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Application of pelvic floor ultrasound during pregnancy to detect patients at risk of cesarean section due to failure of labor progression in a Spanish population

Alicia Guntiñas [a,*], Carolina Galocha [b], Rodrigo Madurga [c], Janette Kirk [d], Ramón Usandizaga [e], Miguel Ángel Rodríguez-Zambrano [f]

[a] Department of Obstetrics and Gynaecology, University Hospital HM Puerta del Sur, Avda Carlos V, 70. Móstoles, Madrid 28938, Spain
[b] Department of Obstetrics and Gynaecology, University Hospital HM Hospitals, Montepríncipe, Madrid 28660, Spain
[c] Faculty of Experimental Science, Universidad Francisco de Vitoria, Madrid. Spain
[d] Department of Obstetrics and Gynaecology, University Hospital HM Puerta del Sur, Avda Carlos V, 70. Móstoles, Madrid 28938, Spain
[e] Chief of Pelvic Floor Section at Department of Obstetrics and Gynaecology, University Hospital La Paz, Paseo de la Castellana, 261, Madrid 28046, Spain
[f] Chief of Department of Obstetrics and Gynaecology, University Hospital HM Puerta del Sur, Avda Carlos V, 70. Móstoles, Madrid 282938, Spain

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ABSTRACT

Objective: Our study is aimed at evaluating the characteristics of the pelvic floor, assessed through transperineal ultrasound, since it may influence or increase the possibility of having a cesarean delivery, with the objective of acting on those variables that can be modified during pregnancy.
Study Design: Transperineal ultrasound was performed on 109 primiparous pregnant women in their first trimester of pregnancy, recruited between May 2018 and February 2019, with the purpose of studying the hiatus area at rest, retention and Valsalva. We have reassessed them at the end of pregnancy and delivery data were recorded. We selected 8 patients as case-study, who had cesarean section delivery due to failure of labor progression. We selected 4 control-cases for each, reaching the total of 32 controls, with similar age and body mass index, to avoid obtaining a biased result from these data.
Results: In the study of hiatal areas, patients who delivered by cesarean section had a smaller hiatal area at rest, during levator ani muscle contraction and during Valsalva maneuver, at all visits. In early pregnancy, the range of the resting hiatal area was 13.8 ± 2.0 cm^2 for cesarean sections, compared to 16.2 ± 2.7 cm^2 for vaginal deliveries with an OR of 0.57 (0.34–0.95, 95% CI). For hiatal area on Valsalva, the OR was 0.55 (0.35–0.88, 95% CI). Therefore, the smaller the hiatal area, the greater the possibility of cesarean section. At the end of pregnancy, between 34 and 36 weeks of gestation, the OR of hiatal area on Valsalva was 0.78 (0.60–1.00, 95% CI).
Conclusion: The hiatus area measured by transperineal ultrasonography at the beginning and at the end of the pregnancy may be useful to identify the patients who are at a higher risk of cesarean delivery due to failure of labor progression.

Introduction

The frequency of cesarean sections (CS) in developed countries is very high. In recent years, in Spain it is around 26% overall. [1]

Although it may seem that having a rate above 10% of CS does not influence mortality, the effects on maternal and perinatal morbidity are not clear [2]. In 2018, the WHO published a statement on this subject, recommending non-clinical actions aimed at reducing the rate of unnecessary CS. These actions can be directed at patients, professionals and institutions. [3]

These latest recommendations compel us towards the search for relevant local determinants, which can be the target of tailored interventions. Many of the research efforts have been directed at the identification of predisposing factors for CS in labor induction, since up to one third of induced deliveries end in CS. [4]

In Spain, Hernández-Martínez et al. developed a predictive model of CS in patients undergoing induction of labor, taking into account maternal factors such as age or BMI and fetal factors such as gestational age or macrosomia, among others. [5]

* Corresponding author.
E-mail addresses: aguntinas@mail.hmhospitales.com, guntinascastillo@gmail.com (A. Guntiñas).

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However, not only demographic or anthropometric factors of the patients are important for the successful completion of labor.

The anatomical and functional characteristics of the pelvic floor musculature, and in particular of the levator ani muscle, seem particularly important in the descent of the fetal head into the birth canal. [6]

Intrapartum transperineal ultrasonography, used to assess the angle of progression among others, has been used in recent years to search for parameters that would help us determine which patients are more likely to deliver vaginally. [7,8]

In addition, transperineal ultrasonography can be of great help in detecting during pregnancy those patients whose pelvic floor seems less conducive to vaginal delivery (VD).

