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Full length article

Exercise during pregnancy is associated with a shorter duration of labor. A randomized clinical trial

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ABSTRACT

Objective: : to examine the influence of an exercise program throughout pregnancy on the duration of labor in healthy pregnant women.

Study design: : A randomized clinical trial was used (Identifier: NCT02109588). In all, 508 healthy pregnant women were randomly assigned between 9 and 11 weeks of gestation to either a Control Group (CG, N = 253) or an Exercise Group (EG, N = 255). A moderate aerobic exercise program throughout pregnancy (three weekly sessions) was used as the intervention. Mann-Whitney and Pearson χ^2 tests were performed to analyze differences between groups. Survival techniques through the Kaplan-Meier method were used to estimate the median time to delivery of each group; and Gehan-Breslow-Wilcoxon tests were performed to compare survival distribution between the two arms. The primary outcome studied was the length of the stages of labor. Secondary outcomes included mode of delivery, gestational age, maternal weight gain, preterm delivery, use of epidural, birthweight, Apgar scores and arterial cord pH.

Results: : Women randomized to the EG had shorter first stage of labor (409 vs 462 min, $p = 0.01$), total duration of labor (450 vs 507 min, $p = 0.01$) as well as combined duration of first and second stages of labor (442 vs 499 min, $p = 0.01$). The probabilities of a woman being delivered at 250 min and 500 min (median times) were 19.1% and 62.5% in the experimental group vs 13.7% and 50.8% in the control group ($Z = -2.37$, $p = 0.018$). Results also revealed that women in the intervention group were less likely to use an epidural; and that the prevalence of neonate macrosomia was higher in the control group.

Conclusion: : A supervised physical exercise program throughout pregnancy decreased the duration of the first phase of labor as well as total time of the first two phases together, leading to a decrease in total labor time.

1 Introduction

Pregnancy and the process of labor and birth determine the future health and quality of a woman's life. Labor can be a relevant biological process with several consequences to maternal health and newborn wellbeing [1]. Many studies suggest that prolonged labor is associated with increased maternal and perinatal morbidity and mortality [2,3,4,5].

From a scientific point of view, there are many factors affecting the duration of labor, such as maternal characteristics or obstetric parameters (body mass index (BMI), maternal age, parity, oxytocin augmentation, epidural analgesia, induction) [6,7,8,9]. From a clinical point of view, childbirth has been divided into three stages with most studies indicating that the majority of perinatal complications are associated with a prolonged second stage [10,11,12], defined as >120 min without epidural anesthesia and >180 min with an epidural [13]. Recent publications report the need to assess the first and second stages as retrospective data are mixed regarding maternal and especially neonatal well-being [13,14].

Physical exercise is one of the most habitual events in the leisure time of pregnant women and many studies report benefits on maternal and newborn outcomes for active pregnant women [15,16]. In fact a recent editorial summarized the benefits of

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exercise during pregnancy based on level-1 evidence of >50 randomized clinical trials (RCTs) and suggested that almost all women should engage in prenatal exercise [17]. With physical exercise becoming an integral part of life for the pregnant population, the effects of exercise throughout pregnancy on perinatal outcomes is highly relevant [18]. Although maternal lifestyle has been associated with maternal and fetal benefits, the relationship of lifestyle to the duration of labor has been poorly studied. Few RCTs have examined the effect of exercise throughout pregnancy on labor length [19,20].

The aim of the present study was to examine the influence of an exercise program throughout pregnancy on the duration of labor in healthy pregnant women. We hypothesized that maternal physical exercise will be associated with a shorter total labor time.

2 Material and methods

The present RCT (Identifier: NCT02109588) was conducted between March 2014 and January 2017 following the ethical guidelines of the Declaration of Helsinki, last modified in 2000. The research protocol was reviewed and approved by the Hospital Severo Ochoa (Madrid, Spain) ethics review board. The onset of patient enrollment was April 2014.

