

Optimum training programme during pregnancy to prevent gestational hypertension and preeclampsia: a systematic review

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Summary

Gestational hypertension and pre-eclampsia are hypertensive disorders which are the world's leading cause of maternal and perinatal mortality. Currently, evidences support the benefit of moderate physical exercise (PE) during uncomplicated pregnancies in the prevention of HTG and pre-eclampsia. However, there is no evidence on which kind of training is more effective for its prevention.

The aim of this study was to analyze which kind of exercise, duration of the intervention and session, frequency and intensity produce the greatest benefits in the prevention of gestational hypertension and pre-eclampsia in women with uncomplicated pregnancies.

An exhaustive search of PubMed and Web of Science was carried out until October 21, 2020. From 705 studies found, we analyzed 14 original full-text intervention articles in English or Spanish, with a PE program in pregnant women without complications, evaluating BP and including in their methodology, at least, frequency, duration, intensity, or kind of exercise. Exercise training in healthy women with uncomplicated pregnancies reduces the incidence of HTG and preeclampsia. The program with most benefits is concurrent training combined with flexibility, with a minimum duration of 29 weeks, from the 8th-9th gestational week to 36, but can be extended until the end of pregnancy. It's recommended to get to a training frequency equal to or greater than 3 days a week, with sessions at 50-70% of the maximum heart rate and 10-14 on the Borg Scale, and a duration of 45 and 60 minutes per session.

Key words:

Pregnancy. Gestational hypertension. Pre-eclampsia. Exercise. Hypertension.

Programa de entrenamiento óptimo durante el embarazo en la prevención de la hipertensión gestacional y preeclampsia: una revisión sistemática

Resumen

La hipertensión gestacional (HTG) y preeclampsia son trastornos hipertensivos, y la principal causa mundial de mortalidad materna y perinatal. Actualmente, la evidencia avala el beneficio del ejercicio físico (EF) moderado durante embarazos sin complicaciones en la prevención de HTG y preeclampsia. Sin embargo, no existe evidencia sobre qué tipo de entrenamiento es más eficaz para su prevención.

El objetivo de este estudio es analizar qué tipo de ejercicio, duración de la intervención y sesión, frecuencia e intensidad producen mayores beneficios en la prevención de la HTG y preeclampsia en mujeres con embarazos sin complicaciones.

Se llevó a cabo una búsqueda exhaustiva en PubMed y Web of Science hasta el 21 de octubre de 2020. De 705 estudios encontrados, analizamos 14 artículos originales de intervención a texto completo en inglés o español, con un programa de EF en embarazadas sin complicaciones, que evaluaran la presión arterial e incluyeran en su metodología, al menos, frecuencia, duración, intensidad o tipo de ejercicio.

El entrenamiento en mujeres sanas con embarazos sin complicaciones reduce la incidencia de HTG y preeclampsia. El programa con más beneficios es el entrenamiento concurrente combinado con flexibilidad, con una duración mínima de 29 semanas, desde la 8ª-9ª semana gestacional hasta la 36, pudiendo extenderse hasta el final del embarazo. Se recomienda una frecuencia de entrenamiento igual o mayor a 3 días semanales, con sesiones al 50-70% de la frecuencia cardíaca máxima y 10-14 sobre 20 en la Escala de Borg, con una duración de 45 y 60 minutos por sesión.

Palabras clave:

Embarazo. Hipertensión gestacional. Pre-eclampsia. Ejercicio. Hipertensión.

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Introduction

The National Institute of Children's Health and Human Development (NICHD) defines pregnancy as the period when a fetus is developing in a woman's uterus¹. This is a physiological process with a standard duration of 36–41 weeks, divided into 3 trimesters when anatomical, physiological, hormonal and emotional changes take place to allow adaptations that maintain the necessary maternal and fetal homeostasis in a fast-changing medium^{2,4}.

Focussing on physiological changes at a vascular level, we can highlight an increase in blood flow volume, plus an accumulative retention of sodium^{5,7}. However, arterial pressure (AP) tends to drop, mainly in the second trimester, principally due to the drop in periphery vascular resistance, associated with the action of nitric oxide, relaxin and progesterone on the muscles of the arterial wall^{7,8}. From the start of the third trimester, average AP rises until it reaches pre-pregnancy values⁸.

Arterial hypertension (AHT) is considered a risk factor for cardiovascular mortality, independently of any other⁹. This pathology presents modifiable risk factors, such as being overweight or obese, high cholesterol levels in the blood, consumption of alcohol and tobacco, and physical inactivity. Unmodifiable risk factors are genetic, being black and being male. Among women, the most likely period to suffer this pathology is after the menopause¹⁰.

According to the American College of Obstetricians and Gynaecologists (ACOG), gestational hypertension (GHT) is defined as a resting systolic AP over 140 mmHg or diastolic AP of 90 mmHg after 20 weeks of gestation (or within 12 weeks of giving birth), without proteinuria (protein/creatinine quotient in urine ≥ 300 mg/g) or shut-down of vital organs⁴. It is usually transitory but it can become chronic and a precursor for preeclampsia or early stages of preeclampsia where proteinuria has yet to appear¹¹. It is related to prenatal complications, including premature birth¹².

