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Hemodynamic Fetal Response to Maternal Isometric Exercise in Pregnant Patients with Diabetes

Monique Soares Paz[1], José Antônio Reis Ferreira de Lima[1], Tatiana Frehner Kavalco[1], Wendel Mombaque dos Santos[2], Francisco Maximiliano Pancich Gallarreta[1]

[1]Department of Gynecology and Obstetrics, Federal University of Santa Maria, Santa Maria, Brazil
[2]The Brazilian Centre for Evidence-Based Health Care: A JBI Centre of Excellence, São Paulo, Brazil
Email: fmgallarreta@gmail.com

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Abstract

Background: Studies on physical activity during pregnancy and its impact on mother and fetus are still limited. International protocols consider only aerobic exercise and fail to provide information about other modalities such as isometric exercise. Isometric exercise promotes cardiorespiratory resistance and muscle strengthening, but it is rarely tested on pregnant women because it increases maternal blood pressure and can subsequently affect placental circulation. **Objectives:** To assess the fetal response by use of Doppler study in diabetes pregnant women submitted to isometric exercise. **Methods:** A cross-sectional experimental study was conducted on 25 diabetes pregnant women with gestational age between 26 and 36 weeks. The patients were submitted to isometric handgrip, and data were collected from the mother (blood pressure, heart rate and Doppler velocimetry for the uterine arteries) and from the fetus (heart rate, Doppler velocimetry for the umbilical artery, middle cerebral artery and ductus venosus). All variables were collected before, during and after the isometric handgrip. **Results:** There was a significant reduction in the pulsatilityindex (average values pre 0.77 ± 0.30, trans 0.65 ± 0.22, and post 0.75 ± 0.22, with $p = 0.001$), resistance index (average values pre 0.49 ± 0.12, trans 0.44 ± 0.10, and post 0.48 ± 0.90, with $p = 0.001$) and Systole/Diastole ratio (average values pre 2.09 ± 0.59, trans 1.87 ± 0.40, and post 2.71 ± 3.43, with $p < 0.002$) of the right uterine artery. These variables were only altered significantly during isometric and not when compared to the pre and post-isometric values. There was also a significant reduction in the pulsatilityindex (average values pre 0.80 ± 0.38, trans 0.69 ± 0.17, and post 0.75 ± 0.25, with $p = 0.027$), resistance index (average values pre 0.50 ± 0.12, trans 0.46 ± 0.07, and post 0.50 ± 0.10, with $p = 0.039$) and Systole/Diastole ratio (average values pre 2.23 ± 1.12, trans 1.93 ± 0.30, and post 2.07 ± 0.49, with $p < 0.023$) of the left uterine artery. These variables were not altered when compared to pre and post-isometric values, as were they not altered during and post-isometric. There was no significant difference in the fetal parameters when compared before, during or after the isometric test. **Conclusion:** We conclude there was significant reduction in the pulsatilityindex, resistance index and Systole/Diastole ratio of the right uterine artery only during isometric and not when compared to pre and post-isometric values. There was also significant reduction in the pulsatility index, resistance index and Systole/Diastole ratio of the left uterine artery. These variables were not altered when compared to pre and post-isometric values, as were they not altered during and post-isometric. The vasodilatation mechanism of the uterine arteries demonstrates the compensation and hemodynamic homeostasis of the gestational period, confirmed by the fetal parameters that don't present alterations when compared before, during or after the isometric test.

Keywords

Isometric Handgrip, Pregnancy, Fetal Hemodynamics, Doppler Velocimetry

1. Introduction

The benefits provided by daily physical activity in the well-being and quality of life during all stages of life are fundamental to reduce the risks of chronic diseases and mortality [1] [2].

In the prenatal period, physical activity has been proposed as a preventive measure, or even therapeutic, in order to reduce complications and thus obtain improvements in maternal and fetal health. By performing physical exercise, pregnant women obtain better weight control, prevent diseases such as gestational diabetes mellitus and preeclampsia, reduce rates of cesarean sections, without adding risks to the pregnancy and/or the fetus [2] [3].

