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Interventions for the Control and Prevention of Metabolic Syndrome. A Systematic Review of a Decade

*Intervenciones para control y prevención de Síndrome Metabólico.
Revisión sistemática de una década.*

SALINAS-ESCUADERO BLANCA IVONNÉ¹, PRIEGO-ÁLVAREZ HEBERTO ROMEO²,
AVALOS GARCÍA MARÍA ISABEL³

¹ Ophthalmologist. Master's Degree in Hospital Management and Administration. PhD Candidate in Public Health. Universidad Juarez Autonoma de Tabasco, Mexico. Orcid: <https://orcid.org/0000-0001-6060-105X>. ivonnesalinas857@gmail.com

² Medical Doctor. PhD in Health Sciences. Research Professor attached to the Academic Division of Health Sciences of the Universidad Juarez Autonoma de Tabasco, Mexico. Orcid: <https://orcid.org/0000-0001-9217-5702>. heberto_priego@hotmail.com

³ Nurse. PhD in Health Sciences. Research Professor attached to the Academic Division of Health Sciences of the Universidad Juarez Autonoma de Tabasco, Mexico. Orcid: <https://orcid.org/0000-0003-0115-4231>. isaavalos67@hotmail.com

Corresponding author: Heberto R. Priego-Alvarez / Maria I. Avalos-Garcia heberto_priego@hotmail.com

SUMMARY

Introduction: Metabolic syndrome is a serious public health problem that culminates in the highest worldwide causes of morbidity and mortality. Effective strategies are required to control it and to prevent its consequences.

Objective: To analyze characteristics that combine two or more therapeutic aspects for the control and management of metabolic syndrome.

Methodology: Systematic literature review using the PRISMA criteria. Databases searched included Pub Med, Science Direct, Scielo, and Redalyc. Controlled and quasi-experimental mixed intervention trials over the last 10 years, with a minimum of 24 weeks duration, were included.

Results: 23 mixed interventions, 19 based on lifestyle, two on physical activity and diet, one on yoga and caloric intake, and one on physical activity plus dietary supplement. Six interventions in children and the rest in adults.

Conclusions Lasting results were observed in multidisciplinary interventions for healthy lifestyles. In children, the school group approach reinforces permanence, while family support was shown to improve outcomes such a reduction in MS and BP. In the case of diet, the Mediterranean one is preferred. The results suggest social media is an excellent educational tool.

Keywords: Metabolic syndrome, Controlled Before-After Studies, humans

RESUMEN

Introducción: El síndrome metabólico es un grave problema de salud pública que culmina en las causas de morbilidad y mortalidad más elevadas en todo el mundo, se requieren estrategias efectivas para controlarlo y prevenir sus consecuencias

Objetivo: Analizar las características de las manifestaciones que combinan dos o más aspectos terapéuticos para el control y manejo del síndrome metabólico

Metodología: Revisión sistemática bajo los criterios de PRISMA. Búsqueda en base de datos Pub Med, Science Direct, Scielo, Redalyc. Se incluyen estudios clínicos controlados y cuasiexperimentales de intervención mixta de los últimos 10 años con un mínimo de 24 semanas de duración

Resultado: 23 intervenciones mixtas, 19 basadas en estilo de vida, dos en actividad física y dieta, uno en yoga e ingesta calórica, y uno de actividad física más suplemento alimentario. Seis intervenciones en niños y el resto en adultos.

Conclusiones En todas las intervenciones resultó la prevalencia de síndrome metabólico, así como los parámetros cardiometabólicos. Resultados duraderos se evidenciaron en las intervenciones multidisciplinarias para estilos de vida saludable. En niños, el enfoque grupal escolar refuerza permanencia, apoyo familiar mejora los resultados. En caso de régimen alimentario se prefiere dieta mediterránea. Redes sociales excelente herramienta educativa.

Palabras Clave: Síndrome Metabólico, intervención, humanos

INTRODUCTION

Metabolic syndrome (MS) is a group of closely linked conditions, which generate a considerable increase in the risk for cardiovascular disease and diabetes, almost double when compared to people who do not have it. MS is characterized by insulin resistance, excess weight, glucose intolerance, dyslipidemia, high triglycerides and low high-density lipoprotein cholesterol (HDL), inflammation, and prothrombotic state. (1)

The International Diabetes Federation (IDF), the National Cholesterol Education Program Adult Treatment Panel III (ATP III), and the American Association of Clinical Endocrinologists (AACE), as well as the World Health Organization (WHO), have formulated their own diagnostic criteria for (MS) (2). The Latin American Diabetes Association (ALAD), based on the definition of the IDF, defines the figures for evaluation of abdominal perimeter in the Latin America Region (3).

Regardless of the classification system, the main concern is early detection and timely intervention.

