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Effect of Face Mask Wearing on Maternal Oxygen Saturation and on Non-stress Test Results

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ABSTRACT

Objectives: This study was conducted to evaluate the maternal oxygen saturation at the 5th minute, as measured by pulse oximetry and non-stress test (NST) results in pregnant women when they were not wearing and wearing a face mask.

Materials and Methods: A prospective observational study was conducted among pregnant women with a gestational age ≥ 32 weeks. Each participant was monitored for maternal oxygen saturation, as measured by pulse oximetry, vital signs, and NST for approximately 40 minutes divided into 20-minute durations under conditions of them not wearing and wearing a face mass, respectively.

Results: In total, 72 participants were enrolled. The mean maternal oxygen saturation was significantly lower at the 5th minute of monitoring the pregnant women when wearing a face mask than at the 5th minute when not wearing a face mask (mean ± standard deviation (SD) = 97.78 ± 1.24% vs 98.15 ± 1.12%, p = 0.009). The mean maternal diastolic blood pressure was also significantly lower at the 5th minute of monitoring participants when wearing a face mask versus not wearing a face mask (mean ± SD = 66.32 ± 7.60 mmHg vs 68.40 ± 8.13 mmHg, p = 0.007). Non-reactive NST results are comparable when wearing and not wearing a face mask (p = 0.313).

Conclusion: The mean maternal oxygen saturation and maternal diastolic blood pressure were significantly lower at the 5th minute of monitoring the participants when wearing a face mask than at the 5th minute when not wearing a face mask, but the trend was no difference when monitoring for a longer time.

Keywords: oxygen saturation, non-stress test, pregnancy, face mask.

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ผลของการใส่หน้ากากอนามัยต่อระดับออกซิเจนปลายนิ้วมือและการตรวจสุขภาพทารกในหญิงตั้งครรภ์ช่วงท้ายไตรมาสสาม

ภัทราพร อุดมพรธนกิจ, กิตติพงษ์ คงสมบูรณ์, ธารารัตน์ หาญประเสริฐพงษ์

บทคัดย่อ

วัตถุประสงค์: *เพื่อศึกษาระดับออกซิเจนปลายนิ้วโดยการวัดความอิ่มตัวออกซิเจนของฮีโมโกลบินจากซีพจร ณ. นาทีที่ 5 และตรวจสุขภาพทารกของหญิงตั้งครรภ์ ขณะก่อนและหลังใส่หน้ากากอนามัย*

วัสดุและวิธีการ: *เป็นการศึกษาแบบไปข้างหน้าโดยเก็บข้อมูลจากหญิงตั้งครรภ์เดี่ยวจำนวน 72 ราย ที่มีอายุครรภ์มากกว่า 32 สัปดาห์ขึ้นไป โดยหญิงตั้งครรภ์จะได้รับการตรวจระดับออกซิเจนปลายนิ้วโดยการวัดความอิ่มตัวออกซิเจนของฮีโมโกลบินจาก ซีพจร และทดสอบสุขภาพทารกของหญิงตั้งครรภ์ด้วยวิธี non stress test เป็นเวลา 40 นาที โดยแบ่ง เป็นช่วงที่ไม่ใส่หน้ากากอนามัยและใส่หน้ากากอนามัยช่วงละ 20 นาที ตามลำดับ*

