ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Impact Of Maternal Anthropometric Parameters, Physical Activity Level, And Psychological Stress On Cardiac Autonomic Activity During The Third Trimester Of Pregnancy.

Ashwini[1], Shailaja S Moodithaya[2]*, and Amrit M Mirajkar[3].

[1]Associate Professor, Department of Physiology, K S Hegde Medical Academy, Nitte (Deemed to be) University, Mangalore-575018, Karnataka, India.
[2]Additional Professor, Department of Physiology, K S Hegde Medical Academy, Nitte (Deemed to be) University, Mangalore-575018, Karnataka, India.
[3]Professor and Head, Department of Physiology, K S Hegde Medical Academy, Nitte (Deemed to be) University, Mangalore-575018, Karnataka, India.

ABSTRACT

Various cardiovascular, metabolic adaptations takes place during pregnancy to sub serve the normal growth and development of fetus. Most of these physiologic mechanisms alter autonomic balance and may increase the risk of cardiovascular disease even during healthy pregnancy. Anthropometric measurements (body mass index, fat percentage, lean body mass), physical activity level, perceived stress level were assessed among seventy-eight healthy pregnant women during their third trimester of pregnancy. The study also evaluated association of these parameters with cardiac autonomic function by assessment of resting heart rate variability. The analysis of the data showed that there is significant correlation of anthropometric parameters and psychological stress scores, with cardiovascular autonomic indices. Anthropometric parameters like body weight, body mass index and fat free mass showed significant positive correlation with HRV indices like LF nu and LF/HF ratio. Similarly, maternal psychological scores also significantly positive correlated with these HRV indices. Further, both anthropometric parameters and psychological scores significantly positive correlated with systolic and diastolic blood pressure. Maternal body composition and psychological stress state during third trimester of pregnancy significantly influences the cardiac autonomic activity. Hence autonomic imbalance during later weeks of pregnancy may predispose the healthy women to future risk of cardiovascular disease.

Keywords: Body composition, Pregnancy, Cardiac autonomic function, Maternal psychological stress

https://doi.org/10.33887/rjpbcs/2020.11.4.9

Corresponding author

INTRODUCTION

Pregnancy offers a unique window into postpartum as well as the future health of a woman. During pregnancy, various physiologic adaptations take place in mothers to support the developing fetus. Hence, pregnancy will be a state of stress to cardiovascular as well as the metabolic system of women. Exaggerated physiological changes in pregnancy may lead to adverse health outcomes in both mothers as well as newborns (1). Studies have reported that healthy pregnant women gain a substantial amount of body fat, mainly during mid-pregnancy in the subcutaneous region (2). Retrospective studies among pregnant women have reported maternal pre-pregnant Body Mass Index (BMI) to be an essential determinant factor in long-term weight gain (3). Excess weight gain in pregnancy or postpartum weight retention or gain also puts women at increased risk of future disease (4). Obesity(5), lack of physical activity (1), and psychological stress (6) are known risk factors for diabetes mellitus and cardiovascular disease (CVD) among pregnant as well as non-pregnant women.

Regular physical activity throughout pregnancy is known to improve maternal cardiovascular health, improve insulin resistance and metabolic control, reduce the risk of gestational diabetes as well as psychiatric disorders (1). In adults, increased cardiac autonomic modulations are associated with higher cardiac as well as aerobic fitness, which may be true even during pregnancy (1).

Pregnancy may be particularly stressful period for a woman (7)and maternal psychological health is one of the sole predictors of maternal, fetal, neonatal and postnatal health outcomes (8). Both acute and chronic stressors have an immense impact on cardiovascular functioning by their effect on the immune, endocrine, and metabolic pathways (9).