2.1 Participants and randomization

A total of 572 Spanish-speaking (Caucasian) pregnant women from two primary care medical centres (*Centro de Salud Los Pedroches, Centro de Salud Leganés Norte*, Madrid, Spain) were recruited during the first prenatal visit at 9–11 weeks of gestation

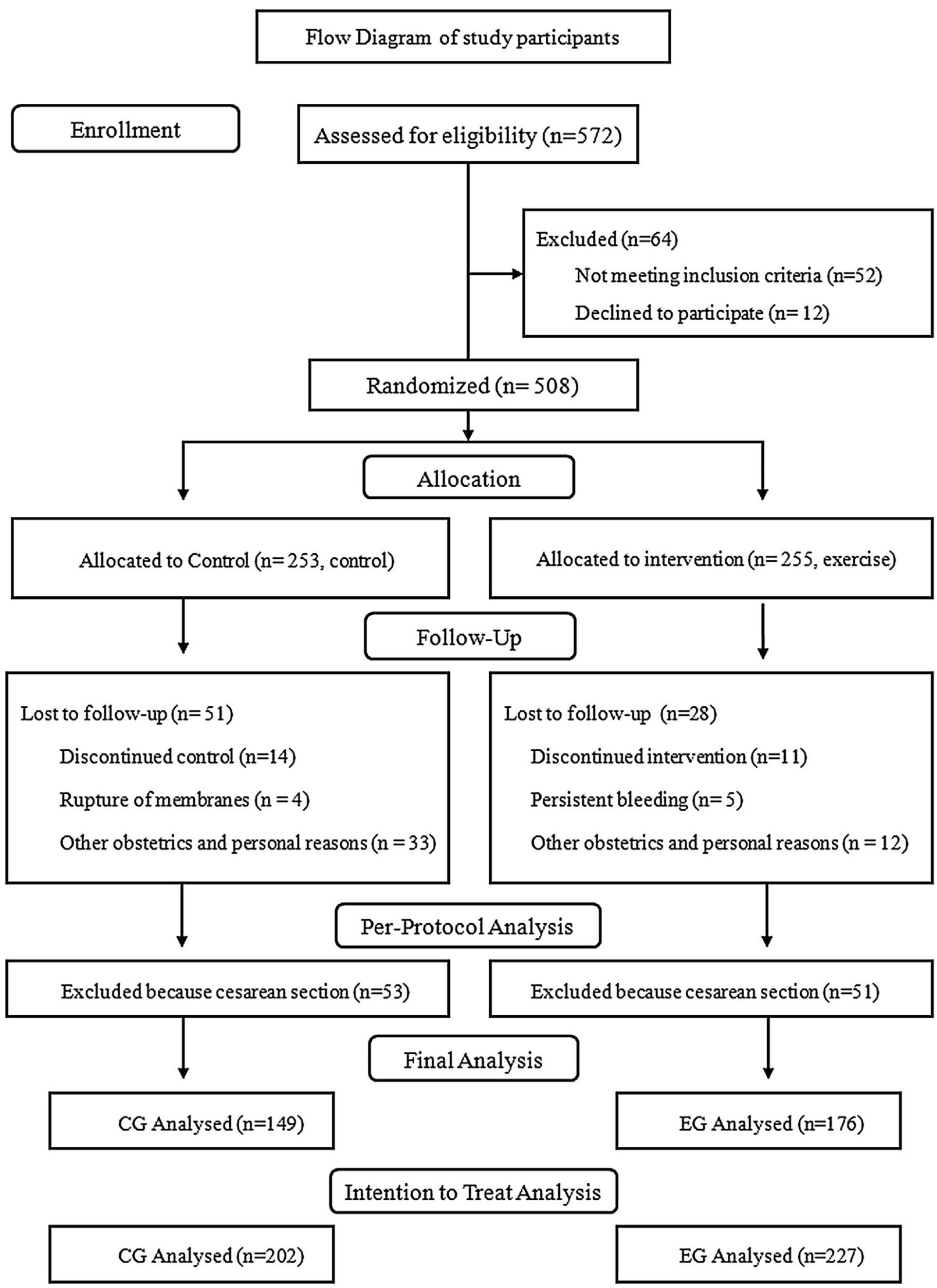

Fig. 1. CONSORT 2010 flow diagram of the study participants.

