ORIGINAL ARTICLE

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Factors associated with decreased respiratory pressures in high-risk pregnant women

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ABSTRACT

Introduction: The gestational period brings anatomical and physiological changes to women in several systems, especially the respiratory system. **Objective:** To determine whether there is an association between gestational age (GA), Diabetes, uterine fundal height (UFH), Body Mass Index (BMI), level of dyspnea, and physical activity with maximum respiratory and nasal pressures. **Methods:** Cross-sectional study that included 55 high-risk pregnant women in the 2nd and 3rd trimester of pregnancy at the Obstetrics Outpatient Clinic of the Hospital das Clínicas in Recife – PE, Brazil, personal, sociodemographic, anthropometric, clinical and Maximal Inspiratory Pressure (MIP) data were described and nasal inspiratory pressure (NIP), that, using regression and multivariate analysis, analyzed the influence of risk factors for high-risk pregnancy with NIP considering a $p<0.005$. **Results:** Among the pregnant women, according to the clinical variables, it was observed that 56.4% (n=31) had a gestational age above 28 weeks, 27.3% (n=15) diabetes, 25.5% (n=14) asthma, 43.6% (n=24) Gestational Hypertension, 56.4% (n=31) obesity, 85.5% (n=47) complaints of dyspnea 38.1% (n=21) mild to severe dyspnea and 65.5% (n=36) vigorous physical activity. Low MIP (76.76 cmH_2O) and NIP (68.62 cmH_2O) values were found for age. An association was observed between an increase in UFH and a decrease of 0.8 cmH_2O in NIP, regardless of gestational age. **Conclusion:** High-risk pregnant women in the second and third trimester of pregnancy have decreased NIP and MIP with a negative association of UFH with NIP regardless of gestational age.

Keywords: pregnancy, high-risk; gestational age; exercise; breathing exercises.

INTRODUCTION

High-risk pregnancies are considered to be those in which the life or health of the mother and/or fetus are at greater risk of morbidity or mortality before or after childbirth than the average for the estimated population[1]. In Brazil, 15% to 20% of pregnancies are high-risk, which is characterized by the presence of certain factors such as hypertension, diabetes mellitus (DM), obesity, and cardiorespiratory diseases[1,2]. Some of these factors, such as diabetes, obesity, and asthma, can cause respiratory muscle weakness[3].

The gestational period brings anatomical and physiological changes in various systems, especially the respiratory system. These changes affect respiratory mechanics and consequently interfere with its function, leading to dyspnea being one of the main complaints during prenatal consultations[4,5]. About respiratory mechanics, there is a compensatory increase of 2 cm in the anteroposterior diameter of the rib cage, a reduction in lung capacity, and a decrease in abdominal breathing, in favor of an increase in the thoracic breathing pattern[6,7].

Regarding respiratory muscle pressure measured by a manovacuometer attached to a mouthpiece, studies[8-10] have shown that low-risk pregnant women had lower inspiratory muscle pressure than the reference values for healthy women, while there are currently no studies showing respiratory muscle pressure in high-risk pregnant women and reference values for the pregnant population.

Among the methods for assessing respiratory muscle function, manovacuometry represents the measurement of maximum static inspiratory and expiratory pressures (respectively MIP and MEP). In addition, nasal inspiratory pressure (NIP) is a new validated method capable of assessing the global pressure of the diaphragm and other inspiratory muscles through a maximum and rapid nasal inspiration[11-15].

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Given the existing gap in inspiratory muscle pressure during high-risk pregnancy, and analyzing possible factors for decreased respiratory muscle pressure, this study aims to determine the association of gestational age (GA), uterine fundal height (UFH), body mass index (BMI), level of dyspnea and physical activity with maximal and nasal respiratory pressures in high-risk pregnant women[16,17].

METHODS

This is a cross-sectional study, whose data collection took place from April to August 2017 at the gynecology outpatient clinic of the Hospital das Clínicas of the Universidade Federal de Pernambuco (HC-UFPE), in the city of Recife/PE, Brazil.

