The Effects of Yoga Nidra on the Cardiovascular System of Pregnant Women

by

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submitted in accordance with the requirements
for the degree of

MASTER OF SCIENCE

in the subject

LIFE SCIENCES

at the

UNIVERSITY OF SOUTH AFRICA

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NOVEMBER 2023

Declaration

I, **CASSANDRA JAYNE TAYLOR,** hereby declare that the dissertation/thesis, titled: **THE EFFECT OF YOGA NIDRA ON THE CARDIOVASCULAR SYSTEM OF PREGNANT WOMEN,** which I hereby submit for the degree of **MSC LIFE SCIENCES** at the University of South Africa, is my own work and has not previously been submitted by me for a degree at this or any other institution. I declare that the dissertation/thesis does not contain any written work presented by other persons, whether written, pictures, graphs, data, or any other information, without acknowledging the source. I declare that where words from a written source have been used, the words have been paraphrased and referenced, and where exact words from a source have been used, the words have been placed inside quotation marks and referenced. I declare that I have not copied and pasted any information from the Internet without specifically acknowledging the source and have inserted appropriate references to these sources in the reference section of the dissertation or thesis. I declare that during my study I adhered to the Research Ethics Policy of the University of South Africa, received ethics approval for the duration of my study prior to the commencement of data gathering, and have not acted outside the approval conditions. I declare that the content of my dissertation/thesis has been submitted through the electronic plagiarism detection program, "Turnitin" (Appendix 2), and underwent language editing (Appendix 3) before the final submission for examination.

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Acknowledgements

"The journey of a thousand miles starts with a single step"- Lao Tzu

It is with ***immense*** gratitude that I thank all those who helped me arrive at the end of this dissertation. The journey involved the assistance, motivation, and guidance of many wonderful individuals — without whom, this would not be possible.

Abstract

Background: Pregnancy involves cardiovascular alterations that include changes in cardiac output, systemic vascular resistance, blood volume, stroke volume, heart rate (HR) and heart size and blood pressure (BP). The cardiovascular system is altered as a natural response to the increased metabolic demands of pregnancy, especially in relation to BP and HR. Abnormal alterations within the cardiovascular system during pregnancy may put a pregnant woman at risk for developing cardiovascular complications during pregnancy. These complications can include preeclampsia, eclampsia, and other hypertensive disorders of pregnancy (to name a few). In many cases, the maternal stressors that are uniquely associated with pregnancy can put further strain on the maternal cardiovascular system. Yoga nidra is an in-depth relaxation technique with promising therapeutic benefits for the cardiovascular system. The aim of this study was to investigate the effects of a single 15-minute yoga nidra practice on the systolic (SBP) and diastolic (DBP) blood pressure (BP) and the heart rate (HR) of pregnant women when compared with baseline and passive relaxation measurements (sitting).

Methods: A total of 31 pregnant volunteers (> 13 weeks gestation) were recruited through non-probability sampling in the Tshwane and Johannesburg regions of Gauteng, South Africa. An experimental pre-test, post-test study design was used to observe the effects of yoga nidra on the cardiovascular system of pregnant women. BP and HR measurements were obtained using an OMRON HEM-7280T-E blood pressure monitor at baseline, after 15 minutes of sitting (passive relaxation) and after 15 minutes of yoga nidra (active relaxation), with a 15-minute washout period between sitting and yoga nidra (normal activity and walking). Data were analysed using dependent *t*-tests and repeated measures analyses of variance (RM-ANOVA).

Results: Dependent *t*-test results showed reductions in SBP (103.8 mmHg vs 101.2 mmHg, $p = 0.003$) and HR (79.6 bpm vs 75.0 bpm, $p < 0.001$) post-yoga nidra, while reductions in SBP (103.8 mmHg vs 101.7 mmHg, $p = 0.006$) and DBP (68.3 mmHg vs 66.4 mmHg, $p = 0.014$) were observed post-sitting. When comparing post-yoga nidra and post-sitting results, DBP and SBP showed no differences, while HR were lower post-yoga nidra (75.0 bpm) than post-sitting (79.0 bpm) ($p < 0.001$). Further investigation through RM-ANOVA revealed that yoga nidra had a significant effect on the HR ($p = 0.002$) of women who were in the third trimester of pregnancy. The mean HR after yoga nidra was 72.6 bpm (95% CI 65.97, 79.19) among women in the second trimester and 76.5 bpm, 95% CI (70.69, 82.36) among women in the third trimester.

Conclusion: The findings demonstrate a significant reduction in HR post-yoga nidra when compared with the post-sitting and baseline measurements of pregnant women, more specifically, women in the third trimester of pregnancy. This lowered HR, which was not observed post-sitting, may indicate parasympathetic activation after yoga nidra. Essentially, the results of this study indicate that yoga nidra could be recommended during the third trimester of pregnancy to assist in lowering HR during the final stages of pregnancy.

Key terms: Pregnancy; Pregnant women; Cardiovascular system; Blood pressure; Heart rate; Yoga; Yoga nidra; Yoga therapy; Relaxation

Opsomming

Agtergrond: Swangerskap behels kardiovaskulêre veranderinge, en in baie gevalle, moederlike stres. Joga nidra is 'n diepgaande ontspanningstegniek met belowende terapeutiese voordele. Die doel van die studie was om die uitwerking van 'n enkele 15-minute joga nidra-sessie op die sistoliese (SBD) en diastoliese bloeddruk (DBD) en hartkloptempo (HK) van swanger vroue te ondersoek wanneer dit met die basislyn en passiewe meting (sit) vergelyk word.

Metodes: 'n Totaal van 31 swanger vrywilligers (>13 weke swanger) is gewerf deur 'n niewaarskynlikheidsteekproefneming in die Tshwane- en Johannesburg-streke van Gauteng, Suid-Afrika. 'n Eksperimentele voortoets, natoets-studie-ontwerp is gebruik om die uitwerking van joga nidra op die kardiovaskulêre stelsel van swanger vroue waar te neem. BD- en HK-metings is geneem deur die OMRON HEM-7280T-E-bloeddrukmonitor by basislyn; na 15 minute van sit (passiewe ontspanning) en na 15 minute van joga nidra (aktiewe ontspanning), met 'n 15-minuut-uitspoelperiode tussen sit en joga nidra (normale aktiwiteit en stap). Data is deur afhanklike t-toetse en herhaalde metingontleding van afwykings (RM-ANOVA) ontleed.

Resultate: Afhanklike t-toetse van basislyn in vergelyking met beide intervensies toon verlaging in SBD (103.8 mmHg vs 101.2 mmHg, $p = 0.003$) en HK (79.6 bpm vs 75.0 bpm, $p < 0.001$) na-joga nidra, terwyl verlagings in SBD (103.8 mmHg vs 101.7 mmHg, $p = 0.006$) en DBD (68.3 mmHg vs 66.4 mmHg, $p = 0.014$) tydens na-sit waargeneem is. By vergelyking van na-joga nidra en na-sit-resultate het BDD en SBD geen verskille getoon nie, terwyl HK laer was na joga nidra (75.0 bpm) as na sit (79.0 bpm) ($p < 0.001$). Verdere ondersoek deur RM-ANOVA het getoon dat joga nidra 'n beduidende uitwerking op die HK ($p = 0.002$) gehad het van vrou in die derde trimester van swangerskap. Die gemiddelde HK na joga nidra was 72.6 bpm, 95% CI [65.97, 79.19] onder vroue in die tweede trimester en 76.5 bpm, (95% CI 70.69, 82.36) onder vroue in die derde trimester.