Some authors, such as Van Veelen et al. or Siafarikas et al. performed studies in their populations showing how the hiatus area during pregnancy, its distensibility and contractile capacity, can influence or determine the possibility of VD. [9,10]

Therewith, we find ourselves in need of finding parameters that would guide our decision making, in order to identify the modifiable factors and to give adequate advice before delivery.

The objective of our study is to evaluate the characteristics of the pelvic floor, assessed by transperineal ultrasound, which can influence or increase the possibility of having a cesarean delivery, with the objective of acting on those modifiable variables during pregnancy, based on the Spanish population.

Materials and methods

Based on previous research and with the premise that the hiatus area during pregnancy may influence the possibility of CS due to lack of progression we have performed a nested case-control study on our population of primiparous patients. In the concept of non-progression, we have included CS performed because of the failure of induction, non-progression of labor or cephalic pelvic disproportion.

Nulliparous patients, aged 18 to 45 years, with ongoing gestation between 10 and 16 weeks, who agreed to participate in the study and signed an informed consent, were recruited between May 2018 and August 2019. The study was approved by the HM Hospitalś Drug Research Ethics Committee and validated by the R&D&I Executive Committee of the HM Hospitalś Research Foundation.

All patients underwent a directed anamnesis on personal and family history of pelvic floor pathology. Demographic and anthropometric characteristics and health habits were recorded.

All patients underwent transperineal pelvic floor ultrasound by Medison V20 or Acuvix A30 ultrasound machines, with a 2–6 mHz volumetric probe to obtain volumes at rest, retention and Valsalva. For the ultrasound, the patient was placed in the lithotomy position with the legs semi-flexed and the bladder empty. The transducer, covered with an ultrasonic probe cover, was placed over the perineal midline. For volumetric acquisition, the image was acquired in the mid-sagittal plane, as previously described by Dietz et al.[11] Images were acquired at rest, on pelvic floor muscle contraction (PFMC) and on Valsalva maneuver (at least 6 s in Valsalva to counteract levator coactivation).

Ultrasound analysis was performed offline with Samsung 5D Viewer software.

The ultrasound was performed by one of the authors (A.G.) an expert in ultrasound and pelvic floor pathology.

Measurement of the hiatus area was performed in the minimal dimension plane, as previously described. [11] (Fig. 1)

A new assessment was carried out at the end of the pregnancy, between the 34th and 36th week, collecting the same data as in the first visit.

The delivery was attended by the patient's gynecologist, who was unaware of the ultrasound data recorded at the two previous visits.

All the delivery data were recorded, such as the duration of the first and second stages of labor, route of birth delivery and analgesia used. The type of birth delivery, vaginal or CS, and the indication for CS were also recorded.

Cesarean delivery for failed induction was decided when 3 cm was not reached after 12 h of oxytocin induction and arrest of first-stage labor from lack of cervical change despite regular contractions after 4 h of oxytocin. We defined a prolonged second stage of labor as >3 h in nulliparous women.

The 8 CS due to failure to progress (FP) were selected as cases, excluding those performed for obstetric reasons such as intrapartum fetal distress or fetal malposition. For each case, four controls, matched by age (above or under 35 years of age) and body mass index (BMI) (higher or lower than 25 kg/m^2), were selected among patients with VD.

The cesarean sections performed in our study correspond to Robson's groups 1 and 2. [12]

We define the elongation capacity (distensibility) of the levator ani muscle as the ratio between the area of the hiatus on Valsalva and the area of the hiatus at rest. In turn, we defined its contractility as the ratio between the area of the hiatus on PFMC and the area at rest.

The normality of the quantitative variables was analyzed using the Shapiro test. Those variables with normal distribution are presented as mean ± standard deviation and the comparison of means was performed using Student's *T*-Test. Variables that do not follow a normal distribution are presented as median (interquartile range) and inference was performed using the Mann-Whitney *U* test. Categorical variables are presented as absolute frequency and relative frequency (%). The dependence of categorical variables was assessed by the Chi-square test or Fisher's test when the conditions for the former were not met. The association between hiatus areas and cesarean delivery was analyzed by conditional logistic regression, controlling the matching of each case and their respective controls.

All statistical analysis was performed using R language (version 4.0.3). Results with p- value < 0.05 were considered statistically significant.