ผลการศึกษา: *จากจำนวนหญิงตั้งครรภ์ทั้งหมด 72 ราย พบว่าค่าเฉลี่ยระดับออกซิเจนปลายนิ้วที่เวลา 5 นาที หลังจากใส่หน้ากากอนามัยมีค่าต่ำกว่าอย่างมีนัยสำคัญทางสถิติ เมื่อเปรียบเทียบกับที่เวลา 5 นาที หลังจากถอดหน้ากากอนามัย โดยมีค่าเฉลี่ยของระดับออกซิเจนปลายนิ้ว (ค่าเฉลี่ย ± ค่า เบี่ยงเบนมาตรฐาน = ร้อยละ 97.78 ±1.24 และ ร้อยละ 98.15 ±1.12, ค่าความน่าจะเป็น = 0.009) และพบว่าค่าเฉลี่ยระดับความดันโลหิตขณะหัวใจคลายตัวที่เวลา 5 นาที หลังจากใส่หน้ากากอนามัย มีค่าต่ำกว่าอย่างมีนัยสำคัญ เมื่อเปรียบเทียบที่เวลา 5 นาที หลังจากถอดหน้ากากอนามัยเช่นกัน (ค่าเฉลี่ย ± ค่าเบี่ยงเบนมาตรฐาน = 66.32 ± 7.6 มิลลิเมตรปรอท และ 68.40 ± 8.13 มิลลิเมตรปรอท, ค่าความน่าจะเป็น = 0.007) ความผิดปกติของสุขภาพทารกในครรภ์ (Non-reactive NST) พบได้ไม่แตกต่างกันในขณะใส่และไม่ใส่หน้ากากอนามัย (ค่าความน่าจะเป็น = 0.313)*

สรุป: *ค่าเฉลี่ยระดับออกซิเจนปลายนิ้วและระดับความดันโลหิตขณะหัวใจคลายตัวที่เวลา 5 นาที หลังจากใส่หน้ากากอนามัยมีค่าต่ำกว่าอย่างมีนัยสำคัญ เมื่อเปรียบเทียบที่เวลา 5 นาที หลังจากไม่ใส่หน้ากากอนามัย แต่ค่ามีแนวโน้มไม่แตกต่างกัน เมื่อติดตามในระยะเวลาที่นานขึ้น*

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Introduction

The coronavirus infection (COVID-19) was first reported in Wuhan, China, in December 2019, and was ultimately found to be caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) strain of coronavirus; the common symptoms of which are fever, fatigue, dry cough, myalgia, and headache. Moreover, in severe cases, the affected patient may present with hemoptysis, dyspnea, and pneumonia[1, 2]. The World Health Organization (WHO) estimated the virus has an overall mortality rate of around 3% - 4%[3, 4]. Some pregnant with COVID-19 had serious morbidity and required intensive care unit admission, and preterm delivery occurred in around 47% of the pregnant women hospitalized with COVID-19[5]. Further, the fetal effects of COVID-19 were noted that the risk of important adverse prenatal and perinatal adverse outcomes, including miscarriage, premature rupture of the membranes, and fetal growth restriction, were increased[6]. Moreover, medical prescription for pregnant women is highly difficult and complicated. Thus, protecting pregnant women from COVID-19 should be a key issue. In this regard, three effective safety methods are universally promoted. The first is the wearing of a face mask, especially when other social distancing measures are difficult to practice and when it is not easy to avoid other people who are not wearing masks; the second is to ensure social distancing by staying at least 6 feet away from other people outside your household; and the last is washing the hands with soap and water for at least 20 seconds or with a hand sanitizer with at least a 60% alcohol content if soap and water are not available[7]. The face mask should be made with at least two layers of fabric or thick densely woven cotton[8]. Until now, the effect of face mask wearing on maternal oxygenation and on the fetus has not previously been evaluated. Consequently, this study was conducted to evaluate the maternal oxygen saturation at the 5th minute, as measured by pulse oximetry, in healthy pregnant women with a gestational age of more than 32 weeks of gestation under conditions of not wearing and wearing a face mask. The secondary aim of this study was also to evaluate the maternal oxygen saturation at the 15th and 20th minute and to identify the effect of face mask wearing on the non-stress test (NST) results. Last, the tertiary aim was to assess the level of discomfort feeling in the pregnant women without and with face mask wearing.

Materials and Methods

This prospective observational study was conducted among singleton healthy pregnant women with a gestational age of more than 32 weeks of gestation who attended the Antenatal Outpatient Unit, Department of Obstetrics and Gynecology, Faculty of Medicine, Srinakharinwirot University, Thailand, between December 2020 and March 2021. Exclusion criteria were women who had labor pain, abnormal vaginal bleeding, rupture of the membranes, fever, hypertension, chronic lung or respiratory tract disorder, including asthma, pneumonia, cardiovascular, or circulatory disorder, past or current smoking, overt diabetes mellitus, fetal growth or structural abnormalities, abnormal amount of amniotic fluid, and those who refused to participate. The study was approved by the institute ethics committee (Srinakharinwirot University Ethics committee-386/2563F) and was registered with the Thai Clinical Trials Registry (TCTR20201124002: 24/11/2020).