(Fig. 1) and were informed about the nature of the study and assessed for eligibility. Women with singleton and uncomplicated pregnancies (no type 1, 2 or gestational diabetes at baseline), with no history or risk of preterm delivery (i.e. ≥1 previous preterm delivery) and not participating in any other trial were invited to participate. Women not planning to give birth in the same obstetric hospital, or with no medical follow-up throughout pregnancy were not included in the study, neither were women having any serious medical conditions (contraindications) that prevented them from exercising safely [21].

Following other previous studies from our research group, a computer-generated list of random numbers was used to allocate the participants into the study groups. The randomization blinded process (sequence generation, allocation concealment and implementation) was performed by three different authors. The treatment allocation system was set up so that the researcher who was in charge of randomly assigning participants to each group did not know in advance which treatment the next person would receive, a process termed "allocation concealment". Allocation concealment prevents researchers from influencing which participants are assigned to a given intervention group.

The women randomly allocated to the Control Group (CG; n = 253) received standard care from health professionals (see below). Women who were randomly allocated to the Exercise Group (EG; n = 255) received similar standard care and performed an exercise program throughout pregnancy. Women were excluded if they did not conform to the specifications of the allotted group.

2.2 Exercise intervention [15,20]

Pregnant women in the intervention group received standard care and all aspects of a structured and supervised (by a qualified exercise professional) group moderate exercise intervention program three days per week (55–60 min per session) from the 9–11th week (immediately after the first prenatal ultrasound) to the end of the third trimester (weeks 38–39). A total of 83–85 group training sessions was originally planned for each participant in the event of no preterm delivery. The exercise program met the standards of the American Congress of Obstetricians and Gynecologists[21] and included the following seven sections:

i Gradual warm-up
ii Aerobic resistance
iii Light muscle strengthening
iv Coordination and balance exercises
v Stretching exercises
vi Pelvic floor strengthening
vii Relaxation and final talk

Women used a heart rate (HR) monitor (Accurex Plus, Finland) during the training sessions (HR was consistently under 70% of age-predicted maximum) and the rating of perceived exertion scale ranged from 12 to 14 (Somewhat Hard) [22].

Some exercises were performed using barbells (2 kg/exercise) or low-to-medium resistance (elastic) bands (therabands). Exercises in the supine position were not performed for more than 2 min.

2.3 Standard-care (CG)

The women assigned to the standard care control group (CG) attended regular scheduled visits to their obstetricians and midwives (programmed by Hospital protocol), usually every 4 to 5 weeks until the 36–38th week of gestation and then weekly until delivery. They received general nutrition and physical activity counselling from the health-care provider.

Women were not discouraged from exercising during pregnancy on their own. However, in the same way as in our previous studies [15,23] women in the CG were asked about exercise habits once each trimester using a "Decision Algorithm" (by telephone).

Question#1: Since the beginning of pregnancy, have you exercised in your leisure time, in a supervised program or on your own?

a aAnswer: No.
b Answer: Yes.

Question #2: (if the previous response was "b"): Given 7 days a week, how many days per week did you exercise?

a Answer: Less than 3 days.
b Answer: 3 days or more.

Question #3: (if the previous response was "b"): Taking into account the total duration of physical exercise continuously, how long did you exercise every day?

a Answer: Less than 20 min each day.
b Answer: 20 min or more each day.

Interpretation of the "Decision Algorithm":

Pregnant women in the CG who reached level b of these three questions, were excluded from the study.

2.4 Participant demographics

Demographics, including pre-gravid weight and height, parity, occupational activity, physical activity level before pregnancy, smoking status, previous pre-term birth and previous miscarriage were obtained at the first prenatal visit either by reviewing the medical records or by a telephone interview. Inclusion/exclusion criteria were determined at this initial visit by the attending obstetrician.

2.5 Outcomes

2.5.1 Primary outcome

Data corresponding to labor and delivery: duration of stages, spontaneous/assisted vaginal delivery, use of epidural, were obtained from delivery records.