Results

A total of 109 patients were recruited during the initial visit. Of these, 9 did not return and 3 had preterm deliveries.

Of the remaining 97 patients, 80 deliveries were performed vaginally and 17 CS, of which 9 were elective procedures due to fetal malposition or urgent cesarean deliveries due to fetal distress before initiation of labor.

Eight CS were included in the analysis, performed due to failure of labor progression.

For each case of CS, 4 controls were sought with VD, matched by age (<35 years and $\geq$ 35 years) and by BMI (<25 and $\geq$ 25 kg/m^2), to monitor possible errors due to these two factors. Therefore, 40 patients were included, 32 patients with VD and 8 CS. Table 1 shows the demographic, anthropometric and lifestyle-habit variables of both groups.

There were no differences in personal medical history between the two groups, nor in the type of exercise they performed. And the characteristics associated with childbirth did not differ significantly in the two groups.

In the study of hiatal areas, the patients who gave birth by CS had a smaller hiatal area at rest, on PFMC and Valsalva, during all visits. (Table 2) Statistically significant differences were noted

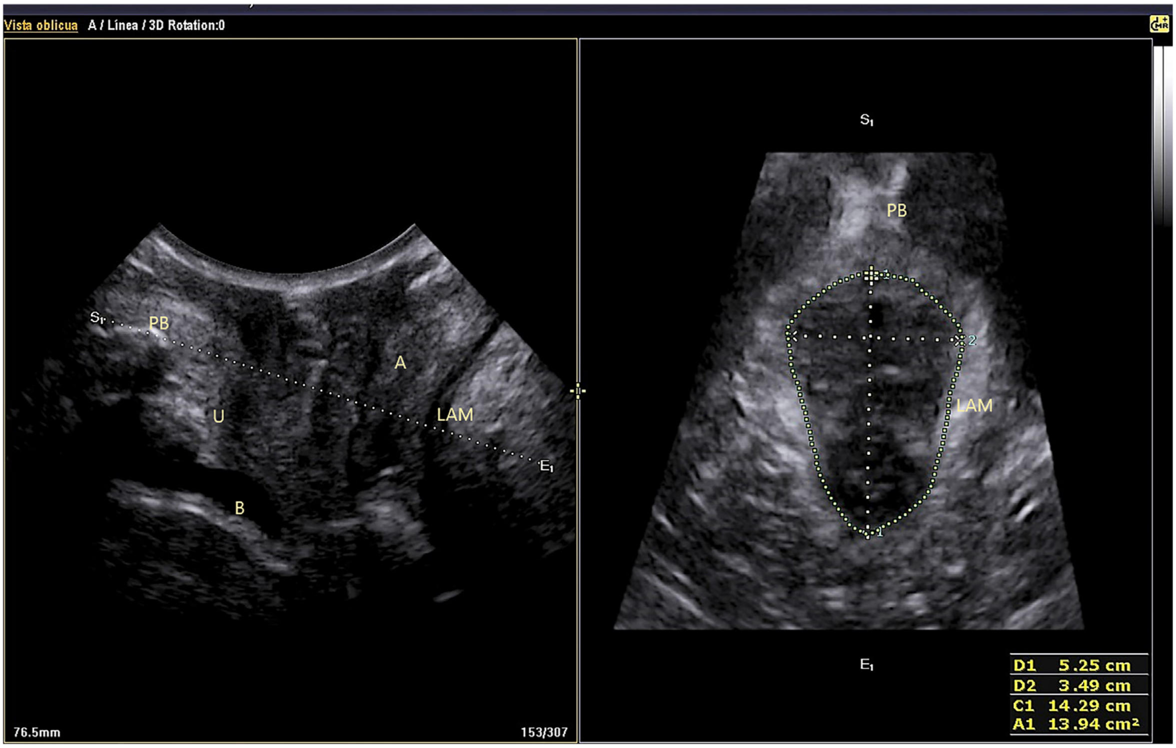

Fig. 1. Hiatus area measured in the minimal dimension plane. Minimal hiatal dimension plane: "minimal distance between the hyperechogenic posterior aspect of the symphysis pubis and the hyperechogenic anterior border of the pubovisceral muscle just posterior to the anorectal muscularis" as described Dietz et al. PB: pubic bone; U: urethra; B: Bladder; A: anal canal; LAM: Levator ani muscle.

Table 1
Demographic and obstetric data of our population.

