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**ORIGINAL PAPER**

# Impact of face mask use during the non-stress test in pregnancy

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**ABSTRACT**

**Introduction and aim.** Face masks used to protect against the COVID 19 pandemic have become a daily routine. The aim of this study was to examine the possible effects of mask use on non-stress test (NST) results during pregnancy.

**Material and methods.** A total of 951 pregnant women were included in the study. They were divided into two groups as those who wear masks and those who do not. These pregnant women were also divided into subgroups as preterm and term periods.

**Results.** The mean age of the pregnant women was 31.2±4.9 and their gestational weeks were between 34+0 and 40+6. There was no significant difference between 34 and 37 gestational weeks pregnants in terms of FHR, reactivity, non-reactivity, deceleration, FHR category distribution and number of fetal movements (p>0.05). The variability was significantly higher in those who did not wear a mask (p<0.05). In pregnancies >37 gestational weeks there was no significant difference in terms of FHR, reactivity, non-reactivity, variability, deceleration and FHR category distribution (p>0.05). The number of fetal movements was significantly (p<0.05) lower in the mask-wearing group.

**Conclusion.** Mask use should be considered in NSTs where variability is reduced or fetal movements are low. Thus, misinterpretation of the NST can be avoided.

**Keywords.** COVID-19, face mask, fetal heart rate, non-stress test

## Introduction

Antepartum fetal surveillance aims to reduce mortality and morbidity during pregnancy. There are several methods used for this purpose. These are maternal perception of fetal movements, non-stress test (NST), contraction stress test, umbilical artery doppler velocimetry, biophysical profile and modified biophysical profile.[1]

NST is routinely recommended to assess fetal well-being during the third trimester.[2] It is a non-invasive assessment method. Fetal heart rate (FHR), fetal movements, presence of uterine contraction and deceleration, number of accelerations and reactivity/non-reactivity are evaluated. If a possible risk is detected during the evaluation, the decision to perform other fetal well-being tests or urgent intervention can be discussed.

COVID-19 was identified in December 2019 in China and was declared a pandemic by the World Health Organization (WHO) on March 2020.[3] Although it generally progresses with clinical findings such as cough, fever, loss of taste, loss of smell, shortness of breath, headache and sore throat, it can also cause serious complications. According to data obtained to date, being infected with COVID-19 during pregnancy may increase the likelihood of hospitalization, admission to the intensive care unit and need for life support.

Main transmission routes of COVID-19 include droplet, contact transmission and airborne transmis-

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sion. The usage of a disposable medical or surgical mask that covers the mouth and nose is routinely recommended to prevent viral transmission. Wearing a mask, which is the most well-known method of protection from COVID-19 during the pandemic, continues in hospital visits as well as daily routine. In a study, it was determined that the usage of surgical masks in term pregnancies significantly reduced oxygen saturation.[4]

## Aim

Based on this finding, we planned to investigate whether wearing a mask during NST for assessment of fetal well-being would affect NST results.

## Material and methods

***Ethical approval***

Ethical approval was obtained from Maltepe University Ethics Committee (No: 2021/900/83) and the study was carried out in accordance with the principles of the Declaration of Helsinki.

***Study design***

The study was carried out in Maltepe University Hospital, outpatient clinic of obstetrics between April 2019 and May 2021. A total of 951 pregnant women who met the criteria were included in the study. Masks have been routinely used since April 2020 to protect against COVID infection. Based on this date, two groups as wearing masks (group B) and not wearing masks (group A) were created.

Those with a singleton pregnancy and >34 gestational weeks were included in the study. Exclusion criteria were multiple pregnancy, <34 weeks of gestation, active labor, maternal disease (hypertension, diabetes mellitus, kidney disease, heart disease) and obstetric risk (preeclampsia, intrauterine growth retardation, chromosomal or structural abnormality).

The age, body mass index and gestational week were checked from patient files. FHR, number of accelerations, presence of deceleration and fetal movements detected in NST were retrospectively analyzed and recorded from the archive. All NST recordings were made by a single device. Those whose NST records could not be fully analyzed, those with a duration of less than 20 minutes and those with missing data in their files were not included in the study.