Most people with MS will develop insulin resistance, which increases the risk for type 2 diabetes. When this type of diabetes is clinically noticeable, the risk of cardiovascular disease rises very noticeably. (4)

Interventions have been implemented around the world to find functional strategies to reverse metabolic syndrome and they range from the use of herbal medicine, alternative and complementary medicine, supplements, probiotic use, drug therapy, bariatric surgery, gut microbiome transplantation, lifestyle changes, and counseling, as well as physical activation and diet, exercise practice, dietary regime.

The purpose of this study is to conduct a systematic literature review to analyze the characteristics of the interventions that combine two or more therapeutic aspects for the control and management of metabolic syndrome.

Methodology

Systematic literature review using the PRISMA criteria. Data collection was carried out from scientific articles published between 2011 and 2021, and whose objective was focused on the effect of interventions on metabolic syndrome.

The review was carried out with the purpose of extracting data and obtaining various intervention alternatives, such as: 1. Lifestyle interventions, including educational interventions (physical or nutritional activation counseling), physical activity, and a dietary approach, 2. Pharmacological, herbal or supplemental interventions, 3. The combination between any of the aforementioned (mixed intervention).

Search Strategy

For the systematic literature review, keywords were used in two categories: from the type of intervention performed in metabolic syndrome, and methodological specification for the characterization of clinical studies.

The articles were obtained from the keywords of the term's metabolic syndrome, intervention, and human. In the collection of clinical studies, the terms article, clinical trial, controlled clinical trial, controlled study, randomized controlled trial, randomized trial, and placebo were used.

We classified identified manuscripts/articles according to inclusion and exclusion criteria to obtain the studies to be analyzed from the interventions with the best effect on metabolic syndrome.

The search strategy was carried out in the databases: Pub Med, Science Direct, Scielo, Redalyc. Once the search was completed, duplicates were excluded, and a database was designed to record the relevant documents for review.

Selection of Studies

The search yielded a total of 30,269 articles, in which specific inclusion and exclusion criteria were used to select the information and compare the various interventions used in the resolution of some aspect of metabolic syndrome.

Inclusion Criteria

Controlled trials in human populations in any age range, the sample of which included a proportion of patients (greater than 1), contained participants diagnosed with metabolic syndrome, and included interventions lasting 24 weeks or more, with or without follow-up.

We classified interventions as lifestyle-related (diet, physical activity, and educational interventions), and as pharmaceutical treatments (medicines or dietary supplements), alone or in combination with any of the lifestyle-related interventions. Articles were included in several languages, and also those in which the diagnosis of metabolic syndrome and the quantifiable parameters before and after the intervention or the combination of these were available.

Exclusion Criteria

Systematic reviews, meta-analyses, pilot studies, intervention proposals, protocols, testing of educational materials and scales, other measurement elements, as well as studies in which the aspects obtained by the results focused on enzymatic, molecular, and hormonal levels that were different from the clinical parameters that make up the diagnosis of metabolic syndrome were excluded. Interventions such as bariatric surgery (with or without lifestyle components) or microbiota transplantation, studies in pregnant women, or in patients with specific pathologies, such as surgical procedures combined with lifestyle modifications, were excluded.