Cardiac autonomic activity is a dynamic entity that varies depending on the body composition, physical activity level, psychological stress state of an individual (10). As pregnancy advances, there is a decrease in parasympathetic modulation and an increment in sympathetic modulation of the Autonomic Nervous System (ANS) (11). Heart Rate Variability (HRV) analyses is widely used, non-invasive tool to assess cardiac autonomic modulation (12). HRV describes beat to beat variation in cardiac R-R interval. Low Frequency (LF) parameter reflects primarily sympathetic modulation, while the High Frequency (HF) reflects parasympathetic modulation. LF/HF ratio signifies the efficiency of sympathovagal balance(13).

Epidemiological studies have suggested the risk of CVD among women with adverse obstetric outcomes like preeclampsia, gestational hypertension, gestational diabetes, or preexisting cardiac disease(14)(15). Studies have also reported an association between adverse maternal health effects and increased sympathetic activity during pregnancy(1). Moreover, it has been reported that most of the pregnancy-related cardiometabolic complications may be preceded by subclinical vascular and metabolic dysfunction(16). Even during a healthy pregnancy, sympathetic autonomic activity increases over three trimesters with maximum activity during the third trimester(17). But whether these physiological changes that occur in ANS during healthy pregnancy predispose the mother to the risk of CVD is not known. Hence, the study aims to evaluate the impact of various CVD risk factors on maternal cardiac autonomic function by assessment of HRV among healthy pregnant women.

MATERIAL AND METHODS

This cross-sectional study was conducted in a tertiary hospital in Mangalore, involving seventy-eight healthy female volunteers with a singleton pregnancy in the age group of 25 to 35 years. The participants were recruited during the third trimester of pregnancy (>32 weeks) after obtaining written informed consent. Women with gestational diabetes mellitus, gestational hypertension, multiple pregnancies, any fetal abnormalities detected by ultrasound, drug abuse, any psychiatric illness, or any mental disorders/ mental retardation that hinders assessment and process of informed consent were excluded from the study. Gestational age was confirmed by menstrual history and first-trimester ultrasound scan. A brief medical history and antenatal examination was done. All of them were assessed for anthropometric measurements, physical activity level, psychological stress levels, and cardiac autonomic function in a single session during the forenoon in a quiet, temperature-controlled room (23±1°C).

Assessment of anthropometric measurements: Height was measured to the nearest 0.01m with a stadiometer, and weight was measured to a nearest 0.1 kilogram with an electronic weighing machine using standard techniques. BMI was calculated as weight (kg) divided by height (m) squared. Skin folds thickness (biceps, triceps, sub-scapular, suprailiac) was measured with calipers using standard techniques. The fat percentage was calculated using pregnancy-specific equations for the third trimester of gestation: Fat mass= weight (kg)/100*((5.6.3/Body density)-473.7). Fat Free Mass (FFM) was calculated using: FFM (kg)= weight [kg] -Fat mass. FFM index(FFMI) was FFMI [kg/m 2] = FFM [kg] / (height [m]) ^{2}.

Assessment of physical activity level: Using previously validated physical activity questionnaire (18), the physical activity of the past month across multiple domains, including discretionary leisure time, household chores, work, sleep, sedentary activities, and other everyday daily activities was assessed. The frequency and average duration for each event were documented. Frequencies were ascertained using fixed categories of 'daily', 'once a week', '2–4 times a week', '5–6 times a week', 'once a month', and '2–3 times a month. The questionnaire provides a measure of overall physical activity computed as the Physical Activity Level (PAL; estimated 24-hour energy expenditure / predicted Basal Metabolic Rate) as well as activity related to specific physical activity domains e.g., discretionary exercise and household chores. In the analysis of the latter, activity within a domain is expressed as MET minutes, the product of the intensity and duration of activities within the specific activity domain.

Assessment of psychological stress level: Using the K-10 questionnaire(19), a screening scale with ten questions about negative emotional states experienced during the four weeks. For each item, there are five level response scales. Each item is scored from 1 for 'none of the time' to 5 for 'all of the time.' Scores for the ten items are then summed, resulting in a minimum possible score of 10 and a maximum possible score of 50. Low scores indicate low levels of psychological distress, and high scores indicate high levels of psychological distress.