The first stage of labor begins when the cervix has a dilation of 3 cm, is mature and three contractions every 10 min exist and ends when the dilatation of the cervix is complete or 10 cm. The second is the most relevant stage of labor, begins when complete dilation of the cervix is reached and ends with fetal expulsion, from the inside of the uterus to the external environment. The third phase begins at the end of the expulsive period (second phase) and concludes with the complete expulsion of the placenta and the ovular membranes[24].

2.5.2 Secondary outcomes

Gestational weight gain was calculated on the basis of the pregravid weight and weight at the last clinic visit before delivery. Gestational weight gain was classified according to the 2009 Institute of Medicine (IOM) guidelines [24]. Excessive body weight gain was determined by IOM guidelines for pre-pregnancy BMI categories for each woman; > 18 kg for underweight; >16 kg for normal; >11.5 kg for overweight; and >9 kg for obese women [25].

Maternal gestational age, birth weight, Apgar Scores and pH of the umbilical cord blood were recorded from hospital perinatal records. Newborns were classified as having macrosomia when birth weight was >4000 g and low birth weight was defined as <2500 g.

2.6 Statistical analyses

Sample size was determined based on *a priori* widely accepted power calculation [26]. In all, 340 subjects were needed to achieve 80% power to detect a shortening of total duration of labor taking into account previous data on duration of labor. The sample size was intendedly increased to account for patient withdrawal and possible problems to follow-up.

A Kolmogorov-Smirnov test was performed to verify the normality of the data in the study variables and showed that it was non-parametric ($p < 0.05$). Thus, Mann-Whitney tests were performed to analyse possible differences between the groups in continuous variables (maternal age, gestational age, pre-pregnancy BMI, neonate birthweight and duration of labor). The Pearson χ^2 test was completed with the observation of standardized adjusted residuals and was used to assess differences between categorical variables (parity, mode of delivery, use of epidural). Survival techniques through the Kaplan-Meier method was used to estimate the median time to delivery of each group.

Comparison of the survival distributions between the two arms (intervention and control) was performed with the Gehan-Breslow-Wilcoxon tests. In our context, this test seems to be more suitable since it allows a weighting method based on the available sample, giving less importance to the difference when the number of patients at risk decreases over time. Finally, to investigate differences in distributions between both groups, the cumulative distribution function of each group was computed and the Mann-Whitney test again was used.

As previous differences had been found between groups in terms of occupation and education levels, two 3×2 MANOVAs were performed to analyse the effects of both variables together with the effect of the intervention on the duration of the stages.

Statistical tests used a 2-sided 0.05 alpha level and SPSS 24.0 was used to analyse the data.

3 Results

A total of 572 women were assessed for eligibility. In all, 64 were excluded for not meeting the inclusion criteria (N = 52) or decline to participate (N = 12), leaving 508 women randomized, 253 in the CG and 255 in the EG.

After randomization and during the study, 51 women in the CG were lost to follow-up because of discontinued follow-up (N = 14), ruptured membranes (N = 4), other obstetric and personal reasons (N = 33). 28 participants in the EG were excluded from the study because of discontinued intervention (N = 11) persistent bleeding (N = 5), and personal reasons (N = 12). Therefore 429 women were followed during the program, 202 in CG and 227 in EG. After data analysis 53 women in CG and 51 in EG were excluded because of cesarean section. A total of 325 pregnant women were finally analyzed, 149 in CG and 176 in EG (Fig. 1).

Baseline characteristics for both groups, are listed in Table 1 and were similar between groups in most of the variables following the intention to treat analysis. Nevertheless, significant differences emerged between groups according to participants' occupation and participants' study level. Standardized adjusted residuals in Pearson χ^2 suggested that the ratio of women whose occupation was defined as a housewife was higher in the control group than in the experimental group; while the ratio of women engaged in a sedentary job was higher in the experimental group. According to education level, the ratio of women who had completed Primary School was higher in the control group; while the ratio of women who had completed university studies was higher in the intervention group.

Table 1
Maternal characteristics (intention to treat analysis).