After the routine antenatal care (ANC) was completed, we explained the details of our study to the pregnant women. The pregnant women who agreed to participate in our study were asked to complete an informed consent form. Informed consent was obtained from all study participants. The participants were asked to complete their demographic information, including maternal age, race, parity, most reliable gestational age, height, weight, body mass index (BMI), and any underlying disease. All the participants were evaluated for fetal presentation,

estimated fetal weight, and amniotic fluid index by ultrasonographic examination (US). Average US was taken approximately 15 minutes where every participant will be rest and limit their activity in the same. Then, each participant was monitored for maternal oxygen saturation, as measured by pulse oximetry, maternal vital signs, and NST for approximately 40 minutes divided into 20-minute durations under conditions of them not wearing and wearing a face mask, respectively. GE Carescape V100, USA device was used for continuously measured the maternal vital signs and pulse oximetry to all participants. Fetal heart rate (FHR) baseline, baseline FHR variability and number of FHR acceleration/deceleration were the NST components of interest. Reactive NST defined as two or more accelerations peaking at 15 beats per minute (bpm) or more above baseline, each lasting 15 seconds or more, and all occurring within 20 minutes of them not wearing and wearing a face mask. If less than two accelerations found lasting to 30 minutes of them wearing and not wearing a face mask, the non-reactive NST was interpreted. NST was interpreted by the Maternal Fetal Medicine doctor who had received the maternal fetal medicine diploma from the Royal Thai College of Obstetricians and Gynaecologists and blinded for timing and participants' face mask wearing status. If the disconcordant interpretation occurred, both of them will discuss and finally conclude together.

The maternal oxygen saturation level and other vital sign variables were recorded at the 5th, 15th, and 20th minutes without and with face mask wearing. Proper face mask wearing was ensured by advising on the importance for the mask to cover the nose and mouth and also for it be secured under the chin. The face masks in our study were three-layer, ear-loop, disposable, melt-blown polypropylene surgical masks (Topwholesome company). The surgical face mask in our study was qualified the production by Thai food and drug administration and international organization for standardization. During the monitoring, all the participants used the same brand face masked and were positioned in the left lateral decubitus position in a separate room. All the study researchers wore a face mask all the time when inside the room. Participants were asked to demonstrate any discomfort feeling they experienced using visual analogue scales (VAS) at the 5th, 15th, and 20th minutes when not wearing and wearing the face mask. The VAS is measurement methods applied to measure a discomfort feeling level that is subjective and difficult to measure directly. The participants were asked to indicated a point along a 10 cm horizontal line (0 = no discomfort feeling and 10 = worst possible discomfort feeling)[9].

The required sample size was estimated using the two-dependent means for paired or matched samples study formula as per the dependent t-test. From a pilot study, we found that the mean oxygen saturations measured by pulse oximetry at the 5th minute in pregnant women with a gestational age of more than 32 weeks of gestation without and with face mask wearing were 97.9% and 97.4%, respectively. The standard deviation for the oxygen saturation measured by pulse oximetry in pregnant women with a gestational age of more than 32 weeks of gestation without face mask wearing was 1.35. To achieve an alpha of 0.05, beta of 0.2, and allowing for 20% lost or missing data, it was determined that at least 70 participants were required.

The demographic and clinical characteristics of the participants at baseline were presented as numbers and percentages or means and the standard deviation. The oxygen saturation measured by pulse oximetry, heart rate, blood pressure, body temperature, and respiratory rate of the participants without and with face mask wearing were compared using the dependent t-test at the 5th, 15th, and 20th minutes. Each variable component of the NST of the participants without and with face mask wearing was compared using the Wilcoxon signed-rank test and chi-square test. Lastly, the VAS level of the participants' discomfort feeling at the 5th, 15th, and 20th minutes without and with face mask wearing were compared at set times using the Wilcoxon signed-rank

test. In all the statistical tests, p values of < 0.05 were considered significant. The statistical analysis was performed with R2.10.0 software (freeware distributed by the R Development Care Team).