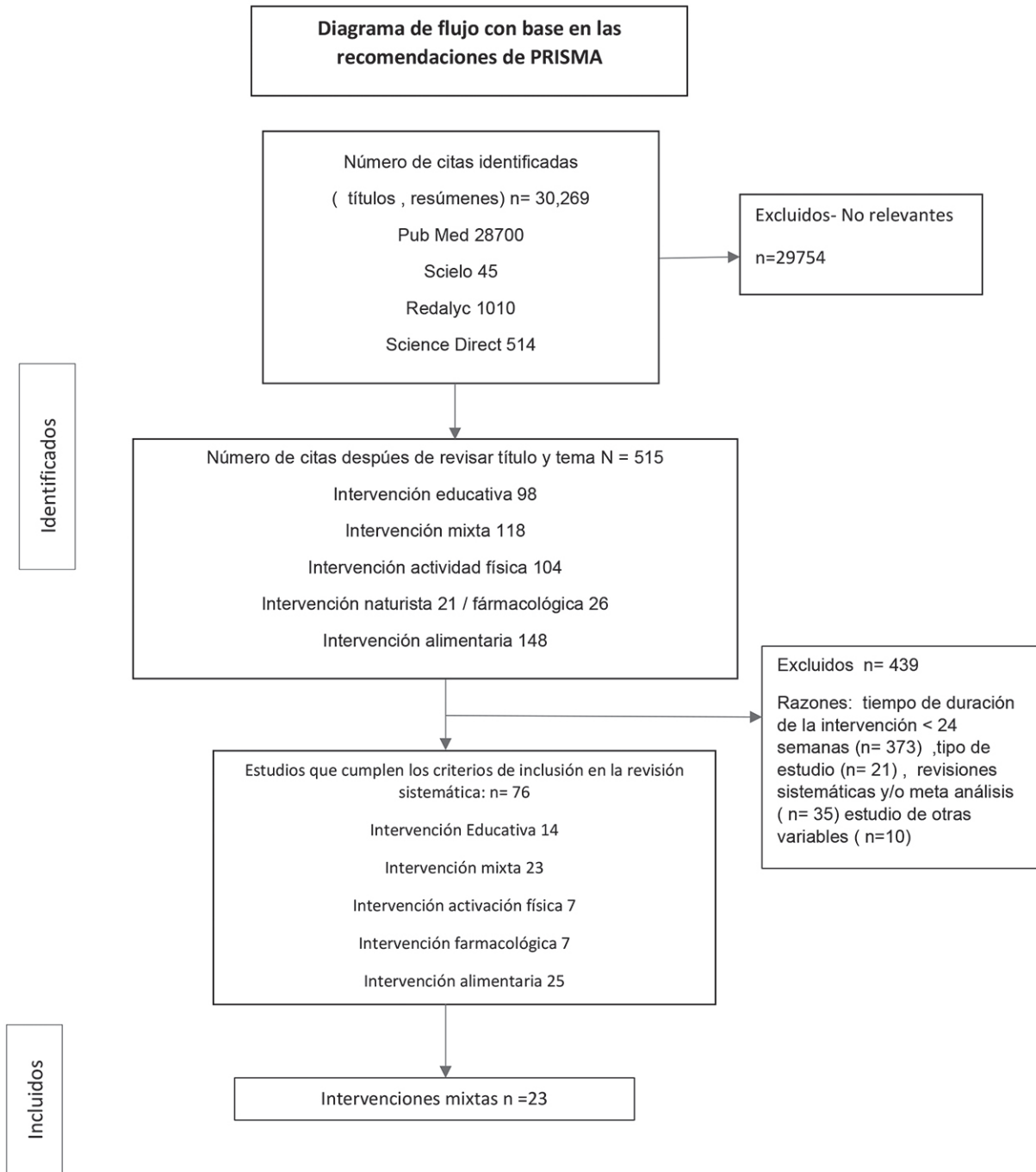
Extracting the Data

A strategy for the extraction and evaluation of data from selected publications was designed, using keywords and capturing data in Excel to verify that the selected revisions met the terms and criteria for inclusion and exclusion. Articles from primary research, country, year, population under study, purpose, type of intervention, duration, outcome, conclusions, and limitations, were taken into account.

RESULTS

30,269 publications of interventions published from January 2011 to November 2021, which met the criteria, were identified. This included the duration and type of intervention. A total of 76 interventions for MS with duration greater than 24 weeks, 14 educational interventions, 7 interventions focusing on activity physical, 7 pharmacological interventions, 25 dietary or dietary interventions, leaving, 23 mixed interventions, that is, two or more of the treatments implemented for metabolic syndrome were combined (dietary counseling, physical activation counseling, practice of physical activity or supervised sessions, implementation of diet, as well as multidisciplinary management in the lifestyle). Therefore, we reviewed the publications in which a mixed intervention for metabolic syndrome was performed.

Table 1 shows the selection process for manuscripts selected for review. These studies were conducted in Europe (Portugal, Spain), Asia (Korea, Japan, Taiwan, Vietnam, and China), America (Canada, United States, Mexico, Cuba, Colombia, and Brazil), and Oceania (Australia).



Note: Classification of publications according to exclusion and inclusion criteria.

Source: Own elaboration

Figure 1. Prisma Diagram

The lifestyle-based interventions were 19, two interventions based solely on physical activity and diet, one intervention based on body-mind exercise (yoga), including physical activity and caloric intake, another of omega 3 dietary supplement and oleate, plus physical training. In 6 studies, the interventions were performed in children and the remaining 17 interventions in adults.

The characteristics of the interventions are detailed in **Table 1**.

No	Author/ Year/Coun- try	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
1	Pedrosa, C. et. al (2011) Portugal (5)	Randomi- zed contro- lled trial	83 children between 7 and 9 years of age	To assess the effect of a lifestyle intervention on para- meters and components of (MS) overweight or obesity	Intervention characterized by individual or group counseling on nutrition and exercise	12 months 4 consecu- tive group sessions and 1 reinforce- ment ses- sion 3,6 and 12 months	Improve- ment in BMI, abdominal perimeter, HDL. Preva- lence of MS was reduced to 14.8%. The group inter- vention with the greatest impact on metabolic parameters of MS, HDL and lower dropout rate.	Sample size, the majority of the population, at the begin- ning, had a normal metabo- lic parameters which prevented finding differen- ces. There was no control group without inter- vention.
2	Potteiger JA,et.al (2012) EU(6)	Randomi- zed contro- lled trial	24 overwei- ght, inactive adults. 27-48 years	To compare training with (ER) with training with (AE) on risk factors for MS	Aerobic and en- durance physical activity combined with dietary ener- gy restrictions	6 months 104 sessions exercise 3 / week start, from 3rd month 4 / week. and daily diet	EA and ER showed a significant reduction in MS z-score at 6 months	Aerobic or resis- tance exercises cannot be com- pared. The Training inten- sity or volume is indeterminate in both cases. Lack of a dietary restriction group.

