iv) studies that analyzed combined interventions based on DM and PA practice, regardless of the duration, frequency or intensity of the interventions;

(v) studies that could additionally include behavioural support strategies or educational counselling; (vi) participants aged 18 years or over; (vii) studies that had at least one of the components of MetS as their primary or secondary outcome (for example: abdominal circumference, BP, fasting glycaemia, triglycerides or HDL-cholesterol).

Likewise, exclusion criteria were drawn up, taking into account: (i) studies that were not randomized clinical trials; (ii) studies that analyzed only one of the interventions (only diet or only PA); (iii) studies conducted with children, adolescents, athletes or individuals with serious chronic diseases, such as cancer or advanced renal failure; (iv) grey literature, such as dissertations, theses, conference abstracts, editorials and letters to the editor; (v) systematic reviews and duplicate studies.

2.3. Data Extraction Process

The study was carried out independently by two researchers, who downloaded all the studies from the databases into the ENDNOTE X7 software and eliminated duplicate articles. Initially, the articles were excluded by reading the titles and abstracts. In the second phase, the articles were read in full and those that did not fulfil the previously established eligibility criteria were excluded, leaving only 893 articles. The results of all the phases were compared (LT and MJ). One of the researchers (LT) exported the relevant information from the articles (authors, year of publication, continent, parents, participants, intervention, variables assessed, results and methodological quality).

2.4. Methodological Quality Assessment

The methodological quality of the studies included in this systematic review was assessed using the RoB 2 (Risk of Bias 2.0) tool proposed by the Cochrane Collaboration and recommended for randomized clinical trials. This tool analyses the risk of bias in five main domains: (1) bias in the randomization process; (2) bias due to deviations from the intended intervention; (3) bias due to missing outcome data; (4) bias in the measurement of the outcome; and (5) bias in the selection of reported results. For each domain, the risk of bias was classified as low risk (+), some concern (–) or high risk (x), according to the criteria established by the tool itself. The methodological quality of the studies was measured independently by two reviewers (LT and MJ), and they were compared and discussed to reach a consensus. The scores awarded to each study are shown in Table 2.

Table 2. Risk of bias analysis for randomized studies (Cochrane Collaboration tool).

Studies	1	2	3	4	5	Total
Martínez-Rodríguez et al. [25]	–	+	+	+	+	–
Pineda-Juárez et al. [26]	+	+	–	+	+	–
García-Gavilán et al. [27]	+	+	+	+	+	+
Montemayor et al. [28]	–	+	+	+	+	–
Rabiee et al. [29]	x	–	–	+	+	x
Tussing-Humphreys et al. [30]	+	+	+	+	+	+
Pavić et al. [31]	–	+	–	+	+	–
Rumbo-Rodríguez et al. [32]	+	+	+	+	+	+
Schröder et al. [33]	+	+	+	+	+	+
Monserrat-Mesquida et al. [34]	+	+	+	+	+	+
Panizza et al. [35]	+	–	+	+	+	–
Ficarra et al. [36]	–	x	+	+	–	x

Table 2. *Cont.*

Studies	1	2	3	4	5	Total
Greco et al. [37]	–	x	+	+	–	x
Monsalves-Álvarez et al. [38]	+	–	+	+	+	–
Barbosa et al. [39]	+	–	+	+	+	–
Candás-Estébanez et al. [40]	–	x	+	+	–	x
Prats-Arimon et al. [41]	–	x	–	–	–	x
Soldevila-Domenech et al. [42]	+	x	+	+	+	x
Sanllorente et al. [43]	+	x	+	+	+	x
Pérez-Veja et al. [44]	+	x	+	+	+	x
Hernando-Redondo et al. [45]	–	x	+	+	–	x
Hassapidou et al. [46]	+	–	x	–	x	x

Notes: the risk of bias was classified as low risk (+), some concern (–) or high risk (x).

3. Presentation of Results

3.1. Selection of Studies

After searching various databases, 1351 studies were identified. In the first phase, duplicate articles were eliminated after reading the titles and abstracts (i.e., articles that did not have a controlled experimental design, such as non-randomized trials, observational studies or that did not provide clear quantitative data for the primary outcomes). After this phase, 69 studies with relevant potential for the study were identified and moved on to the next phase. Considering the eligibility criteria established and the reading of the articles, a sample of 22 studies was constituted for full analysis. Of the studies eliminated, 47 were considered unreadable due to non-randomization and studies that did not have a PA intervention programme. See Figure 1.

