Artículo original

Fetal and maternal heart rate responses to exercise in pregnant women. A randomized Controlled Trial

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Recibido:
Aceptado:

Summary

Objective: To examine whether regular physical exercise during pregnancy improves the fetal and maternal heart rate response to different intensities of acute exercise.
Material/methods: A randomized controlled trial was conducted. Sixty-three women with healthy singleton pregnancies were analyzed (n=38 in the exercise group (EG); n = 25 in the control group CG). Women from EG participated in a supervised exercise program from 9-12 until 38-40 weeks of gestation. Maternal and fetal response were evaluated in late pregnancy (week 34.08±2.27) walking for 3 minutes at different intensities: light exercise (LE: 40% maternal heart rate reserve) and moderate exercise (ME: 60% maternal heart rate). The primary outcome was the fetal heart rate response after maternal exertion at both intensities.
Results: After maternal effort, the fetuses from the EG showed lower increases in heart rate than the fetuses from the CG at both intensities (LE: EG 139.1±14.2 vs. CG: 149.0±10.5; p = 0.004) and (ME: EG: 139.9±13.5 vs. 150.9±17.9; p = 0.008).
The fetuses from the EG presented a lower time to recovery than those from the CG after LE (86±104.7 sec. vs. 405.2±384.7 sec.; p = 0.000) and ME (160.4±234.3 sec. vs. 596.9±461.4 sec; p = 0.000). The program was effective for improving maternal recovery after LE (341.2±281.6 sec. vs. 577.4±277.0 sec.; p = 0.002) and ME (525.8±309.0 sec. vs. 876.1±362.6 sec.; p = 0.000).
Conclusion: Regular exercise during pregnancy may be associated with faster maternal and fetal recovery after maternal exertion, and with a lower increase in fetus heart rate.
Registro Ensayo Clínico: clinicaltrials.gov NCT01723293

Key words:
Heart rate.
Exercise.
Pregnancy.

Respuesta de la frecuencia cardiaca fetal y materna al ejercicio en gestantes. Ensayo clínico aleatorio

Resumen

Objetivo: Examinar si el ejercicio físico regular durante el embarazo mejora la respuesta de la frecuencia cardiaca fetal y materna a diferentes intensidades de ejercicio físico.
Material/métodos: Se desarrolló un ensayo clínico aleatorio. Sesenta y tres mujeres sanas y con embarazo simple fueron analizadas (n=38 en el grupo de ejercicio (GE); n = 25 en el grupo de control CG). Las mujeres del GE participaron en un programa de ejercicio físico supervisado desde la semana 9-12 de gestación hasta la 38-40. La respuesta materna y fetal fue evaluada al final del embarazo (semana 34,08±2,27) caminando durante 3 minutos a diferentes intensidades: ejercicio ligero (EL: 40% frecuencia cardiaca de reserva) y ejercicio moderado (EM: 60% frecuencia cardiaca de reserva). La variable dependiente principal fue la respuesta de la frecuencia cardiaca fetal tras ambas intensidades de esfuerzo materno.
Resultados: Tras el esfuerzo materno, los fetos del GE mostraron un menor incremento de la frecuencia cardiaca a ambas intensidades en comparación con los fetos del GC (EL: GE 139,1±14,2 *vs.* GC: 149,0±10,5; p = 0,004) y (EM: GE: 139,9±13,5 *vs.* GC: 150,9±17,9; p = 0,008).
Los fetos del GE presentaron un menor tiempo de recuperación que los fetos del GC después de EL (86±104.7 seg. *vs.* 405,2±384,7 seg.; p = 0,000) y EM (160,4±234,3 seg. *vs.* 596,9±461,4 seg; p = 0,000). El programa de ejercicio físico fue efectivo en la mejora de la recuperación materna tras el EL (341,2±281,6 seg. *vs.* 577,4±277,0 seg.; p = 0,002) y EM (525,8±309,0 seg. *vs.* 876,1±362,6 seg.; p = 0,000).
Conclusión: El ejercicio regular durante el embarazo puede estar asociado con una recuperación más rápida tanto materna como fetal tras el esfuerzo materno, y con un menor incremento de la frecuencia cardiaca fetal.
Registro Ensayo Clínico: clinicaltrials.gov NCT01723293

Palabras clave:
Frecuencia cardiaca.
Ejercicio.
Embarazo.