Only 15% of women perform the minimum recommendation of 150 minutes per week of physical activity during pregnancy [4]. Many barriers prevent patients from performing daily physical activity, among them the small number of studies and protocols, causing physicians to feel unprepared to perform the prescription of physical exercise during pregnancy [2] [5].

In 2019, a Canadian guideline on physical activity during pregnancy was published, providing guidance that all women without contraindications should maintain physical activity during pregnancy [2]. Exercises should include aerobic and resistance exercises, thus generating better results [6] [7]. However, in the case of patients with gestational diabetes, there is a lack of studies demonstrating the real benefits of performing physical activity [2].

The performance of muscle strength exercises such as weightlifting or other types of resistance training allows a better adaptation of the maternal organism to the several alterations resulting from the gestational evolution. When the exercises are well oriented, there is an improvement in venous return, increases oxygenation of the fetus, improves flexibility, and thus decreases the possibility of developing physiological pathologies such as gestational diabetes mellitus and preeclampsia [8] [9].

Many of the movements performed in everyday life, repetitively, carrying weight or lifting objects, involve muscle contraction, characterizing an isometric exercise [10] [11]. Adherence to isometric exercise is advantageous due to its simplicity, lower cost, and shorter exercise time [10]. However, little is known about the fetal repercussion of isometric exercises performed by diabetic pregnant women.

Pregnant women without clinical or obstetric complications, when subjected to aerobic treadmill exercise until fatigue, showed no changes in fetal repercussions to the Doppler study after exercise. This shows that a healthy fetus has the ability to adapt and compensate at the time of aerobic exercise [12]. However, there are still few studies evaluating fetal hemodynamic response and perinatal outcomes after isometrics [13].

Isometric exercise is part of patients' daily lives when performing daily movements [14]. It involves performing muscle contractions while performing little or no movement [10]. It is known that the cardiovascular repercussions involved in performing isometric exercise are directly linked to the intensity of the contractions performed [11]. The activation of large muscle groups provides a better use of glucose and simultaneously increases the sensitivity to insulin [15].

The metabolic alterations caused by the gestational period propitiate the development of gestational diabetes in patients with preexisting risk factors, such as obesity and sedentarism. Thus, the risk of developing complications in the course of life increases, developing a greater number of type 2 diabetes [16]. However, the risks of pre-eclampsia, cesarean delivery and urinary infection also increase [17]. Therefore, regular exercise during pregnancy, for at least 30 minutes a day, can benefit and prevent GDM [1], besides reducing the incidence of symptoms present during pregnancy, such as edema, cramps and fatigue [18] [19].

Isometric exercise has many benefits due to the practicality and low cost with which they are made available to patients [10]. The most recent studies use easy-to-use devices, such as the dynamometer, to perform isometric exercises, [20]. At the moment there are few studies exploring and evaluating perinatal outcomes and the fetal hemodynamic response after isometric testing [13].

Due to the scarce literature referring to the maternal-fetal hemodynamic effects triggered by maternal isometric activity, this study is justified, whose results may bring new information about the effects of this isometric activity on hemodynamics, as well as the understanding of the maternal-fetal physiological response in response to isometric activities in the daily routine, generating more security for the prescription of physical exercises by health professionals, and more encouragement for patients when performing them.

2. Methodology

2.1. Research Design

A cross-sectional experimental study was conducted with pregnant women diagnosed with GDM from the high-risk prenatal care of the University Hospital of Santa Maria (HUSM), located in the municipality of Santa Maria, Rio Grande do Sul, during the period from March to July 2018. This method allowed the patients to be chosen before the isometric activity in a specific period of time (26 to 36 gestational weeks) and multiple variables to be studied independently.