3.2. Studies Characteristics

3.2.1. Origin

The studies analyzed showed a wide geographical diversity, with a strong predominance of research carried out in European countries. Spain stood out as the country with the highest number of publications in a total of 12 studies [25,27,28,32–34,40–45]. Other European countries were also represented, such as Portugal [39], Croatia [31], Italy [36,37], Greece [46]. In addition to the European continent, the research included studies carried out in Mexico [26], the United States [30,35], Chile [38] and Iran [29], demonstrating a global interest in the subject under investigation. This varied geographical distribution reinforces the international relevance of the results and suggests possible regional differences in the application of the interventions studied.

3.2.2. Participants

The studies included participants of varying ages, ranging from young adults to the elderly. Most of the research focused on adult populations, with average ages ranging from 35 to 70.

Participants of both sexes were recruited in 17 of the 22 studies analyzed, which represents the majority of the investigations [27,28,30–36,38–45].

Five studies recruited only women [25,26,29,37,46] and no study included only men, evidencing a gap in males in clinical trials focusing on DM and PA applied to MetS.

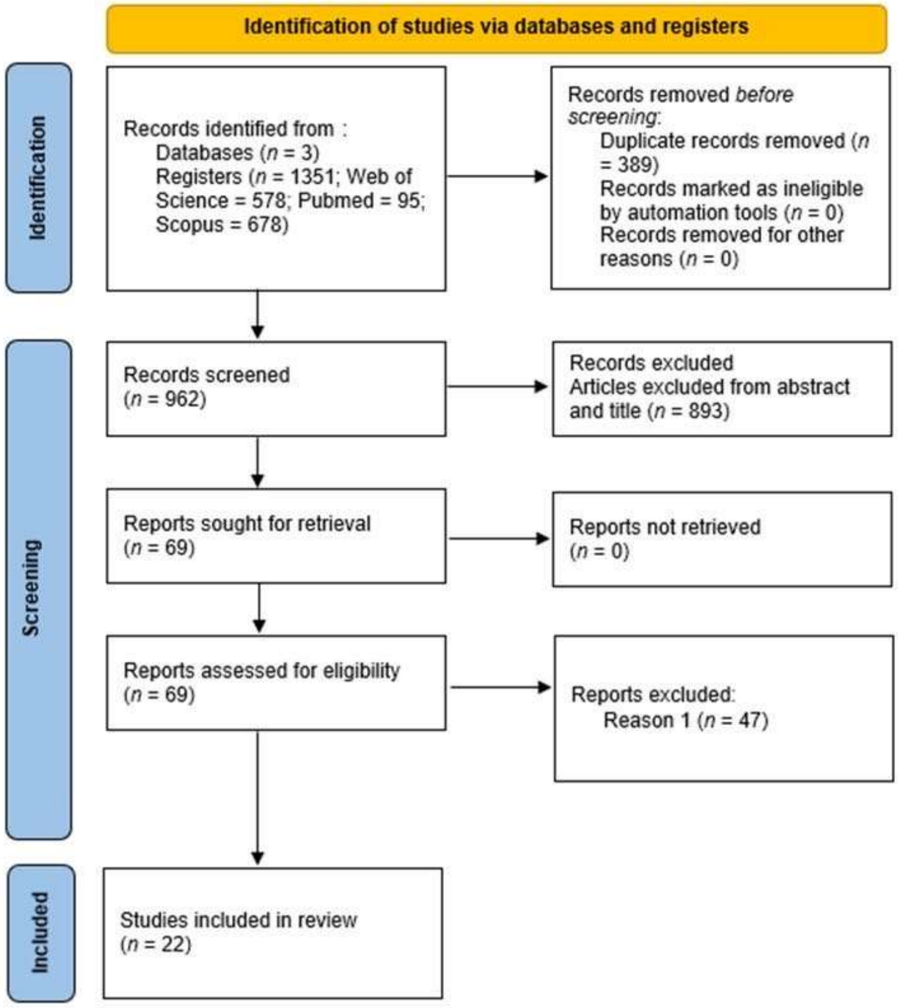

Figure 1. PRISMA 2020 flow diagram for new systematic reviews including searches of databases and registers only.

In terms of sampling, the sizes varied, with small samples as in Ficarra et al. [36] (*n* = 22) and Greco et al. [37] (*n* = 35), to large studies such as Schröder et al. [33] (*n* = 6874) and Hassapidou et al. [46] (*n* = 4026). The distribution between the intervention and control groups was balanced in most cases.

The studies totalled approximately 11,478 participants, of whom around 5816 were allocated to groups with a combined DM and PA intervention, while the remaining 5662 made up the control groups, which varied between diet without calorie restriction, no exercise, or basic education with no active intervention. Some of the studies included in this review had three or more intervention groups, which required a specific division between different experimental groups in order to compare the isolated and combined effects of DM and PA [26,28–30,38,39], allowing for different analyses between the groups that received only diet, only exercise or a combination of both.