Trabajo presentado y premiado con Premio Femede a la Investigación 2015.

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Introduction

As the number of pregnant women who want to participate in sports activities continues to increase, questions about the safety and benefit of maternal exercise for the mother and fetus become more important[1-3]. In fact, normal fetal development is wholly dependent upon the mother[4].

During exercise, blood flow is redistributed to the muscles. The reduced flow to the visceral organs may compromise the uterine blood flow because the fetus requires a continuous and adequate supply of oxygen and nutrients for its metabolism, growth and waste product removal[5]. Severe and acute interference with the supply of blood flow is likely to cause hypoxic damage, whereas milder, more chronic reductions may result in suboptimal growth[6].

Although characterized by "beat to beat" variations, the fetal heart rate (FHR) is considered an important index of fetal well-being, especially during the third trimester of pregnancy[4,7]. In addition, an increase in the FHR of 5-25 beats per min (bpm) in response to maternal exercise has been established as a normal reaction[8].

Nonetheless, the influence of physical exercise on normal FHR response to maternal exercise has remained unclear for several reasons. First, it is difficult to measure FHR accurately during maternal exercise. Secondly, the physiological burden imposed by the exercise and the physiological alterations in fetal behavioral states must be taken into account.

Because of motion artifacts induced by maternal exercise, most authors have reported on FHRs measured not during but before and after exercise[9,10].

Most of the studies obtained data using a conventional Doppler ultrasound cardiotocograph[11,12] or fetal biomagnetometer[3,13] measurements prior to and following maternal exercise[1,12]. The present study used wireless technology as an agile and reliable way to measure the FHR in response to maternal effort.

Base on the previous section, it is still necessary to clarify the fetal and maternal HR responses to exercise. The aim of this study was to examine the fetal and maternal heart rate responses to different intensities of acute maternal exercise in physically active and sedentary healthy pregnant women. We hypothesized that regular exercise during pregnancy would be associated with a faster recovery of the fetal and maternal heart rate in response to acute maternal exercise.

Material and methods

The present study was a randomized controlled trial (RCT, NCT01723293).

We studied 63 Caucasian women belonging to a low to medium socioeconomic class as a part of randomized, controlled trial which was in accordance with CONSORT guidelines (http://www.consort-statement.org).

All participants were informed about the aim and the study protocol, and all provided written informed consent. The research protocol was reviewed and approved by the Research Ethics Committee of Severo Ochoa Hospital (Madrid, Spain) (Number: 240/09). The study was performed following the ethical guidelines of the Declaration of Helsinki, which was last modified in 2008.

Healthy gravida recruited in the same primary care medical center, aged 31.9 ± 3.2 years, with uncomplicated singleton gestations, were randomly assigned to either an exercise or control group (n = 38 EG; n = 25 CG). Participating in another structure exercise program was an exclusion criterion, this was verified in EG at the beginning of the study. Women in the CG confirmed they did not exercise throughout their pregnancies.

All pregnant women interested in the study and who met the inclusion criteria of not having any obstetrics complication and had a gestational age under 12 weeks were randomly allocated into each study group. For allocation of the participants, a computer-generated list of random numbers was used. Three different authors were responsible for carrying out the randomization process, consisted of a sequence generation, allocation concealment and implementation.

Sample Size

The variable used to calculate the sample size was the recovery of the maternal heart rate after moderate exercise (ME), to detect a difference between groups of 35% in the percentage of pregnant women who recover properly, with a two-sided 5% significance level and a power of 80%, a sample size of 25 pregnant women per group was necessary, given an anticipated dropout rate of 15%[14].

Standard care group (Control): Women in the CG did not exercise during this period; they received the usual information provided by their midwives or health care professionals.

Exercise Intervention

The physical exercise program included a total of three 55-60 minute sessions per week, which lasted from the beginning of the pregnancy (weeks 9–12) until the end of the third trimester (weeks 38–40). Therefore, an average of 85 training sessions was planned. They wore a heart rate (HR) monitor (Polar FT7, Finland) during the sessions to ensure that the exercise intensity was light to moderate.

Each session included 25-30 minutes of aerobic dance at 55-60% of the maternal heart rate reserve calculated by Karvonen Formulation[15] that was preceded by a gradual warm-up of 7–8 minutes in duration which consisted of walking and static stretching of most muscle groups. Some specific exercises were then performed to increase muscle strength, to improve balance and to prevent some muscle imbalances that are common among pregnant women.