	CG (n = 202)	IG (n = 227)	*P* value
Maternal age (Mean ± SD)	31.25 ± 3.36	31.77 ± 4.56	0.069
Pregnancy BMI (Mean ± SD)	23.69 ± 3.78	23.37 ± 3.73	0.225
Prepregnancy BMI (n/%)			0.957
<18	4 (2.0%)	4 (1.8%)	
18–24.9	144 (7;1;1.6%)	158 (70.5%)	
25–29.9	40 (19.9%)	49 (21.9%)	
>30	13 (6.5%)	13 (5.8%)	
Parity (n/%)			0.094
No previous birth	142 (70.3%)	141 (62.1%)	
One previous birth	54 (26.7%)	71 (31.3%)	
More than one previous birth	6 (3.0%)	15 (6.6%)	
Previous miscarriage (n/%)			0.722
None	144(71.3%)	168 (74.0%)	
One	51 (25.2%)	50 (22.0%)	
Two or more	7 (3.5%)	9 (4.0%)	
Physical activity level before pregnancy (n/%)			0.050
Sedentary (none or one time a week)	58 (28.7%)	42 (18.5%)	
Some activity (one or two times a week)	59 (29.2%)	68 (30.0%)	
Medium activity (three or four times a week)	51 (25.2%)	62 (27.3%)	
Very active (from four to six times a week)	34 (16.8%)	55 (24.2%)	
Study levels (n/%)			0.001
Primary School	71 (35.1%)	28 (12.3%)	
Secondary School	86 (42.6%)	85 (37.4%)	
Tertiary Education	45 (22.3%)	114 (50.3%)	
Occupation (n/%)			0.008
Housewife	57 (28.2%)	30 (13.3%)	0.470
Sedentary job	76 (37.6%)	115 (50.9%)	
Active job	69 (34.2%)	81 (35.8%)	
Smoking (n/%)	43 (22.1%)	42 (18.2%)	
Caesarean Section (n/%)	53 (25.2%)	51 (22.5%)	0.310

Table 2
Labor and delivery outcomes (per protocol analysis).

	CG (n = 149)	EG (n = 176)	*P* value
First stage of labor[b] (mean ± SD)	462.83 ± 208.37	409.15 ± 185.74	0.01[a]
Second stage of labor[b] (mean ± SD)	36.21 ± 25.93	33.23 ± 22.53	0.68
Cumulative first and second stage of labor[b] (mean ± SD)	499.04 ± 215.84	442.37 ± 188.72	0.01[a]
Third stage of labor[b] (mean ± SD)	8.14 ± 1.86	8.37 ± 2.16	0.66
Total duration of labor[b] (mean ± SD)	507.19 ± 216.06	450.74 ± 188.64	0.01[a]
Mode of delivery (n/%)			
Spontaneous	115 (77.2%)	139 (79.0%)	0.69
Assisted	34 (22.8%)	37 (21%)	

[a] Statistically significant at $p < 0.05$.
[b] Minutes.

Labor and obstetrical outcomes are presented in Table 2. The total duration of labor (first, second, and third stage) was significantly shorter in the intervention group compared with the control group (450 vs 507 min, $p = 0.01$. Significance was also demonstrated in the first stage of labor (409 vs 462 min, $p = 0.01$) as well as in the combined duration of first and second stage of labor (442 vs 499 min, $p = 0.01$). However, no significant differences were found in the second and the third stages taken individually.

The proportion of women undelivered at any point of time in both groups is illustrated in the Kaplan-Meier survival plot in Fig. 2. Women in the intervention group completed labor faster than the control group on average as the Breslow (generalized Wilcoxon) test was significantly different between the two groups ($\chi^2_{Breslow} = 5.59$; $p = 0.018$). Fig. 3 depicts the cumulative probability for a woman to be delivered at a specific point in time for both groups. Using cumulative distribution function and Mann-Whitney test ($Z = -2.37$, $p = 0.018$), statistically significant differences were found between the probability for women to be delivered in the intervention group compared to the control group. For example, at 250 min, the probability for a patient to be delivered in the intervention group is 19.1% compared to 13.7% in the control group and at 500 min, these probabilities are 62.5% and 50.8%, respectively.

There was no difference noted in the mode of delivery between the two groups.