3.2.3. Interventions

Mediterranean Diet

The nutritional interventions based on the MD showed considerable variation across the included studies, both in terms of dietary composition and caloric restriction, meal structure, behavioural support, and the format of follow-up. Most interventions aimed to adapt the traditional principles of the MD to different cultural contexts and clinical profiles, with a focus on promoting weight loss, improving metabolic parameters, and reinforcing healthy long-term habits.

Many studies have implemented DM with calorie restriction (er-MedDiet), generally reducing the participants' daily energy needs by between 25 and 30 per cent [27,30,34,36–38,40,42–45]. These interventions maintained the principles of DM (high consumption of vegetables, fruit, whole grains, olive oil and fish; reduction in red meat, sweets and ultra-processed foods), but with strict energy control to promote weight loss.

On the other hand, other studies have chosen to apply ad libitum DM, without explicit calorie restriction, focussing on food quality. DM ad libitum is characterized by the absence of strict calorie control, allowing individuals to eat freely within the principles of the Mediterranean pattern, prioritizing the quality of the food consumed [47]. This approach was used by Schröder et al. [33], Pavic et al. [31], Panizza et al. [35], Pineda-Juárez et al. [26], Martínez-Rodriguez et al. [25] and Rumbo-Rodriguez et al. [32]. The strategy made it possible to assess the effects of DM, without the interference of energy deficit, compared to the effects of combining it with PA or other dietary patterns.

Studies have incorporated educational programmes and structured nutritional counselling as a fundamental part of the intervention, in individual and group sessions [25,30–32]. On the other hand, other studies have complemented the process with behavioural, culinary and psychological support [34,41,42]. Strategies such as goal setting, dietary monitoring, cooking workshops and reinforcement of adherence by health professionals were common among the studies that sought sustainable lifestyle changes.

Different levels of individualisation of the diet plan have also been observed and have adapted Mediterranean diets based on individual anthropometric characteristics and energy expenditure, personalizing macronutrient and calorie recommendations [36,37,46]. In the study by Panizza et al. [35], a cultural adaptation of the DM to the local context (Hawaii) was also observed, incorporating regional foods such as papaya, mango and tofu, while maintaining the nutritional structure of the Mediterranean standard.

In terms of macronutrient distribution, most of the hypocaloric interventions evaluated followed a balanced composition aimed at improving metabolic parameters. Fat intake represented between 30 and 40 per cent of the total energy value (TEV), with priority given to unsaturated fats—especially monounsaturated fats, such as oleic acid found in olive oil, and polyunsaturated fats, such as omega-3 and omega-6 fatty acids, found in fish, seeds and nuts. These fats are associated with cardioprotective effects, such as improving the lipid profile and reducing inflammation [47,48]. On the other hand, saturated fats (common in processed meats, whole dairy products and industrialized products) and trans fats were restricted due to their negative impact on cardiovascular health, including increased LDL-cholesterol and the risk of adverse metabolic events [49]. Protein intake varied between 20% and 25% of the VET, favouring satiety and the preservation of lean mass during calorie restriction, while carbohydrates generally corresponded to 40–50% of the VET, prioritizing sources with a low glycemic index, such as whole grains, legumes and vegetables, with the aim of promoting greater glycemic control and an attenuated insulin response [48]. These proportions have been explained in studies such as those by [28,34,35,37].

Some interventions also applied modified versions of the MD, as in the study by Barbosa et al. [39], which incorporated principles of the planetary diet (EAT-Lancet diet) into the MD, emphasizing vegetarian meals, overnight fasting, a reduction in red meat and greater consumption of legumes. Other variations included DM with high meal frequency [28] and intermittent energy restriction strategies [35].

The included studies applied DM in terms of its core dietary principles, but with different levels of energy restriction, individualisation, educational complementation and behavioural support, reflecting the flexibility and adaptability of this approach in different clinical and cultural contexts.

Physical Activity

The PA interventions demonstrated wide variability across the included studies. The protocols involved moderate-intensity aerobic exercises, regular walking, and, to a lesser extent, supervised or high-intensity activities.

Eight studies adopted walking or light-to-moderate aerobic exercises as the primary form of physical intervention, recommending between 30 and 60 min of daily walking or equivalent exercises, typically five to seven days per week [31–33,40,43–46]. The common goal was to achieve at least 150 min of moderate-intensity PA per week, in alignment with the WHO guidelines.