In turn, preeclampsia is a specific disease to human pregnancy, characterised by AHT and proteinuria after 20 weeks of gestation^{13,14}. It is considered severe when the aforementioned symptoms are accompanied by signs that multiple organs are affected. In most cases, severe preeclampsia leads to miscarriage¹¹. As for GHT, its aetiology is unknown, although some sources suggest dysfunction of vascular endothelial cells, which reduces the synthesis of vasodilators, leading to a vasospasm that will cause AHT^{15,16}. In addition, their risk factors are similar, which might indicate similarities in the aetiology of the two conditions¹⁷. These risk factors are genetics, obesity, excessive weight gain during pregnancy, nulliparity, history of preeclampsia, diabetes, AHT and a sedentary lifestyle¹⁶.

These hypertensive disorders are the main cause of maternal and perinatal mortality throughout the world²². Both GHT and preeclampsia develop after the 20th week of pregnancy and follow the same pathogenic process¹¹. Onset of GHT is characterised by an increase in cytokine levels in plasma, while preeclampsia is characterised by greater placenta dysfunction^{18–20}.

Prevention of these disorders is based on prenatal medical checks, and intake of calcium and anti-hypertension and antiplatelet drugs²¹. However, calcium supplements have only been shown to be effective in populations with nutritional deficiency²². The efficacy of low doses of aspirin is only recognised among women with preeclampsia in more than one previous pregnancy and in cases of chronic AHT with added preeclampsia in prior pregnancies²³.

Due to lack of knowledge on what causes these disorders, there is not one specific preventive method for the general obstetric population¹¹, which brings about the need to investigate possible non-pharmacological preventive strategies such as physical activity (PA) as, when performed regularly, it improves cardiovascular capacity and reduces risk factors for these hypertensive disorders, such as lowering the risk of diabetes, endothelial dysfunction and obesity prior to pregnancy, and not gaining excessive weight during gestation^{24–26}. All this would help reduce the risk of GHT and preeclampsia, which would open doors to a new preventive strategy.

Many institutions support pregnant women remaining physically active during pregnancy and post-partum to improve their maternal-foetal health without any counter-indications^{27,28}. The latest Canadian Guideline for Physical Activity during Pregnancy sets a minimum of 150 minutes a week of moderate PA, in at least 3 sessions per week, combining aerobic training (AT) and strength training, also known as concurrent training (CT)²⁸.

The ACOG has recently published recommendations for training during pregnancy for healthy women: 3 or 4 days a week, at an intensity of 60–80% of maximum heart rate (HR_{max}) or 12–14 on the Borg Rating of Perceived Effort (RPE)²⁹, from the first trimester to birth, in 30- to 60-minute sessions²⁷. During pregnancy, CT is the type of exercise that seems to bring the greatest benefits to maternal health³⁰.

Although studies on the effect of physical exercise (PE) during pregnancy on the foetus and the new-born have begun recently, scientific evidence indicates the safety and efficacy of maternal training during pregnancy in terms of foetal and neonatal health²⁴.

Among the general population, moderate regular PE reduces the incidence of AHT, helping lower systolic and diastolic AP, and ensuring adequate venous blood flow to the heart³¹. Furthermore, it has been seen that carrying out supervised PE can safely and significantly improve physical performance and quality of life for patients with AHT³².

Knowing that physical inactivity is a modifiable risk factor, PE is shown as a possible tool to lower the risk of suffering GHT and preeclampsia^{33–35}.

Although evidence supports the benefits of PE during pregnancy in terms of GHT and preeclampsia, the type of training which is most effective to prevent these pathologies is still unclear, as mentioned in ACOG (2020) for pregnancies without complications, generically.

Consequently, this review aims to analyse which type of exercise, intervention duration and which session, frequency and intensity produce the greatest benefits in preventing GHT and preeclampsia in women with uncomplicated pregnancies.

Methodology

This study carried out an exhaustive search of 2 scientific literature databases. PubMed and Web of Science (WOS), up to 21/10/2020. Intervention studies were included that analysed the effect of training during pregnancy among healthy women in relation to GHT and preeclampsia. Consequently, the search descriptors used are grouped into pregnancy, training, GHT and preeclampsia (Table 1).

The PubMed search used a combination of keywords and MeSH terms, while WOS used keywords, selecting its "Main Collection" as a database. Regarding the search field, the "Topic" filter was used.

After determining the search strategy, inclusion and exclusion criteria were given to select studies that would form part of the review.

The inclusion criteria were: 1) Complete text studies in Spanish or English, published on PubMed or WOS; 2) Original studies of PE intervention programmes for pregnant women, that include a detailed description of the intervention (at least frequency, duration, intensity and type of exercise); 3) Studies that evaluate the AP.

Studies were excluded if their main sample had at-risk pregnancies according to the NICHD:¹ 1) Age under 18 or over 35; 2) Illnesses prior to pregnancy: Prior AHT, diabetes or being HIV positive; 3) Overweight or obesity; 4) Multiple pregnancy; 5) Consumption of tobacco, alcohol and drugs.

Two researchers (SSP and ASD) independently evaluated the titles, abstracts and complete texts of the recovered articles using the search

strategy to determine eligibility according to the inclusion criteria. When they did not reach a consensus between the two of them, a third researcher (JCP) took the final decision on inclusion. Out of the 705 studies found, 14 were included after the review. The reasons for excluding studies are shown in Figure 1.