Samevatting: Die bevindings toon 'n beduidende verlaging in HK na joga nidra in vergelyking met na-sit en basislynmeting van swanger vroue, meer spesifiek, vroue in die derde trimester van swangerskap. Hierdie laer HK, wat nie na-sit waargeneem is nie, dui moontlik op parasimpatiese aktivering na joga nidra. Die resultate van hierdie studie toon dat joga nidra tydens die derde trimester van swangerskap aanbeveel moet word om HK tydens die finale stadiums van swangerskap te verlaag.

Sleutelterme: Swangerskap; Swanger vroue; Kardiovaskulêre stelsel; Bloeddruk; Hartkloptempo; Joga, Joga nidra; Jogaterapie; Ontspanning

Isifinqo

Isendlalelo: Ukukhulelwa kufaka phakathi ukuguqulwa kwenhliziyo nemithambo yegazi futhi, ezimweni eziningi, ukucindezeleka komama. I-Yoga nidra iyindlela yokuphumula ejulile enezinzuzo ezithembisayo zokwelapha. Inhloso yalolu cwaningo bekuwukuphenya imiphumela yomkhuba owodwa wemizuzu eyi-15 ye-yoga nidra kusistolikhi kanye nedayastokhi umfutho ophezulu wegazi kanye nesilinganiso senhliziyo sabesifazane abakhulelwe uma kuqhathaniswa nesisekelo kanye nezilinganiso zokuphumula ezingenzi lutho (uhlezi).

Izindlela: Ithothali yamavolontiya akhulelwe angama-31 (> amasonto ayi-13 okukhulelwa) abuthwa ngamasampula okungewona amathuba esifundeni saseTshwane naseGoli eGauteng, eNingizimu Afrika. Umklamo wokuhlola wangaphambi kokuhlolwa, wangemuva kokuhlolwa wasetshenziselwa ukubuka imiphumela ye-yoga nidra ohlelweni lwenhliziyo nemithambo yegazi yabesifazane abakhulelwe. Izilinganiso zomfutho ophezulu wegazi nesilinganiso senhliziyo zitholwe kusetshenziswa i-OMRON HEM-7280T-E yokuqapha umfutho wegazi ekuqaleni; ngemuva kwemizuzu eyi-15 uhlezi (ukuphumula kancane) nangemuva kwemizuzu eyi-15 ye-yoga nidra (ukuphumula okusebenzayo), nenkathi yokugeza eyimizuzu eyi-15 phakathi kokuhlala kanye ne-yoga nidra (umsebenzi ovamile nokuhamba). Idatha yahlaziywa kusetshenziswa ukuhlola kuka-t okuncike kanye nokuhlaziywa kwezinyathelo eziphindaphindiwe zokuhluka (RM-ANOVA).

Imiphumela: Imiphumela yokuhlolwa kwe-t encikile kusukela kuyisisekelo uma kuqhathaniswa nakho kokubili ukungenelela ibonise ukuncipha kwe-SBP (103.8 mmHg vs 101.2 mmHg, $p = 0.003$) kanye nesilinganiso senhliziyo (79.6 bpm vs 75.0 bpm, $p < 0.001$) yoga nidra-yangemuva, kuyilapho ukuncipha kweSolikhi (103.8 mmHg vs 101.7 mmHg, $p = 0.006$) kanye nedayastolikhi (68.3 mmHg vs 66.4 mmHg, $p = 0.014$) kubhekwe ngemuva kokuhlala. Uma kuqhathaniswa nemiphumela ye-yoga nidra yangemuva kanye nokuhlala kwangemuva, i-DBP ne-SBP ayizange ibonise umehluko ngenkathi isilingangiso senhliziyo sasingaphansi kwe-yoga nidra ngengemuva (75.0 bpm) kunokuhlala kwangemuva (79.0 bpm) ($p < 0.001$). Uphenyo olwengeziwe nge-RM-ANOVA luveze ukuthi i-yoga nidra ibe nomthelela omkhulu kuyisilinganiso senhliziyo ($p = 0.002$) yabesifazane ababe kuyitrayisimista yesithathu yokukhulelwa. Isilinganiso senhliziyo ngemuva kwe-yoga nidra sasinga-72.6 bpm, (95% CI 65.97, 79.19) phakathi kwabesifazane kutrayisimista yesibili kanye no-76.5 bpm, (95% CI 70.69, 82.36) phakathi kwabesifazane ku-trayisimista yesithathu.

Isiphetho: Okutholakele kukhombisa ukuncipha okukhulu kwe-silinganso senhliziyo kuyi-yoga nidra yangemuva uma kuqhathaniswa nezilinganiso zangemuva kokuhlala kanye nesisekelo sabesifazane abakhulelwe, ikakhulukazi, abesifazane ku-trayisimista yesithathu yokukhulelwa. Lokhu kwehlise isilinganiso senhliziyo, engazange ibonwe ngemuva kokuhlala, kukhombisa ukusebenza kwekomuzwa ongagcwele ngemuva kwe-yoga nidra. Empeleni, imiphumela yalolu cwaningo ikhombisa ukuthi i-yoga nidra inganconywa ngesikhathi setrayisimista yesithathu yokukhulelwa ukusiza ekwehliseni iSilinganiso Senhliziyo phakathi nezigaba zokugcina zokukhulelwa.

Amagama abalulekile: Ukukhulelwa; Abesifazane abakhulelwe; Uhlelo lwenhliziyo nemithambo yegazi; Umfutho ophezulu wegazi; Isilinganiso Senhliziyo; I-Yoga; I-Yoga nidra; Ukwelashwa kwe-yoga; Ukuphumula

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List of Abbreviations

% – percent

BMI – body mass index

BP – blood pressure

bpm – beats per minute

CAES – College of Agricultural and Environmental Sciences

CI – confidence interval

CO – cardiac output

DASH – Dietary Approaches to Stop Hypertension

DBP – diastolic blood pressure

FDA – Food and Drug Administration

H_0 – null hypothesis

HDP – hypertensive disorders of pregnancy

HIV – human immunodeficiency virus

HR – heart rate

HREC – Health Research Ethics Committee

HRV – heart rate variability

kg – kilograms

kg/m^2 – kilograms per metres squared

M1 – baseline cardiovascular measurement

M2 – post-sitting cardiovascular measurement

M3 – post-yoga nidra cardiovascular measurement

m – metres

MAP – mean arterial pressure

mmHg – millimetres mercury

n – number of participants

NO – nitric oxide

PIH – pregnancy-induced hypertension

PP – pulse pressure

PSS – pregnancy-specific stress

REM – rapid eye movement

RHR – resting heart rate

RM-ANOVA – repeated measures analysis of variance

SD – standard deviation

SBP – systolic blood pressure

SPSS – Statistical Package for the Social Sciences

SV – stroke volume

SVR – systemic vascular resistance

WHO – World Health Organisation

Chapter One:

Introduction

1.1 Background

The cardiovascular system undergoes immense strain during gestation due to the vast increase in cardiac requirements and haemodynamic changes to support a healthy pregnancy (de Haas *et al*., 2022). Hypertensive disorders are the most common cardiovascular complications during pregnancy and affect between 5% and 10% of all pregnancies (Regitz-Zagrosek *et al*., 2018). These conditions have been associated with increased mortality and morbidity rates for both the mother and child (Roberts *et al*., 2003; Khosravi *et al*., 2014). According to Say *et al.* (2014), around 14% of the worldwide maternal deaths between 2003 and 2009 were due to hypertensive complications. In South Africa, hypertension is one of the leading causes of maternal deaths with 622 recorded maternal deaths between 2005 and 2007 (Moodley, 2011). Furthermore, hypertensive disorders of pregnancy (HDP) were responsible for 14% of maternal deaths in South Africa between 2008 and 2010 (Moodley *et al*., 2014).