***NST interpretation***

By following the fetal heart rate tracing in NST; basal FHR, variability, accelerations, and decelerations can be measured. FHR is the average beats per minute (bpm) over a 10-minute interval. The normal value is between 110-160 bpm. Basal FHR <110 bpm is called bradycardia and >160 bpm is called tachycardia. Significant and sudden increases in FHR are called accelerations. It is defined as an increase of ≥15 bpm lasting at least 15 seconds and maximum 2 minutes at ≥32 weeks of gestation. Absence of accelerations may be associated with fetal metabolic acidemia and hypoxic injury.[5-7]

Early decelerations are defined as FHR decreases with normal variability accompanying uterine contractions. They are not associated with hypoxia and acidosis. Prolonged decelerations are decreases in FHR of at least 15 beats lasting the shortest 2 minutes and the longest 10 minutes. The absence of variability or the presence of minimal variability and absence of accelerations requires urgent evaluation for hypoxic risk. Variable decelerations are sudden drops in FHR. The shape and size of the deceleration are not related to uterine contractions. They account for most decelerations during labor and reflect the baroreceptor-mediated fetal autonomic response to transient mechanical compression of the umbilical cord. Late decelerations are symmetrical decreases and outputs in heart rate together with uterine contractions. These decelerations reflect the chemoreceptor-mediated response to fetal hypoxemia.[8,9]

Variability occurs depending on the integration of the sympathetic and parasympathetic systems. A normal (moderate) variability is defined as the amplitude in the range of 5-25 bpm. It shows that oxygenation of the central nervous system is normal, hypoxic damage and metabolic acidemia are absent.[10] Amplitude >25 bpm is called saltatory pattern and <5 is called minimal variability.

One of the most important indicator in the evaluation of fetal well-being is the reactivity of NST. Reactive (negative) NST is a normal result showing that there are accelerations that occur at least 2 times within a maximum of 20 minutes. Nonreactive (positive) NST is the absence of two or more accelerations of at least 15 beats lasting, at least 15 seconds within 20 minutes. While 50% of NSTs are non-reactive under 28 weeks of gestation, 15% of NSTs between 28-32 weeks are non-reactive. [1] NST of a normal preterm fetus is usually non-reactive rather than reactive.

FHR patterns were classified in 3 categories in the workshop held by the National Institute of Child Health and Human Development, the American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine in 2008 (Table 1).[6] Category I FHR monitors predict normal fetal acid-base status at the time of observation. They are routinely followed and no special action is required.[7] Category III monitoring is associated with abnormal fetal acid-base status. In these cases, a prompt clinical evaluation should be made. To quickly resolve the abnormal FHR pattern, maternal oxygen support, change in maternal position, cessation of labor stimulation, treatment of maternal hypotension, and treatment of tachysystole can be planned. If a positive response is not achieved despite the precautions taken, delivery can be planned. Category II FHR follow-ups are uncertain and do not predict abnormal fetal acid-base status.

**Table 1.** Three-tier fetal heart rate interpretation system[6]

| |
|---|
| **CATEGORY I** |
| *Category I fetal heart rate (FHR) tracings include all of the following:* |
| • Baseline rate: 110–160 beats per minute (bpm) |
| • Baseline FHR variability: moderate |
| • Late or variable decelerations: absent |
| • Early decelerations: present or absent |
| • Accelerations: present or absent |
| **CATEGORY II** |
| *Category II FHR tracings include all FHR tracings not categorized as Category I or Category III. Category II tracings may represent an appreciable fraction of those encountered in clinical care. Examples of Category II FHR tracings include any of the following:* |
| **Baseline rate** |
| • Bradycardia not accompanied by absent baseline variability |
| • Tachycardia |
| **Baseline FHR variability** |
| • Minimal baseline variability |
| • Absent baseline variability not accompanied by recurrent decelerations |
| • Marked baseline variability |
| **Accelerations** |
| • Absence of induced accelerations after fetal stimulation |
| **Periodic or episodic decelerations** |
| • Recurrent variable decelerations accompanied by minimal or moderate baseline variability |
| • Prolonged deceleration ≥2 minutes but <10 minutes |
| • Recurrent late decelerations with moderate baseline variability |
| • Variable decelerations with other characteristics, such as slow return to baseline, "overshoots," or "shoulders" |
| **CATEGORY III** |
| *Category III FHR tracings include either:* |
| • Absent baseline FHR variability and any of the following: |
| - Recurrent late decelerations |
| - Recurrent variable decelerations |
| - Bradycardia |
| • Sinusoidal pattern |