Figure 1. Article selection process according to PRISMA.

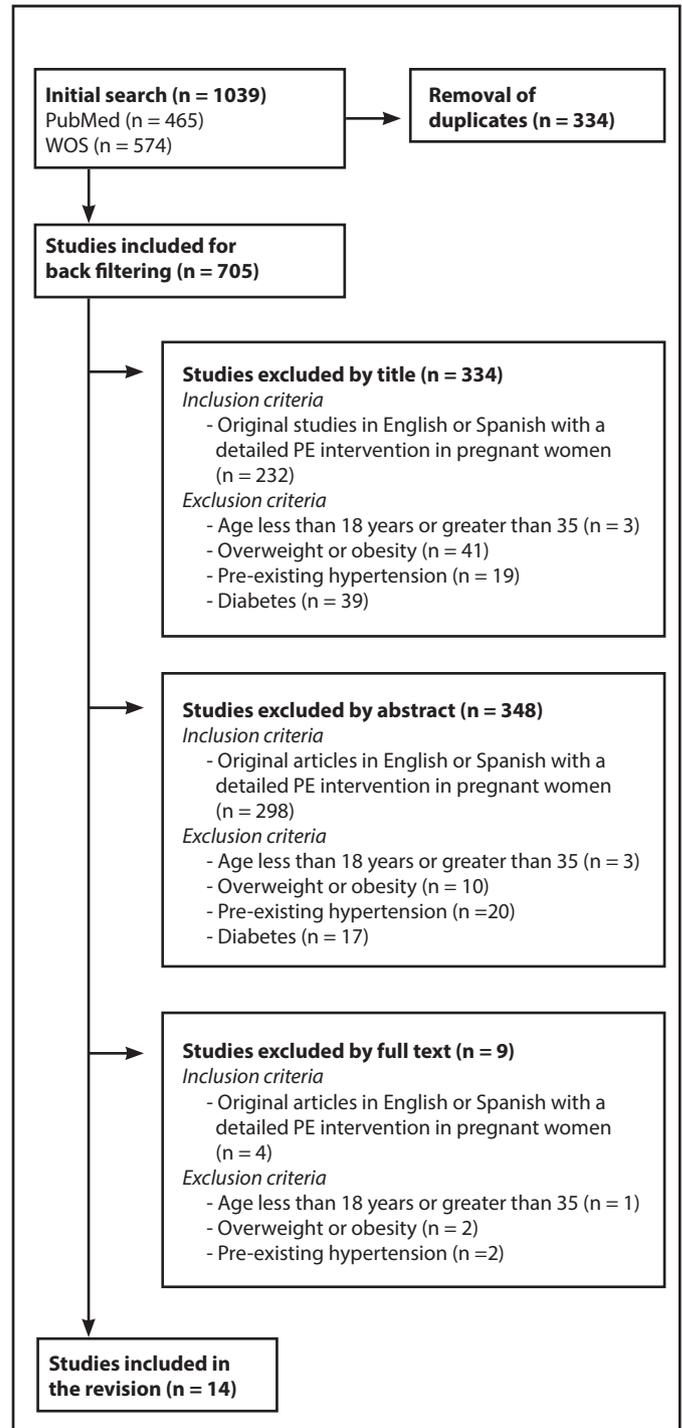


Table 1. Search strategies used in the databases.

Database	Search strategy	Limits
Pubmed	("Pregnant women"[Mesh] OR "Pregnant women" OR "Pregnancy"[Mesh] OR "Pregnancy") AND ("Exercise"[Mesh] OR "Exercise") AND ("Hypertension, Pregnancy-Induced/prevention & control"[Mesh] OR "Hypertension" OR "Pre-Eclampsia/ prevention & control"[Mesh] OR "Preeclampsia")	Publication date: "Up to 2020/10/21" Species: "humans"
WOS	("Pregnant women" OR "Pregnant Women*" OR "Pregnant Woman*" OR "Pregnancy" OR "Pregnancies*" OR "Gestation*") AND ("Exercise" OR "Physical Activity*" OR "Physical Activities*" OR "Physical Exercise*" OR "Physical Exercises*" OR "Acute Exercise*" OR "Acute Exercises*" OR "Isometric Exercises*" OR "Isometric Exercise*" OR "Aerobic Exercise*" OR "Aerobic Exercises*" OR "Exercise Training*" OR "Exercise Trainings*") AND ("Hypertension, Pregnancy-Induced/prevention & control" OR "Gestational Hypertension*" OR "Transient Hypertension*" OR "Pre-Eclampsia/prevention & control" OR "Pre Eclampsia*" OR "Preeclampsia*" OR "Pregnancy Toxemias*" OR "Pregnancy Toxemia*" OR "Edema Proteinuria Hypertension Gestosis*" OR "Toxemia Of Pregnancy*" OR "Toxemia Of Pregnancies*" OR "EPH Complex*" OR "EPH Toxemias*" OR "EPH Toxemia*" OR "EPH Gestosis*" OR "Preeclampsia Eclampsia 1*")	Document types: "article"

Results

After study selection, 14 intervention studies were included in the review whose characteristics and results are given in Table 2.

Sample

The 14 studies included in the review comprise a total sample of 4,756 women with uncomplicated pregnancies. Out of them, 2,778 were included in a control group, while 1,978 carried out a specific PE programme.