Assessment of cardiac autonomic function: All subjects were requested to refrain from strenuous physical activity for 24 hours, any caffeinated/ non-caffeinated beverages for 2 hours before recording. Basal Blood Pressure(BP) was measured using a non-invasive intermittent automated BP monitoring device (Omron IA2 model) in the supine position. Lead II electrocardiogram was recorded to obtain heart rate using a computerized 4-channel data acquisition module (Power lab 26-T, AD instruments, New South Wales, Australia) at a sampling rate of 1000 Hz in the supine position for 5 minutes. Subjects were instructed to breathe normally during the recording. Ectopics and artifacts were identified and excluded from the raw recordings manually. Power spectral analysis was performed using a non-parametric Fast Fourier transformation-based approach with the HRV module of Lab Chart V7, AD Instruments. The power spectrum was expressed as LF (0.04-0.15 Hz), HF (0.15-0.4 Hz), Total Power (TP) in absolute units, LF in normalized units (LFnu), HF in normalized units (HFnu) and LF/HF ratio (13).

Statistical Analysis

Data are expressed as mean, accompanied by Standard Deviation (SD). Normality tests were performed for quantitative variables and data were considered to be normally distributed if $p > 0.05$. For those variables that do not follow a normal distribution, normality tests were applied after log transformation. If data distribution is still not normal, non-parametric tests were used for determining the strength of association. The strength of the association between anthropometric, psychological stress parameters, PAL and cardiac autonomic function during the third trimester of pregnancy was assessed using Spearman's rank correlation test. Probability value $p < 0.05$ was considered as statistically significant. All the statistical analysis was performed using SPSS 20.0.

RESULTS

A total of seventy-eight subjects in the age group of 27 ± three years were recruited during the third trimester of pregnancy. The anthropometric measurements, PAL, psychological stress levels during pregnancy are given in Table 1. Various HRV parameters are presented in Table 2

ISSN: 0975-8585

Table1: Subject characteristics, anthropometric measurements, physical activity level, psychological stress scores during third trimester of pregnancy (n=78)

Variables	Mean ± SD
Age (yrs)	27 ± 3
Fasting blood glucose levels (mg/dl)	83.27 ± 7.43
Haemoglobin (g%)	11.03 ± 0.95
Packed cell volume (%)	33.65 ± 2.53
Weight (kg)	57.27 ± 7.66
Height (m)	1.56 ± 0
BMI (kg/m2)	23.65 ± 2.89
Pulse rate (beats/ minute)	76.83 ± 9.5
Systolic blood pressure (mm Hg)	115.64 ± 10.32
Diastolic blood pressure (mmHg)	77.67 ± 8.08
Fat percentage (%)	13.06 ± 0
Fat-free mass (kg)	44.22 ± 6.16
Fat-free mass index	17.05 ± 2.06
Physical activity level	1.61 ± 0.35
Psychological stress scores	17.46 ± 7.49

Table 2: Indices of HRV during the third trimester of pregnancy (n=78)

Variables	Mean ± SE
Average heart rate	94.61 ± 1.46
Total power (ms^2)	6538.13 ± 891.13
HF abs (ms^2)	1394.63 ± 209.92
HFnu	34.08 ± 1.36
LFabs (ms^2)	1876.95 ± 300.87
LFnu	51.86 ± 1.6
LF/HF	1.89 ± 0.14

HFabs: high frequency in absolute units; HFnu: High frequency in normalized units; LFabs: Low frequency in absolute units; LFnu: Low frequency in normalized units

The correlation statistics show that there are significant correlations between anthropometric parameters, psychological stress scores, and HRV parameters. There was a significant positive correlation between weight, BMI (Figure1& Figure 2), FFM, FFMI and LFnu, LF/HF ratio. And, there is a significant positive correlation between fat percentage and LF/HF ratio (Table 3). Also, there is a significant negative correlation between the anthropometric parameters like weight, BMI, fat percentage, FFM, FFMI and HFnu (Table 3). There also exists a significant positive correlation between psychological stress scores and LFnu, LF/HF ratio, and a significant negative correlation between stress scores and HFnu (Table 4).