Another group of studies incorporated interval or high-intensity exercises, such as High-Intensity Interval Training (HIIT) protocols aimed at optimizing energy expenditure in a shorter amount of time. Structured HIIT protocols involved running or cycling exercises designed to reach intensities above 85% of maximum heart rate. These interventions were of short duration per session (20–30 min), but required high physical effort, and were combined with hypocaloric diets following the Mediterranean pattern [29,38].

In addition, some studies implemented supervised training in controlled environments with qualified professionals, which ensured greater precision in intensity control and safety of practice. Martinez-Rodriguez et al. [25] used supervised aquatic resistance training, while Tussing-Humphreys et al. [30], Barbosa et al. [39] and Prats-Arimon et al. [41] offered regular supervised sessions with technical and behavioural support. Greco et al. [37] also incorporated partial supervision into their online Pilates programme, with one out of every three weekly sessions guided by an instructor. These protocols typically included ongoing performance evaluation and adjustments to exercises according to individual progress.

The standardized recommendation of PA without direct supervision has been observed in several studies [27,28,34,35,42]. In these cases, the participants were given general guidelines to practise PA regularly (walking, aerobic exercise, among others), with targets for steps/day or weekly minutes of exercise, but without systematic monitoring by professionals or real-time intensity control.

Behavioural Support

Notable among the studies were those that combined structured behavioural interventions with the encouragement of PA practice, incorporating behaviour change techniques such as goal setting, activity logging, and educational reinforcement sessions [30,34,40–42]. These strategies contributed to increased adherence to exercise recommendations and promoted sustainable lifestyle changes.

3.3. Duration, Frequency, and Timing of Interventions

The studies analyzed show a wide variation in the duration, frequency and intensity of interventions related to PA and nutrition. Most of the studies used intervention periods of between 13 weeks and 3 years, with a predominance of studies lasting 12 months [27,28,33]. Shorter interventions, lasting between 8 and 12 weeks, have been observed in intensive protocols such as high-intensity interval training [29,36,38]. On the other hand, long-term studies (≥6 months) prioritized moderate and sustainable activities, such as brisk walking (≥45 min/day) and programmes based on WHO guidelines (≥150 min/week of moderate activity), as evidenced in the studies by Monserrat-Mesquida et al. [34] and Sanllorente et al. [43].

With regard to weekly frequency, it was observed that three sessions per week were the most common among the included studies [25,28,29,36–38], reflecting a preference for structured physical exercise protocols with moderate frequency, while interventions with greater adherence to daily exercise (5–6×/week) were less frequent but present in studies that emphasized a continuous PA routine [31,33]. As for the duration of the sessions, there was a significant variation: from 20–25 min in HIIT protocols [29,38] to prolonged sessions (≥120 min) in combined exercise and nutrition education programmes [39].

Moreover, multidisciplinary interventions that integrated PA, diet, and behavioural support were predominant in studies lasting longer than six months [42,46]. These programmes often included periodic assessments (e.g., baseline, 6 months, 12 months) to monitor adherence and effectiveness [40,45].

Although interventions varied in terms of structure, frequency, and intensity, there was a clear predominance of protocols aligned with international health promotion guidelines, with an emphasis on moderate aerobic exercises, regular walking, and, to a lesser extent, supervised or high-intensity activities, often combined with nutritional and behavioural strategies.

Variables Assessed

Among the studies included in this systematic review, most interventions combining the MD with PA assessed measures such as weight (kg), BMI (kg/m^2), waist circumference (cm), and body composition—parameters directly related to visceral obesity, one of the main criteria of MetS. Concurrently, metabolic biomarkers such as glucose, insulin, HOMA-IR, HbA1c, and lipid profile (HDL, LDL, triglycerides, and total cholesterol), frequently used to diagnose insulin resistance and dyslipidemia, were widely assessed [28,38,40]. BP evaluation, another critical component of MetS, was also recurrently measured [36,45].

Additionally, some studies incorporated complementary variables such as cognitive parameters [30], and functional lipoprotein measures [43], broadening the understanding of the involved pathophysiological mechanisms.