Results

In total, 72 pregnant women were enrolled on the study. The demographic and clinical data of the participants are presented in Table 1.

Table 1. Demographic characteristics of the enrolled patients (n = 72).

Clinical variables	
Age (years), mean ± SD	27.6 ± 6.02
Race, n (%)	
Thai	51 (70.8 %)
Others	21 (29.2 %)
Nulliparous, n (%)	
Yes	27 (37.5 %)
No	45 (62.5 %)
Delivery route of previous pregnancy, n (%)	
Vaginal delivery	38 (52.8%)
Cesarean section	7 (9.7%)
Gestational age (days), mean ± SD	146.9 ± 8.63
Gestational age (weeks), n (%)	
$32–33^{+6}$ weeks	10 (13.9 %)
$34–36^{+6}$ weeks	28 (38.9 %)
≥ 37 weeks	34 (47.2 %)
Height (cm), n (%)	
≤ 145	1 (1.4 %)
> 145	71 (98.6 %)
BMI (kg/m^2), n (%)	
Underweight (< 18.5)	0 (0 %)
Normal weight (18.5–24.9)	27 (37.5 %)
Overweight (25–29.9)	31 (43.1 %)
Obese (> 29.9)	14 (19.4 %)

SD: standard deviation, BMI: body mass index

Table 2 presents a comparison of the participants maternal oxygen saturation, heart rate, systolic and diastolic blood pressure, body temperature, and respiratory rate at the 5^{th}, 15^{th}, and 20^{th} minutes without and with face mask wearing. The mean maternal oxygen saturation was significantly lower at the 5^{th} minute with face mask wearing than at the 5^{th} minute without face mask wearing (mean ± SD = 97.78 ± 1.24% vs 98.15 ± 1.12%, p = 0.009). The mean maternal diastolic blood pressure was significantly lower at the 5^{th} minute with face mask wearing than at the 5^{th} minute without face mask wearing (mean ± SD = 66.32 ± 7.60 mmHg vs 68.40 ± 8.13 mmHg, p = 0.007).

Table 2. Comparison of the oxygen saturation, heart rate, blood pressures, and body temperature of participants without and with face mask wearing.

Variables	Without face mask wearing (mean ± SD)	With face mask wearing (mean ± SD)	Mean difference (95%CI)	p value*
Oxygen saturation (%)				
at 5th minute	98.15 ±1.12	97.78 ± 1.24	0.42 (0.11–0.73)	0.009
at 15th minute	97.79 ± 1.06	97.79 ± 1.16	0.03 (0.29–0.23)	0.83
at 20th minute	97.78 ± 1.24	97.89 ± 1.15	0.11 (0.37–0.15)	0.40
Heart rate (bpm)				
at 5th minute	87.9 ± 13.54	87.8 ± 12.61	0.056 (2.5–2.6)	0.966
at 15th minute	89.9 ± 17.6	88.8 ± 11.12	1.139 (2.6–4.89)	0.547
at 20th minute	89.2 ± 12.12	88.58 ± 12.83	0.639 (1.162–2.44)	0.482
Systolic blood pressure (mmHg)				
at 5th minute	110.81 ± 9.59	109.04 ± 13.71	1.764 (1.511–5.039)	0.287
at 20th minute	109.14 ± 8.51	108.97 ± 8.75	0.167 (1.586–1.919)	0.850
Diastolic blood pressure(mmHg)				
at 5th minute	68.4 ± 8.13	66.32 ± 7.60	2.056 (0.578–3.533)	0.007
at 20th minute	66.85 ± 7.35	66.92 ± 7.65	0.069 (1.532–1.393)	0.925
Body temperature (degree Celsius)				
at 5th minute	36.45 ± 0.45	36.48 ± 0.49	0.038 (0.1788–0.101)	0.581
at 20th minute	36.48 ± 0.47	36.48 ± 0.48	0.001 (0.131–0.128)	0.983
Respiratory rate (breaths per minute)				
at 5th minute	18.89 ± 1.49	19.06 ± 1.57	0.167 (0.47–0.136)	0.276
at 20th minute	18.83 ± 1.49	18.92 ± 1.46	0.083 (0.338–0.172)	0.516