2.2. Population and Sample

The sample was composed of pregnant women in the high-risk prenatal care of HUSM, without previous diseases or complications during prenatal care except for diabetes in pregnancy, who were in the gestational period for participation. The sample size calculation to obtain significance of 5% and test power of 80%, based on a previous meta-analysis [10], indicated a sample size of 25 gestational diabetic pregnant women. All participants signed the informed consent form (ICF) provided by the researchers.

The sample was acquired by convenience. The recruitment was made by the high-risk prenatal care physician who identified patients with inclusion criteria and invited those patients to participate in the study. Convenience sampling has some limitations such as a reduced capability of the study to be fully representative of the population, undermining the ability to make generalizations and to replicate the results. Non-respondents may affect the accuracy of data, important cases may not be detected, and finally high risk of observer bias. This method of sampling was chosen due to its feasibility in our institution.

Inclusion criteria were pregnant women with single fetus, GDM, with gestational age (GA) between 26 and 36 weeks and willing to participate in the study. Exclusion criteria were women with a previously diagnosed history of chronic conditions such as hypertension and diabetes mellitus type I and II, or who were smokers, drinkers, or users of illicit drugs. Presence of complications during pregnancy that have been diagnosed before or during the collection, such as premature labor, pre-eclampsia, premature rupture of membranes, placenta previa, multiple gestation, among others. Presence of any of the contraindications to physical activity, listed according to the guidelines of the 2019 Canadian Guidelines for physical activity in pregnancy (**Table 1**).

2.3. Data Collection

Data were collected in the Fetal Medicine Department of the HUSM, between March and July 2018, with approval of the study by the Research Ethics Committee (REC) of the institution.

Pregnant women who agreed to participate in the research were contacted by

Table 1. Contraindications to exercise.

Absolute	Relative
• Rupture of membranes. • Premature labor. • Persistent unexplained vaginal bleeding. • Placenta previa after 28 weeks gestation. • Preeclampsia. • Incompetent cervix. • Intrauterine growth restriction. • High-order multiple pregnancy (e.g., triplets). • Uncontrolled type I diabetes. • Uncontrolled hypertension. • Uncontrolled thyroid disease. • Other serious cardiovascular, respiratory, or systemic diseases.	• Recurrent pregnancy loss. • Gestational hypertension. • A history of spontaneous preterm birth. • Mild/moderate cardiovascular or respiratory disease. • Symptomatic anemia. • Malnutrition. • An eating disorder. • Twin pregnancy after 28 weeks. • Other significant medical conditions.

PPT: Preterm Labor. IUGR: Intrauterine Growth Restriction. Source: adapted from MOTTOLA *et al*., 2019 [2].

phone or during prenatal appointments. Arriving at the sector, they were accompanied by one of the researchers responsible to a room where the TCLE was read and signed and initial information was recorded: date, maternal age, dominant hand, GI at collection, sedentarism before pregnancy and sedentarism during pregnancy. Then they were instructed on how to use the handgrip dynamometer (Crown 100 kgf hand dynamometer) and performed three consecutive attempts of maximum voluntary contraction (MVC), being used in data collection the isometric activity at 50% of the average MVC of these measurements, during 1 minute for each vessel studied. Then, they remained at rest for at least 15 minutes in semifowler position.

Maternal blood pressure (BP) was checked with a Welch AllynTM manual sphygmomanometer, maternal heart rate (HRM) with a Contec Montserrat Cms50d digital oximeter, and maternal and fetal ultrasound data with a GE Voluson I ultrasound device with a 3.5 to 5.0 MHz convex transducer. For Doppler, data were performed following the ISUOG practice guidelines for performing Doppler ultrasound of the feto-placental circulation, with the capture of four to seven waves for each blood vessel studied. Only for the verification of the ductus venosus it was necessary to perform manual reading of the spectral pattern, due to the better adjustment of the sensitivity of the wave captured in the device used.