### *Statistical analysis*

In the descriptive statistics of the data mean, standard deviation, median minimum, maximum, frequency and ratio values were used. The distribution of variables was measured with the Kolmogorov Smirnov test. Mann-Whitney U test was used in the analysis of quantitative independent data. Chi-Square test was used in the analysis of qualitative independent data and the Fischer test was used when the Chi-Square test conditions were not met. SPSS 28.0 program (IBM, Armonk, New York, United States) was used in the analysis.

## Results

In our study, pregnant women were divided into two groups because it was planned to examine the effects of mask use on maternal and fetal oxygenation. Pregnant women whose NST data were analyzed in the pre-pandemic period were named group A and pregnant women whose NST data were analyzed during the pandemic were named group B. In addition, because the rate of non-reactive NST was found to be higher in the preterm period than in the term period, the pregnant women were divided also into subgroups according to their weeks.

Those between 34-37 gestational weeks were classified as A1 and B1 groups and those with >37 gestational weeks were classified as A2 and B2 groups. The mean age of the pregnant women was 31.2±4.9 and their gestational week was between 34+0 and 40+6 (Table 2).

**Table 2.** Demographic characteristics of all participants

| | | Min-Max | | | Median | Mean±SD/n-% | |
|---|---|---|---|---|---|---|---|
| Age | | 19 | – | 44 | 31 | 31.2 | ± 4.9 |
| Gestational Week | | 34 | – | 40.6 | 37.1 | 36.8 | ± 1.6 |
| FHR | | 100 | – | 170 | 130 | 129.6 | ± 10.1 |
| Non-reactivity | | | | | | 162 | 17% |
| Reactivity | | | | | | 789 | 83% |
| Variability | I | | | | | 64 | 6.7% |
| | II | | | | | 719 | 75.6% |
| | III | | | | | 168 | 17.7% |
| FHR Category | I | | | | | 766 | 80.5% |
| | II | | | | | 154 | 16.2% |
| | III | | | | | 31 | 3.3% |
| Deceleration | No | | | | | 905 | 95.2% |
| | Yes | | | | | 46 | 4.8% |
| Fetal Movements | | 0 | – | 36 | 9 | 11.5 | ± 8.6 |

There was no significant difference between the A1 and B1 groups, in which only pregnancies below 37 weeks were compared in terms of gestational weeks, FHR, reactivity, non-reactivity, deceleration, FHR category distribution and fetal movement number (p>0.05) (Table 3). The variability in the A1 group was significantly higher than in the B1 group (p<0.05).

**Table 3.** Comparison of NST features <37 gestational week

| | | A1 | | | | B1 | | | | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean±SD/n-% | | | Median | Mean±SD/n-% | | | Median | | |
| Gestational Week | | 35.5 | ± | 1.0 | 35.5 | 35.5 | ± | 0.8 | 35.6 | 0.858 | m |
| FHR | | 129.5 | ± | 10.2 | 130 | 130 | ± | 10.9 | 130 | 0.535 | m |
| Non-reactivity | | 41 | | 17.7% | | 41 | | 17.1% | | 0.852 | $X^2$ |
| Reactivity | | 190 | | 82.3% | | 199 | | 82.9% | | | |
| Variability | I | 8 | | 3.5% | | 15 | | 6.3% | | 0.027 | $X^2$ |
| | II | 175 | | 75.8% | | 195 | | 81.3% | | | |
| | III | 48 | | 20.8% | | 30 | | 12.5% | | | |
| FHR Category | I | 179 | | 77.5% | | 197 | | 82.1% | | 0.482 | $X^2$ |
| | II | 43 | | 18.6% | | 35 | | 14.6% | | | |
| | III | 9 | | 3.9% | | 8 | | 3.3% | | | |
| Deceleration | No | 219 | | 94.8% | | 227 | | 94.6% | | 0.914 | $X^2$ |
| | Yes | 12 | | 5.2% | | 13 | | 5.4% | | | |
| Fetal Movements | | 11.4 | ± | 7.4 | 9 | 10.9 | ± | 8.2 | 9 | 0.351 | m |

[m] Mann-Whitney U test/ $X^2$ Ki-kare test

Furthermore, those with pregnancies >37 weeks of gestation were also analyzed as A2 and B2 groups. There was no significant difference ($p>0.05$) in terms of gestational weeks, FHR, reactivity, non-reactivity, variability, deceleration and FHR category distribution. Solely, the number of fetal movements in the B2 group was significantly ($p<0.05$) lower than the A2 group (Table 4).