* Dependent t-test.

bpm: beats per minute, SD: standard deviation, CI: confidence interval

Table 3 and 4 present comparisons of each variable component of the NST results of the participants without and with face mask wearing and information on the non-reactive NST cases, respectively. All the NST records were of a good quality for interpretation. Non-reactive NST results were comparable when wearing and not wearing a face mask (p = 0.313). Overall, 5/13 participants showed non-reactive NST in both cases, with and without face mask wearing, but only 1 case revealed an adverse pregnancy outcome, which involved thick meconium-stained amniotic fluid and needed emergency cesarean delivery. For the remaining 4 non-reactive NST cases, the additional biophysical profile variables, including fetal breathing, fetal tone, fetal movement, and amount of amniotic fluid, were normal. Then, repeat NST was performed on the same day and the results revealed reactive NST. Thus, the pregnancies were continued and all the cases ultimately delivered healthy newborns without

any adverse pregnancy outcome. For all the reactive NST cases in participants with and without face mask wearing, no adverse neonatal pregnancy was presented within 1 week of the test. The true positive rate value of NST in our study was 20% (1 adverse neonatal outcome case out of 5 non-reactive NST cases in participants with and without face mask wearing). The true negative rate value of NST in our study was 94% (67 reactive NST cases during tests in participants with or without face mask wearing out of 71 cases of no adverse pregnancy outcome within 1 week of the test).

Table 3. Comparison of each variable component of non-stress test of participants without and with face mask wearing.

Variables	Without face mask wearing	With face mask wearing	p value
FHR baseline (bpm) median (IQR)			
at 5th minute	140 (130-145)	140 (130-145)	0.908*
at 20th minute	140 (130-145)	140 (130-145)	0.752
Baseline variability			
at 5th minute			0.084**
Minimal	20 (27.8)	15 (20.8)	
Moderate	48 (66.7)	54 (75)	
Mark	4 (5.6)	3 (4.2)	
at 20th minute			0.064**
Minimal	19 (26.4)	13 (18.1)	
Moderate	49 (68.1)	54 (75)	
Mark	4 (5.6)	5 (6.9)	
Number of accelerations during 20 minutes median (IQR)	5 (3-8)	6 (4-9)	0.261*
Number of decelerations at 10 minutes			1.000**
No	68 (94.4)	69 (95.8)	
Early deceleration	0	0	
Late deceleration	0	0	
Variable deceleration	4 (5.6)	3 (4.2)	
At 20 minutes			1.000**
No	70 (97.2)	71 (98.6)	
Early deceleration	0	0	
Late deceleration	0	0	
Variable deceleration	2 (2.8)	1 (1.4)	
NST interpretation, n(%)			0.313**
Reactive	61 (84.7)	65 (90.3)	
Non-reactive	11 (15.3)	7 (9.7)	

* Wilcoxon signed-rank test, **chi-square test.

FHR: fetal heart rate, bpm: beats per minute, IQR: interquartile range, NST: non-stress test

Table 4. Information of non-reactive non-stress test cases in this study.