		All (n = 40)	Control (n = 32)	Cases (n = 8)	p value
Age (years)	Mean ± SD	34.4 ± 3.9	34.5 ± 4.0	34.0 ± 3.8	0.74
	< 35	25 (62.5%)	20 (80.0%)	5 (20.0%)	1
	> 35	15 (37.5%)	12 (80.0%)	3 (20.0%)	
Comorbidities	Hypothyroidism	12 (30.0%)	10 (83.3%)	2 (16.7%)	1
	Allergic asthma	8 (20.0%)	8 (100.0%)	0 (0.0%)	0.17
	UTI	6 (15.0%)	5 (83.3%)	1 (16.7%)	1
Tobacco	Yes	10 (25.0%)	6 (60.0%)	4 (40.0%)	0.09
Exercise	Sedentary	15 (37.5%)	13 (86.7%)	2 (13.3%)	0.69
	Active	25 (62.5%)	19 (76.0%)	6 (24.0%)	
BMI (kg/m2)	Median (IQR)	23.5 (21.5–26.5)	23.3 (21.2–26.2)	24.8 (23.1–28.0)	0.13
BMI.2 (kg/m2)	Normal (<25)	25 (62.5%)	20 (80.0%)	5 (20.0%)	1
	Overweigh (>25)	15 (37.5%)	12 (80.0%)	3 (20.0%)	
Gestational age at delivery	Median (IQR)	39.5 (38.7–40.6)	39.8 (39.0–40.8)	38.9 (38.4–39.4)	0.06
Latent phase (hours)	Median (IQR)	10 (0–15.8)	9.5 (0–15.2)	12.5 (7.5–15.8)	0.46
Dilation (hours)	Median (IQR)	5.4 (3.8–9.0)	5.4 (4.0–8.6)	4.8 (0–10.5)	0.51
Cephalic circumference (cm)	Mean ± SD	34.0 ± 1.2	34.1 ± 1.2	34.0 ± 1.3	0.90
New Born Weight (gr)	Mean ± SD	3247 ± 485	3264 ± 515	3176 ± 359	0.65
Induction	Yes	22 (55.0%)	16 (72.2%)	6 (27.8%)	0.26
Epidural anesthesia	Yes	38 (95.0%)	31 (81.6%)	7 (18.4%)	0.36

between compared groups for hiatal area at rest in the first visit and for hiatal area on Valsalva in all visits.

At the beginning of pregnancy, the mean value of the resting hiatus area was 13.8 ± 2.0 cm^2 for CS, compared to 16.2 ± 2.7 cm^2 for VD. On Valsalva the mean values were 15.3 ± 1.8 cm^2 for CS and, 19.5 ± 3.3 cm^2 for VD. At the end of pregnancy, the hiatal areas increased in both groups, maintaining the differences observed in the first trimester, with the area on Valsalva being 18.2 ± 3.0 cm^2 in the cesarean group and, 21.2 ± 4.7 cm^2 in the control group. (Fig. 2)

Conditional logistic regression analysis was performed for the hiatus areas at rest, on PFMC and on Valsalva in both groups.

In early pregnancy, the OR for hiatal area at rest was 0.57 (0.34–0.95, 95% CI). For hiatal area on maximum Valsalva, the OR was 0.55 (0.35–0.88, 95% CI). Therefore, the smaller the hiatal area, the greater the possibility of CS. At the end of pregnancy, between 34 and 36 weeks of gestation, the OR of hiatal area on Valsalva was 0.78 (0.60–1.00, 95% CI). (Table 3)

However, neither the degree of contractility of the hiatus, nor its distensibility, showed significant differences in the two groups.

Table 2
Levator ani hiatus area at the beginning (V1) and the end (V2) of pregnancy.

	Visit	Control	Case
Levator hiatus area at rest (cm^2)	V1	16.2 ± 2.7	13.8 ± 2.0
Levator hiatus area during PFMC (cm^2)	V1	13.0 ± 2.5	11.8 ± 1.3
Levator hiatus area during Valsalva (cm^2)	V1	19.5 ± 3.3	15.3 ± 1.8
Contractility	V1	0.81 ± 0.15	0.86 ± 0.13
Distensibility	V1	1.21 ± 0.16	1.11 ± 0.13
Levator hiatus area at rest (cm^2)	V2	17.9 ± 3.3	15.5 ± 1.7
Levator hiatus area during contraction (cm^2)	V2	14.0 ± 2.4	12.3 ± 1.3
Levator hiatus area during Valsalva (cm^2)	V2	21.2 ± 4.7	18.2 ± 3.0
Contractility	V2	0.80 ± 0.14	0.8 ± 0.08
Distensibility	V2	1.19 ± 0.19	1.18 ± 0.19

Values are given as mean ± SD.
Distensibility: Ratio between the area of the hiatus on Valsalva and the area of the hiatus at rest.
Contractility: Ratio between the area of the hiatus on PFMC and the area at rest.