Results of the 3 × 2 MANOVA regarding the effects for occupation and intervention showed a main effect of the intervention ($F = 2.86$, $p < 0.05$) in stages of labor. There were no main effects of occupation ($F = 0.59$, $p > 0.05$) or significant interaction effect ($F = 1.41$, $p > 0.05$) between both factors. Subsequent separate ANOVAs for the different stages showed a significant main effect for the intervention in the times of first stage ($F = 8.15$, $p < 0.05$), first and second stages ($F = 8.22$, $p < 0.05$) and total labor time ($F = 8.18$, $p < 0.05$).

With respect to the 3 × 2 MANOVA regarding education levels, the intervention group showed a main effect of the intervention ($F = 5.66$, $p < 0.05$) for stages of labor. There were no main effects for occupation ($F = 0.22$, $p > 0.05$) or a significant interaction effect ($F = 0.11$, $p > 0.05$) between both factors. Subsequent separate ANOVAs for the different stages showed a significant main effect for the intervention group in the times of first stage ($F = 5.67$, $p < 0.05$), first and second stages ($F = 5.71$, $p < 0.05$) and total labor time ($F = 5.66$, $p < 0.05$).

Finally, other outcomes of interest analyzed in the study are presented in Table 3 (per protocol) and Table 4 (intention to treat). Our results showed that by using per protocol analysis (Table 3), the ratio of neonate macrosomia was higher in the control group than in the intervention group ($p = 0.01$). When following the intention-to-treat principle (Table 4), both maternal weight gain ($p = 0.02$) and the proportion of women showing excessive maternal weight gain ($p = 0.02$) were higher in the control group than in the experimental group.

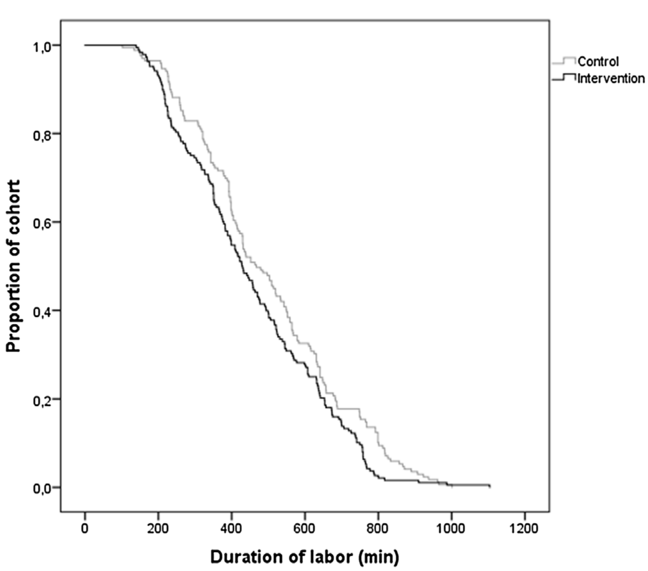

Fig. 2. Total duration of labor stratified by study group.

4 Comment

4.1 Principal findings

The aim of the present study was to examine the effect of a supervised and moderate physical exercise program throughout pregnancy on the total duration of labor, as well as the timing of the stages of labor individually. Different from our previous work, the main novelty of the current study is the integration of light resistance, toning, aerobic dance, stretching and pelvic floor exercises in the same program throughout pregnancy and examining the resultant effects on labor. Our exercise program reduced the total duration, the first stage as well as the combined duration of first and second stages of labor without risk for mother and fetus during pregnancy. Furthermore, the overall health status of the newborn is unaffected, as reflected by the results of the worldwide used Apgar scores.

When birth weight was examined further we found that the percentage of newborns with macrosomia was lower in the intervention group (following per protocol analysis), which we have previously observed [15] adding additional evidence that physical exercise may improve perinatal outcomes by preventing excessive accumulation of weight during fetal development.