The session finished with 10 minutes of pelvic floor muscle training to prevent urinary incontinence.

To maximize program safety, adherence and efficacy, all sessions were i) supervised by a qualified fitness specialist (working with groups of 10–12 subjects) and with an obstetrician's assistance; ii) accompanied by music; and iii) performed in the Health Care Center in a spacious, well-lit room under favorable environmental conditions (altitude 600 m; temperature 19–21ºC; humidity 50–60%). An adequate intake of calories and nutrients was confirmed before the start of each exercise session.

Protocol for measuring FHR

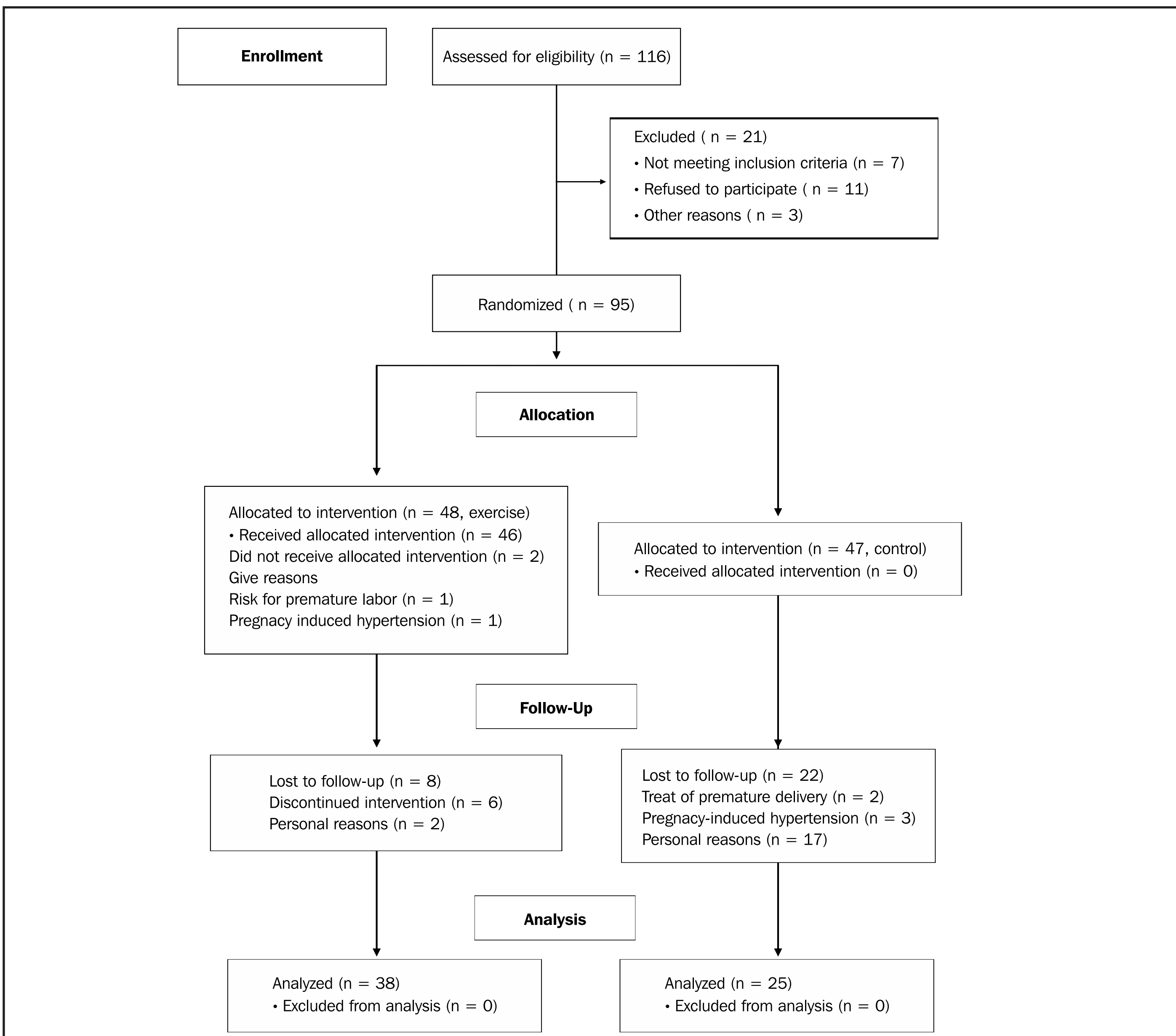
All of the women were evaluated in late pregnancy (week 34.08 ± 2.27). The protocol consisted of two series of walking at different intensities: light exercise (LE) and moderate exercise (ME). We expected the maternal and fetal HR to return to resting levels between the two series. Participants exercised (walk) at their calculated target HR zone of 40% heart rate reserve (HRR) for 3 minutes (LE: light exercise) and 60% HRR for 3 minutes (ME: moderate exercise). We used the Karvonen formulation to determine the maternal exercise protocol heart rate[15]. The women wore a HR monitor (Polar FT7, Finland) to ensure that they were exercising within the predetermined target HR zone.