Table 3: Correlation between anthropometric parameters and HRV Indices during pregnancy.

Variables		HFnu	LFnu	LF/HF
Weight	r value	-0.34	0.29	0.38
	p value	0.003*	0.01*	0.001*
Fat mass	r value	-0. 281,	0.01	0.271
	p value	0.01*	0.3	0.02*
Fat free mass	r value	-0.32	0.31	0.37
	p value	0.005*	0.006*	0.001*
FFM index	r value	-0.25	0.23	0.31
	p value	0.03*	0.04*	0.006*

*p< 0.05 is considered to be statistically significant

HFnu: High frequency in normalized units; LFnu: Low frequency in normalized units

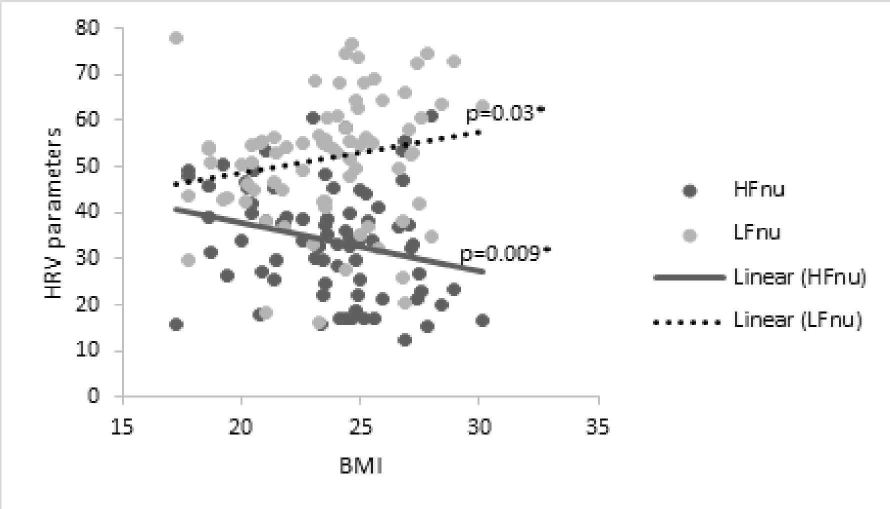
ISSN: 0975-8585

Table 4: Correlation between psychological stress scores and HRV Indices during pregnancy.

Variables		HFnu	LFnu	LF/HF
Psychological stress scores	r value	-0.55	0.59	0.64
	p value	0.000*	0.000*	0.000*

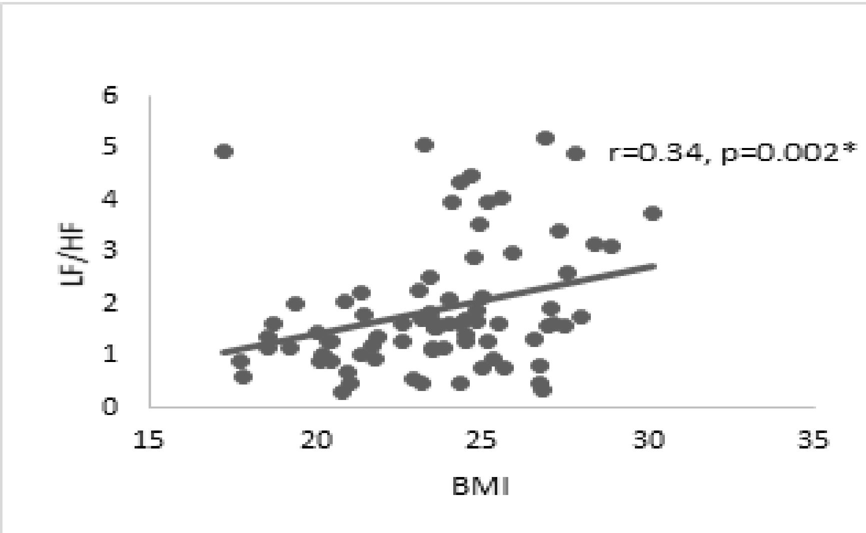
*p< 0.05 is considered to be statistically significant
HFnu: High frequency in normalized units; LFnu: Low frequency in normalized units