Table 2. Table summarising the articles included in the review.

Study	Sample	Type of exercise	Duration of the intervention	Frequency, duration and intensity of the session	Results of the training programme	Conclusions
(42)	N: 765 IG: 383 CG: 382	Aerobic, strength and flexibility	Week 9/11 of pregnancy - end of pregnancy	F: 3 days/week. D: 50-55 minutes I: <70% HR _{max} 12-14 RPE	GHT incidence (IG vs CG): 2.1% vs 5.7% (OR=2.96; CI= 1.29-6.81; p=0.01 between groups) Preeclampsia incidence (IG vs CG): 0.5% vs 2.3% (p=0.03 between groups) Excessive weight incidence (IG vs CG): 26.4% vs 34.2% (OR=1.47; CI= 1.06-2.03; p=0.02 between groups) Macrosomia incidence (IG vs CG): 1.8% vs 4.7% (OR=2.53; CI= 1.03-6.2; p=0.04 between groups)	Maternal exercise can prevent AHT and helps control maternal and fetal weight gain
(2)	N: 200 IG: 93 CG: 107	Aerobic, flexibility and pelvic floor	Week 9/13 of pregnancy - end of pregnancy	F: 3 days/week. D: 55-60 minutes I: 55-60% HR _{max} 12-13 RPE	Excessive weight incidence (IG vs CG): 21.2% vs 35.6% (p=0.02 between groups)	Moderate regular exercise did not represent a maternal-fetal risk and helps control maternal weight gain.
(36)	N: 171 G1: 54 G2: 60 CG: 57	Aerobic	Week 13 (G1) / 20 (G2) – 38 of pregnancy	F: 3 days/week. D: > 15 minutes I: 60-80% HR _{max} 12-16 RPE	VO _{2max} (G1 vs G2 vs GC): ↑11.2% vs ↑11.1% vs ↓1.16% (p=0.03 between groups) With no significant relationship between groups in preeclampsia, macrosomia, AP and pulsatility index (p>0.05)	The intervention improved the physical condition of the pregnant women without affecting the placenta blood flow or fetal growth.
(44)	N: 639 IG: 426 CG: 213	Aerobic, strength and flexibility	Week 16/20 – 32-36 of pregnancy	F: 3 days/week. D: 60 minutes I: 12-14 RPE	No significant relationship with the risk of premature birth, preeclampsia, weight gain, gestational diabetes and macrosomia (p>0.05)	Although it does not relate exercise during pregnancy with premature births or preeclampsia, it does not present a risk for the fetus.
(37)	N: 61 IG: 26 CG: 35	Aerobic and strength	Week 12 – >24 of pregnancy	F: 2 days/week. D: 60 minutes I: 12-14 RPE	Systolic resting AP (IG vs CG): ↓2.6% vs 3.4% (CI=1.5-12.6; p=0.013 between groups)	The exercise reduces the AP in previously inactive pregnant women
(41)	N: 358 IG: 147 CG: 211	Aerobic and strength	Not specified	F: 3 days/week. D: 60 minutes I: <1.25 on 5-point Likert Scale	Premature births (IG vs CG): 4% vs 7% (p=0.0065 between groups) Bradycardia (IG vs CG): 10% vs 16.3% (p=0.001 between groups) Preeclampsia incidence (IG vs CG): 6.6% vs 12.3% (p=0.002 between groups)	The intervention reduced the intensive care for new-borns and the health costs
(43)	N: 1348 IG: 660 CG: 688	Aerobic, strength, flexibility and pelvic floor	Week 9-38/39 of pregnancy	F: 3 days/week. D: 50-55 minutes I: <60% HR _{max} 10-12 RPE	Excessive weight (IG vs CG): ↓ (OR=0.6; CI=0.52-0.84; p = 0.001) GHT incidence: ↓ GHT (OR= 0.39; CI=0.67; p=0.001) Diabetes incidence (IG vs CG): ↓ (OR=0.48; CI=0.28-0.84; p = 0.015) Cardiometabolic diseases (IG vs CG): ↓ (OR=0.27; CI=0.08-0.95; p = 0.041) Macrosomia incidence (IG vs CG): (OR=0.36; IC=0.2-0.63; p=0.007) Previous weight in 6 months (IG vs CG): ↑ (OR=2.37; CI=1.26-4.54; p = 0.007)	Exercise during pregnancy can protect maternal-fetal health.

(keep going)