The sample, selected sequentially for convenience, included 55 pregnant women with a high-risk medical diagnosis in the 2nd and 3rd trimesters. The following were included in the study: high-risk pregnant women with asthma, obesity, chronic and gestational hypertension, type 1, 2, and gestational diabetes mellitus, followed up during prenatal care at the gynecology outpatient clinic at HC-UFPE, aged between 18 and 40, primigravida or multigravida, in the 2nd and/or 3rd trimester of pregnancy. The following were excluded from the study: pregnant women with bleeding or fluid loss, twin pregnancies, systemic blood pressure greater than 160x100 mmHg, those with neuromuscular diseases, deformities of the spine or rib cage, a history of smoking, colds/flu 15 days before the assessment, and inability to understand or perform the procedures.

This study was approved by the Human Research Ethics Committee of the Federal University of Pernambuco under CAAE no. 63171216.0.0000.5208 and opinion no. 1.937.525 and the pregnant women who agreed to take part signed the Free and Informed

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Consent Form according to the criteria prescribed by resolution 466/12 of the Brazilian National Research Council.

All the pregnant women underwent a preliminary assessment which consisted of obtaining personal, sociodemographic, and anthropometric data using a form drawn up by the researchers. Gestational age was calculated from the last menstrual period (LMP) date, and/or by 1st trimester ultrasound when there was doubt about the LMP. BMI was calculated using current weight in kilograms divided by height in meters squared (kg/m^2)[18].

Physical examinations were then conducted to assess the pregnant woman's respiratory function. They began with manovacuometry, a method capable of assessing maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP)[17].

MIP values were obtained from the Residual Volume (RV) and a minimum of three and a maximum of five maneuvers were performed, choosing the highest value obtained with a difference of less than or equal to 10% between the maneuvers[17]. The maneuvers were conducted using an analog manovacuometer (record, model GA-RA), with a background scale of -120 to 120, and systematically calibrated. The measurements were taken with the pregnant woman sitting on a chair with a backrest, with her feet flat on the floor, hips, and knees at 90°, upper limbs relaxed at the side of the body, and then a nose clip and mouth adapter were fitted, containing an orifice of approximately 2 mm in diameter, to prevent intraoral pressure from rising due to air escaping. Verbal encouragement was also given to each of the women, as well as visual feedback via the device's monitor to achieve maximum effort when performing the maneuver[17].

Next, nasal inspiratory pressure (NIP)[19] was evaluated, which is a non-invasive, alternative method for assessing inspiratory muscle pressure, especially in the diaphragmatic muscles. The measure consists of evaluating the peak nasal pressure during

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sniffing, based on the functional residual capacity. This pressure corresponds to an estimate of nasopharyngeal pressure and is characterized by a ballistic maneuver but with a brief, natural characteristic, with a maximum diaphragmatic activation pattern easily reached[19].

NIP was measured using a manovacuometer, the same one used to assess NIP, which was attached to a silicone nasal plug connected to one nostril. The maneuver consisted of a maximum sniff through the contralateral (free) nostril, with the mouth closed, and 10 measurements were taken from the functional residual capacity, choosing the highest value[14].

To assess dyspnea, the Modified Borg Scale was used, which quantifies dyspnea on a vertical scale of 0-10, where 0 represents no symptom and 10 represents maximum symptom[20], the pregnant woman was asked in which activity she had the most dyspnea and she quantified it.

The height of the uterine fundus was measured with the pregnant woman in the supine position with hips and knees extended and abdomen uncovered, using a flexible, non-stretchable tape measure. The tape was located at its initial end at the upper edge of the pubic symphysis, passing through the index and middle finger to the cubital edge of the hand, reaching the fundus of the uterus[21].

The level of physical activity was ascertained using the Physical Activity Questionnaire for Pregnant Women (*Questionário de Atividade Física para Gestantes - QAFG*) validated in Brazil by Silva et al.[22] and expressed in METS.minute/week. This questionnaire is made up of 33 questions, the first about the last day of menstruation and the second about the baby's expected birth. The other 31 questions seek to identify energy expenditure during physical activity. All the questions put pregnant women in front of situations that are often part of their daily lives[22].