4. Results

4.1. Body Weight

Of the 22 studies included in this systematic review, most showed a significant reduction in body weight after combined DM and PA interventions. For example, Montemayor et al. [28] reported reductions of between −4.6 kg and −7.1 kg, while García-Gavilán et al. [27] observed a difference of −4.2 kg between groups ($p < 0.001$). Similar results were seen by Rabiee et al. [29], with −2.45 kg, and Domenech et al. [42], with −3.83 kg (95% CI: −4.57 to −3.09). Hernando-Redondo et al. [45] reported an intergroup difference of −4.84 kg (95% CI: −5.60 to −4.08), while Rumbo-Rodríguez et al. [32] found −2.9 kg ($p = 0.017$). Pavic et al. [31] observed a reduction of −8.7 kg in the DM intervention, and Sanllorente et al. [43] reported a significant difference of −3.83 kg ($p < 0.001$). Other studies, such as those by Tussing-Humphreys et al. [30], Monserrat-Mesquida et al. [34], Greco et al. [37], Barbosa et al. [39], Ficarra et al. [36], and Prats-Arimon et al. [41], also showed statistically significant weight reductions in the intervention groups.

On the other hand, some studies have shown no significant differences between the groups. In the study by Pineda-Juárez et al. [26], the group that combined DM with PA had a non-significant reduction of −0.4 kg ($p = 0.88$). Panizza et al. [35] reported a reduction of −5.9 kg in the intervention with IER + DM, although with methodological limitations regarding the application of DM. Hassapidou et al. [46] showed a difference of −4.2 kg in the intervention group ($p < 0.001$), contrasting with an increase of 0.2 kg in the control group. The study by Martinez-Rodriguez et al. [25] showed no significant change between groups ($p = 0.570$). Despite these exceptions, the overall data indicates a consistent trend of body weight reduction with combined interventions.

4.2. Body Mass Index

Regarding body mass index (BMI), the majority of studies (18 out of 22) reported significant reductions after intervention with the MD and PA. For example, García-Gavilán et al. [27] observed an intergroup difference of -1.5 kg/m^2 ($p < 0.001$), and Montemayor et al. [28] reported reductions of between -1.6 and -2.5 kg/m^2. Pavic et al., 2019 [31] found a decrease of -3.0 kg/m^2, and Domenech et al. [42] reported -1.43 kg/m^2 (95% CI: -1.71 to -1.16). Significant reductions have also been observed in studies such as [30,32,35,38–41,43–45].

However, not all studies showed significant reductions. Ficarra et al. [36] found a minimal change in BMI ($p = 0.954$), and Monserrat-Mesquida et al. [34] observed a reduction without statistical significance ($p = 0.132$). In addition, three studies reported an increase in BMI in the control or intervention groups: Martinez-Rodriguez et al. [25] observed an increase of +0.5 kg/m^2 in the control group; Rabiee et al. [29] identified an increase of +0.14 kg/m^2 also in the control; and Hassapidou et al. [46] reported an increase of +0.1 kg/m^2 in the control group, although the intervention group reduced significantly ($p < 0.001$).

These findings reinforce that, although the general trend is for BMI reduction with combined DM and PA intervention, factors such as intervention time, adherence, the type of activity prescribed, and the inclusion of behavioural support directly influence the results.

4.3. Waist Circumference

WC, an important marker of visceral adiposity, was significantly reduced in several studies included in this review. García-Gavilán et al. [27] observed a reduction of -5.5 cm ($p < 0.001$), while Pavic et al. [31] and Sanllorente et al. [43] identified average reductions of between -5.1 cm and -7.7 cm in the groups that followed the MD combined with PA. The greatest reduction was reported by Monsalves-Alvarez et al. [38], with -7.8 cm in the DM group alone and -7.4 cm in the group combined with PA. Studies such as those by Schröder et al. [33] and Prats-Arimon et al. [41] also showed significant reductions, demonstrating that longer interventions with good adherence are more effective.

However, not all studies observed significant reductions. The study by Panizza et al. [35], although it reported a decrease in WC in the intervention group, showed no statistically significant difference between the groups. Similarly, Martinez-Rodriguez et al. [25] found no relevant difference in WC after the intervention. These results suggest that, despite the overall positive trend, factors such as duration, intensity of the intervention and adherence may influence the magnitude of the changes observed in WC.

4.4. Body Composition

Improvements in body composition were observed, especially a reduction in body fat. Martinez-Rodriguez et al. [25] showed a significant reduction in body fat in the intervention group (from 32.3% to 29.5%, $p < 0.001$). Similar reductions were described by Panizza et al. [35], Greco et al. [37] and Rabiee et al. [29], being more expressive in the groups that combined DM with physical training (such as HIIT or aerobics), indicating a synergistic effect.

4.5. Blood Pressure

Several studies have documented reductions in SBP and DBP. Domenech et al. [42] and Sanllorente et al. [43] reported falls of up to -4.36 mmHg (SBP) and -3.57 mmHg (DBP). Panizza et al. [35] found reductions of -9.0 mmHg in SBP and -6.7 mmHg in DBP in the DM group with intermittent fasting. Monserrat-Mesquida et al. [34] and Montemayor et al. [28] also showed a trend towards improvement, although with varying statistical significance.