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No	Author/ Year/Coun- try	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
3	Elizon- do-Mon- temayor L et.al (2013) Mexico (7)	Controlled test	96 overwei- ght/obese children aged 6 to 12 years (mean age 9.06 years) from eight schools.	Analyze changes in prevalence of overweight/ obesity and MS with lifestyle in- tervention	Lifestyle inter- vention with personalized sessions with die- tetic and physical education	10 months 13 sessions 130 daily reminders for parents and 130 reminders for children motiva- tional and activity	Decrease in MS preva- lence from 44% to 16%, hypertrigly- ceridemia dropped from 64% to 35%, SAH from 19% to 0%, HDL \leq 40 from 60% to 41%, BP, from 72% to 57%, hyperglyce- mia from 1% to 0%, BMI and body fat percentage (3.31 to -1.55).	Results not generalizable due to voluntary participation and small sam- ple size.
4	Garcia- Beau- tiful et.al. (2014) Spain (8)	Controlled clinical trial	18 sedentary male children (8-11 years) with BMI equal to or greater than the 97th percentile for age and sex	to assess the effects of detraining program in obese children (6 months) on MS after 31-month in- terventions: a) exercise b) diet and exercise	Intervention of an exercise program and another program consisting of diet plus exercise intervention.	31 months each inter- vention and evaluation 6 months later 372 exercise sessions, daily diet	Decrease in lipoproteins in both in- terventions. Prevalence of MS and obesity was completely eliminated only in the exercise-on- ly group (no-risk and no-obesity patients)	Due to the size of the popu- lation, it can be considered a preliminary study

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No	Author/ Year/Coun- try	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
5	Zuluaga, NA. et.al (2020) Co- lombia (9)	Cohort based Re- trospective observa- tional and analytical study	53 patients aged 11 ± 2 years, men 52.8% inclu- ding fathers	To describe clinical and metabolic changes in patients with obesity after a compre- hensive care program in childhood obesity	Educational intervention with cognitive-be- havioral metho- dology, healthy eating, physical activity, cardiac rehabilitation, clinical care	The fo- llow-up of the patients was 18 ± 6 months, although in 30% of them it was from 31 to 36 mon- ths, in 12 sessions	79.25% of patients reduced the BMI Z score. BMI greater than 3 went from 33.4 to 14.6%. The number of positive criteria for MS decreased at follow-up. Triglyceride and (HbA1c) levels impro- ved signifi- cantly	Inability to do the same follow-up timeframe in all patients
6	Serra-Paya N. et.al (2015) Spain (10)	Multicenter randomized controlled trial	113 overwei- ght/obese children aged 6 to 12 years and their parents	Multiple component intervention effectiveness for overwei- ght and obe- se children compared to usual group counselling interven- tions in primary care	Intensive behavioral intervention, theoretical-prac- tical sessions, physical activity, family-based and healthy eating	8 months Sessions 90 of physi- cal activity, 21 theoret- ical practice, 3 behavioral strategy, 3 sessions end of sem	Participants of the GI (Ne- reu Program) improvement in physical activity and dietary behaviors, compared to GC	Statistical power of the effect of the parame- ters limited by loss rate and missing values, despite the high adherence to the program.

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No	Author/ Year/Coun- try	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
7	Soca M.et.al (2012) Cuba (11)	Multicenter randomized clinical trial	Cluster sampling of 150 obese women with MS without glycemic alterations. Gpo.control (n=70) 59.2 +/-1.5 years. Gpo. experi- mental (n=80) 50.0 +/- 1.6 years	To evaluate the efficacy of a pro- gramme of nutritional recommen- dations and physical exercises in women with MS	Intervention in the experimental group was applied a balanced hypocaloric diet and a physical exercise program. The control group received the usual care	12 months Sessions exercise 3 times/week from 20 to 80 min	In the GI, more diasto- lic pressure, cholesterol, triglycerides and LDL-cho- lesterol de- creased and HDL-cho- lesterol was raised	Evaluation of the short-term effect, cannot be generalized to men, other ages, and therapies
8	PB milk. et.al (2017) Brazil (12)	Clinical trial	24 obese adults (BMI 34.80 ± 3.17 kg/m ² ; 41.21 ± 6.28 years)	To evaluate interdis- ciplinary therapy on symptoms of Binge Eating Disorder (BP) and prevalence of MS	Interdisciplinary food therapy, exercise, educa- tion.	32 weeks 96 Sessions 3 sessions 2 hours a day	MS prevalen- ce decreased from 75% to 45.8% after therapy. Posi- tive effects on HAS, PA and HDL.	The size of the sample, and working with volunteers, pre- vents generali- zation.
9	Blackford, K. et.al. (2017) Aus- tralia (13)	Randomised controlled trial (RCT)	201 parti- cipants. be- tween 50 and 69 years with MS or at risk of suffering	Encourage diet and physical acti- vity of adults with MS or with predis- position	Home interven- tion to improve physical activity and dietary beha- viors	6 months Sessions six moti- vational sessions Phone calls	Most prefe- rred attrac- tive print resources sui- table for their age group. The website was the least preferred resource.	Lack of fa- ce-to-face component. Rural Study Population and Older Age Limits Effect of Video Calls