Our results showed by using the intention to treat protocol a significant decrease both in total weight gain and in the percentage

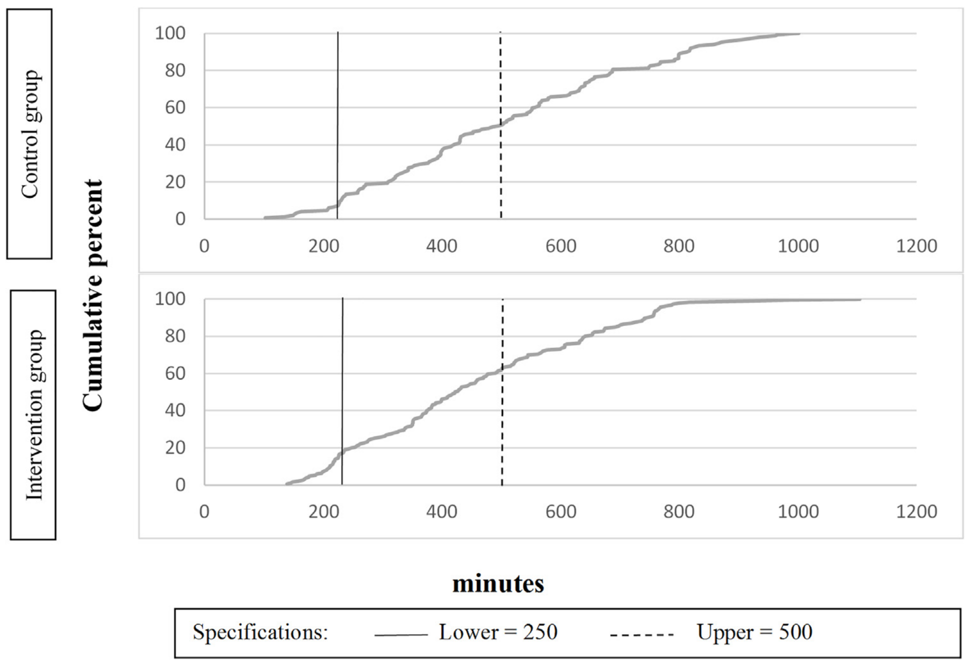

Fig. 3. Cumulative distribution function.

Table 3
Other maternal and new born outcomes (per protocol analysis).

	CG (n = 149)	EG (n = 176)	*P* value
Mother			
Gestational age[b] (Mean ± SD)	277.79 ± 8.57	278.05 ± 11.00	0.46
Maternal weight gain[c] (Mean ± SD)	12.8 ± 3.8	12.0 ± 3.3	0.10
Excessive maternal weight gain (n/%)	37 (24.8%)	33 (18.8%)	0.18
Preterm delivery (>37 weeks) (n/%)	2 (1.3%)	5 (2.8%)	0.35
Use of epidural (n/%)			0.61
No	7 (4.7%)	6 (3.5%)	0.61
Yes	142 (95.3%)	169 (96.5%)	
Newborn			
Birthweight (Mean ± SD) grs.	3256.17 ± 466.44	3273.18 ±415.43	0.52
Macrosomia (n/%)	11 (7.4%)	3 (1.7%)	0.01[a]
Apgar 1 min. (Mean ± SD)	8.76 ± 1.22	8.78 ± 1.21	0.61
Apgar 5 min. (Mean ± SD)	9.94 ± 0.85	9.80 ± 0.58	0.18
pH arterial cord (Mean ± SD)	7.27 ± 0.07	7.28 ± 0.08	0.17

[a] Statistically significant at $p. < 0.05$.
[b] Days.
[c] Kg.

of pregnant women with excessive weight gain in the intervention group compared to the control women.

4.2 Meaning of the findings-Clinical implications

From a scientific point of view we believe that the main difference between our results (regarding shorter delivery) and other studies could be based on the duration of the intervention (exercise program). A longer intervention timeframe throughout pregnancy would increase the physiological effects generated by exercise that favor contractility during childbirth. In this sense a poor uterine contractility has been demonstrated in obese women [27] leading to longer labor times.

Other authors have examined the effects of physical exercise on the duration of labor with different designs and results. Methodologically, the main difference between our study and the other RCTs is the duration of the intervention While most studies were initiated in the second trimester (week 18–20), the pregnant women in our program performed the exercise throughout pregnancy and started immediately after the first prenatal ultrasound (week 9–11). Starting earlier and engaging in the intervention throughout pregnancy may explain the difference in study results.