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It captures these physical activities conducted during leisure time, exercise, sport, work, transportation, caring for other people, and household chores, showing the average time spent on each activity, in minutes or hours. The QAFG intensity estimate for light to vigorous intensity activities is based on the average MET/hour per week for the total activity. Each activity was classified by its intensity: sedentary (<1.5 METs), light (1.5 - <3.0 METs), moderate (3.0 - 6.0 METs), or vigorous (>6.0 METs)[22].

The sample size was calculated using the recommendations of Vittinghoff et al.[23] where 10 subjects are needed for each predictor. This study included six predictors (gestational age (GA), obesity (BMI), asthma, uterine fundal height (UFH), level of dyspnea, and level of physical activity) in the regression models. Therefore, by this calculation, 60 pregnant women were required for inclusion in the study.

A descriptive analysis of the data was conducted, including mean, standard deviation, and percentage to characterize the sample. Pearson's Correlation Coefficient was used to check the strength of the linear relationship between the respiratory variables and the clinical variables related to the pregnant women's information. Multiple regression analysis was used to determine the influence of the explanatory variables on the response variable, NIP. Univariate analysis was conducted separately for each predictor variable about NIP using the backward procedure. Only variables with a significance level <0.20 were included in the bivariate analysis and a significance of $p<0.05$ was considered in the final model. R 3.4.2 and SPSS version 22 (SPSS Inc., Chicago, IL, USA) were used to analyze the data.

RESULTS

During data collection, patients were assessed to check their eligibility. Of the 136 pregnant women, 61 were eligible. However, six volunteers were unable to understand,

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perform the test, and/or refused to undergo the assessment, totaling 55 high-risk pregnant women (Figure 1).

According to the clinical variables, most of the pregnant women were over 28 weeks of gestational age and had diabetes, asthma, and gestational hypertension. Around 56.4% (n=31) were obese, 85.5% (n=47) had complaints of dyspnea (Borg scale of 2-10) where they reported a level of dyspnea ranging from slightly severe to very severe, and they engaged in vigorous physical activity. The characterization of high-risk pregnant women according to sociodemographic and clinical variables is shown in Table 1.

The inspiratory pressures of the high-risk pregnant women are shown in Table 2, with a reduction in the percentages of the predicted in both the NIP and the MIP.

Table 3 shows the parameter estimates for the regression model, with NIP as the response. The final model has the UFH variable as significant at the 5% level. The regression coefficients indicate that keeping the other factors constant, an increase of one unit in the UFH variable leads to a decrease of 0.8 cmH_2O in NIP.

DISCUSSION

This study is the first to assess inspiratory muscle function in high-risk pregnant women and found low values of inspiratory muscle strength obtained by NIP and MIP. Among the factors associated with NIP, the regression coefficients indicated that a one-unit increase in the UFH variable leads to a decrease in NIP values.

The NIP is considered a non-invasive test of inspiratory muscle function that is easy to apply and can be used as a complement to MIP[24], but it has never been assessed in women during pregnancy. This study showed a reduction in the percentages predicted for both NIP and MIP when using the mathematical model for women proposed by Araújo et al.[14], who determined the NIP reference values for healthy Brazilian women to be

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between 76 and 129.6 cmH_2O (20 to 29 years) and 74.7 and 114.5 cmH_2O (30 to 39 years).

The results described above can be attributed to the anatomical changes that occur during pregnancy, since with abdominal expansion and consequent elevation of the lower ribs, there is an increase in the subcostal angle and the circumference of the rib cage, causing compression of the diaphragm which limits the generation of inspiratory pressure[7,25]. In addition, pregnant women have obstetric risks such as hypertension, asthma, diabetes, and obesity, among which are risk factors for a decrease in respiratory muscle strength, which, except hypertension, are also factors that can favor a decrease in respiratory muscle strength during this period[26-28].