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No	Author/ Year/Coun- try	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
10	Nazaré JA,etal (2013) (14) Canada	Clinical trial	144 men (aged 30-65 years) with abdominal obesity during the 6 months prior to the intervention	Identify components of a lifestyle intervention program with physical activity and diet quality	Lifestyle intervention, dietary changes with anenergy deficit d (500 kcal) daily, 45 to 50% carbohydrates, 20 to 25% proteins) and 25 to 30% lipids and Physical Conditioning (160 min / week).	12 months Sessions exercise of 2 to 7 sessions of 30 to 60 min per week,365 walking sessions 10,000 steps	Men with abdominal obesity significantly improved the quality of their diet, and increased physical activity with reductions in weight, fat mass, visceral fat and thigh fat.	Not generalizable by population of only one sex
11	Seo,YG.et.al (2021) (15) Korea	Quasi-experimental intervention clinical trial	242 children aged 6 to 17 years (145 boys and 97 girls) average: 11.3 ± 2.06 years with obesity and overweight	To assess the effectiveness of a multidisciplinary intervention programme with a balanced diet and physical training on BMI and cardiometabolic parameters in children and adolescents with obesity or overweight	Multidisciplinary intervention three groups: 1 dietary advice, physical activity and behavior modification. 2 exercise, 3 nutritional care	6 months 8 sessions personal nutritional counseling. Exercise Sessions 78 3 times a week x 1 hour (group and at home)	After 6 months, the exercise and nutrition groups with BMI lower than the baseline data by about 0.14 and 0.075,	Semi-randomized study and short follow-up

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No	Author/ Year/Coun- try	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
12	Brewer,P.et.al (2019) Cana- da (16)	Clinical trial	205 patients with MS	To assess changes in nutrient in- take and diet quality over 12 months in lifestyle change programme in MS	Multidisciplinary intervention changes in nu- trient intake and diet quality, indi- vidualized dietary counseling. HEI-C and MDS Dos reminders/ 24 hours.	12 months Sessions: Home 1 teleconfe- rence, Kinesio- logist 12 sessions Reinforce- ment 12 months with 2 reminders / day	Total energy intake decreased by 145 ± 586 kcal for 3 months and decreased from 76 ± 452 kcal for 3-12 months. Decreased prevalence of MS	Limited validity of diet assess- ment tools in intervention studies, and change at the beginning of the Mediterranean diet, 6 months after starting the study
13	Jane, M. et.al (2017) Aus- tralia (17)	Three-arm, randomized, controlled trial.	137 partici- pants randomly assigned to Control Group: n = 45; (diet and activation advice) Group of pamphlets: n = 46; Face- book Group: n=46	To assess the effectiveness of social networks in increasing the imple- mentation and support of a weight management programme for people who are overweight and obese during an intervention	GC diet informa- tion and national physical recom- mendations GP and GF instruction to take the Total Wellness Diet and with pedometer Additional GF intergroup inte- raction support network	24 without 24 Sessions Facebook group 1 weekly 24 weeks	More effecti- ve interven- tion in GF by reducing wei- ght, BMI, BP, fat mass, lean mass and energy intake compared to GC and PG, and a higher step count than PG at the end	Small popula- tion. Selected statis- tical analyses could not be ge- neralized. Mis- sing to analyze data obtained as psychometric measurements and Facebook group activity