Risk factors for the development of HDP can be divided into modifiable and non-modifiable groups. Higher maternal age, primipara, multiple pregnancies, gestational diabetes, and a history of hypertensive complications in previous pregnancies are non-modifiable risk factors associated with HDP development (Umesawa & Kobashi, 2017). Genetic predispositions such as a family history of HDP, genetic variants and race are other non-modifiable risk factors (Ghosh *et al*., 2014; Umesawa & Kobashi, 2017). Some modifiable risk factors include a higher body mass index, anaemia, a history of smoking, and regular alcohol consumption (Umesawa & Kobashi, 2017).

Stress is also considered a risk factor for the development of preeclampsia (Thilaganathan & Kalafat; 2019) as it has been shown to affect the cardiovascular system of non-pregnant individuals due to an activation of the sympathetic nervous system (Yaribeygi, *et al*., 2017). Stress is further linked with pre- and postnatal anxiety and depression (Redingera, *et al*., 2020; Osuna, et al., 2023). In South Africa, depression and anxiety rates are relatively high during pregnancy, (24–28%) and (14–18%) respectively (Redingera, *et al*., 2020). Postnatally, depression rates range between 20% and 30% in South Africa (Osuna, et al., 2023).

During gestation, women may experience stress that could be directly related to their pregnancy, in the form of pregnancy-specific stress (PSS) (Lobel *et al*., 2008) or related to external circumstances (Isgut *et al*., 2016). PSS explains that the stress a pregnant woman may experience is a direct result of the physiological changes and thoughts associated with pregnancy (Lobel *et al*., 2008). Other stressors specific to pregnancy can include regular doctor's visits (Isgut *et al*., 2016), and the expenses required during pregnancy (Taylor *et al*., 2021). Furthermore, working during gestation may make a pregnant woman more prone to developing hypertensive conditions such as preeclampsia (Higgins *et al*., 2002). A pregnant woman could thus derive benefit from a variety of relaxation techniques and other mind-body practices to assist with the stress, anxiety or depression that may be experienced during pregnancy (Teixeira *et al*., 2005; Urech *et al*., 2010; Isgut *et al*., 2016; van der Zwan *et al*., 2019; Bauer *et al*., 2021).

Research has shown that mind-body practices might be effective coping strategies for the management of blood pressure (BP) (Devraj *et al*., 2021), cardiovascular diseases (Moridani *et al*., 2021), stress and anxiety (Bussotti & Sommaruga, 2018; Dossett *et al*., 2020)), even during pregnancy (Isgut *et al*., 2016). Since yoga and meditation have been considered mind-body practices (Rani *et al*., 2011; Ferreira-Vorkapic *et al*., 2018), yoga nidra could also be considered one because of its relaxation and meditative aspects. "Yoga nidra" translates to "yogic sleep" as the word "nidra" means "sleep" in Sanskrit (Saraswati, 2012). This practice has been revealed as being effective in assisting with various conditions such as insomnia (Datta *et al*., 2017), diabetes (Amita *et al*., 2009), menstrual irregularities (Rani *et al*., 2011), anxiety and depression in adolescents (Vaishnav *et al*., 2018) and adults (Ferreira-Vorkapic *et al*., 2018) as well as a reduction in BP levels (Monika *et al*., 2012; Devraj *et al*., 2021).

When yoga nidra is practised by non-pregnant individuals, there are promising results in lowering the levels of stress hormones and improving cardiovascular health (Devraj *et al*., 2021), which suggests that the practice has the potential to promote more favourable cardiovascular conditions during pregnancy. However, to the best of our knowledge, there is limited research available regarding the effects of yoga nidra alone on the cardiovascular system of pregnant women, especially in a South African context where HDP rates are substantial (Moodley, 2011; Moodley *et al*., 2019).

1.2 Problem Statement

Pregnancy is often described as a stressful period for women (Sanghavi & Rutherford, 2014; van der Zwan *et al*., 2019), not only because of the physical adaptations (Regitz-Zagrosek *et al*., 2011; Kintiraki *et al*., 2015) but also because of the emotions and mental stressors that may arise specifically due to pregnancy (Lobel *et al*., 2008). Work stress (Higgins *et al*., 2002), financial strains and medical demands (Taylor *et al*., 2021), as well as physical discomfort from the growing uterus (Hutchison *et al*., 2012; Özkana & Rathfisch, 2018) and poor sleep quality and duration (Özkana & Rathfisch, 2018; Azwarda *et al*., 2021), are other factors that could increase a woman's level of stress during pregnancy. The management of prolonged stress is important because if left untreated, it could lead to a higher risk for cardiovascular disease, hypertension (Chu *et al*., 2021; Devraj *et al*., 2021) and preeclampsia during pregnancy (Thilaganathan & Kalafat, 2019).

Today's modern way of living may make individuals more susceptible to stress (Bhimani *et al*., 2011; Saraswati, 2012). In non-pregnant individuals, prolonged stress can create consistently high BP levels, which could lead to increased cardiovascular strain for longer periods (Schneiderman *et al*., 2005; Chu *et al*., 2021). Immediately after a stressful event, there is an increase in cardiac output (CO), stroke volume, heart rate (HR), and BP, together with a redirection of blood flow to large muscles (Schneiderman *et al*., 2005; Yaribeygi *et al*., 2017; Chu *et al*., 2021). Physiological adaptations during pregnancy also require increases in maternal HR and CO, together with BP changes and redirection of blood flow to the placenta (Teixeira *et al*., 2005; Taranikanti, 2018). Since pregnancy is already considered a stressful time, should a pregnant woman experience continued stress, the disturbance to the intrauterine environment may have lasting effects on the child's growth and development (Sandman *et al*., 2011; Isgut *et al.*, 2016).

Taking medications during pregnancy can also affect foetal growth and development (Sachdeva *et al*., 2009). For this reason, and the fact that medication can lead to maternal complications, there is much concern about pregnant women taking medication to manage the discomforts and stress associated with pregnancy (Sachdeva *et al*., 2009; The American College of Obstetricians and Gynecologists, 2015; Lynch *et al*., 2017). Furthermore, pregnant women are considered a "scientifically complex" population group in research due to the range of maternal physiological adaptations (The American College of Obstetricians and Gynecologists, 2015) and are thus often excluded from research involving medicinal drugs (The American College of Obstetricians and Gynecologists, 2015). Pregnant women are even excluded from research relating to mind-body practices such as yoga nidra (Monika *et al.* 2012; Devraj *et al*. 2021).

Relaxation, meditation, mindfulness, yoga, and yoga nidra, can be termed “mind-body” practices, and are non-invasive, cost-effective, require no medication (Ferreira-Vorkapic *et al*., 2018; Devraj *et al*., 2021), and have no side effects (Rani *et al*., 2011). They have been shown to be effective coping strategies for managing stress, anxiety (Isgut *et al*., 2016; Dossett *et al*., 2020) and cardiovascular disorders (CVD) (Moridani *et al*., 2021).When these practices are done during pregnancy, they might help to improve maternal cardiovascular results such as systolic BP (SBP), HR (Urech *et al*., 2010) as well as foetal HR (Hamdiah *et al.* 2017). They have also been found to assist with reducing maternal anxiety (Teixeira *et al*., 2005) and stress (Hamdiah *et al*., 2017; Kusaka *et al*., 2016; Bauer *et al*., 2021).

Yoga nidra is a mind-body practice that can promote and develop feelings of deep relaxation (Saraswati, 2012; Pandi-Perumal *et al*., 2022). The duration of a yoga nidra session can be adapted to suit a person’s needs and time availability (Saraswati, 2012). Yoga nidra studies on non-pregnant individuals have shown that it can assist with a variety of conditions such as anxiety and depression Ferreira-Vorkapic *et al*., 2018; Vaishnav *et al*., 2018) as well as hypertension (Devraj *et al*., 2021). However, most of these studies investigate the effects of long yoga nidra practices ranging from 35–50 minutes (Monika *et al*., 2012; Ferreira-Vorkapic *et al*., 2018; Devraj *et al*., 2021) despite the possibility of shorter practices (Saraswati, 2012; Moszeik *et al*. 2022) that might be more accessible in today’s constantly advancing and competitive way of living (Bhimani *et al*., 2011).