Measurements

The primary outcome was FHR (bpm: beats per minute) after maternal exertion at both intensities of exercise (LE and ME), it was measured by Telemetry, Rimkus model T800 Corometrics 170 series Monitors (Spain). This technology is normally use in primary care for the fetus.

The secondary outcomes were the maternal and fetus recovery time to rest levels after LE and ME (sec: seconds); maternal RPE (Rate of Perceived Exertion) using the Borg Scale after 60% of their HRR according to the Borg's rate during pregnancy[16] and pregnancy outcomes, such as maternal weight gain, birth weight, type of labor, apgar score and pH umbilical cord which were obtained from the medical records at delivery.

Figure 1. Flow Chart of the study participants.



Statistical analysis

All analyses were performed using the Statistical Package for Social Sciences (SPSS) program, version 20.0.

The Kolmogorov-Smirnov test showed that data were normally distributed. Student unpaired t-tests were used to examine the differences in descriptive characteristics between the EG and CG, the pregnancy outcome (except type of delivery), as well as the differences in the MHR, FHR and time to recovery after exercise for the mother and fetus. The results are presented as the means±standard deviation. Cohen's d was used to determine the effect size[17].

For the type of delivery and other maternal characteristics one-way ANOVA and the χ^2 test were used, and statistical significance was set at $p < 0.05$.

An interim analysis to assure the safety of the intervention was performed during the trial (n =3 0). The levels of significance maintained an overall *p* value of 0.05 and were calculated according to the O'Brien-Fleming stopping boundaries[18].

Results

Regarding adherence to the protocol and the possible adverse effects of exercise, we report the following: Two women from EG did not receive intervention because of risk of premature labor (n = 1) and pregnancy-induced hypertension (n = 1); eight women were lost to follow-up because of discontinued intervention (n = 6) and personal reasons (n = 2). Twenty-two participants in the CG were excluded from the study because of treat of premature delivery (n = 2), pregnancy-induced hypertension (n = 3) and personal reasons (n = 17). A total of 63 women (n = 38 EG; n = 25 CG) were analyzed. Adherence to the exercise program was 80% (Figure 1).

The data collected at the beginning of the study (9-12 weeks) regarding the maternal characteristics were similar between the groups (Table 1).

After walking, the fetuses from the EG showed lower increases in heart rate than the fetuses from the CG at both intensities (LE: $t_{60} = 2.98$; $p = 0.004$) and (ME: $t_{59} = 2.73$; $p = 0.008$) (Table 2). Regarding FHR at rest, fetuses from CG had a significant increase in the heart rate after LE and ME (LE: t_{24}: -4.70; $p = 0.000$; ME: t_{24}:-2.92; $p = 0.007$) whereas this increase was not significant in the EG (LE: $t_{23} = 0.20$; $p = 0.84$ ME: $t_{35} = -0.20$; $p = 0.84$) (Figure 2 and 3).

The physical exercise program might have a positive effect on the recovery time for MHR and FHR. The fetuses from the EG showed a lower time to recovery than the fetuses from the CG after LE ($t_{26.55} = 4.03$; $p = 0.000$) and ME ($t_{33.10} = 4.33$; $p = 0.000$) (Table 2). Furthermore, the physical exercise program was effective for maternal recovery after LE ($t_{61} = 3.27$; $p = 0.002$) and also after ME ($t_{59} = 4.05$; $p = 0.000$). The percentage of pregnant women who recover in 20 minutes after walking was significantly higher in the EG after ME (X^{21}=8.8; $p = 0.003$). Regarding fetal recovery, the data showed a higher percentage of the fetuses from EG who recover in 20 minutes after ME ($X^{21} = 9.08$; $p = 0.003$). No significant differences were found in RPE after ME between groups ($t_{1.87} = 61$; $p = 0.06$) (Table 2).