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No	Author/ Year/Country	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
14	Gomez-Huelgas R. et.al (2015) Spain (18)	Rand- omized, prospective controlled trial	601 SM patients. Age 18-80 years 53.8 ± 14 Intervention Group(IG) (298) and GC (300)	Effects of long-term lifestyle intervention with DM and exercise for the treat- ment of MS in primary care settings	lifestyle inter- vention with Me- diterranean diet (DM) and aerobic exercise versus usual primary care	36 months 587 daily walking sessions (150 min per week), daily diet, 27 consul- tancies	GI lifestyle large diffe- rences com- pared to GC in BP, blood pressure and HDL Reduction of MS prevalen- ce to 29%	Specific popula- tion type cannot be extrapola- ted, the use and dosage of lipid-lowering and hyperten- sive drugs may affect results. No intermediate results
15	Sanllorren- te,A. et.al (2021) (19) Spain	Randomi- zed trial	391 older adults with MS (mean age, 65; Mean BMI, 33.3 kg/ m2) 190 patients in a group and 201 in the other group	To determi- ne whether intensive intervention with Medite- rranean diet and energy restriction plus physical activity im- proves HDL compared to non-hypo- caloric Me- diterranean diet without physical activity	Restricted Me- diterranean diet intervention plus physical activity (intensive lifes- tyle) compared to a non-restrictive Mediterranean diet intervention without physical activity	6 months sesiones182 of daily aerobic activity and 48 sessions muscular strength2/ week, daily diet ions	Intensive lifestyle GI showed weight improvement at 6 months. no change in HDL compa- red to control diet partici- pants, also decreased triglycerides	The results in specific popula- tion cannot be generalized. When finding an active compar- ator as a control, the differences are moderate between inter- vention arms.

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No	Author/ Year/Coun- try	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
16	Watanabe,M. et.al (2017) Japan (20)	Randomi- zed clinical trial	193 male workers diagnosis or risk factors for MS	To deter- mine the effectiveness of lifestyle education programme, personal support for reducing risk factors in people with MS	Intervention based on coun- seling and phone calls, specific food education with caloric reduction and improving quality	9 months, with 6 months of intensive care In two sessions and phone calls	IMC y BP reductions	By the popula- tion, it cannot be generalized. The ability of dietitians, pos- sible selection bias, plus aban- donment in the control group, can influence results.
17	Chirinos DA et. al (2016) USA (21)	Randomi- zed contro- lled trial (CHARMS) Community Health and Risk Reduc- tion for MS	120 adults with SM Age 51.7 (D:E 8.4) Hispanics 84.0% Afri- can Ameri- can 10.9%, Non-Hispanic Whites 5.0%	To examine effects of li- festyle inter- vention on weight and MS compo- nents among low-income minority adults	Intervention fo- cused on dietary habits and physical activity through educa- tion, behavior modification and stress ma- nagement GC 60 (usual medical care) and GI 60 (lifestyle intervention)	12 months 8 advisory sessions And one of reinforce- ment at 9 months Physical activity: 144 ses- sions of 15 to 30 minutes	GI Significant effects on weight and glucose were maintained at 6 months and also during the 12-month assessment	Small popula- tion to generali- ze results
18	Chang SH et. to (2019) Taiwan (22)	Randomi- zed contro- lled trial	69 older adults with MS	To examine long-term lifestyle effects of community intervention on biochemi- cal indicators and the prevalence of MS in older adults	GI exercise and diet. GC exercises.	18 months Sessions 18 dietary advice, daily diet, exercise and walking 182 sessions	All decreased prevalence of MS, changes in weight, BMI, BP, blood pres- sure.	Does not con- sidered factors such as smoking and drinking. Does not have a real control group because there was no group without intervention

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No	Author/ Year/Country	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
19	Fernández-Ruiz V. et.al (2018) Spain (23)	Randomized, controlled clinical trial	74 patients with MS (experimental group n = 37; control group n = 37).	To evaluate the effectiveness of an interdisciplinary program led by nurses focused on (MS) and cardiovascular risk (CVR)	Intervention: interdisciplinary educational program, modification of unhealthy eating habits and change for healthy with physical activity	12 months and review 1 year post intervention Physical activity 208, psychologist 12, nutritionist 24, doctor 24, educational nursing 50 And 50 multidisciplinary sessions	GI Significant reduction in short-term diagnosis of MS by 48.1% at 6 months and at 12 months by 83.8%. It was maintained 1 year after intervention	In those
20	Tran VD. et.al. (2017) Vietnam (24)	Randomized controlled trial	417 people aged 50 to 65 years with MS Randomly assigned an intervention group 214 and a control group 203	To determine the effectiveness of a physical activity and nutrition programme in reducing MS and its components among adult carriers	GI received a nutrition and physical activity program for 6 months, the GC received advice on diet and physical activity on one occasion	6 months 4 educational sessions, 3 physical activity counseling sessions Diet and physical activity 182 sessions	GI improvement in HDL, BP, weight, BMI compared to GC. In both groups the proportion of MS was reduced. The clinical parameters of MS decreased more in GI	It is unknown which components of lifestyle changes are most effective in improving metabolic parameters. It is short-term, there may be reversal in the weight lost, ideal longer