4.6. Blood Glucose and Insulin

Fasting blood glucose showed a modest improvement in most studies. Domenech et al. [42] and Sanllorente et al. [43] showed an average reduction of −4.7 mg/dL ($p < 0.05$). Although some studies, such as Tussing-Humphreys et al. [30] and Monsalves-Alvarez et al. [38], did not find statistical significance in relation to glycaemia, the results indicate a tendency towards reduction, especially when there is greater associated weight loss.

4.7. Lipid Profile (Total Cholesterol, Hdl, Ldl and Triglycerides)

With regard to the lipid profile, the findings were predominantly heterogeneous among the included studies. Most of the clinical trials did not identify statistically significant differences between the intervention and control groups in total cholesterol and LDL-cholesterol levels. This lack of effect was observed in several studies [27–31,34–36,38,43–45].

On the other hand, a slight but favourable increase in HDL-cholesterol levels was observed in several studies, indicating a possible qualitative improvement in the lipid profile resulting from the combined intervention with DM and PA [27,28,30,41,45].

Regarding triglycerides, the results were more consistent, with reductions observed predominantly in the intervention groups. Studies such as those by Panizza et al. [35], Domenech et al. [42], Sanllorente et al. [43], Hernando-Redondo et al. [45], Montemayor et al. [28] and Prats-Arimon et al. [41] reported average decreases ranging from −20 to −30 mg/dL.

5. Discussion

This systematic review analyzed the combined effect of DM and PA on the components of MetS in adults, based on 22 RCTs.

The results confirm what Malakou et al. [24] had already found: interventions that combine DM and PA promote significant improvements in several metabolic risk factors. However, our study brings important novelties. We updated the search until October 2024, including more recent studies and current protocols. Furthermore, we incorporated interventions that, in addition to DM and PA, also involve behavioural and educational support, broadening the understanding of integrated lifestyle strategies. We also carried out a detailed analysis of the characteristics of the interventions, such as duration, frequency and intensity, which offers a more practical and applied view. Finally, we evaluated individual MetS outcomes—such as BMI, glycaemia, BP and lipid profile—for a more in-depth understanding.

Our analysis showed that the combination of DM and PA promotes significant improvements in 10 of the 11 risk factors evaluated, including waist circumference, BMI, systolic and diastolic BP, glucose, triglycerides, total cholesterol and HDL, when compared to the control group. No studies reported negative effects, reinforcing the potential of this approach for metabolic health.

5.1. Behavioural Support

The inclusion of behavioural support in the interventions analyzed in this review represents an important advance over previous evidence, such as that by Malakou et al. [24], which did not consider this component. Evidence shows that interventions based solely on diet or physical exercise tend to have low long-term adherence [50,51]. Strategies such as goal setting, individualized follow-up and motivational support have been associated with greater permanence in programmes and better metabolic results [22].

In addition, multicompetent interventions—which combine diet, PA and behavioural support—have been shown to be more effective in reducing abdominal obesity, controlling glycaemia and improving lipid profiles [52]. These programmes also tend to increase participants' involvement, promoting greater motivation, autonomy and a positive perception of their own health.

By integrating this component, this review offers a more realistic and applicable perspective to clinical practice, aligning with contemporary approaches to health promotion and MS management.

5.2. Waist Circumference

Wais circumference (WC) a key indicator of visceral adiposity, showed clinically relevant reductions in the included studies, with variations between −5.1 cm and −7.8 cm in the groups that followed interventions combining DM and PA [27,38]. These data confirm previous findings [53], who reported an average reduction of −4.2 cm after six months of intervention.

On the other hand, less expressive results were observed in studies with low-intensity exercise, without supervision or with low adherence [30]. This suggests that the intensity and regularity of PA are decisive in reducing abdominal fat.

A diet rich in fibre, antioxidants and healthy fats helps reduce visceral inflammation and improves leptin sensitivity, contributing to the mobilization of abdominal fat [5]. High-intensity exercise and resistance training activate pathways such as AMPK, increasing fatty acid oxidation [4]. This combination also acts on insulin resistance, a central factor in the accumulation of visceral fat [17].

Given its strong link with cardiometabolic risk, WC should be a priority monitoring parameter. The best results were seen in programmes that combined aerobic and resistance exercise with moderate calorie restriction (~30% of VET), reinforcing the effectiveness of multi-competent interventions.