Regarding MIP values, the pregnant women in this study had a MIP of only 79.63% of the predicted MIP, which does not corroborate the study by Neder et al.[17], who evaluated Brazilian women aged between 20 and 39 years, whose mean MIP was 101.6 cmH_2O, showing that high-risk pregnant women had a 26.4% decrease in predicted MIP.

The studies by Lemos et al.[8], Lemos et al.[9,] and Pinto et al.[10] evaluated respiratory muscle function in low-risk, eutrophic pregnant women aged between 20 and 29 and found that inspiratory muscle strength (88.54; 87.78; 69.06 cmH_2O, respectively) was lower than the reference value for healthy women. This study, when compared to the aforementioned studies, found a reduction in MIP of 11.74%, 11.02%, and 7.7%, respectively, which can be explained by the presence of gestational risk factors such as obesity, diabetes, and asthma. Therefore, high-risk pregnancy seems to have influenced the reduction in MIP obtained.

Regarding the association between gestational age, asthma, BMI, level of dyspnea and physical activity with NIP, it was observed from the associations made in the present study that an increase in UAF is associated with a decrease in NIP, which is probably due

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to the progression of abdominal size resulting from the growth of the uterus, causing compression of the diaphragm, altering the length-tension relationship[7,25], thus causing a 0.8 cmH_2O decrease in inspiratory muscle strength when there is a 1cm increase in UFH.

UFH can vary from pregnant woman to pregnant woman, considering that between the 20th and 34th weeks, uterine height in centimeters is equivalent to gestational age. Therefore, it seems important to classify UFH during pregnancy to be able to identify an atypical increase for gestational age early on[20] and then predict a reduction in inspiratory muscle strength and, if necessary, offer respiratory muscle training if there are repercussions on functional capacity or quality of life.

It is difficult to compare the results of this study with those in the literature since there are no reference values for the population of pregnant women and the prediction of the equations for the adult population comprises a broad age group. However, despite this difficulty, the data from this study allowed for consistency in the MIP and NIP values obtained in the preliminary studies[29].

Despite not correlating with NIP values, dyspnea was one of the most common complaints, in around 85.5% of pregnant women. Changes in lung function are not enough to cause these symptoms, which can be justified by the perception of increased respiratory work due to the increase in the subcostal angle and the circumference of the rib cage[30]. The hypothesis is that pregnant women with greater difficulty breathing tend to have a higher minute volume, due to the increase in respiratory rate. This hyperventilation may therefore explain the number of subjective complaints of dyspnea during pregnancy and is not associated with a decrease in respiratory muscle strength[10,25].

About obesity, 56.4% of the pregnant women in the sample were obese. The World Health Organization (WHO) considers obesity when BMI is over 30 kg/m^2. In this study, BMI showed no significant association with NIP. There are controversies

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regarding the effect of high BMI on respiratory pressure. Studies[31-33] have shown that there is a positive correlation and suggest that this is due to an increase in diaphragmatic muscle mass after pulmonary function improves with weight gain. Other studies[34-36] have not shown this association and do not provide a clear interpretation of it.

The study by Lemos et al.[9], which assessed respiratory pressures in low-risk pregnant women, showed that weight and BMI reflected an exceptionally low magnitude or no correlation at all, so there was no correlation with MIP. This was also the case in this study, although most of the pregnant women were obese.

About the presence of asthma, 25.5% of the pregnant women in the sample had been diagnosed with asthma. Asthma is an obstructive pneumopathy that can be exacerbated in pregnancy, present in between 3.7 and 8.4% of pregnancies, and when uncontrolled can cause hypoxia and, consequently, an increase in maternal lethality[37]. Physical activity at all stages of life maintains and improves cardiorespiratory fitness, reduces associated comorbidities, and results in greater longevity[38]. In the present study, 65.5% of the pregnant women had a vigorous level of physical activity, which explains the lack of a relationship with a reduction in NIP.