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No	Author/ Year/Coun- try	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
21	Yoo S et.al (2012) Korea (25)	Randomi- zed clinical trial	480 adults aged 60 years or older with MS. in the interven- tion group (GI)223 or the compa- rison group (CG).207	To examine the effec- tiveness of lifestyle modification programs in MS status and in stages of change in lifestyle behaviors associated with MS in Korean adults	GI advice and health, health education, a self-management manual, newslet- ters and a health diary. GC control group received minimal information on MS and lifestyle modification	6 months Individual counseling sessions 12, gener ales 2, monthly newsletters (12 newslet- ters)	Decrease in the preva- lence of MS at 38.1% GC and 52.4% in the GI. The GI improved more parame- ters such as BP, blood pressure and triglycerides, improvement in stages of feeding be- havior more than GC	In the scope of the transtheore- tical model, de- cisional balance and self-efficacy are ignored. It does not explain the socioeconomic details of the participants, ca- loric intake and the characteris- tics of physical activity
22	Siu P.M et.al(2015) China (26)	Randomi- zed trial	182 Adults, mean age \pm SD = 56 \pm 9.1)	To examine effects of 1 year of (mind) yoga exercise on RCV factors in midd- le-aged and older Chi- nese adults with MS	Yoga Practice Intervention (GC) 84 people, (GC) 98 Covariate Analysis: Level of Physical Activi- ty and Caloric Intake.	12 months 144 mee- tings yoga 1 informa- tive session benefits Monitoring 12 months, 12 months by phone	The yoga intervention associated with reduc- tion of meta- bolic aspects related to MS as well as im- proved blood pressure and BP-	No active con- trol group

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No	Author/ Year/Coun- try	Design	Population	Purpose	Type of intervention	Duration	Results	Limitations
23	Ortega JF, et. to (2016) Spain (27)	Dou- ble-blind randomized trial	36 patients with MS 18 patients aged 53 ± 2 years and 18 with 54 ± 2 years	To study the effects of physical training alone or in combination with dietary supplements of omega-3 polyun- saturated fatty acids (Ω-3PUFA) and oleate on the compo- nents of MS	All with physi- cal training in high intensity intervals. GC (18) took daily 500 ml of semi-skimmed milk (8 g of fat; placebo milk) GI 18) daily took 500 ml of skim- med milk added with 275 mg of Ω-3PUFA and 7.5 g of oleate (Ω-3 + OLE).	24 weeks 72 Exercise sessions (3 times a week) 148 Sessions of Taking Placebo or Supplement	Both groups, similar re- sults in blood pressure, BP, body fat and trunk fat mass. C-reactive protein concentration and HDL im- proved only in the Ω-3 + OLE group	In the said

Source: Own elaboration.

A decrease in the prevalence of MS, and/or its cardiometabolic parameters contemplated in the quantification studies at the beginning, and whose condition was modified in the course of the intervention, was classified as good of the intervention.

Interventions in Children

A total of 605 participants between the ages of 6 and 17 were included in the analysis. The duration was between 6 and 31 months. One of the interventions for children assessed the effect of detraining after 31 months of intervention; the remaining 5 studies were educational and multidisciplinary lifestyle interventions. In one study, individual educational counseling compared with group counseling on good nutrition and exercise, the latter had a better effect by decreasing MS parameters, showing less dropout. An educational intervention in the school environment focused on lifestyle, personalized by instructing parents or caregivers, significantly decreased all parameters, as well as the prevalence of MS. There was no negative effect on detraining 6 months after diet and exercise interventions. Educational intervention aimed at patients and parents, or

caregivers combined with physical activity sessions, reduced the criteria as the diagnosis of MS improved. The Nereu program, characterized by behavioral interventions for children and families in an integrated manner, presented an improvement in eating and physical behaviors. In multidisciplinary intervals with constant physical activation and adequate feeding, MS parameters were reduced. Interventions in children in food and physical counselling showed improvement in clinical parameters and decreased MS prevalence.

Interventions in Adults

There were 3448 adults included in the reviewed studies, with ages between 27 and 69 years. Adult interventions lasted between 6 and 36 months. Four interventions did not include females in the sample; however, results did not differ from those found in populations of both sexes. The interventions positively impacted the clinical parameters of MS, reduced its prevalence, or achieved a change in eating behavior and physical activity.

DISCUSSION

The result of our review supports previous findings (Aguilar et.al, 2014) which found that, if in an intervention includes physical activity, diet, and reinforcements (positive??), better results are obtained. The collaboration of the family is a factor of greater impact than food education itself, when it comes to guaranteeing results. In the present (28) review, group counseling was effective among children, and the use of motivational reminders against sedentary lifestyle were regarded as useful tools. The group approach reinforced adherence. Personalized, multidisciplinary care in children with family support offers success in acquiring healthy lifestyles such as diet and physical activation.