5.3. Body Mass Index

The studies included in this review reported significant reductions in BMI, ranging from −1.5 to −2.2 kg/m^2, after combined interventions with DM and PA [29,46]. The effects were more pronounced in women, possibly due to greater adherence to dietary guidelines. These results are in line with the meta-analysis by Esposito et al. [54], which found average reductions of −1.8 kg/m^2 in similar programs.

Although diets with high calorie restriction (>30% of VET) lead to faster initial weight loss, their effectiveness tends to decline over time, as shown by the findings of Panizza et al. [35]. This reinforces the importance of more gradual strategies adapted to the cultural context, with a focus on replacing ultra-processed foods with Mediterranean foods, rather than severe restrictions.

The impact of DM on BMI can be explained by the high fibre and vegetable protein content of legumes, nuts and whole grains, which increase satiety and regulate appetite hormones such as leptin and ghrelin, as well as positively modulating the gut microbiome [55,56]. PA, especially resistance training, helps to preserve lean mass during weight loss, avoiding the drop in basal metabolism and the plateau effect common with isolated diets [57].

It is therefore recommended to prioritize interventions that combine DM without strict calorie restriction with regular PA, in order to achieve sustainable results. The inclusion of direct assessments of body composition is also essential to better understand the effects on the redistribution of fat and lean mass.

5.4. Blood Pressure

Most of the studies analyzed indicated that interventions combining DM and PA contributed to a reduction in blood BP, although the intensity and significance of these effects varied. Studies such as those by Monserrat-Mesquida et al. [34] and Sanllorente et al. [43] reported consistent reductions in systolic and diastolic BP after structured programmes with low-calorie DM, regular exercise and behavioural support. These findings reinforce the data from Malakou et al. [24], who observed average reductions of −0.83 mmHg in systolic BP and −1.96 mmHg in diastolic BP in similar interventions—modest but clinically relevant values.

Filippou et al. [58], in a meta-analysis of 35 RCTs, also showed that DM can significantly reduce BP, especially in people with hypertension and in interventions lasting more than 16 weeks. The mechanisms involved include improved endothelial function, increased antioxidant-induced vasodilation, higher potassium intake and lower sodium intake—typical characteristics of DM [10]. PA potentiates these effects by improving vascular tone, regulating the sympathetic nervous system and contributing to weight control.

On the other hand, studies such as García-Gavilán et al. [27] and Pavic et al. [31] did not find significant reductions in BP, which may be linked to the short duration of the interventions, the low intensity of the exercises or the lack of specific BP targets. In addition, the effects tend to be more evident in individuals with pre-existing hypertension [58], reinforcing the importance of considering the clinical profile of the participants.

The combination of DM and PA shows potential for improving BP, especially in populations at high cardiovascular risk. Well-planned interventions with clear goals and ongoing support are key to maximizing results, both in clinical and community settings.

5.5. HDL and LDL

The effects on HDL and LDL cholesterol levels varied between the included studies. Some studies, such as Pavic et al. [31] and Monserrat-Mesquida et al. [34], observed slight increases in HDL levels after structured programmes with low-calorie DM and regular PA practice. However, other studies, such as those by Panizza et al. [35] and Tussing-Humphreys et al. [30], did not identify statistically significant changes. This heterogeneity may be related to the duration of the interventions, the intensity of the exercise, the composition of the diet and the degree of adherence of the participants.

Recent evidence reinforces the potential of DM to improve the lipid profile. A meta-analysis published in JAMA Network Open indicated that DM interventions are associated with increases in HDL and reductions in LDL, especially in overweight young adults [59]. In addition, Grao-Cruces et al. [60] point out that DM not only raises HDL levels, but also improves its functionality, increasing antioxidant and anti-inflammatory properties—relevant aspects in the prevention of cardiovascular diseases.

With regard to LDL, the effects were less consistent. Studies such as Schröder et al. [60], which did not set specific targets for replacing saturated fats or strictly controlling cholesterol intake, reported little or no change. Martínez-González et al. [7] reinforce that LDL reduction is strongly associated with the quality of the fats ingested, adherence to the diet and the magnitude of weight loss.

In summary, the combined DM + PA intervention tends to benefit HDL, especially in longer, well-structured interventions. For LDL reduction, more specific dietary strategies are needed, including a focus on replacing saturated fats with unsaturated ones and maintaining a moderate calorie deficit.

5.6. Blood Glucose

The effects of the combination of the MD and PA on fasting blood glucose were variable between studies. Some reported modest reductions [31,38], while others found no significant changes [33,35]. This variation may be linked to the short duration of the interventions, the lack of continuous follow-up or the inclusion of participants with normal glycemia.