Table 1. Maternal characteristics.

Variables	EG n= 38	CG n= 25	*p*
Age (years)	32 ± 3.47	31.84 ± 2.80	0.84
BMI	23.38 ± 4.23	23.08 ± 3.06	0.76
Group pre-pregnancy BMI (n/%)			
Under weight	1/2.6	1/4	
Normal weight	26/68.4	19/76	
Overweight	8/21.1	5/20	0.53
Obese	3/7.9	0/0	
Parity (n/%)			
No previous gestation	28/73.7	12/48	
One previous gestation	9/23.7	12/48	0.11
Two previous gestations	1/2.6	1/4	
Smoking during pregnancy (n/%)			
No	22/88	34/89.5	0.85
Yes	3/12	4/10.5	
Education (n/%)			
Primary	7/28	10/26.3	
Higher	13/52	19/50	0.94
University	5/20	9/23.7	
Reproductive history (n/%) Abortion			
No previous	26/68.4	21/84	0.36
One previous	10/26.3	3/12	
Two previous	2/5.3	1/4	
FHR rest (bpm)	139.47 ± 6.59	140.44 ± 7.62	0.59
MHR rest (bpm)	90.32 ± 14.48	91.88 ± 13.36	0.66
MHR (LE) (bpm)	129.84 ± 9.54	130.16 ± 8.20	0.89
MHR (ME) (bpm)	147.71 ± 6.35	148.88 ± 5.88	0.46

BMI: Body Mass Index at the beginning of the study; FHR: Fetal Heart Rate; MHR: Maternal Heart Rate; LE: Light Exercise; ME: Moderate Exercise.

The exercise program had no negative effect on the maternal and fetal outcomes. Indeed, the women from the EG gained significantly less weight than the women from the CG ($t_{61} = 3.97$; $p = 0.000$). The weight gain recommendations during pregnancy[19] were followed significantly more closely by the women in the EG than those in the CG ($X^{21} = 5.64$; $p = 0.01$). Babies from the EG were born at lower weights than babies from the CG (t_{58}=2.11; $p = 0.039$) (Table 3).

Disscusion

The aim of this study was to provide basic information about the effects of physical exercise throughout pregnancy on the fetal and maternal response to exercise.

An additional novel intervention in our study was the integration of aerobic dance, strength and pelvic floor exercises in the exercise program, which are not commonly available to pregnant women.

Figure 2. Fetal heart rate at rest and after light exercise.

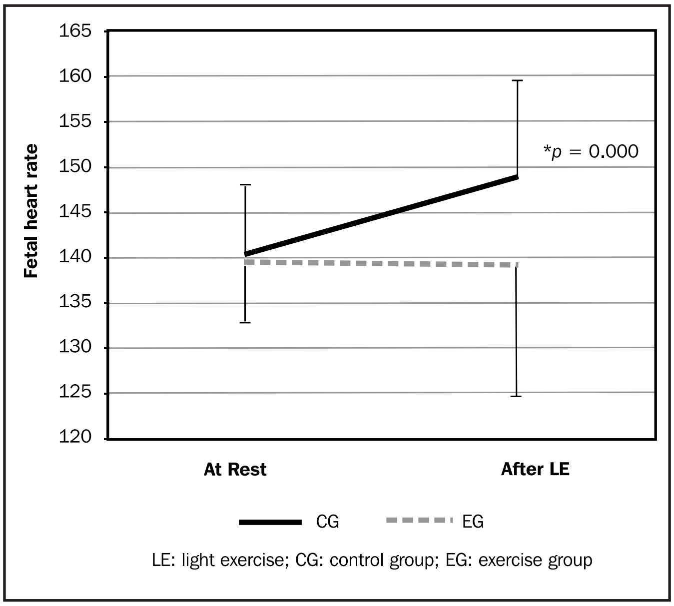


Figure 3. Fetal heart rate at rest and after moderate exercise.