Thus, maternal pre-isometry data were collected: systolic (SBP) and diastolic blood pressure (DBP), maternal heart rate (MHR) and Doppler of the right and left uterine arteries (VAS); and fetal pre-isometry data: fetal heart rate (FHR), Doppler of the umbilical artery (UmA), middle cerebral artery (MCA) and venous duct (VD). The Doppler study variables used were pulsatility index (PI), resistance index (RI), and systole/diastole (S/D) ratio.

After collecting the resting data, the pregnant women started the isometric test on the hand dynamometer, with isometry maintained for at least one minute to start capturing the Doppler flow parameters, being maintained until the end of the collection of each wave considered adequate by the examiner. This isometric effort was repeated for the collection of each of the maternal and fetal variables of the Doppler study (right and left AU, MCA, UmA, RV), with an interval of one minute between contractions. There was no order for data collection, as it depended on fetal static, the fetus being at rest, and the absence of fetal respiratory movements. If fetal movements prevented the collection of some fetal variable, the pregnant women were instructed to repeat the isometry after the usual one-minute interval, which was counted as extra isometry.

During the isometric test, the participants were qualitatively evaluated for pain or discomfort in the hand or forearm, muscle tremor, and increased respiratory rate.

At the end of the isometric test, the participants rested again for five minutes. At this time, fetal biometry, amniotic fluid quantification, and placental evaluation were performed. Then, all post-isometric maternal and fetal Doppler flow variables were collected.

3. Statistical Analysis

The information obtained quantitatively and entered into Microsoft Office Excel 2010 spreadsheets were imported into the statistical package SPSS version 13.0 (Statistical Package For The Social Science), belonging to the Teaching and Research Management of HUSM. For interpretation, the data were analyzed and presented through tables and graphs.

For statistical analysis, Friedman's double analysis of variance test of related samples by ranks was used, considering significance for p value < 0.05, to compare the values found for maternal and fetal variables before, during and after the isometric test. The Bonferroni test was subsequently used for comparison between each of the collection periods, pre-, trans-, and post-isometry.

4. Results

A total of 28 pregnant women were contacted by telephone and asked to come to the Fetal Medicine Service of HUSM to explain the research protocol and schedule the collection to be performed.

Of the 28 scheduled pregnant women, three did not show up for the collection, leaving a total of 25 pregnant women.

In the collection of postnatal data, one patient developed preeclampsia, three patients developed gestational hypertension in late pregnancy, two had hypertensive peak at the time of hospitalization for delivery, and one had postpartum hypertensive peak, as shown below (**Table 1**).

The mean age of the participants was 29.72 (±6.71) years, with a minimum age of 18 and a maximum of 40 years. As for parity, eight were nulliparous and

17 were multiparous. The mean GA at the time of collection was 33.24 weeks (±2.47), with a minimum GA of 26 weeks and five days and a maximum of 36 weeks. The sedentary rate among women before pregnancy was 88%, increasing to 96% during pregnancy. The prevalence of active pregnant women was 4% (**Table 2**).

At the beginning of the application of the research protocol, the pregnant women were asked about their dominant hand, which was mostly the right hand (23), and asked to perform the MVC in the handgrip dynamometer with the dominant hand. The average MVC was 23.24 kgf (±3.95), with minimum of 15 kgf and maximum of 30 kgf.

In the analysis of the results on maternal parameters, there was a significant reduction in PI (mean values pre 0.77 ± 0.30, trans 0.65 ± 0.22, and post 0.75 ± 0.22, with $p = 0.001$), IR (mean values pre 0.49 ± 0.12, trans 0.44 ± 0.10 and post 0.48 ± 0.90, with $p = 0.000$) and S/D (mean values pre 2.09 ± 0.59, trans 1.87 ± 0.40, and post 2.71 ± 3.43, with $p < 0.002$) of the right AU (**Table 2**). These variables changed significantly only during isometry, and not when comparing pre- and post-isometry values. There was also a significant reduction in PI (mean values pre 0.80 ± 0.38, trans 0.69 ± 0.17, and post 0.75 ± 0.25, with $p = 0.027$), IR (mean values pre 0.50 ± 0.12, trans 0.46 ± 0.07, and post 0.50 ± 0.10, with $p = 0.039$) and S/D (mean values pre 2.23 ± 1.12, trans 1.93 ± 0.30, and post 2.07 ± 0.49, with $p < 0.023$) of the left AU (**Table 3**). These variables did not change when comparing pre- and post-isometry values, as well as did not change during and post-isometry.