Table 3
Conditional logistic regression analysis of association between levator hiatus area and cesarean delivery.

Variable	OR (95% CI)
Levator hiatus area at rest (V1)	**0.57 (0.34–0.95)**
Levator hiatus area during PFMC (V1)	0.72 (0.49–1.08)
Levator hiatus area during Valsalva (V1)	**0.55 (0.35–0.88)**
Contractility_V1	7.62 (0.05–1187)
Distensibility_V1	0.02 (0.00–4.55)
Levator hiatus area at rest (V2)	0.69 (0.46–1.05)
Levator hiatus area during PFMC (V2)	0.63 (0.38–1.03)
Levator hiatus area during Valsalva (V2)	**0.78 (0.60–1.00)**
Contractility_V2	1.37 (0.00–529)
Distensibility_V2	1.98 (0.02–223)

V1: Values at the beginning of pregnancy.
V2: Values at the end of pregnancy.

We can say that, in our sample, the greater the hiatus area, the greater the possibility of VD, and that this is independent of demographic and anthropometric variables such as age and BMI.

Discussion

Finding objective indicators of cesarean risk in our population is a challenge.

Some models have been published with the purpose of predicting CS in induced deliveries, since a significant percentage of inductions end in CS. [13,14] The characteristics associated with labor, such as cervicometry or the angle of progression, have been suggested by some researchers as possible solutions in the calculation of the probability of CS due to induction failure. [8,15]

Age and BMI have been established as risk factors for CS in different studies, although in some of them they did not differentiate by indication for CS; in a way that age or BMI could act as predisposing factors for other pathologies, which in turn favor the indication for CS. [4,5,16]

Eggebo et al. developed a predictive model of prolonged labor in which age and BMI, among others, appear to be independent factors by logistic regression, although the sample is not big enough. [7]

Other studies suggest a predictive model of failure of labor induction in which age appears to be one of the predisposing factors, but did not find sufficient evidence to include BMI as a risk factor for a CS. [15,17]

We cannot be sure that age and BMI are independent factors for failure of labor progression since further studies are needed to shed more light on this subject. For this reason, we matched the cases and controls for these factors with the intention to minimize possible interference that could be attributed to them.

There is little evidence linking smoking to the risk of cesarean delivery. The studies are contradictory; on the one hand, in some studies it is observed that women who smoke <10 cigarettes a day have a higher probability of VD because they have a lower birth weight. On the other hand, it is argued that women who smoke have a higher rate of CS due to non-reassuring fetal status. [18,19]

In our study, since CS for risk of fetal distress were not included, we did not include smoking as a factor to be controlled. Although there were more smokers in the cesarean delivery group, the differences were not statistically significant.

Transperineal ultrasound performed during pregnancy is a safe and reliable method for the study of the levator ani muscle. [11]

In addition to the demographic and anthropometric variables of the pregnant women, the anatomical and functional characteristics of the pelvic floor appear to be important factors in the route of birth delivery. The hiatus area during pregnancy could be a predictor of the type of delivery. [20]

Along these lines, van Veelen's study [9] stratifies by differentiating between eutocic, instrumental or cesarean delivery, in addition to assessing whether CS or instrumentation was indicated for lack of progression or for fetal distress. They found that the antero-