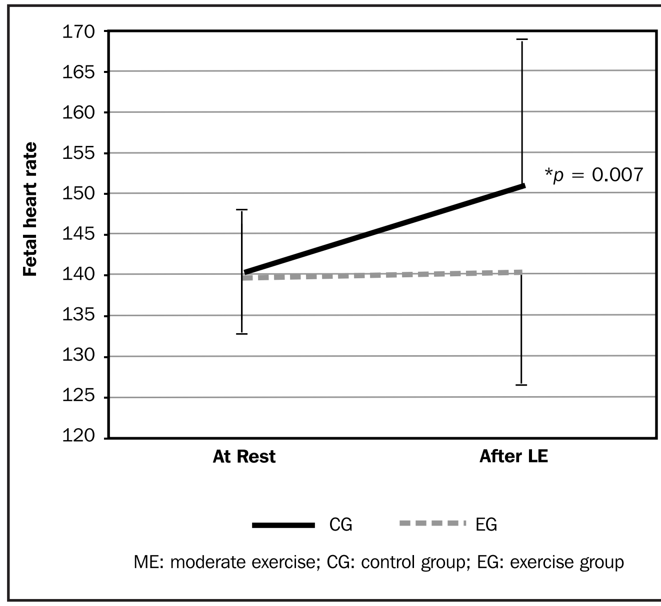


Table 2. Fetal and maternal responses to exercise.

Variables	EG n= 38	CG n= 25	*p*	Effect size
FHR (bpm) (LE)	139.1±14.2	149.0±10.5	0.004*	0.78
FHR (bpm) (ME)	139.9±13.5	150.9±17.9	0.008*	0.72
FRT (LE) (sec.)	86.8±104.7	405.2±384.7	0.000*	1.24
FRT (ME) (sec.)	160.4±234.3	596.9±461.4	0.000*	1.27
MRT (LE) (sec.)	341.2±281.6	577.4±277.0	0.002*	0.86
MRT (ME) (sec.)	525.8±309.0	876.1±362.6	0.000*	1.07
Maternal recovery (LE) (n/%)				
No	2/5.26	1/4	0.81	
Yes	36/94.7	24/96		
Maternal recovery (ME) (n/%)				
No	3/8.3	10/40	0.003	
Yes	35/91.7	15/60	*	
Fetal recovery (LE) (n/%)				
No	0/0	2/8	0.084	
Yes	36/100	23/92		
Fetal recovery (ME) (n/%)				
No	0/0	6/24	0.003	
Yes	34/100	19/76	*	
RPE	12.2±1.5	13.0±1.9	0.06	

FHR (LE): Fetal Heart Rate after Light Exercise; FHR (ME): Fetal Heart Rate after Moderate Exercise; FRT= Fetal Recovery Time. MRT: Maternal Recovery Time; RPE: Rate of Perceived Exertion. *Significance at level 0.05.

Table 3. Maternal and fetal outcomes.

Variables	EG n=38	CG n=25	*p*	Effect size
Maternal Weight gain (Kg)	11.36±3.56	15.36±4.39	0.000*	1.04
Maternal weight gain according to IOM recommendation (n/%)				
Excessive	7/18.9	11/47.8	0.01*	
Adequate	30/81.71	12/52.2		
Birth weight (g)	3005.86±463.21	3249.76±406.34	0.039*	0.56
Type of labor (n/%)				
Normal	25/71.4	15/60	0.58	
Instrumental	5/14.3	6/24		
Cesarean	5/14.3	4/16		
Apgar Score (n/%)				
1 min.	8.65±1.25	9.08±0.86	0.14	
5 min.	9.85±0.35	9.84±0.47	0.90	
pH umbilical cord	7.28±0.05	7.27±0.08	0.45	

IOM: Institute of Medicine; *Significance at level 0.05.

Our results show that mothers and fetuses in the EG recovered to their resting heart rate before those in the CG. Furthermore, our data show that a higher percentage of pregnant women and fetuses from the EG were able to recover after walking at ME. The findings of the present study suggest that regular and moderate exercise during healthy pregnancy may be associated with a positive effect of exercise in both the mother and the fetus, without any adverse outcomes.

These findings are in accordance with those based on non-pregnant populations, which demonstrate that moderate exercise efficiently improves aerobic fitness[20].

Some authors have investigated about the influence of maternal exercise training during pregnancy on FHR response to acute maternal exercise, however most of these studies do not consider the recovery time to resting levels, and maternal physical activity level was measured by questionnaire, the most commonly used is the Modifiable Physical Activity Questionnaire (MPAQ) .