Case	Without face mask wearing	With face mask wearing	Information and result of pregnancy
1	Non-reactive	Reactive	$G_4P_2A_1$ 37^{+5} weeks, continued pregnancy until normal vaginal delivery at 38^{+4} weeks, healthy 3,610 g newborn, no abnormality
2	Reactive	Non-reactive	$G_4P_2A_1$ 35^{+5} weeks, continued pregnancy until normal vaginal delivery at 38^{+2} weeks, healthy 3,120 g newborn, no abnormality
3	Non-reactive	Reactive	$G_2P_0A_1$ 36^{+5} weeks, continued pregnancy until normal vaginal delivery at 37^{+2} weeks, healthy 2,360 g newborn, no abnormality
4	Non-reactive	Non-reactive	G_1P_0 38^{+2} weeks, admitted and cesarean delivery on the same day, thick meconium-stained AF, 2,690 g newborn, no abnormality
5	Non-reactive	Reactive	G_4P_3 40^{+3} weeks, induced labor at 41^{+3} and cesarean delivery due to failed induction, healthy 3,240 g newborn, no abnormality
6	Non-reactive	Reactive	G_1P_0 38^{+3} weeks, continued pregnancy until normal vaginal delivery at 38^{+5} weeks, healthy 2,720 g newborn, no abnormality
7	Non-reactive	Non-reactive	G_2P_1 37^{+3} weeks, BPP 8/10 then reactive NST on the same day, continued pregnancy until normal vaginal delivery at 38^{+3} weeks, healthy 2,920 g newborn, no abnormality
8	Non-reactive	Non-reactive	$G_3P_{/2}$ 33^{+3} weeks, BPP 8/10 then reactive NST on the same day, continued pregnancy until normal vaginal delivery at 37^{+5} weeks, healthy 2,990 g newborn, no abnormality
9	Non-reactive	Reactive	G_2P_1 37^{+6} weeks, continued pregnancy until normal vaginal delivery at 39^{+5} weeks, healthy 3,360 g newborn, no abnormality
10	Non-reactive	Non-reactive	$G_3P_{/2}$ 35^{+1} weeks, BPP 8/10 then reactive NST on the same day, continued pregnancy until normal vaginal delivery at 39^{+5} weeks, healthy 3,290 g newborn, no abnormality
11	Non-reactive	Non-reactive	$G_3P_{/2}$ 33^{+4} weeks, BPP 8/10 then reactive NST on the same day, continued pregnancy until normal vaginal delivery at 37^{+5} weeks, healthy 2,900 g newborn, no abnormality
12	Reactive	Non-reactive	$G_4P_2A_1$ 34^{+5} weeks, continued pregnancy until normal vaginal delivery at 39^{+2} weeks, healthy 3,190 g newborn, no abnormality
13	Non-reactive	Reactive with variable deceleration 1 time	G_1P_0 38^{+1} weeks, continued pregnancy, diagnosed preeclampsia with severe features at 38^{+5} weeks, cesarean delivery due to failed induction, healthy 2,440 g newborn, no abnormality

NST: non-stress test, BPP: biophysical profile scores, g: grams, AF: amniotic fluid

Lastly, Table 5 presents the median and interquartile ranges (IQR) of VAS level scores showing the participants' discomfort feeling at the 5^{th}, 15^{th}, and 20^{th} minute without and with face mask wearing. The median and IQR of VAS level scores of participants' discomfort feeling at the 5^{th},

15th, and 20th minute were significantly higher when wearing a face mask than when not wearing a face mask [0.95 (0.15-2.75) vs 0.15 (0-1.8), 0.9 (0.2-2.65) vs 0.35 (0-1.8) and 1.0 (0.1-2.9) vs 0.4(0.1-1.35) cm, p = 0.002, 0.003, and 0.003, respectively)].

Table 5. The median (interquartile ranges) of visual analogue scale level of participants' discomfort feeling at the 5th, 15th, and 20th minutes without and with face mask wearing.

	Without face mask wearing	With face mask wearing	p value
VAS (cm)			
at 5th minute	0.15 (0–1.8)	0.95 (0.15–2.75)	0.002
at 15th minute	0.35 (0.1–1.8)	0.9 (0.2–2.65)	0.003
at 20th minute	0.4 (0.1–1.35)	1.0 (0.1–2.9)	0.003