Study	Sample	Type of exercise	Duration of the intervention	Frequency, duration and intensity of the session	Results of the training programme	Conclusions
(26)	N: 62 IG: 31 CG: 31	Aerobic	Week 12/14 - >36 of pregnancy	F: 4 days/week. D: 45-60 minutes I: 12-14 RPE	VO _{2max} (IG vs CG): ↑ GI (p<0,05) Strength (IG vs CG): ↑ GI (p<0.01) C-section incidence (IG vs CG): 6% vs 32% (p<0.01) Post-partum recovery time (IG vs CG): ↓ IG (p<0.05) GHT incidence (IG vs CG): ↓ IG (p=0.16)	Exercise improved physical aptitude among previously inactive women and reduced complications during the birth
(38)	N: 20 IG: 10 CG:10	Aerobic and strength	Week 16/20 – 28/32 of pregnancy	F: 3 days/week. D: 85 minutes I: 55-75% HRmax	Nitrous oxide and nitric oxide (IG vs CG): ↑ IG (p=0.05) Mitochondrial superoxide (IG vs CG) ↓ 8% compared to CG (p=0.05) Hydrogen peroxide in the placenta mitochondria (IG vs CG): ↓ 37% compared to CG (p=0.05)	The changes caused by exercise at a placenta level benefit the vascular system and reduce the risk of preeclampsia, diabetes and GHT
(45)	N: 64 IG: 31 CG: 33	Aerobic	Week 16/20 – 32/36 of pregnancy	F: 3 days/week. D: 60 minutes I: 50-65% HR _{max}	VO _{2max} (IG vs CG): ↑ 2.4 vs ↓ 4.7% (p=0.014 between groups) Dilatation measured by flow (IG vs CG): No changes vs ↓ 0.01% (p=0.02 between groups) Resting HR (IG vs CG): ↑ 11.2% vs ↑ 19.8% (p=0.02 between groups)	The intervention improved the endothelial dependent vasodilation in pregnancy, which could prevent disorders due to endothelial dysfunction
(46)	N: 855 IG: 429 CG: 426	Aerobic, strength and balance	Week 20 – 36 of pregnancy	F: <3 days/week (1 supervised) D: 60 minutes I: 13-14 RPE	Gestational diabetes incidence (IG vs CG): 7% (CI=4.3-9.7) vs 6% (CI=3.3-8.6) (p=0.52 between groups) GHT incidence (IG vs CG): 2.9% vs 3.2% (OR=0.9; CI= 0.4-2; p=0.77 between groups) Preeclampsia incidence (IG vs CG): 3.8% vs 3.8% (OR=1; CI= 0.5-2; p>0.99 between groups)	The exercise intervention did not avoid gestational diabetes or improve resistance to insulin among healthy pregnant women.
(39)	N: 10 IG: 5 CG: 5	Aerobic	Week 20 – 36 of pregnancy	F: 5 days/week. D: not specified (walking 0.6-3km) I: <40% reserve HR	Systolic AP (IG vs CG): ↑ 1.8% vs ↑ 3.7% (p<0.05 between groups) Diastolic AP (IG vs CG): 2.6% vs 1.35% (p>05 between groups)	Aerobic exercise could alleviate the increase in AP and reduce the incidence of GHT
(16)	N: 124 G1: 60 G2: 64	G1: flexibility G2: aerobic	Week 18 of pregnancy - end of pregnancy	F: 5 days/week. D: 40 minutes I: 55-69% HR _{max} 12-13 RPE	Resting HR (G1 vs G2): ↑ 8±11ppm (CI=5,1-11,2) vs ↑ 14±16 ppm (CI=9.1-17-9; p<0.01 between groups)	Regular flexibility training during pregnancy can reduce the risk of preeclampsia
(34)	N: 79 G1: 41 G2: 38	G1: flexibility G2: aerobic	Week 18 of pregnancy - end of pregnancy	F: 3-5 days/week. D: 31-40 minutes I: 55-69% HR _{max} 12-13 RPE	Preeclampsia incidence (G1 vs G2): 2.6% (CI=0.07-13.8) vs 14.6% (CI=5.6-29.2) (p<0.05 between groups) GHT incidence (G1 vs G2): 40% (CI=23.2-55.8) vs 22% (CI=8.7-35.2) (p<0.05 between groups)	Regular flexibility training during pregnancy can reduce the risk of preeclampsia

Abbreviations: CG, control group; IG, intervention group; F, frequency; D, duration; I, intensity; HR, heart rate; AHT: arterial hypertension; GHT, gestational hypertension; AP, arterial pressure; CI, confidence interval at 95%; RPE, Borg Rating of Perceived Effort.

Seven studies included pregnant women who had previously been sedentary (n = 527),^{16,26,36-40} while one analysed active pregnant women (n = 358)⁴¹. Two studies included as many previous active pregnant women (n = 346), as sedentary pregnant women (n = 1.767)^{42,43}. Four studies did not provide details of the PE prior to the sample^{2,44-46}. Thereby,

76.5% of the women studied in this review were sedentary (n = 2.294), while 23.5% (n = 704) were physically active.

The average age was 29.62 years old, and the body mass index was 24.24. 64.3% of the pregnant women were nulliparous (n = 2,882), while 35.7% (n = 1599) had given birth previously.

Intervention

Type of exercise

All the studies in this review include AT in their intervention. The methodology differed according to the authors, but the most often repeated aerobic activities were walking^{2,16,26,34,36,38,39,42} and dancing sessions^{2,37,43,46}.

Four studies carried out an exclusively AT intervention^{26,36,39,45}, three combined AT and strength^{37,38,41}, and two combined AT and strength and flexibility^{42,44}. Two studies, that include pelvic floor (PF) training in their programme, analyse the combined effect of AT, flexibility and PF on the one hand², and combining AT, flexibility, PF and strength on the other⁴³. Two studies divided their sample into women who did AT and those worked on flexibility^{16,34}. Finally, one study combined AT, strength and balance⁴⁶.