Larger studies, such as ATTICA [61], show that prolonged DM adherence significantly reduces the risk of type 2 diabetes. Recent reviews also indicate that the combination with aerobic PA improves insulin sensitivity and glycemic control, especially in individuals at metabolic risk [62].

Therefore, the greatest glycemic benefits are observed in populations with insulin resistance or pre-diabetes, when the intervention is long-term, personalized and adequately supported.

5.7. Triglycerides

Combined DM and PA interventions have shown consistent effects on reducing triglyceride (TG) levels. Most studies, such as Pavic et al. [31] and Monserrat-Mesquida et al. [38], reported significant drops after structured programmes with low-calorie DM and regular exercise. These results are attributed to DM's high intake of monounsaturated fats, fibre and antioxidants, along with the fat-burning effects of PA.

A recent meta-analysis of more than 10,000 participants showed an average reduction of 7.93 mg/dL in TG in those who followed DM, compared to conventional diets [63]. Another study with older adults in Australia also confirmed a significant reduction after six months [64].

These data indicate that the combination of DM and PA is effective in controlling triglycerides, especially when the interventions are well planned and adapted to each person.

5.8. Strengths

This systematic review showed that combined DM and PA interventions promote more significant benefits in important MetS parameters, such as body weight, WC and triglyceride levels, when compared to isolated interventions with only DM or PA.

Studies with multiple groups, such as those by Pineda-Juárez et al. [26], Montemayor et al. [28] and Rabiee et al. [29], showed that combining DM + PA led to greater reductions in weight (e.g., −4.9 kg versus −2.5 kg in isolated groups) and waist circumference (−5.5 cm versus −3.2 cm). Similar results were observed for triglycerides, with steeper falls in the combined groups.

5.9. Limitations

The effects of the combined intervention on BP and lipid profile, especially HDL and LDL, were less consistent. In many studies, there was no significant difference between the combined and isolated groups, indicating that some components of MetS may respond differently to interventions. For example, PA alone may have a more direct impact on BP.

This heterogeneity of results can be explained by the variety in study protocols, including differences in duration, intensity, type of intervention and adherence to interventions. The lack of standardization and the absence of control groups in some cases make direct comparisons and the generalization of findings difficult.

Furthermore, most of the research was conducted in Mediterranean countries, where adherence to DM is culturally facilitated. In other contexts, cultural and socio-economic factors can limit the acceptance and viability of the diet, pointing to the need for cultural adaptations to broaden applicability.

Assessment of the risk of bias in the included studies indicated that 60% were at low risk overall, but there were common problems related to the randomization process and the selection of reported outcomes. Blinding was a frequent challenge due to the nature of the interventions, although some studies adopted strategies to minimize bias, such as blinding the evaluators and using objective measures to monitor adherence.

Finally, the lack of studies with tripartite groups (DM, PA and DM + PA) and the scarcity of long-term trials limit a complete understanding of the synergistic effects and sustainability of interventions. It is also important to expand the evaluation to include biomarkers of inflammation and endothelial function, as well as to analyze the cost-effectiveness of the strategies. In addition to dietary modifications and regular physical activity, the contribution of specific nutraceuticals as complementary strategies deserves closer examination. Evidence suggests that soy isoflavones can improve cardiometabolic outcomes, particularly in postmenopausal women, a group frequently affected by MetS. Future studies might focus on how a Mediterranean diet and PA, when combined with well-supported nutraceuticals, could offer a more tailored and comprehensive framework for managing MetS and slowing the onset of non-communicable diseases.

6. Conclusions

This systematic review demonstrated that the combination of the MD and PA yields significant beneficial effects in managing the components of MetS, with results superior to those of isolated interventions.

One of the most relevant findings was the enhancing role of behavioural support—a distinguishing element of this review compared to previous studies. The analysis showed that programmes combining personalized nutritional guidance, structured exercise prescription, and motivational follow-up not only achieve greater metabolic effectiveness but also promote better long-term adherence, often a neglected challenge in public health interventions.

To increase the applicability of such interventions, future research should explore their feasibility across diverse cultural and socioeconomic contexts, as well as conduct long-term investigations to assess the sustainability of outcomes. These strategies represent a promising tool for public health policy and clinical practice, standing out as an effective and accessible approach in addressing metabolic syndrome.

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Abbreviations

PA	Physical Activity
ALT	Alanine Aminotransferase
AST	Aspartate Aminotransferase
MD	Mediterranean Diet
HDL	High-Density lipoprotein
HIIT	High-intensity Interval Training
BMI	Body Mass Index
LDL	Low-Density lipoprotein
METS	Metabolic Syndrome
TG	Triglycerides

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