Table 2. Description of maternal age, parity, gestational age, sedentarism before and during pregnancy and dominant hand of gestational diabetic pregnant women submitted to isometric exercise.

	Total (N = 25)
Maternal Age	29.72 (±6.71)
Parity	
Nulliparous	8 (32%)
Multiparous	17 (68%)
Gestational age in weeks	33.24 (±2.47)
Sedentary before pregnancy	
Yes	22 (88%)
No	3 (22%)
Sedentary during pregnancy	
Yes	24 (96%)
No	1 (4%)
Dominanthand	
Right	23 (92%)
Left	2 (6%)

Data represent means ± standard deviation or number of cases with their percentages.

Table 3. Analysis of age, gestational age at collection, sedentary lifestyle before and during pregnancy, hand pain and tremor in the control group and in the CGD group.

Features	Control Group	CGD
Age	25.69 (±6.90)	29.72 (±6.71)
Gestational age at collection	33.22 (±2.05)	33.24 (±2.47)
Sedentary before pregnancy		
Yes	35 (76.08%)	22 (88%)
No	11 (23.91%)	3 (22%)
Sedentary during pregnancy		
Yes	42 (91.30%)	24 (96%)
No	4 (8.70%)	1 (4%)
Hand pain		
Yes	31 (62%)	23 (92%)
No	19 (38%)	2 (8%)
Tremor		
Yes	45 (90%)	9 (36%)
No	5 (10%)	16 (64%)

Data represent means ± standard deviation or number of cases with their percentages.

There was no significant difference in maternal and fetal parameters when comparing before, during or after the isometric test including fetal heart rate, pulsatility index, resistance index, and systole/diastole ratio of the middle cerebral and umbilical arteries, and pulsatility index of the ductus venosus (**Table 4** and **Table 5**).

During isometric testing, participants were qualitatively assessed for pain or discomfort in the hand or forearm, muscle tremor, and increased respiratory rate. Nine participants (36%) experienced tremor in the recruited upper limb while sustaining isometric contractions, 11 (44%) reported pain in muscle groups in the forearm, while 23 (92%) complained of pain in the hand related to the dynamometer grip. The increase in respiratory rate was observed by the sonographer himself during the exam, who noticed a greater interference of maternal respiratory movements while the Doppler velocity study of the variables was performed, and this increase was noticed in only one of the pregnant women during isometrics (**Table 6**).

The mean estimated fetal weight was 2346.76 grams (±624.76), with a maximum of 3730 g and a minimum of 1087 g. According to the biometry performed, 17 (68%) fetuses were classified as adequate for gestational age and eight (32%) were macrosomic (**Table 7**).

Regarding postnatal data of the participants, 68% had no complications, 16% had gestational hypertension, 4% had hypertensive spikes, 4% used magnesium sulfate, and 4% had premature rupture of amniotic membranes. The mean birth weight of the newborns was 3224.60 grams (±379.26), with a mean GA at birth of 38.18 (±1.27), an Apgar score of 8.96 (±0.67) in the first minute and 9.8 (±0.50) in the fifth minute. Four newborns were premature (**Table 8**).

Table 4. Analysis of systolic blood pressure, diastolic blood pressure, heart rate, pulsatility index, resistance index, and systole/diastole ratio of the right and left uterine arteries pre-, trans-, and post-isometry.