**Table 4.** Comparison of NST features >37 gestational week

| | | A2 | | B2 | | p | |
|---|---|---|---|---|---|---|---|
| | | Mean±SD/n-% | Median | Mean±SD/n-% | Median | | |
| Gestational Week | | 38.2 ± 1 | 38.1 | 38 ± 0.8 | 38 | 0.259 | m |
| FHR | | 128.6 ± 9.1 | 130 | 130.1 ± 10.2 | 130 | 0.134 | m |
| Non-reactivity | | 34 15.4% | | 46 17.8% | | 0.475 | $\chi^2$ |
| Reactivity | | 187 84.6% | | 213 82.2% | | | |
| Variability | I | 21 9.5% | | 20 7.8% | | 0.609 | $\chi^2$ |
| | II | 162 73.3% | | 187 72.5% | | | |
| | III | 38 17.2% | | 52 20.2% | | | |
| FHR Category | I | 185 83.7% | | 205 79.1% | | 0.279 | $\chi^2$ |
| | II | 32 14.5% | | 44 17.0% | | | |
| | III | 4 1.8% | | 10 3.9% | | | |
| Deceleration | No | 215 97.3% | | 244 94.6% | | 0.1 | $\chi^2$ |
| | Yes | 6 2.7% | | 15 5.8% | | | |
| Fetal Movements | | 13 ± 9.1 | 10 | 11 ± 9.1 | 8 | 0.011 | m |

## Discussion

During pregnancy, maternal and fetal metabolic activities increase. To compensate these increases, significant changes are observed in the respiratory system and cardiovascular system. Adaptive changes are observed in static lung volumes, gas exchange and ventilation. Besides, cardiovascular changes such as increased plasma volume and cardiac output and decreased vascular resistance are also observed.[11] In addition to these possible changes observed during pregnancy, we planned our research considering that the use of masks can also change respiratory physiology. In our study, we examined the possible effect of the mask use on NST results. As a primary outcome, we evaluated the difference in terms of FHR, reactivity, non-reactivity, variability, deceleration rate, FHR category distribution and fetal movements.

The first usage of mask in the literature was described by Mikulicz in 1897. He suggested the usage of a mouth bandage made of gauze in operations and took the first step regarding surgical masks.[12] The possible physiological effects of mask use over time were investigated. While some studies did not show a possible harm of using masks, some studies showed a disruptive effect on vital signs. A study by Zhang et al showed that wearing a surgical mask in healthy young people had adverse effects on cardiopulmonary function during exercise.[13] In a similar study, Shaw K et al. showed that wearing a face mask during exercise had no significant effect on healthy young people in terms of percutaneous oxygen saturation ($SpO_2$), exercise maximum load, tissue oxygenation index, exercise hearth rate and rating of perceived exertion.[14]

On the other hand, it was found that as long as the surgeons used a mask, their saturation was lower even if they were within the normal range.[15] In a study conducted with 50 university students, it was determined that the usage of masks caused an increase in heart rate and a decrease in blood oxygen saturation.[16] Lässing et al. showed that the heart rate and cardiac output were higher while wearing a surgical mask but there was no change in the values of blood pressure and blood lactate level during the exercise.[17]