The evidence above suggests that yoga nidra could have therapeutic benefits for both the mother and foetus during pregnancy. To the best of our knowledge, there is limited research available that examines the effects of yoga nidra alone on pregnant women. Because pregnancy is associated with increased stressors, discomforts, and cardiovascular demands, we therefore, aimed to investigate the effects that a short session of yoga nidra may have on the BP and HR of pregnant women.

1.3 Aim:

To investigate the effects of a single 15-minute yoga nidra practice on the blood pressure (systolic and diastolic, mmHg) and heart rate (beats per minute [bpm]) of pregnant women in Gauteng, South Africa.

1.4 Objectives:

1. To describe the blood pressure (systolic and diastolic, mmHg) and heart rate (bpm) of pregnant individuals before and immediately after a 15-minute yoga nidra session.
2. To compare the change in blood pressure (systolic and diastolic, mmHg) and heart rate (bpm) after two different sessions: 15 minutes of sitting and a 15-minute session of yoga nidra.
3. To investigate whether any relationships exist between yoga nidra and the change in cardiovascular measures, blood pressure (systolic and diastolic, mmHg) and heart rate (bpm), in pregnant women.

1.5 Hypothesis:

H_0: The blood pressure (systolic and diastolic, mmHg) and heart rate (bpm) of pregnant individuals will not change after a session of yoga nidra when compared with a period of sitting.

1.6 Research Question:

What will the effect of yoga nidra be on the blood pressure (systolic and diastolic, mmHg) and heart rate (bpm) of pregnant women after a 15-minute session of yoga nidra?

1.7 Dissertation Layout

The dissertation is divided into five chapters of the following format:

Chapter One: Introduction

The background and problem statement are presented to provide the context and relevance of the research. The aims, objectives, hypothesis, and research question are also given together with a chapter layout of the dissertation document.

Chapter Two: Literature Review

The literature review provides an overview of the literature relating to the cardiovascular system during pregnancy. It explores literature surrounding stress as a major occurrence during pregnancy and the potential of a mind-body practice, known as yoga nidra, as a possible intervention to manage BP, HR, and the negative effects of stress during pregnancy.

Chapter Three: Methodology

This chapter encompasses the study design and setting along with the population, sample, and recruitment, with the relevant inclusion and exclusion criteria. The methods to assess the variables pertaining to intervention and cardiovascular measures, and how these are statistically analysed, are explained in detail. Furthermore, this chapter takes note of quality criteria, limitations of the study, and ethical considerations pertaining to the research.

Chapter Four: Results and Discussion

This chapter presents and discusses the results in accordance with the aims and objectives of the study. The results are presented in the form of tables and graphs for ease of interpretation.

Chapter Five: Conclusion and Recommendations

Finally, relevant conclusions are drawn from the findings presented in chapter four. This chapter essentially integrates the dissertation by presenting the results in relation to the study objectives, highlighting the study’s limitations and providing recommendations for future studies. The chapter ends with a list of references and appendices.

Chapter Two:

Literature Review

2.1 Introduction

Pregnancy is described as a state that begins with the fertilisation of the egg is characterised by implantation in the uterus, or elsewhere in the body, and ends through termination or delivery (Pascual & Langaker, 2023). During pregnancy, there are a variety of immense changes that occur within all the maternal organ systems to support the growth and development of the foetus (Pascual & Langaker, 2023). These changes include sympathetic activity activation, baroreceptor sensitivity (Sanghavi & Rutherford, 2014) and cellular alterations as well as changes within the female reproductive system, pulmonary system, gastrointestinal system, endocrine system, metabolism, and the renal and cardiovascular systems (Pascual & Langaker, 2023).

The cardiovascular system undergoes immense changes to accommodate pregnancy and foetal development (Sanghavi & Rutherford, 2014). Although many of the specific mechanisms behind the alterations to the cardiovascular system during pregnancy have not been fully investigated and revealed yet (Hall *et al*., 2011), according to Sanghavi & Rutherford (2014), the cardiovascular system changes are mechanisms in themselves that occur to meet the amplified metabolic demands during pregnancy to sustain the mother, her organs, and supply blood to the growing foetus for normal growth and development. If the haemodynamic changes within the maternal cardiovascular system are inadequate, there is a possibility of foetal and maternal mortality, as well as a range of cardiovascular complications and disorders (Sanghavi & Rutherford, 2014). Understanding the cardiovascular system changes during pregnancy can provide more insight with regards to caring for and diagnosing cardiovascular complications throughout gestation (Sanghavi & Rutherford 2014; Loerup, *et al*., 2019).

Alongside the range of specific maternal physiological adaptations that must occur during pregnancy to sustain the growing foetus, there are also mental stressors that may arise specifically due to pregnancy, which include concerns about the baby and pregnancy itself (Lobel *et al*., 2008). Other stressors that can be exacerbated by pregnancy may involve work stress (Higgins *et al*., 2002), financial strains, and medical demands (Taylor *et al*., 2021). Stress that is experienced during pregnancy can result in mental conditions such as anxiety and depression (Rochat, *et al*., 2011) as well as cardiovascular diseases such as preeclampsia (Thilaganathan & Kalafat, 2019).

Mind-body therapies, for example, meditation, relaxation, mindfulness, and yoga, have been shown to be effective coping strategies for managing stress, anxiety (Isgut *et al*., 2016; Dossett *et al*., 2020) and cardiovascular disorders (CVD) (Moridani *et al*., 2021). During pregnancy, relaxation can help reduce self-reported maternal stress (Bauer *et al*., 2021) and heart rate (HR) (Urech *et al.*, 2010). Relaxation studies on pregnant women have shown that it is an effective way to reduce HR, with active forms of relaxation being more effective in lowering HR than passive ones (Teixeira *et al*., 2005; Urech *et al*., 2010). Active relaxation techniques involve a conscious effort to enter a state of relaxation, while passive relaxation techniques involve practices such as sitting quietly and reading (Teixeira *et al*., 2005; Urech *et al*., 2010).

Yoga nidra is a mind-body practice that focuses on actively inducing feelings of relaxation (Saraswati, 2012; Pandi-Perumal *et al*., 2022). Studies have shown that this practice can assist with a variety of conditions such as anxiety and depression in adolescents (Vaishnav *et al*., 2018) and adults (Ferreira-Vorkapic *et al*., 2018) as well as a reduction in BP levels (Monika *et al*., 2012; Devraj *et al*., 2021). Furthermore, practices like yoga nidra are cost-effective (Ferreira-Vorkapic *et al*., 2018), have no side effects (Rani *et al*., 2011) and have a great potential for therapeutic application (Saraswati, 2012), especially during pregnancy, when medical treatment is a concern for both maternal and foetal safety (Lynch *et al*., 2017).

This literature review provides a narrative overview of published literature on the cardiovascular system during pregnancy with special consideration to hypertension and CVD. It does this by highlighting major changes that occur within the cardiovascular system during pregnancy, and identifying the effects these conditions have on the mother and child during pregnancy and postpartum. There is further exploration of current available treatments and stress as a major occurrence during pregnancy. The literature review also describes the potential for mind-body practices as a way to possibly manage blood pressure (BP), HR and stress during pregnancy with specific consideration of a mind-body relaxation technique known as yoga nidra.