Figure 1: Correlation between BMI and HRV parameters



*p< 0.05 is considered to be statistically significant
BMI: Body Mass Index; HRV: Heart Rate Variability; HFnu: High frequency in normalized units; LFnu: Low frequency in normalized units

Figure 2: Correlation between BMI and HRV parameters



*p< 0.05 is considered to be statistically significant
BMI: Body Mass Index, LF/HF: Low Frequency: High-Frequency ratio

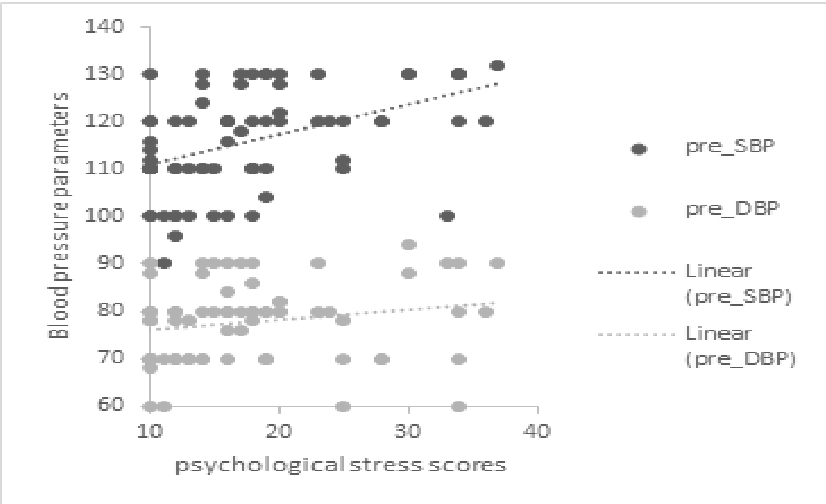
There is a significant positive correlation between anthropometric parameters like weight, BMI, FFM with both systolic as well as diastolic BP during the third trimester of pregnancy (Table 5). Also, there was a significant positive correlation between fat mass and systolic BP (r= 0.23, p= 0.04). The psychological stress scores showed significant positive correlation with both systolic (r= 0.5, p=0.000) as well as diastolic BP (r= 0.27, p=0.02) during third trimester of pregnancy (Figure 3). However, there is no association between PAL and cardiac autonomic function in the present study.

Table 5: Correlation between anthropometric and blood pressure parameters

Variables		SBP	DBP
Weight	r value	0.32	0.23
	p value	0.004*	0.04*
BMI	r value	0.28	0.22
	p value	0.01*	0.04*
Fat free mass	r value	0.34	0.22
	p value	0.002*	0.04

*p< 0.05 is considered to be statistically significant
SBP: Systolic Blood Pressure; DBP: Diastolic Blood pressure; BMI: Body Mass Index

Figure 3: correlation between psychologic stress scores and blood pressure parameters during pregnancy.



SBP: Systolic Blood Pressure; DBP: Diastolic Blood pressure

DISCUSSION

The present study is a cross-sectional study involving seventy-eight healthy pregnant women. The various cardiovascular risk factors like anthropometric parameters, PAL, and psychological stress levels were assessed during the third trimester of pregnancy. Also, the association of these risk parameters with cardiac autonomic function (HRV) was evaluated.