There is still no standardization in the literature of reference values for respiratory muscle pressure in low- and high-risk pregnant women. Therefore, studies are needed to establish predictive equations respecting clinical, socioeconomic, anthropometric, geographic, and racial differences, which are of necessary clinical importance, so that during prenatal care, the condition of the respiratory muscles can be assessed and thus included in the training and preparation protocols for childbirth, given that an adequate cardiopulmonary and muscular condition has a positive impact during labor.

Limitations of the study include the small sample size leading to a low adjusted R^2 of the regression, which made it impossible to form a control group with low-risk

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pregnant women to obtain a more robust analysis. Despite the limitations mentioned above, there is a gap in the scientific literature on this subject, and this study is the first to evaluate MIP and NIP in high-risk pregnant women.

High-risk pregnant women in the second and third trimesters, with systemic arterial hypertension, complaints of dyspnea, diabetes, high BMI, and vigorously active showed decreased NIP and MIP, and that a 0.8 cmH_2O decrease in NIP is associated with increased UFH, regardless of gestational age.

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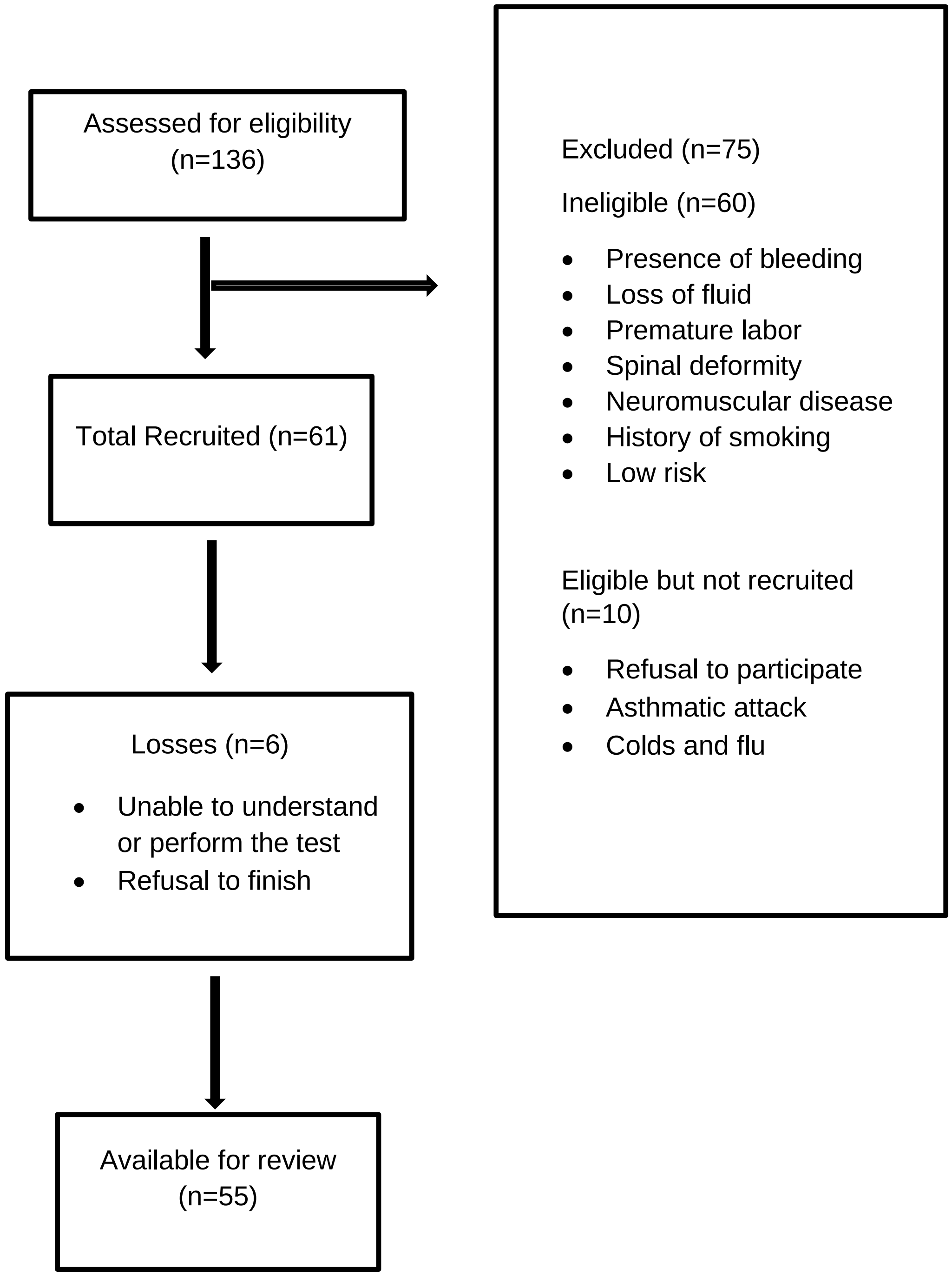