Duration of the training programme

The average duration of the programmes being analysed was 20 weeks. Three studies featured an intervention less than or equal to 16 weeks^{37,38,46}, while 3 ran their programme for more than 26 weeks^{2,42,43}. Lombardi *et al.*⁴¹ did not specify the duration of their intervention.

Most studies finished their training programme after the 36th week of pregnancy, with the exception of 2 studies that finished beforehand^{37,38} and another that did not specify it.⁴¹ However, there is reasonable heterogeneity at the start of the intervention. Five studies began in the 9th-14th gestational week^{2,26,37,42,43}, and 7 studies in the 16th-20th week^{16,34,38,39,44-46}. One study divided its sample into women who began training in the 13th week, and those who began in the 20th week; 36 while another study did not provide data on the start of its programme⁴¹.

Weekly frequency

In general, the studies included a training frequency of 3 days a week. Some studies set a greater frequency^{16,26,34,39,46}. In the study by Haakstad *et al.*,³⁷ the sample trained for a minimum of 2 days a week.

Intensity of the sessions

To monitor the intensity of the sessions, HR_{max} and/or RPE 6-2029 was used with the exception of one study⁴¹. Six used both measurements^{2,16,34,36,42,43}. 4 studies only used RPE^{26,37,44,46}, and 2, HR_{max}^{38,45}. Stutzman *et al.*³⁹ monitored the combined intensity of reserve HR and RPE, while Lombardi *et al.*⁴¹ used the Likert scale.

In terms of the most used measurement techniques (HR_{max} and RPE), the average maximum intensity for the interventions was 68.5% of the HR_{max} and an RPE of 13.6. The minimum^{39,45} and maximum³⁶ intensity values compiled were between 50-80% of the HR_{max} and an RPE of 11-16.

Duration of the sessions

Ten out of the 14 articles carried out sessions lasting between 40 and 60 minutes. Only two interventions programmed training with a

duration outside this interval, lasting 85 minutes³⁸ and 31-40 minutes each session³⁴. Two articles did not provide this detail^{16,39}. The average total duration of the sessions from the included studies was approximately 60-65 minutes.

Study results

After analysing the included studies, we saw that none of the interventions presented a risk for maternal-foetal health. All the studies except two^{44,46} reported significant improvements in the intervention group in some of the evaluated measurements compared to the controls.

Seven studies directly analysed the effect of the training on the risk of GHT and/or preeclampsia^{26,36,41-44,46}. Four studies did not find significant differences between groups^{26,36,44,46}. Although Price *et al.*²⁶ did not find this difference, there was no case of GHT in the intervention group.

Barakat *et al.*⁴² concluded that women who were inactive during pregnancy were 3 times more likely to develop AHT, independently of their body mass index, compared to women who followed a training programme (OR = 2.96; 95% CI = 1.29-6.81; *p* = 0.01). They also found that the controls were 1.5 times likely to gain excessive weight during pregnancy (OR = 1.47; 95% CI = 1.06-2.03; *p* = 0.02). This coincides with the study by Barakat *et al.*² and Perales *et al.*³⁰ (OR = 0.60; 95%CI = 0.46-0.49).

Lombardi *et al.*⁴¹ found a significant reduction among women that remained active during pregnancy in relation to the risk of preeclampsia (*p* = 0.0002). Perales *et al.*³⁰ concluded that PE during pregnancy reduced the risk of GHT (OR = 0.39; 95%CI = 0.23-0.67).

Lower incidence of GHT and preeclampsia and a lower resting HR have been observed among pregnant women who trained with flexibility^{16,34}. On the other hand, de Oliveria *et al.*³⁶ compared the same training programme among pregnant women that began in week 13 (G1), those that began in week 20 (G2) and controls (G3). In week 28, there was a greater VO_{2max} in G2 (VO_{2max} = 27.3±4.3 (G1); 28±3.3 (G2); 25.5±3.8 (G3); *p* = 0.03). In week 32, they saw an increase in VO_{2max} with no significant differences between G1 and G2, although higher than the controls (3.2±0.43 (G1); 3.1±0.55 (G2); 1.4±0.41 (G3); *p* = 0.001).

Stafne *et al.*⁴⁶ studied the effect of an AT, strength and balance programme, without finding any significant differences between groups in terms of gestational diabetes (7%; 95%CI = 4-11.4 (IG); 6%; 95%CI = 3.3-8.6 (CG)), GHT (2.9%(IG) vs 3.2%(CG)); OR=0.9; 95%CI=0.4-2(CG)) and preeclampsia (3.8% in both groups).

Except for Oliveria *et al.*³⁶ and Stafne *et al.*⁴⁶, they found that AP and HR dropped in the intervention groups compared with the controls^{37,39,45}.

Regarding foetal weight, a greater risk of macrosomia was found among inactive women during pregnancy^{42,43}, while another 2 did not bring up any significant differences^{36,44}. Barakat *et al.*⁴² observed that women who were inactive during pregnancy were 2.5 times more likely to give birth to a macrosomic baby (OR = 2.53; 95%CI = 1.03-6.20; *p* = 0.04). Perales *et al.*⁴³ also ratified it (OR = 0.36; 95% CI = 0.20-0.63).

To evaluate the cardiorespiratory capacity, the test used 6 minutes walking⁴⁵, the 2-mile test²⁶ or the treadmill test³⁶. All the studies agreed that the women who were active during pregnancy presented greater cardiorespiratory capacity: $p = 0.01445$, $p < 0.0526$ and $p < 0.00136$.