Two studies have been found that measured the time takes for the FHR to return to pre-exercise values after moderate exercise. Mean time was 22 minutes (range 12 to 30 minutes) in healthy active pregnant women[21]. Our results showed less recovery time after walking at both intensities. O´Neill *et al.* [22] examined the influence of maternal cycling posture (semi-supine and upright) on many maternal and fetal parameters, they reported that increases in FHR were similar in both postures and had not returned to resting values by 10 minutes.

Brenner *et al.*[23] in an experimental study examined the effects of advancing gestational age and maternal aerobic training on FHR response to maternal exercise. They found an increased FHR during exercise, transient reduction in FHR immediately post-exercise, followed by a delayed increasing in FHR during recovery period.

May *et al.*[3,13,24] present three studies in which they examine the influence of physical exercise performed throughout pregnancy on fetal cardiovascular parameters. The first study examines whether there is a dose-response relationship between maternal physical activity and FHR, Herat Rate Variability (HRV), and sympathovagal balance found a strong support that maternal physical activity dose during pregnancy is associated with a fetal heart training response (based on FHR and heart rate variability measurements)[24].

In the second study with 26 regularly exercising and 35 healthy non-exercising pregnant women, they found that maternal exercise throughout gestation results in significantly lower FHR[3].

In a recent study they investigated if more time spent performing non-continuous leisure time physical activity during pregnancy is associated with lower FHR and increased HRV, they concluded that fetuses of mothers with non-continuous physical activity during pregnancy may have an adaptive advantage[13].

In overview, FHR responses to maternal exercise have been found to vary from no change to an increased or decreased rate and it seems to depend on level and type of exercise. Artal *et al.* found an increase in FHR after maternal exercise. Fetal bradycardia was recorded in few women, which seems to be transitory and was compensated for an increase in FHR after maternal exertion[25,26]. Silveira *et al.*[12] informed no changes between pre and post exercise values of FHR in an experimental study of aerobic physical activity in water with 133 healthy sedentary pregnant women.

Collings *et al.*[27] studied twenty-five pregnant women who exercised during pregnancy at an intensity of 61% to 73% of maximal capacity and also showed an increased in FHR after maternal exercise.

Only one randomized study has been found that examined FHR response to maternal exercise comparing EG (n = 11) and CG (n = 12). They did not found any significant change in FHR which indicate that there were no cardiovascular signs of fetal stress after moderate short-term maternal exercise[28].

Our results show that fetuses whose mothers exercised during pregnancy had a lower increase in FHR after walking at LE and ME, yet the increases in the FHR found in our results were considered normal in other study (small rise in fetal heart rate of 5-25 bpm)[8]. No association was found in this study between regular exercise and lower values in the fetal and maternal heart rate at rest.

No significant differences were found in the perception of exertion between groups, but it was slightly lower in EG than in CG at the same exercise intensity.

The overall health status of the baby was unaffected by exercise, as reflected and reinforced by the results of the globally used Apgar score. Similarly, we found a lower maternal weight gain in the EG and a lower birth weight in babies from the same group. In addition, more pregnant women from the EG followed the weight gain recommendations[19] according to their BMI before becoming pregnant consistent with other studies[29,30].

Taken together, the present data and those of previous research indicate that a regular physical exercise throughout pregnancy promotes improvements in the cardiovascular response of the fetus, which could be a protective factor in the final trimester of pregnancy and especially in the delivery stage. This finding is important to consider from the physiological point of view because in late pregnancy, an increased exchange of maternal and fetal blood is produced, which requires an efficient fetal cardiovascular system. Indeed regular physical exercise during pregnancy may be associated with faster maternal and fetal recovery after maternal exertion. Additionally, excessive maternal weight gain and abnormal birth weight could be avoided without adverse outcomes.

Although many studies have informed about fetal variables in response to maternal effort, the strength of this RCT is the information related to fetal and maternal recovery as factor of physical condition.

The main limitation of this study was the lack of fetal registration during maternal exertion; hence fetal heart rate was measured immediately after exertion.

What are the new findings?

Knowing the association of physical exercise throughout pregnancy with the fetal major variable: FHR.

Examining the response of the MHR and FHR by a very common activity inserted on the life of the pregnant woman: walking.

How might it impact on clinical practice in the near future?

The protocol and the results of this study can be used as a tool to promote regular physical exercise programs during pregnancy.

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