Recently Salvensen et al. [28] found no difference between the study groups in relation to the total duration of labor, however the duration of the active second stage of labor was shorter in the control group in a subgroup analysis (women with a singleton cephalic fetus and spontaneous start of term delivery). However, the intervention was a 12-week exercise program conducted between the 20th and 36th week of gestation. Similar results were found by Dias et al. [29] in a RCT with 42 pregnant women using an intervention of pelvic floor muscle training (PFMT).

In the same way, Agur et al. [30] reported no difference in the duration of the second stage of labor or in the need for instrumental delivery by a secondary analysis of a RCT with 268 primigravidae between those women who engaged in PFMT and control.

Table 4
Other maternal and new born outcomes (intention to treat analysis).
[b]Days.
[c]Kg.

	CG (n = 202)	IG (n = 227)	*P* value
Mother			
Gestational age[b] ($Mean_{Days} \pm SD$)	277.24 ± 9.84	277.11 ± 12.92	0.643
Maternal weight gain[c] (Mean ± SD)	13.27 ± 4.1	12.26 ± 3.6	0.015[a]
Excessive maternal weight gain (n/%)	61 (30.2%)	47 (20.7%)	0.024[a]
Preterm delivery (>37 weeks) (n/%)	7 (3.5%)	10 (4.4%)	0.618
Use of epidural (n/%)			0.653
No	39 (19.3%)	40 (17.6%)	
Yes	163 (80.7%)	187 (82.4%)	
Neonate			
Birthweight, ($Mean_{grams} \pm SD$)	3255.42 ± 470.60	3266.25 ± 450.43	0.660
Macrosomia (n/%)	14 (6.9%)	8 (3.5%)	0.110
Apgar 1 min. (Mean ± SD)	8.68 ± 1.32	8.77 ± 1.24	0.333
Apgar 5 min. (Mean ± SD)	9.92 ± 0.77	9.79 ± 0.56	0.072
pH arterial cord (Mean ± SD)	7.27 ± 0.07	7.28 ± 0.07	0.059

[a]Statistically significant at $p. < 0.05$.
[b]Days.
[c]Kg.

In our previous study [20] with a smaller sample (N = 166) we found a shorter first phase of labor, although we did not analyze the first and second phases together as in the present study.

Kardel et al. [31] measured the maximal oxygen uptake in 40 nulliparous women at 35–37 weeks of gestation and examined labor outcomes. They concluded that increased aerobic fitness was associated with shorter labor in nulliparous women who started labor spontaneously.

The clinical implications of our results suggest that all health practitioners recommend early programs of moderate exercise for pregnant women and to encourage women to maintain exercise throughout pregnancy in order to achieve the aforementioned physiological improvements.

4.3 Strengths and limitations

The major strengths of our study are the large RCT with high adherence >80% attendance and the identification of those women in the CG who did not remain sedentary built into the study design. In our opinion, the present results provide health practitioners with the scientific basis for the recommendation of programmed and supervised physical exercise throughout pregnancy to maintain or improve the quality of life relating to labor and birth for pregnant women. Another strength of our study was the analyses of the timing of the stages of labor because labor duration was defined through consistent and similar methods by the hospital nursing staff and recorded in the hospital records.

One limitation was that nutrition or energy intake was not assessed, however, all pregnant women had (by their obstetricians and midwives) standard care and regular information regarding a healthy lifestyle during pregnancy. The supervised exercise program was the only difference between study groups. In addition, we found differences between the study groups for occupation and educational level of participants which could potentially influence the results.

4.4 Conclusion with future research implications

We conclude that a supervised physical exercise program initiated early and continued throughout pregnancy decreases the duration of the first phase of labor as well as total time of the first two phases together, leading to a decrease in total labor time. Future research should examine the influence of programmed structured supervised exercise on maternal and fetal perinatal outcomes with high adherence to the intervention.

Conflict of interest

The authors report no conflict of interest.

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