Figure 1: Flow diagram for attracting pregnant women

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Table 1: Characterization of high-risk pregnant women according to sociodemographic and clinical variables.

Variable	Mean (SD)	
Age (years)	28.36±5.03	
Weight (kg)	83.4±15.90	
Height (cm)	1.63±0.14	
BMI (kg/m²)	31.84±6.02	
UFH (cm)	27.48±7.16	
Education	**n**	**%**
Elementary school incomplete	8	14.5
Elementary school complete	3	5.5
High school incomplete	5	9.1
High school complete	30	54.5
Higher education incomplete	2	3.6
Higher education complete	7	12.7
Postgraduate	0	0
Race/skin color		
White	20	36.4
Brown	14	25.5
Black	21	38.2
Income		
No income	8	14.5
Up to 1 minimum wage	29	52.7
1 to 2 salaries	15	27.3
3 to 4 salaries	3	5.5
More than 4 salaries	0	0
Marital status		
Married	41	74.5
Divorced	0	0
Widowed	1	1.8
Single	13	23.6
Gestational age		
14 to 27 weeks	24	43.6
Above 28 weeks	31	56.4
Diabetes		
Yes	15	27.3
No	40	72.7
Asthma		
Yes	14	25.5
No	41	74.5
Gestational hypertension		
Yes	24	43.6
No	31	56.4
Obesity		
Yes	31	56.4
No	24	43.6
Dyspnea		
Yes	47	85.5
No	8	14.5
Dyspnea level		
Absolutely nothing	8	14.5
Not much	4	7.3
Very little	14	25.5
Regular	8	14.5
A little strong	8	14.5
Strong	7	12.7
Very strong	4	7.3
Level of physical activity		
Sedentary (>1.5)	1	1.8
Light (1.5-3.0)	0	0
Moderate (3.0-6.0)	18	32.7
Vigorous (>6.0)	36	65.5

BMI: Body Mass Index; UFH: uterine fundal height

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Table 2: Inspiratory pressures in high-risk pregnant women (n=55)

Variables	Mean ± SD
Measured NIP	-68.62 ± 18.2
Predicted NIP	-100.11 ± 1.81
%NIP prediction	-68.59 ± 18.42
Measured MIP	-76.76 ± 22.17
Predicted MIP	-96.5 ± 2.47
%MIP prediction	-79.63 ± 23.21

PIN: Nasal Inspiratory Pressure; MIP: Maximum Inspiratory Pressure

Table 3: Association of gestational age, asthma, dyspnea, uterine fundal height, and BMI with PIN in high-risk pregnant women.

Variables - NIP	Initial model		Final model	
	Coefficients	p-value	Coefficients	p-value
Gestational age	-3.52	0.681	[a]	
Asthma	-1.74	0.82	[a]	
Dyspnea	-5.75	0.436	[a]	
UFH	-0.55	0.431	-0.8	0.021*
BMI	0.72	0.105	0.76	
Physical Activity Level	0.42	0.585	[a]	
n	55		55	
R^2	15.30%		12.70%	
Adjusted R^2	4.70%		9.30%	

BMI: body mass index; UFH: uterine fundal height; [a]not significant; *significance level: $p<0.05$.