2.2 Cardiovascular System Changes during Pregnancy and into Labour

To emphasise the enormous changes that occur to the cardiovascular system during pregnancy, this section explores the changes in (1) cardiac output (CO), (2) systemic vascular resistance (SVR), (3) blood volume, (4) stroke volume (SV), (5) BP, (6) HR and heart size as well as what happens to the cardiovascular system during (7) labour and delivery. Figure 2.1 at the end of this section provides a visual summary of these changes.

Furthermore, it is important to note that this section focuses on the observable changes that arise within the maternal cardiovascular system during pregnancy which occur to accommodate and assist the growth and development of the foetus. The detailed mechanisms that cause one component of the cardiovascular system alone to change, are complex and intertwine with a variety of components that make up the cardiovascular system, as well as other systems, such as hormonal secretions and the renin-angiotensin-aldosterone system.

It is beyond the scope of this literature review to delve into the gastrointestinal, renal, pulmonary, hormonal, metabolic, musculoskeletal, or cellular changes during pregnancy (Pascual & Langaker, 2023) however, they will be briefly mentioned if it relates to the cardiovascular system.

2.2.1 Cardiac Output

CO refers to the mechanism by which the blood flows around the body and is calculated by how much blood is pumped by the heart in one minute. All the body's tissues require the heart's functioning for sustenance, repair, and growth (King & Lowery, 2022). During pregnancy, a woman has to supply blood to her own organs and a new and growing one — the placenta (Burton & Fowden, 2015).

The placenta becomes the "home" of the foetus from conception until birth and has the main role of providing nutrients and oxygen to the growing baby (Burton & Fowden, 2015). A maternal circulatory connection develops through the alteration of the spiral arteries of the uterus (Burton & Fowden, 2015). According to de Haas *et al*. (2022), the haemodynamic changes accompanying pregnancy are essential to promote uteroplacental circulation.

Placental blood flow as well as the haemodynamic state of the mother is greatly affected by her physical position (Burton & Fowden, 2015; Soma-Pillay, *et al*., 2016). There can be a 25% reduction in CO when a pregnant woman moves from the lateral position to a supine position due to the pressure of the uterus on the inferior vena cava (Soma-Pillay, *et al*., 2016). Adopting a lateral position over a supine position wherever possible is therefore advised to not only reduce the fall in CO and SV (Soma-Pillay, *et al*., 2016) but to also maintain adequate uterine blood flow (Soma-Pillay, *et al*., 2016) and reduce placental oxidative stress from any oxygen fluxes (Burton & Fowden, 2015).

Oxygen demands increase during pregnancy because the mother requires her usual supply of oxygen and needs to supply it to the growing foetus (Sanghavi & Rutherford 2014; Burton & Fowden, 2015). Under normal physiological conditions, when the body's oxygen requirements change, such as during exercise (King & Lowery, 2022), or pregnancy (Sanghavi & Rutherford 2014), CO is altered by adjusting the SV and HR (King & Lowery, 2022) (SV is explained in further detail in Section 2.2.4 below). In early pregnancy, CO is thought to be facilitated by the increase in SV, while HR is thought to be the driving force behind it later on during gestation (Sanghavi & Rutherford, 2014).

Essentially, by the eighth week of pregnancy, CO has risen by 20% to meet the demands of pregnancy (Soma-Pillay, *et al*., 2016; Taranikanti, 2018) and promote foetal development (Sanghavi & Rutherford, 2014). CO continues to increase readings up to 45% over non-pregnant ones by about 24 weeks. Together with the immense rise in CO, there is a fall in SVR (Hall, *et al*., 2011; Sanghavi & Rutherford, 2014).

2.2.2 Systemic Vascular Resistance

According to Soma-Pillay, *et al*., (2016), the primary event for the rise in CO is probably peripheral vasodilation which leads to a 25%–30% decline in SVR and is said to be mediated by endothelium-dependent factors that include, nitric oxide (NO) synthesis. NO is thought to increase vasodilation during pregnancy (Hall *et al*., 2011) and plays a role in the female reproductive system (Sanghavi & Rutherford, 2014), but according to Sanghavi & Rutherford (2014) its role in pregnancy remains uncertain.

Hormones such as estrogen and relaxin might increase the amount of maternal NO during pregnancy (Hall *et al*., 2011). Relaxin is a peptide hormone produced by the corpus luteum (Hall *et al*., 2011; Sanghavi & Rutherford, 2014) and has been shown to increase CO and systemic arterial compliance, and reduce SVR (Hall *et al*., 2011).

SVR (*also known as total peripheral resistance)* refers more specifically to the pressure exerted on the circulating blood by the blood vessels within the body (Trammel & Sapra, 2022). The force of the circulating blood in the body is affected by three things: (1) the blood vessel length, (2) the blood vessel diameter and (3) the thickness (viscosity) of blood through the blood vessels (Trammel & Sapra, 2022). To calculate SVR mathematically, one must observe the relationship between mean arterial pressure (MAP) and CO; MAP = CO x SVR (Trammel & Sapra, 2022). Therefore, the increase in CO and the slight decrease in BP during pregnancy accounts for the reduction in SVR (Hall, *et al*., 2011). This decrease in SVR and increase in CO during pregnancy leads to blood circulation that is high in volume and low in resistance (Thilaganathan & Kalafat, 2019).

2.2.3 Blood Volume

The reduction in SVR together with BP stimulate the renin-angiotensin-aldosterone system (Pascual & Langaker, 2023). The activation of this system increases the maternal plasma levels of aldosterone, which accounts for the increase in plasma volume during pregnancy (Soma-Pillay, *et al*., 2016). Plasma volume increases by about 40% on average, together with an increase in erythrocyte production and mass (Sanghavi & Rutherford, 2014). Increases in plasma volume have been directly related to increases in foetal growth (Sanghavi & Rutherford, 2014) which may be influenced by the endocrine functionality of the placenta to induce maternal blood flow and ensure that enough nutrients reach it, and the growing foetus (Burton & Fowden 2015). Inadequacies in plasma volume have been linked to conditions such as preeclampsia (Sanghavi & Rutherford, 2014). This means that a sufficient increase in plasma volume is essential for maintaining BP, uteroplacental perfusion and the circulating blood volume (Soma-Pillay, *et al*., 2016).

The blood volume is the total amount of blood that moves through the veins, venules, arteries, capillaries, and heart chambers (Sharma & Sharma, 2022). About 60% of total blood volume is plasma, and about 40% is comprised of erythrocytes, leukocytes, and platelets (Sharma & Sharma, 2022). According to Soma-Pillay, *et al*., (2016), total blood volume increases by 45% during pregnancy.

2.2.4 Stroke Volume

In pregnancy, higher blood volume is a contributing factor to the rise in SV (Bruss & Raja, 2022)**.** SV is essentially the quantity of blood pumped out of the left ventricle of the heart during a systolic contraction (Bruss & Raja, 2022)**.** Three things affect the SV: (1) contractility of the heart, (2) preload and (3) afterload (Bruss & Raja, 2022)**.**

SV initially increases in pregnancy to mediate CO and continues to increase until the end of the second trimester (Sanghavi & Rutherford, 2014). From the third trimester, there may be a plateau or a slight decrease in SV (Sanghavi & Rutherford, 2014). The increase in SV during pregnancy reflects the increase in myocardial contractility (Hunter & Robson, 1992) as well as the increase in the preload (blood volume) (Bruss & Raja, 2022). According to Hall *et al*. (2011), there is also a significant reduction in afterload during pregnancy due to the fall in SVR. In non-pregnant individuals, afterload may cause SV to decrease if an individual experiences, for example, long-term hypertension (Bruss & Raja, 2022)**.**

2.2.5 Blood Pressure

NO, various hormones (namely progesterone, estrogen and relaxin) as well as the renin-angiotensin-aldosterone system have been shown to have some influence on CO, BP and vasodilation (Hall *et al*., 2011; Sanghavi & Rutherford, 2014). Elevated levels of progesterone during pregnancy are responsible for decreasing the arterial BP and vascular resistance because it allows for smooth muscle relaxation (Pascual & Langaker, 2023). Relaxin stimulates vasopressin secretions and the maternal desire for drinking, which results in increased water retention (Sanghavi & Rutherford 2014). This hormone is already elevated in the luteal phase of the menstrual cycle, rises after conception to peaks within the first trimester, before declining to medium values in the second and third trimesters (Soma-Pillay *et al*., 2016).