The study findings showed that there was a significant association between anthropometric parameters and HRV indices like HFnu, a marker of parasympathetic autonomic function, LFnu, a sympathetic autonomic marker as well as LF/HF, an indicator of sympathovagal balance. Also, similar associations were found between psychological stress scores and HRV. The findings imply that, as the weight, BMI, stress level increased, there was a significant increase in sympathetic activity and a decrease in parasympathetic autonomic activity during the third trimester of pregnancy. However, there was no association between PAL and HRV indices.

A study that evaluated cardiovascular autonomic modulation in relation to anthropometry , body composition among apparently healthy young males have reported that cardiac autonomic activity is significantly related to maximal aerobic fitness and body composition(20). The same study showed that reduced HRV have been associated with higher BMI and higher body fat percentages. The Atherosclerosis Risk in communities Study, a population based longitudinal prospective study of CVD among hypertensive and normotensive individuals over a period of 9 years showed that, individuals with low baseline HRV were at an increased risk of developing hypertension, thus indicating that decreased HRV often precedes the development of hypertension(21). On the other hand, longitudinal investigations have shown an improvement in HRV after dietary weight loss interventions, prolonged endurance-training programs and combinations of both(21). Several studies of obesity in children (22)and adolescence(23) have also found that vagal function is reduced in obese individuals compared to non-obese individuals. Reduced HRV reflects sympathovagal imbalance in the form of increased sympathetic and/or reduced vagal activity(24). Therefore, ANS, sympathetic component in particular is involved in regulation of body weight by modulating the energy expenditure (25). Even in present study among healthy pregnant females there is association between BMI, body composition and HRV. Our study subjects had an average normal BMI in third trimester of pregnancy and did not have any underlying CVD risk factors based on history. This implies that, body weight could influence the activity of ANS, not only in those with CVD risk but also among healthy individuals.

Poor lifestyle choices, including a lack of physical activity have also been associated with autonomic imbalance and decreased parasympathetic activity Thayer et al. (26) reported that habitual physical activity was associated with significantly higher vagally mediated HRV in both men and women. Another study among young adults also found that HF power rose after 12 weeks of aerobic conditioning among men, which returned to pretraining levels after deconditioning. However, the same effect was not observed among women (27). Similar cardioprotective findings were reported even during pregnancy (28). However, present study there was no association between physical activity and cardiac autonomic function.

Research studies which focused on association between real life stressors, work place stressors and changes in HRV(29) concluded that, both acute and chronic psychological stressors cause a decrease in HRV, which in turn reduces the ability to cope with external and internal stressors (30). These studies confirmed that HRV is a reliable indicator of stress. Sloan et al. analyzed 24-hour electrocardiographic recordings from 33 healthy participants to examine the association between HRV responses and periodic diary entries measuring physical position, negative affect, time of day (31). Also, Dimitriev et al. evaluated the association between mental stress and HRV parameters (32). Both the authors concluded that psychological stress was associated with low parasympathetic activity, which is characterized by a decrease in HF and an increase in the LF spectral power. But these studies were among non-pregnant individuals.

Studies among pregnant women are few, and have shown that there is association between psychological self-reported questionnaire and physiological responses (HRV). A study that assessed cardiac autonomic response among pregnant women by assessing sleep wake rhythm during stress test showed a reduced HRV among women with anxiety (33). Similar findings were obtained in present study. This implies that pregnancy related psychological stress may have long term effects on cardiovascular function. This may in turn predispose otherwise healthy women to CVD risk during pregnancy.

The autonomic imbalance explains the cause for cardiovascular morbidity and mortality associated with change in maternal body composition, reduced physical activity, and pregnancy related psychological stress. The identification of a link between these cardiovascular risk factors and ANS activity by early screening using noninvasive measures like HRV assessment provides an opportunity to identify undiagnosed underlying CVD risk factors among healthy pregnant individuals and plan effective strategies.

CONCLUSION

Maternal body composition and psychological stress state during third trimester of pregnancy significantly influences the cardiac autonomic function. Hence autonomic imbalance during later weeks of pregnancy may predispose the healthy women to future risk of cardiovascular disease.

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