* Wilcoxon signed-rank.
VAS: visual analogue scale, cm: centimeters

Discussion

A significant lowering of mean maternal oxygen saturation was observed at the 5th minute in the healthy pregnant women when wearing a face mask compared to at the same time when not wearing a face mask. We hypothesized that this was related to a reduction in oxygen uptake by the barrier function of the face mask and aggravated by CO_2 accumulation occurring beneath the face mask. This finding was similar to in the previous study that evaluated surgeons' oxygen saturation levels before and after wearing a surgical face mask during performing major operations. The study found that surgeons' oxygen saturation decreased after the first hour of surgical mask wearing, especially in surgeons older than 35 years old. Moreover, the level of oxygen saturation decrease was found to be greater in longer times[10]. For pregnant women, previous studies found that oxygen saturation was significantly reduced, especially when using double surgical mask[11, 12]. Fortunately, the significant lowering of maternal saturation was revealed only at the 5th minute with face mask wearing, while the mean maternal oxygen saturation was not significantly different for participants with and without face mask wearing at the 15th and 20th minutes. Thus, healthcare providers can be reassured about the safety of face mask wearing in the context of the level of maternal oxygen saturation for avoiding COVID-19 spreading in healthy pregnant women. However, the physiologic mechanism that the pregnant woman uses to compensate for the oxygenation reduction is still unclear. The maternal respiratory rate and heart rate in our study did not show any significant differences in the cases without and with face mask wearing. Possibly, temporary deep breathing may be induced in the pregnant women in the first 5 minutes of face mask wearing.

A significant reduction of the mean diastolic blood pressure was observed in the healthy pregnant women at the 5th minute with face mask wearing compared to at the 5th minute without face mask wearing. This finding contrasted with a previous study that monitored the maternal heart rate, blood pressure, mean arterial blood pressure, total peripheral resistance, stroke volume, and oxygen saturation between pregnant and non-pregnant women with and without wearing an N95 filtering face piece respirator. That study found that diastolic blood pressure was significantly increased in both pregnant and non-pregnant women, but not differently between the pregnant and non-pregnant women. That different finding compared to our study may be explained by

the different gestational age of the participants and differences in the activities between both studies. Anyway, the physiological response to the diastolic blood pressure changing remains unclear[13].

The incidence of non-reactive NST in our study was 6.9%, which was lower than in many other studies, probably because our participants were healthy pregnant women. Most the NST in previous studies were performed in high-risk pregnancies. The true positive rate and specificity true negative rate of NST in this study were 20% and 94%, respectively. The rates were comparable with previous studies[14, 15]. Fortunately, non-reactive NST results were comparable in both groups. Moreover, most of the non-reactive NST results in our study were false-positive tests. We hypothesized that the duration and difference in the sleep–wake cycle in individual fetuses may explain this finding, not directly reasoned by the face mask wearing effect. Anyway, the limitation of the study was our number of sample size may be not enough to answer the effect of face mask wearing to NST. The duration of NST has been found to influence the appearance and the relative percentage of fetal reactivity during the NST. A longer NST time increased the rate of reactive NST. We plan to perform a further cross study in which participants will be introduced to NST with face mask wearing before NST is performed without face mask wearing[16]. Moreover, other fetal well-being assessments should be additionally performed for reassurance of the fetal status. Finally, a feeling of discomfort was significantly presented by the pregnant women in our study. Despite this, face mask wearing is a strongly effective method for preventing the spread of COVID-19. Thus, healthcare providers should be aware of potential feelings of discomfort which could affect the mask wearing status and should encourage all healthy pregnant women to wear a face mask at all times when other social distancing measures are difficult to adhere to. There are many face mask types. We plan to evaluate the maternal response to other types of face mask in a further study. Moreover, we plan to perform a cross sectional study to evaluate the rate of non-reactive NST by monitoring the NST results in participants with wearing a mask first, and then without wearing a mask. The current study is the first to evaluate the effect of face mask wearing on maternal oxygen saturation and other vital signs and also its effect on NST results interpretation during the current COVID-19 pandemic. The reduction of the diastolic blood pressure found at the 5th minute in participants with face mask wearing could not be clearly explained by the pathogenesis. Although mean maternal oxygen saturation and diastolic blood pressure were statistically significantly lower at the 5th minute of monitoring the pregnant women when wearing a face mask than at the 5th minute when not wearing a face mask, these may not be clinically significant.

Conclusion

In conclusion, it was evident that the mean maternal oxygen saturation and maternal diastolic blood pressure were significantly lower in participants at the 5th minute of being monitored when wearing a face mask than at the 5th minute in participants not wearing a face mask, but no differences were found when monitoring for a longer time. Non-reactive NST results are comparable when wearing and not wearing a face mask. The pregnant women also significantly presented a feeling of discomfort when wearing the face mask compared to when not wearing the face mask.

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Potential conflicts of interest

The authors declare no conflicts of interest.

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