Water and salt retention is also stimulated by angiotensinogen (a renin substrate) that increases throughout pregnancy and plays a role in maintaining BP (Sanghavi & Rutherford 2014). The presence of progesterone (as an aldosterone antagonist) prevents salt retention and hypokalaemia (Sanghavi & Rutherford 2014). Aldosterone is important in the prevention of preeclampsia; whereby low levels of aldosterone and plasma volume are evident (Sanghavi & Rutherford 2014). According to Sanghavi & Rutherford (2014), higher serum levels of progesterone and relaxin in early pregnancy have been associated with a lowered systolic blood pressure (SBP) in the second and third trimesters in pregnancy. Furthermore, pregnant women with higher diastolic blood pressure (DBP) readings (those elevated above 90mmHg) in late pregnancy, had lowered serum concentrations of relaxin (Sanghavi & Rutherford 2014).

During pregnancy, SBP, DBP and MAP decrease during the second trimester and increase slightly during the third trimester (Sanghavi & Rutherford, 2014; Kintiraki *et al*., 2015). Although the exact degree of alteration is unknown due the possibility of poor evidence-based research and differing BP measurement tools (Loerup *et al*., 2019), it appears that DBP and MAP decrease more than SBP during pregnancy, with most of the decrease in values occurring early on in pregnancy, at around 6–8 weeks' gestation (Sanghavi & Rutherford, 2014).

MAP has a mathematical relationship with CO and SVR (as mentioned in Section 2.2.2) as well as DBP and SBP as per the following formula, MAP = DBP + 1/3(SBP – DBP). This could explain why there appears to be similarity in the DBP and MAP values decreasing more than SBP during pregnancy. According to Cnossen, *et al*., (2008), first and second trimester MAP readings are a good indicator for the development of preeclampsia when compared with SBP, DBP or an increase in BP values.

SBP and DBP form part of the cardiac cycle (Pollock & Makaryus, 2021). In the cardiac cycle, a systole represents a ventricular contraction (the blood going out of the heart), and a diastole represents ventricular filling (the blood going into the heart) (Rehman & Nelson, 2021). Therefore, the SBP reading represents the peak pressure of the blood against the arteries during a systole, while the DBP reading represents the minimum pressure exerted on the arteries during a diastole (Rehman & Nelson, 2021). BP monitoring forms an important part of clinical visits for assessing, monitoring, and managing cardiovascular complications during pregnancy (Loerup, *et al*., 2019).

2.2.6 Heart Rate and Heart Size

Together with BP, HR is also an important vital sign measured by clinicians (Loerup, *et al*., 2019). This is because tachycardia is common during pregnancy and clinical assessment is often needed to distinguish between normal physiological changes and pathology (Coad & Frise, 2021) Essentially, HR values increase steadily throughout gestation (Sanghavi & Rutherford, 2014). This increase is due to an increase in myocardial alpha receptors (Loerup, *et al*., 2019) as well as the increase in CO and SV (Hall, *et al*., 2011). HR increases by 10–20 beats per minute (bpm) and reaches its maximum during the third trimester, accounting for a 20%–25% increase over baseline (Sanghavi & Rutherford, 2014). There is a vast range in HR readings reported during pregnancy (68–115 bpm) (Coad & Frise, 2021). However, a recent meta-analysis by Loerup *et al.* (2019) shows that there is a mean increase of 7.6 bpm rather than the above-mentioned, and generally agreed-upon, increase of 10–20 bpm (Sanghavi & Rutherford, 2014; Loerup *et al*., 2019). Coad and Frise (2021) suggest that careful investigation should be taken if a pregnant woman presents with high HR to rule out whether the elevation in HR is pathological or physiological.

Along with the increase in HR, the heart undergoes physical structural remodelling with increases in size by up to 30% during gestation (Regitz-Zagrosek *et al*., 2011). There is an increase in the left ventricular wall thickness (Morton, 2021; Hantoushzadeh *et al*., 2022) and mass, by between 28%–52%, above pre-pregnancy readings, and a right ventricular mass increase of around 40% (Sanghavi & Rutherford, 2014). According to Eghbali, *et al*., 2005, the increase in heart size is as a result of an increase in mechanical stress and CO, however, they say that the exact mechanism behind this hypertrophy is unknown. Studies on pregnant mice indicate that the increase in heart size is a normal physiological response to pregnancy and enables the heart to improve its pumping capacity due to the increased metabolic demands (Eghbali, et al., 2005).

2.2.7 Labour and Delivery

Labour can put an immense strain on the cardiovascular system of a pregnant woman, with HR readings reaching values similar to those observed during moderate to heavy physical activity by the second stage of labour (Söhnchen *et al*., 2011)**.** According to Hutchison *et al.* (2022), the dilation of the cervix divides labour into three stages. The first stage is from the onset of labour until the cervix is fully dilated to about 10cm. The second stage begins with the fully dilated cervix and ends with the birth of the foetus, and the third stage begins with the foetal delivery and ends with placental delivery (Hutchison *et al*., 2022)**.** Labour can be a long, tiring, and stressful process with an average duration of 20 hours (Hutchison *et al*., 2022)**.**

During the first stage of labour, CO increases by about 12%–15% (Hunter & Robson, 1992; Soma-Pillay *et al*., 2016) and to around 50% during the second stage (Soma-Pillay *et al*., 2016)**.** The CO increase during the first stage was noted to be due to the rise in SV, whereas a greater increase in HR was seen during the second stage (Hunter & Robson, 1992)**.** Overall, there is an increase in CO by between 60%–80% above pre-pregnancy values and about 300–500 millilitres of blood moves from the uterus back into the systemic circulation of the mother during uterine contractions (Sanghavi & Rutherford, 2014; Soma-Pillay *et al*., 2016)**.**

For pregnant women with normal cardiac functioning, labour can occur in its natural and spontaneous way (Regitz-Zagrosek *et al*., 2011)**.** However, induction may be a more appropriate way to facilitate labour during high-risk cases, such as hypertension, as there may need to be a more highly skilled team available to assist with birth (Regitz-Zagrosek *et al*., 2011)**.** As seen through the various stages of labour, a strong cardiovascular system would be essential in ensuring that a woman meets the demands of labour and delivery.