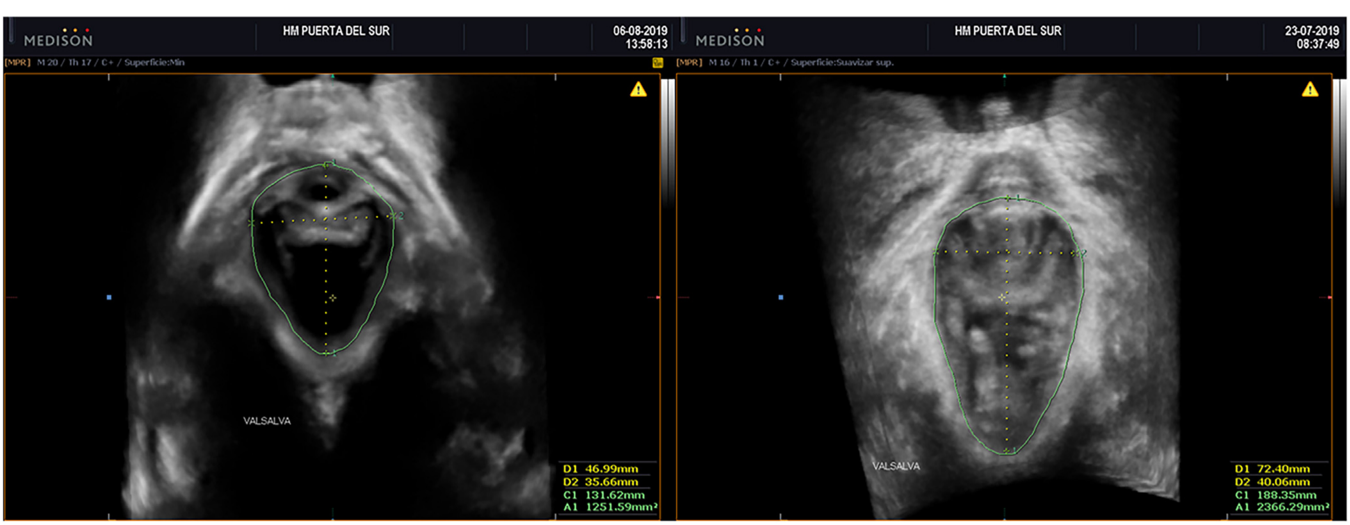

Fig. 2. Hiatal area on Valsalva at the end of pregnancy in a case and a control. Left image shows hiatal area on maximum Valsalva (12.51 cm^2) in a patient who delivered by cesarean section. On the right, the image shows hiatal area on Valsalva (23.66 cm^2) in a patient who delivered vaginally.

posterior diameter of the hiatus and the area of the hiatus on PFMC were lower in patients requiring instrumentation or CS than in patients with normal delivery.

In our sample we included for analysis only CS indicated because of the lack of progression, specifically to study those in which the characteristics of the levator ani could be determinant. We did not stratify instrumental deliveries because the aim of this study was to find objective parameters of predisposition to CS.

Some researchers suggest that distensibility of the puborectalis muscle is determinant in the route of birth delivery. [21,22]

In our sample, the hiatus area at rest and on Valsalva were significantly smaller in cesarean deliveries. However, neither contractility nor levator distensibility were statistically different when compared between CS and VD groups. This will need to be confirmed in further studies by increasing the sample size.

Contractility and distensibility may not be significantly different among groups, because the patients did not undergo pelvic floor muscle training (PFMT) and in addition, nulliparous women are more likely to coactivate the levator than multiparous women, and therefore less able to increase the hiatal area on Valsalva. [23] The coactivation phenomenon has been defined as a reduction in the anteroposterior diameter of the levator hiatus on Valsalva with respect to the diameter at rest. [20,24] It appears that PFMT before delivery favors levator distensibility and decreases the second stage of labor [25,26,27]. Furthermore, PFMT may improve postpartum pelvic floor dysfunction. [28,29]

In our search for identifiable factors that influence the route of delivery, we found that pelvic floor ultrasound is important, since it could help identify patients at higher risk of CS due to anatomical and functional characteristics of their pelvic floor that with tailored interventions, such as type of exercise and PFMT, could be modifiable during pregnancy, therefore, lowering the individual risk for CS.

Further studies are required to confirm whether specific activities aimed at improving pelvic floor distensibility can decrease the rate of CS conducted for this reason.

The key strengths of this study are that it is observational and prospective, with a case-control design aimed at monitoring age and BMI bias. Special attention was given to the objective assessment of the pelvic floor during pregnancy.

It should be noted that the present study has important limitations, being the most notorious one the sample size, which encourages us to expand recruitment in order to confirm our findings, thus establishing a pattern of predisposition to CS in early pregnancy and recommending specific measures that could decrease cesarean section rates in late pregnancy.

Conclusions

The hiatus area measured by transperineal ultrasonography at the beginning and at the end of the pregnancy may be useful to identify the patients who are at a higher risk of cesarean delivery due to failure of labor progression. These findings should be confirmed and validated in further studies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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