	PRE	TRANS	POST	P	post-hoc Bonferroni		
					P1	P2	P3
PAS	113.20 (±8.52)	116.40 (±11.13)	114.00 (±10.80)	0.273	-	-	-
PAD	76.40 (±7.57)	76.40 (±8.10)	76.40 (±9.52)	0.980	-	-	-
MHR	81.00 (±9.81)	83.96 (±9.57)	82.04 (±9.21)	0.633	-	-	-
PI UA D	0.77 (±0.30)	0.65 (±0.22)	0.75 (±0.22)	**0.001**	**0.009**	**0.001**	1.000
RI UA D	0.49 (±0.12)	0.44 (±0.10)	0.48 (±0.90)	**0.000**	**0.017**	**0.001**	1.000
SD AU D	2.09 (±0.59)	1.87 (±0.40)	2.71 (±3.43)	**0.002**	**0.033**	**0.002**	1.000
IP AU E	0.80 (±0.38)	0.69 (±0.17)	0.75 (±0.25)	**0.027**	1.000	**0.033**	0.169
IR AU E	0.50 (±0.12)	0.46 (±0.07)	0.50 (±0.10)	**0.039**	0.537	**0.040**	0.774
SD AU E	2.23 (±1.12)	1.93 (±0.30)	2.07 (±0.49)	**0.023**	1.000	**0.022**	0.231

Values represent mean ± standard deviation. P: double Friedman's analysis of variance of Related Samples by Post. P1: post test comparing pre and trans; P2: post test comparing trans and post; P3: post test comparing pre and post. SBP: systolic blood pressure; DBP: diastolic blood pressure; MHR: maternal heart rate; PI: pulsatility index; RI: resistance index; S/D: systole/diastole ratio; RU D: right uterine artery; LU E: left uterine artery.

Table 5. Analysis of fetal heart rate, pulsatility index, resistance index, and systole/diastole ratio of the middle cerebral and umbilical arteries, and pulsatility index of the ductus venosus pre-, trans-, and post-isometry.

	PRE	TRANS	POS	P
FHR	139.28 (±10.50)	134.05 (±28.81)	138.36 (±11.11)	0.426
MCAPI	2.01 (±0.43)	2.07 (±0.33)	1.96 (±0.51)	0.809
MCARI	0.84 (±0.07)	0.85 (±0.05)	0.91 (±0.34)	0.504
MCA SD	7.78 (±3.28)	7.84 (±2.75)	7.55 (±3.65)	0.395
A UMB PI	0.93 (±0.27)	1.00 (±0.16)	0.98 (±0.17)	0.223
A UMB RI	0.59 (±0.13)	0.63 (±0.07)	0.62 (±0.06)	0.426
A UMB SD	2.69 (±0.81)	2.80 (±0.47)	2.72 (±0.45)	0.179
DV PI	0.69 (±0.17)	0.67 (±0.18)	0.73 (±0.16)	0.178

Values represent mean ± standard deviation. P: two Friedman's analysis of variance of Related Samples by Positions. FHR: fetal heart rate; PI: pulsatility index; RI: resistance index; S/D: systole/diastole ratio; MCA: middle cerebral artery; UM: umbilical artery; DV: ductus venosus.

5. Discussion

Aiming to evaluate maternal and fetal hemodynamics, this study sought to demonstrate the effects generated by isometric exercise in pregnant women diagnosed with gestational diabetes. By using the protocol described in a study from the year 2018 [20], patients underwent isometric contractions, through the use of a dynamometer, for a period of one minute, performing 50% of the MCV.

In a study published in 2017 by the International Working Group on Maternal

Table 6. Evaluation of maximum voluntary contraction, hand pain, forearm pain, upper limb tremor, increased respiratory rate during isometrics.

	Total (N = 25)
Average MVC	23.24 (±)
Hand Pain	
Yes	23 (92%)
No	2 (8%)
Pain in the forearm	
Yes	11 (44%)
No	14 (56%)
Upper limb tremor	
Yes	9 (36%)
No	16 (64%)
Increased respiratory rate	
Yes	1 (4%)
No	24 (96%)

Data represent means ± standard deviation or number of cases with their percentages. MVC: maximum voluntary contraction. Source: the authors.