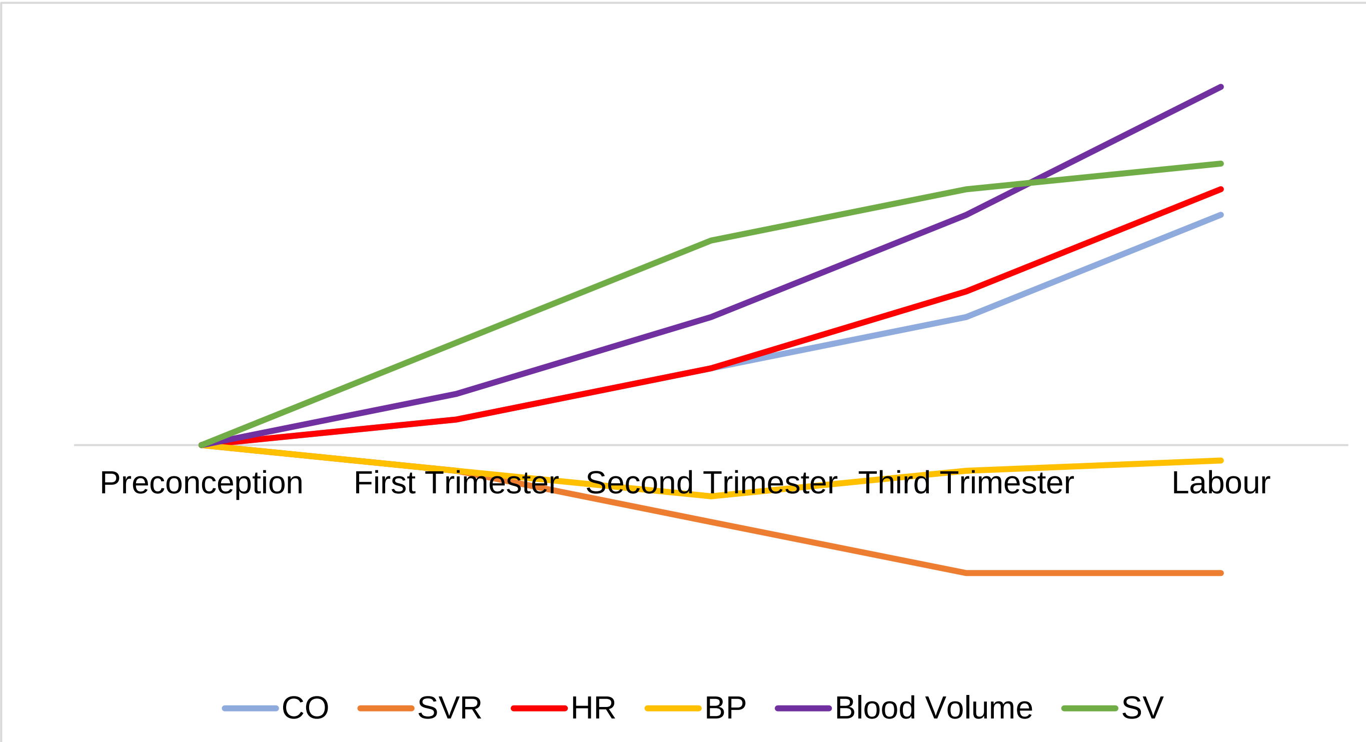

Figure 2.1: A summary of the general trend of the major cardiovascular variables that change during pregnancy from preconception. Adapted from Sanghavi and Rutherford, (2014) and Taranikanti, (2018).

Cardiac output (CO); systemic vascular resistance (SVR); HR, heart rate (HR); blood pressure (BP); Blood Volume; and Stroke Volume (SV).

2.3 Cardiovascular Complications during Pregnancy

Because of the drastic cardiovascular changes that occur during pregnancy, there is an enormous burden on the body of a pregnant woman to maintain her own physiological stability, which Billman, (2020) terms "homeostasis", while also ensuring the proper growth and development of the foetus (Sanghavi & Rutherford, 2014). Within the cardiovascular system, underlying conditions may come to the surface, or new ones could arise as a result of the adaptations to pregnancy (Iftikhar & Biswas, 2022). Both BP and HR monitoring are important vital signs used in the clinical assessment of pregnant women (Loerup, *et al*., 2019). Regular BP screening during pregnancy if often recommended as an accessible way to detect hypertensive complications and thus possibly reduce the number of preventable maternal and foetal deaths (Moodley, *et al*., 2019).

This section highlights hypertensive disorders of pregnancy (HDP) by exploring literature pertaining to various risk factors for hypertension and CVD development, the implications these conditions have for the mother and child during pregnancy and postpartum, as well as the treatment options available during gestation.

2.3.1 Cardiovascular Disorders during Pregnancy

Maternal heart disease results in 1%–3% of pregnancy complications and is the third most common cause of maternal deaths during pregnancy (Arafeh & Baird, 2006). HDP affect between 5%–10% of pregnancies around the world (Regitz-Zagrosek *et al*., 2018) and was recorded as the second most common cause of maternal deaths (accounting for 14%) between 2003 and 2009 (Say *et al*., 2014). In South Africa, hypertension is one of the leading causes of maternal deaths with 622 recorded maternal deaths between 2005 and 2007 due to hypertensive disorders (Moodley, 2011). Furthermore, HDP were responsible for 14% of maternal deaths in South Africa between 2008 and 2010 (Moodley *et al*., 2014).

Hypertension in pregnancy can be defined as SBP ≥ 140 mmHg and, or, both a DBP ≥ 90 mmHg, with SBP ≥ 160 mmHg and, or, both a DBP ≥ 110 mmHg defined as severe hypertension (Garovic *et al*., 2022; Magee *et al*., 2022). Preeclampsia can be defined as SBP ≥ 140 mmHg or DBP ≥ 90 mmHg with the presence of proteinuria after 20 weeks gestation, which can progress to eclampsia (with seizures) (Chobanian *et al*., 2003).

Differentiation and classification of HDP are important because hypertensive conditions can present themselves in a myriad of ways; for example, preeclampsia is classified as high BP with proteinuria, whereas gestational hypertension is classified as high BP alone with the risk of developing into preeclampsia (Chobanian *et al*., 2003). Furthermore, differentiation and classification of HDP are also essential for approaches in the treatment and prevention of CVD postpartum and into second pregnancies (Chobanian *et al*., 2003; Veerbeek *et al*., 2014) with differing effects on the mother and child during pregnancy and postpartum (Shen *et al*., 2017).

2.3.2 Implications of Hypertensive and Cardiovascular Disorders for Mother and Child

HDP can lead to complications during gestation, and complications, for both mother and child long-term (Roberts *et al*., 2003; Khosravi *et al*., 2014). During pregnancy, the mother is at risk for cardiac and renal failure, heart attack, cerebrovascular complications (Khosravi *et al*., 2014), stroke (Hall *et al*., 2011), placental abruption and multiple organ failure (Regitz-Zagrosek *et al*., 2018). Postpartum, hypertensive complications put the mother at risk for high cholesterol (Veerbeek *et al.,* 2014), diabetes mellitus, kidney disease (Kintiraki *et al*., 2015), hypertension, ischemic heart attack, CVD (Tooher *et al*., 2017) and perinatal mortality (de Haas *et al*., 2022).

Hypertensive complications during pregnancy also increase the risk for the offspring developing CVD during childhood and into adulthood (Huang *et al*., 2021). According to a study by Huang *et al.* (2021), children born to mothers with preeclampsia or eclampsia, or gestational hypertension had an increased risk of developing CVD by 22% and 25%, respectively. The unborn child of a hypertensive mother may be at risk for intrauterine growth retardation, preterm delivery of stillbirths, preterm delivery, low birth weight and foetal morbidity (Regitz-Zagrosek *et al*., 2018).

According to Tooher *et al*. (2017), the severity of the hypertensive complication is associated with the risk of CVD postpartum. This study found that women with gestational hypertension were at a higher risk for hypertension and ischemic heart disease postpartum when compared with women who had preeclampsia. Verbeek *et al. (*2015) showed similar findings in that CVD postpartum is related to the severity of the hypertensive disorder experienced during pregnancy — especially whether preeclampsia is early-onset, late-onset, or if a woman had pregnancy-induced hypertension (PIH).

Women who have cardiac problems during pregnancy have an increased risk for preeclampsia, postpartum haemorrhage, and early labour (Regitz-Zagrosek *et al*., 2018). About 18%–30% of infants from mothers with heart disease experience complications (Regitz-Zagrosek *et al*., 2018), such as congenital heart disease, low birth weight and premature birth (Head & Thorne, 2004).