Since pregnancy has different dynamics, maternal and fetal effects of mask use during pregnancy have been investigated for a long time. The physiological changes detected were variable similar to the general population. In a study conducted with pregnant healthcare workers using N95 masks, it was shown that the exhaled oxygen concentration increased by 3.2% and the exhaled carbon dioxide increased by 8.9%. These values are indicative of increased forced expired $CO_2$ concentration and decreased forced expired $O_2$ concentration. In contrast, there was no change in maternal and fetal heart rates, fingertip capillary lactate levels and oxygen saturation, and the degree of perceived exertion.[18] In a case-controlled study of 48 patients using masks there were no differences between the pregnant and non-pregnant in heart rate, respiratory rate, transcutaneous carbon dioxide level and oxygen saturation. Likewise, there was no significant effect on FHR.[19] A systematic review examined the physiological effects of N95 face mask use by pregnant women. It was determined that short-term usage of N95 filtered face mask did not have a negative effect on maternal heart rate, respiratory rate, blood oxygen saturation and FHR.[20] On the other hand, Roberge et al. found an increase in subcutaneous $CO_2$ levels over time during exercise in pregnant women using N95 FFR face masks.[21] In another study supporting this result, it was determined that the usage of surgical masks in term pregnancies significantly reduced oxygen saturation.[4]

In our study, while examining the pregnant population, we paid attention to the distinction of preterm fetus, which may constitute a handicap. We know that NST of most preterm fetuses is often non-reactive.[22] In order to avoid possible misinterpretation that may arise from this, we compared 34-37 weeks of pregnancy and >37 weeks of pregnancy as two groups. No negative effects of mask use on FHR, reactivity rate, non-reactivity rate, deceleration rate and FHR category distribution were found in the comparison of both groups ($p>0.05$).

As negative effects of mask usage, we found a tendency to decrease in variability in the preterm period and a decrease in the number of fetal movements in the term period ($p <0.05$). Fetal movements are one of the oldest method used to demonstrate fetal well-being. Although fetal movement count is still being used, studies have not found a proven effectiveness of fetal movement count in predicting fetal well-being.[23] Location of the placenta, amniotic fluid volume, fetal presentation, maternal smoking, fetal sex, primiparity, obesity, and acute exercise have been associated with decreased fetal movements.[24] Similarly, there are many factors that can affect variability. Possible variables include gestational week, maternal daily exercise amount, daily rhythm, fetal respiratory movements, fetal gross movements, fetal behavioral conditions, smoking, fetal gender and ethnic differences.[25] Since we did not investigate these parameters, we think that the decrease in fetal movement numbers or differences in variability cannot be associated with the usage of masks alone.

It has been reported that the usage of masks during physical activities in people with known lung disease will cause physiological changes, even if minimal. From this point of view, it can be concluded that attention should be paid to possible decrease in saturation in prolonged NST scans in pregnant women with known lung disease.[26]

The negative side effects caused by masks become more evident over time. Since it can affect many parameters such as temperature increase, humidity, facial irritation, itching, headache, acne, vocal fatigue, perceived voice problems, increased stress, impaired motor function and cognition, a decrease in the use of masks is observed in the society from time to time.[20,27,28] We think that the most important limitation of our study is that pregnant women may have removed the mask even for a short time due to these possible side effects during NST. Other weaknesses of our study are that we did not question the type of masks patients used and how long they had been wearing them. We state this as another limitation, since CO2 uptake in the dead space increases due to long-term use of masks and each mask has a different filter mechanism.

## Conclusion

It seems that the usage of masks will take place in our lives for a while due to the COVID-19 pandemic. No significant effect of mask usage on FHR, reactivity, non-reactivity, deceleration rate and FHR category distribution was observed. On the contrary, we determined that the usage of masks may cause a decrease in baby movements and a decrease in variability. We think that possible misinterpretations will be avoided when NSTs with decreased baby movements and decreased variability are evaluated in the light of this information. Prospective studies with large samples are needed for more comprehensive results on this subject.

## Declarations

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***Author contributions***

Conceptualization, A.G.; Methodology, A.G. and E.D.T.; Software, A.G..; Validation, A.G. and E.D.T.; Formal Analysis, A.G. and E.D.T.; Investigation, A.G. and E.D.T.; Resources, A.G. and E.D.T.; Data Curation, A.G. and E.D.T.; Writing – Original Draft Preparation, A.G. and E.D.T.; Writing – Review & Editing, A.G.; Visualization, A.G.; Supervision, A.G.; Project Administration, A.G.; Funding Acquisition, A.G.

***Conflicts of interest***

The authors have no conflict of interest.

***Data availability***

The datasets used and/or analyzed during the current study are open from the corresponding author on reasonable request.

***Ethics approval***

The study was approved by the Maltepe University Medical Ethics Committee Reference Number No: 2021/900/83.

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