Regardless of a personalized or group intervention for children, family involvement helped decrease MS, overweight, and obesity. When the mixed intervention included diet, there are good results in decreasing MS. The Mediterranean diet, which was the most implemented in the present review, shows good reduction of energy intake, optimization of the regimen with 24-hour reminders, constant nutritional advice, and ideas for adaptations to the Mediterranean diet.

The symptoms of binge eating disorder, which are excessive and recurrent food intake, with the feeling of losing control, without compensatory and appropriate weight control behaviors, were

controlled in one of the multidisciplinary interventions, as well as the decrease in the prevalence of MS from 75% to 45% and changes in metabolic parameters. (29) Binge eating disorder (BED) is considered the most prevalent food disorder, and a major risk factor for obesity and MS. (30)

Findings from educational home intervention on healthy lifestyles in adults from rural communities in Australia (Blackford K, et.al, 2019) (19) suggest the majority of people in this study preferred printed resources to the Internet. We considered that this phenomenon could be attributable to population characteristics such as age, rurality, and disinterest in access to technology. This result contrasts with another Australian study (Jane M et al., 2017) (23), which found that using the web (Facebook) worked as an excellent tool as a support network to modify diet and physical activity for weight control. It appears that technology could serve as a barrier or facilitator, depending on the population group, when addressing MS in different population groups.

We found similarity with what was stated by Yamaoka K et al. (2012) in relation to the improvement of the cardiometric parameters (31) of MS since the lifestyle interventions in the significantly reduced the mean values of blood pressure and the abdominal perimeter.

Evidence from clinical trials (32, 33, and 34) has shown that the key points to prevent diabetes in adults are increased physical activity and weight loss. In people at risk of developing type 2 diabetes, it was possible to reduce the risk by 50 to 60% in the intervention period of 3 to 6 years, through the combination of diet, exercise, with the objectives of weight loss and increase in physical activation and, despite decreasing, the effect of the intervention may continue (35, 36, and 37). The large-scale implementation of dietary interventions and physical activity in clinical settings and communities is beginning to be carried out, but requires dissemination.

It is not yet decisive how it is recommended to carry out the reinforcement and if it is different in children or adults, since the maintenance phase must be structured to extend as long as possible the change of behavior and habits that favor the healthy lifestyle become customary. Having access to information technologies motivates us to imagine that the maintenance of what has been learned in the interventions will be strengthened with interactive virtual programs and constant communication for the user, and that it will possibly be an accessible instrument in interventions for children.

In the present review, one study (Fernández-Ruiz et al., 2018) (30) demonstrated effectiveness and efficacy in MS reduction of an interdisciplinary nursing-guided intervention at 6, 12, and 24 months, respectively, with a reduction in metabolic syndrome of 83.8% at 12 months. The literature suggests that interventions that transmit knowledge, modify sedentary lifestyle, change dietary patterns, promote self-care, and promote self-responsibility, positively change the health conditions of society. The literature also suggests that reinforcement is indispensable for permanent change.

Findings from this literature review support previous findings (Dunkley AJ et al., 2012) (38) that any interventions is useful to reverse metabolic syndrome, but multidisciplinary lifestyle interventions (Guzmán A et al., 2019) are more effective by promoting the acquisition of behaviors that modify and prevent metabolic syndrome in a more lasting way. Based on this review, a minimum of 24 weeks is ideal for optimal results

CONCLUSIONS

Attention to MS includes the reduction of its causes (obesity and physical inactivity) and the treatment of associated risk factors through the modification of lifestyles, especially nutritional habits and physical activity. In children, interventions in school environments control and decrease MS, group participation leads to a lower dropout rate, there is more effectiveness in integrating the family, and the reduction in prevalence in individual or group programs is similar.

More experience and implementation of adaptable and modifiable models in the different populations at risk is required, to be able to make primary care more efficient and effective in the management and knowledge of metabolic syndrome, and realize the importance of intervening, as well as disseminating throughout the population, the tangible benefits of stopping before the appearance of something that will bring the imminent deterioration of health.

Interventions that combine the promotion of healthy lifestyles, diet, and physical activation show a clear improvement in the prevalence of metabolic syndrome, as well as in decreasing the number of cardiometabolic risk factors in the people under study. Programs are effective in a wide range of characteristics, but interdisciplinary lifestyle interventions seem to be better at achieving the desired goal. It is necessary to implement long-term designed interventions, and to

monitor the results to know which objectives that were achieved in the control are the most impactful, and how to make them permanent through reinforcement, evaluation, and continuous feedback, to achieve effective strategies to prevent and control Metabolic Syndrome, and that could be managed as health policies.

Contribution of the authors

All authors have approved the final version of the article.

Conflict of interests

The authors of this review declare that they have no conflicts of interest.

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