Table 7. Average, standard deviation, minimum and maximum of sonographic parameters: biparietal diameter, head circumference, abdominal circumference, femur, humerus and weight.

	Average	Standard Deviation	Minimum	Maximum
Biparietal diameter (cm)	8.21	0.64	6.9	9.1
Cephaliccircumference (cm)	29.70	4.53	10.7	33.6
Abdominal circumference (cm)	30.54	3.25	24.2	38
Femur (cm)	6.27	0.52	4.9	7.2
Humerus (cm)	5.62	0.42	4.6	6.3
weight (g)	2330.48	627.01	1087	3730

Cm: centimeters; g: grams. Source: the authors.

Haemodynamics, recommendations for hemodynamic testing during the gestational period were described [13]. To perform the exercise, the dynamometer was used, performing manual grip of about 20% to 40% of the MCV, for 2 to 3 minutes. In the present study we used manual grip of 50% of the MCV for 1 minute. During the performance of the same occurs an increase in the activity of the sympathetic nervous system, thus occurring increase in blood pressure and heart rate [21]. However, this increase was not seen in our study, the patients did not show an increase in blood pressure and heart rate.

Table 8. Type of delivery, birth, Apgar score, average weight, gestational age at birth, complications.

Parameters	Total (N = 25)
Type of delivery	
Vaginal	13 (52%)
Cesarean section	12 (48%)
Birth	
Full term	21 (84%)
Pre-term	4 (16%)
Apgar index	
1st minute	8.96 (±0.67)
5th minute	9.80 (±0.50)
Average weight	3224.60 (±379.26)
GA atbirth (weeks)	38.18 (±1.27)
Complications	
No	17 (68%)
Premature rupture of membranes	1 (4%)
Gestational hypertension	4 (16%)
Use of magnesium sulfate	1 (4%)
Hypertensive peak	2 (8%)

Source: The authors.

Unlike a study conducted with healthy patients [20], maternal BP, as already described, showed no changes in this study. We can infer that among the healthy patients there were patients without a diagnosis of gestational hypertension, they performed prenatal care in their basic health units and did not have the diagnosis elucidated and/or referral to high-risk prenatal care.

Despite all the known benefits during pregnancy, exercise suffers a reduction in the number of practitioners after the diagnosis of pregnancy [22]. In a study conducted in China, it was concluded that only 11% of patients practiced physical activity according to international recommendations of 150 minutes per week [23].

In Brazil, these rates can reach a prevalence between 12.9% and 32.8% of physically active pregnant women [24] [25]; however, sedentarism prevails and can reach 100% in the third trimester [26]. In our study it was no different, sedentarism before pregnancy obtained a rate of 88%, increasing to 96% after the pregnancy diagnosis, which coincides with the existing literature, according to which patients end up adopting more sedentary attitudes as the gestational period goes by.

During isometry, there was a significant reduction in the values of PI, RI, and S/D in the right UA, but in the left UA we noticed that the time for normalization after exercise is longer, thus showing their compensatory vasodilation. This compensatory mechanism maintains the placental hemodynamic flow, with no changes in fetal parameters.

Similarly, as in the study by Pontes [11], there was no increase in fetal heart rate during exercise, never exceeding the limits considered safe beats per minute. According to the American College of Gynecology and Obstetrics, exercise is capable of modifying the physiological variables of the pregnant woman and, consequently, it will do so in relation to the fetus. In their studies aerobic exercises were used, but this statement is valid for the results of the present study. That is, the heart rate of the pregnant women when performing isometric exercise did not present modification, as well as there was no modification of the FHR.