Discussion

The purpose of this review was to analyse which type of exercise, duration of intervention and session, frequency and intensity produce the greater benefits in preventing GHT and preeclampsia in women with uncomplicated pregnancies. The results obtained show that there is a beneficial relationship for healthy women between carrying out a PE programme in pregnancy and the risk of suffering these hypertensive disorders.

Type of exercise

After reviewing the literature, we conclude that healthy pregnant women can carry out PE during gestation without negatively affecting their maternal-foetal health^{36,44}.

The aerobic PE mainly used among this population is walking, dancing and the exercise bike^{2,16,26,34,36-39,42,43,46}. Strength exercise mainly used hand weights, elastic bands or exercises to strengthen the pelvic floor^{2,37,38,41-44}. In addition, flexibility was also widely studied^{2,16,34,42-44}. The ACOG fundamentally recommends carrying out a CT programme²⁷.

Price *et al.*²⁶ found that pregnant women who have followed an AT programme during their gestation reduced the incidence of C-sections and their recovery time after the birth.

Stutzman *et al.*³⁹ related AT to a drop in resting AP and incidence of GHT. However, this contradicts Oliveria *et al.*³⁶ who, although they related it to an increase in VO_{2max} , did not find any significant differences in the risk of preeclampsia, macrosomia, AP and the pulsatility index. Ramírez-Vélez *et al.*⁴⁵ endorse other benefits of AT in pregnancy, such as the increase in average dilation per flow or reduction of the resting HR.

Yeo *et al.*^{16,34} compared AT and flexibility in pregnant women. Their results show that the group that carried out flexibility training presented lower resting AP and incidence of preeclampsia. However, this group showed lower incidence of GHT, which might be due to the fact that this disorder can occur as a precursor to preeclampsia¹¹, and a programme of flexibility exercises could prevent it from developing.

Currently, training recommendations in pregnancy are focussed on CT programmes²⁷. Barakat *et al.*^{2,42} and Perales *et al.*³⁰ relate it to a greater gain in excess maternal weight and, except for Barakat *et al.*², who do not mention it, also with a lower risk of fetal macrosomia. In turn, de Stafne *et al.*⁴⁶ and Ginar *et al.*⁴⁴ do not find this relationship. Three studies made a CT intervention^{37,38,41} and another 3 combined CT and flexibility⁴²⁻⁴⁴. Four studies investigated the effect of the training on the incidence of GHT^{42,43} or preeclampsia^{41,42,44}. They all reduced the risk of suffering these hypertension disorders, except for Ginar *et al.*⁴⁴, who did not find significant differences. Compared with AT, there is greater evidence on

the preventive effect of CT on the incidence of GHT or preeclampsia⁴¹⁻⁴³ than any that only use aerobic training. By comparing AT and flexibility, pregnant women who carry out flexibility training had lower evidence of preeclampsia and reduced their resting HR^{16,34}.

To do so, optimum training to reduce the risk of GHT and preeclampsia would be to combine CT and flexibility.

Duration of the training programme

The recommendations indicate that healthy pregnant women should start training after the 12th week of gestation²⁷, because, as explained by the Office on Women's Health in the US Department of Health and Human Services (OWH), in the first trimester of pregnancy, there is a greater risk of a spontaneous miscarriage, particularly in the first 8 weeks⁴⁷. In the studies analysed, nobody began their intervention in the first 8 weeks of pregnancy, and the majority did so once they had passed the 12 week mark^{16,26,34,36-39,44-46}. However, there is evidence to back up that, for healthy women, training in the first trimester of pregnancy does not represent a risk for maternal-fetal health^{2,42,43}.

The ACOG (2020) does not set recommendations on the duration of the training programme that women with uncomplicated pregnancies should undertake. This might explain why there is great heterogeneity in the duration of the interventions of this review, as there are studies where the training lasts 12 weeks³⁷ and others that run for practically the entire pregnancy⁴³.

The end of the training programme is much more uniform. The majority pick interventions that continue until at least week 36^{2,16,26,34,36,39,42-46}.

Studies where the training programme lasts longer (29-31 weeks)^{42,43} demonstrate a lower incidence of GHT among the pregnant women. Studies with a programme lasting less than 12 weeks^{37,38} do not measure this variable, although Haakstad *et al.*²⁵ obtained a lower systolic resting AP in their intervention group compared to the control group. De Oliveria *et al.*³⁶ carried out an intervention lasting 25 and 18 weeks, depending on the groups into which their sample was divided, and Ginar *et al.*⁴⁴, for 12-16 weeks. Nobody found a significant relationship between the risk of GHT and preeclampsia and training in pregnancy. The study by Price *et al.*²⁶ did not report cases of GHT in the intervention group, which lasted 22-28 weeks, although the differences between groups were not significant. Oliveria *et al.*³⁶ suggest that one possible cause for there being no significant differences in their measurements might be that the intervention began in week 13 or 20 depending on the group, as opposed to another study that they used as a reference, that began its programme at 8-9 weeks⁴⁸, just like Perales *et al.*³⁰ and Barakat *et al.*⁴², who did find a significant relationship. In the same way, Ginar *et al.*⁴⁴ did not find a relationship in the incidence of preeclampsia when beginning their intervention at week 16-20 of pregnancy. Furthermore, the training ended at week 32-36, the typical time for preeclampsia to begin⁴⁴. Nor did Stafne *et al.*⁴⁶ find any differences in the incidence of GHT or preeclampsia, which might be due to the short duration of the intervention programme (16 weeks), or the high experimental mortality of the study.

For all these reasons, it seems that there is a greater reduction in the incidence of GHT and preeclampsia in interventions with a minimum duration of 29 weeks, and its preventive effect is seen to increase if the duration increases. The best results have been seen in interventions that began between the 8th and 9th week, finishing after the 36th week of pregnancy. More studies would be required to accurately determine the duration of a training programme for a greater reduction of the incidence of GHT and preeclampsia.

Weekly frequency

The ACOG recommends that women with uncomplicated pregnancies train at least 3-4 times a week²⁷.

Most studies carried out an intervention of 3 days a week^{2,36,38,41-45}. From them, Barakat *et al.*⁴² and Perales *et al.*³⁰ found that the women who had carried out the intervention had a lower risk of GHT, and Lombardi *et al.*⁴¹ found a lower incidence of preeclampsia. Price *et al.*²⁶, with a training frequency of 4 days a week, found a reduced risk of GHT, although it was not significant. De Oliveria *et al.*³⁶ Ginar *et al.*⁴⁴ with a frequency of 3 days a week, did not find significant differences in the incidence of preeclampsia, just like Stafne *et al.*⁴⁶, with a minimum frequency of 3 days a week. Stutzman *et al.*³⁹ with a frequency of 5 days a week, obtained a lower resting AP among the pregnant women who were training. Haakstad *et al.*³⁷, whose women trained for a minimum of 2 days per week, found that the intervention group obtained a lower systolic resting AP, but the same did not happen for the diastolic AP.

Consequently, the ACOG²⁷ recommendations are ratified, indicating that a minimum training frequency of 3 days per week would be ideal to reduce the risk of GHT and preeclampsia.

Intensity of the sessions

Current recommendations for training during pregnancy state that the intensity of the sessions must be between 60-80% of the HR_{max}²⁷.

The average maximum intensity of the studies in this review is 68.5% of the HR_{max} and 13.6 out of 20 for RPE. The majority trained with an intensity between 12-14 of RPE^{2,16,34,37,42,44,46}. However, Ramírez-Vélez *et al.*⁴⁵ and Stutzman *et al.*³⁹ ran studies with a lower intensity. Although Ramírez-Vélez *et al.*⁴⁵ did not directly study the incidence of GHT or preeclampsia, they obtained a drop in resting HR and an improvement in aerobic capacity and dilation measured by flow. Stutzman *et al.*³⁹ observed a drop in AP in the intervention group, which might induce lower incidence of GHT.

The study carried out by De Oliveria *et al.*³⁶ involved greater intensity, following ACOG recommendations²⁷. However, they did not find a significant relationship between training and lowering the risk of preeclampsia, just like Ginar *et al.*⁴⁴ and Stafne *et al.*⁴⁶ whose training sessions ranged between 12 and 14 of RPE. The studies that found a drop in GHT or preeclampsia followed training with intensity between 12-14 of RPE^{26,42}, or even less, 10-12 as the case of the study by Perales *et al.*³⁰ Lombardi *et al.*⁴¹ also found significant improvements in the risk of preeclampsia, in sessions with intensity under 1.25 on the 5-point Likert Scale.

Consequently, the results show that the optimum training intensity to reduce the risk of GHT and preeclampsia would be between 50-70% of the HR_{max} and between 10-14 out of 20 of the RPE.

Duration of the sessions

The ACOG recommends that, in uncomplicated pregnancies, training should be done in 30- to 60-minute sessions²⁷.

All the studies fall within this margin, except for Ramírez-Vélez *et al.*³⁸ with 85 minutes, and de Oliveria *et al.*³⁶ whose sessions lasted a minimum of 15 minutes. Perhaps, the limited duration of the sessions for this study³⁶ might explain why it is the only one, along with Ginar *et al.*⁴⁴ and Stafne *et al.*⁴⁶ that when studying the incidence of preeclampsia, did not find a drop among the pregnant women who were training. The studies that registered a lower risk of GHT^{42,43}, preeclampsia⁴¹ or a reduction of resting AP^{37,39} had 45- to 60-minute sessions, except for Stutzman *et al.*³⁹ who did not mention the duration.

Consequently, 45- to 60-minute training sessions would be effective to reduce the risk of GHT and preeclampsia.

Conclusion

Training during pregnancy for healthy women reduces the incidence of GHT and preeclampsia. The intervention programme with the most benefits is CT combined with flexibility training and with a minimum duration of 29 weeks, that ranges between the 8th-9th week of pregnancy, up to the 36th week, and can be extended to the end of pregnancy. A minimum training frequency of 3 days a week is recommended, with sessions between 50-70% of the HR_{max} and an RPE of 10-14 out of 20. For an optimum effect for the training in terms of reducing GHT and preeclampsia, the sessions must range between 45 and 60 minutes.

These recommendations mostly concur with the recommendations suggested by ACOG for training among healthy women in pregnancy.

Conflict of interests

The authors do not declare any conflict of interests.

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