Pigatto *et al*. [12] demonstrated that healthy fetuses are able to adapt to aerobic exercise. However, the performance of isometric exercise, according to Meah, and the fetal hemodynamic response and, consequently, its perinatal results are still little studied. Which demonstrates that our study contributes to the advancement of research related to maternal-fetal hemodynamic responses and gestational and perinatal outcomes of GDM patients undergoing isometric exercise [13].

Weiner also shows that, to perform the isometrics in the time of 2 to 3 minutes, many patients end up interrupting the exercise before the end of the time, or even before the desired collection, due to muscle fatigue or pain [21]. Indeed, most patients complained of discomfort in the hand when performing the pressing with the dynamometer, interrupting the isometry before the end of the desired time or before the Doppler study was performed in the vessel observed. Thus, it is necessary to repeat the isometry and collection. Demonstrating that a shorter isometric time may be more feasible for the experiment.

Like Soares *et al* [20] in this study performed fetal hemodynamic assessment at all times of the research protocol, during isometry performed by the participants, which is one of the strengths of the study. As Meah and colleagues state, it is difficult to perform fetal assessments during physical exercises, most of them being performed after the end of the exercise [13].

The entire research protocol in this study was applied by two interviewers, and the sonographic variables were collected by the same sonographer, being the most experienced among the researchers, and the entire study was carried out with the same device, thus reducing the chances of collection and measurement biases.

As a possible limitation of the study, isometry for only one minute is one of them. As well as the fact that the collection was done in a single moment, it was not possible to evaluate the possible systemic adaptive responses in the participants in the long term.

One advantage to be considered is the practicality of performing isometric exercise, as it can be done at home using simple, low-cost equipment, which can reduce the costs necessary for training and, thus, favor adherence to the exercises. Thus, isometric exercise becomes a form of incentive for more pregnant women to make the practice of exercise a habit in their lives, thus reducing the sedentary lifestyle in the pregnant population. According to Van Hook (1993) [14], isometric exercise is in the daily life of patients, when they perform their daily movements.

The practice of physical exercise would be a determining factor in trying to curb the increase of obesity in the world. And during pregnancy, obesity is associated with a greater number of pathologies, thus increasing the risk for these patients. GDM has increased in the same proportion, and the lack of control leads to miscarriages, anomalies, pre-eclampsia, fetal death, and macrosomia, among other complications. In addition, diabetes during the pregnancy cycle also increases the risk of obesity and type 2 diabetes in the children of affected mothers [27].

In some populations only lifestyle changes are able to control GDM in 70% - 85% of the patients so diagnosed. Lifestyle change becomes an essential element and may be the key to treatment for women diagnosed with GDM [28]. The risk of fetal complications such as macrosomia and delivery complications is also present in this population. In the present study, the rate of macrosomia reached a percentage of 32% among the population studied.

The cardiovascular repercussions involved in isometric exercise are directly linked to the intensity of the contractions performed [11]. A better utilization of glucose occurs and, therefore, a better sensitization to insulin at the moment of the exercise, with the use of large muscle groups [15]. This adds even more importance to the performance of exercise in the population of pregnant women with GDM, contributing to the reduction of risks and fetal complications.

The importance of prenatal monitoring and multidisciplinary care in the care of pregnant women is increasing, demonstrating that the encouragement of good health practices and a healthy lifestyle can bring benefits and prevent complications during pregnancy and in the future of the unborn child. The support to the practice of physical activity in the gestational period and the acquisition and transmission of adequate information by the health professional may be the future for the prevention of complications for the gestation and future of the newborns.

6. Conclusion

We conclude that there was a significant reduction in the PI, RI, and S/D of the right UA only during isometry, and not when comparing the pre- and post-isometry values. There was also a significant reduction in the PI, RI, and S/D of the left UA. These variables did not change when comparing pre- and post-isometry values, as well as did not change during and post-isometry. The mechanism of the UA vasodilation demonstrates the hemodynamic compensation and homeostasis of the gestational period, confirmed by the fetal parameters that did not change when compared before, during and after the isometric test.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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