2.3.3 Risk Factors for the Development of Cardiovascular Disorders

Some modifiable risk factors for the development of HDP include regular alcohol consumption, history of smoking, and a higher body mass index (BMI) (Umesawa & Kobashi, 2017). There is a close association between the regular consumption of alcohol and the development of HDP (Ye, *et al*., 2014). In a study by Ye, *et al*., (2014) on the risk factors associated with the development of HDP during pregnancy amongst Chinese women, the risk for developing HDP was 1.75 times higher amongst women who consumed alcohol when compared with those who didn't. However, the pattern of drinking was not investigated and a review article by Umesawa & Kobashi (2017) suggested that alcohol consumption and the development of cardiovascular disorders during pregnancy is not clear.

Smoking during pregnancy is also not a clear indicator for the development of cardiovascular complications (Umesawa & Kobashi, 2017). Some studies even indicate that smoking during pregnancy may lower the risk of gestational hypertension, preeclampsia and PIH compared with non-smoking pregnant women (Peltier & Ananth, 2007; Ye, *et al*., 2014; Umesawa & Kobashi, 2017). However, maternal smoking during pregnancy is associated with adverse effects for the foetus which include a risk for foetal congenital heart defects, small-for-gestational age, kidney disease, hypertension, and increased BMI for the offspring later on in life (Mund, *et al*., 2013).

According to Umesawa & Kobashi (2017) and Ye, *et al*., (2014) a higher pre-pregnancy BMI was associated with an increased risk for the development of HDP. The research study by Ye, *et al*., (2014) comprised of Chinese women. A review article by Umesawa & Kobashi (2017) provided the same results regarding the relationship between BMI and HDP with reference to a study done between Pakistani and white British Women. These findings highlight that BMI might be risk factor for the development of cardiovascular complications, irrespective of race.

Race is a non-modifiable risk factor for the development of HDP which could be due to the differing lifestyles, genetic factors as well as the differing social and medical situations of countries (Umesawa & Kobashi, 2017). According to the results of a study by Ghosh *et al*., (2014) non-Hispanic black women were more likely to enter pregnancy with chronic hypertension and had a higher chance of developing preeclampsia when compared to Hispanic white women. Furthermore, Hispanic white women and Asian/Pacific Islanders were had the lowest risk of developing hypertensive complications during pregnancy.

Some other non-modifiable risk factors include being of a higher maternal age when falling pregnant, primipara, having a multiple pregnancy, and a family history of cardiovascular complications, as well as diabetes (Umesawa & Kobashi, 2017). According to Ye, *et al*., (2014), women between the ages of 25–29 years had the lowest risk for the development of HDP while those who were 40 years and older had the highest risk. Umesawa & Kobashi (2017) revealed similar findings in their review article in that maternal age was associated with an increased risk for HDP as well as PIH and preeclampsia. However, Gaillard, *et al*., (2011) concluded in their research study that maternal age was not a consistent indicator for the development of HDP because their study revealed that older maternal age was associated with lower SBP readings in the second and third trimesters of pregnancy. They further concluded that BMI and maternal age might be more closely related to increasing a woman's risk for developing PIH.

According to Shen, *et al*., (2017), while multiparous women have a reduced chance of developing gestational hypertension and preeclampsia when compared to primiparous women, this reduced risk appears to be lost after a large interval between pregnancies (≥ 5 years). A multiple pregnancy, such as a twin pregnancy, can also increase a pregnant woman's risk for the development of HDP (Ye, *et al*., 2014; Shen *et al*., 2017; Umesawa & Kobashi, 2017). This might be due to the increase in physiological changes and the size of the placenta when having a multiple birth that is not seen in a singleton pregnancy (Shen *et al*., 2017). According to Sanghavi & Rutherford (2014) CO is 15% higher in a twin pregnancy than in a singleton pregnancy. Understanding the normal changes that occur within the cardiovascular system during pregnancy are important to help care for pregnant women patients that may present with cardiovascular diseases (Sanghavi & Rutherford, 2014).

2.4 Therapeutic Options for Cardiovascular Complications During Pregnancy

This section briefly indicates therapeutic options for cardiovascular complications during pregnancy, as well as their possible effectiveness.

2.4.1 Pharmaceutical Medicine

There is much concern about using medications during pregnancy (Lynch *et al*., 2017). The physiological adaptations during pregnancy, such as increases in blood volume, renal perfusion, and hepatic metabolism, mean that higher doses of medications are generally needed to have the desired outcomes (Regitz-Zagrosek *et al*., 2011). Medicine selection therefore needs to involve careful consideration of the foetal safety and appropriate monitoring of the mother and her unborn baby (Chobanian *et al*., 2003; Lynch *et al*., 2017).

In many cases, medication is essential; for example, it is recommended that severe hypertension during pregnancy be medically treated to prevent maternal death (World Health Organisation [WHO], 2018) and to prevent vascular complications such as stroke (Hall *et al*., 2011). However, some medications have been associated with negative effects on the foetus because the drugs can cross the placenta (Sachdeva *et al*., 2009). Some medications that are contraindicated during pregnancy include warfarin, antidepressants, hormonal supplements such as estrogen and androgens as well as aspirin and other salicylates (Sachdeva *et al*., 2009).

Anticoagulants such as warfarin may cause foetal malformations when taken during the second and third trimesters of pregnancy. When warfarin is taken in the first trimester, it can cause "Foetal warfarin Syndrome" whereby a baby is born with nasal hypoplasia and a depressed nasal bridge. If estrogens or androgens are taken during pregnancy, they can cause genital tract malformations for the foetus (Sachdeva *et al*., 2009). Antidepressants taken during pregnancy can also cause foetal malformations, but more specifically to the heart. Other side-effects of antidepressants can include lethargy, decreased muscle tone, nephrogenic diabetes insipidus and an underactive thyroid gland for the newborn baby (Sachdeva *et al*., 2009). Furthermore, if aspirin or other salicylates are taken during pregnancy, the foetus can experience jaundice or brain damage and there can be bleeding problems in the newborn and the women during and after delivery as well as a potentially delayed onset of labour (Sachdeva *et al*., 2009).

It is, therefore, essential that when medication is given during pregnancy, it is under clinical guidance and advice, and adheres to the general guidelines outlined by the Food and Drug Administration (FDA) (Sachdeva *et al*., 2009). The main aim of treatment is essentially to prevent maternal and infant complications (Hall *et al*., 2011).

2.4.2 Alternative Medicine

Herbal medicines are not required to be approved by the FDA, meaning that they are not regulated in the same way as conventional medicines, and they may provide an incorrect sense of safety (John & Shantakumari, 2015). Kennedy *et al*. (2013) conducted a multinational study involving pregnant women from 23 countries distributed within the regions of Northern, Western and Eastern Europe, North and South America, and Australia, to determine how many pregnant women used herbal medicine during gestation. They found that 28.9% of the 9 459 respondents used herbal medicine during their pregnancy and were usually on their initiative (Kennedy *et al*., 2013). However, healthcare practitioners were also recommending the use of herbal medicines during pregnancy despite the fact that they might not be approved by the FDA (Kennedy *et al*., 2013). This finding by Kennedy *et al.* (2013) highlights the fact that women, and healthcare providers, may be looking for alternative ways to treat and manage the changes that come through pregnancy despite the unknown risks of safety for the mother and foetus.

2.4.3 Supplementation

The WHO recommends the supplementation of micronutrients to meet the vitamin and mineral maternal and foetal needs during pregnancy (WHO, 2020). In terms of hypertensive prevention, both folic acid and calcium may help to reduce the risk of preeclampsia (Shen *et al*., 2017; WHO, 2018; WHO, 2020). Shen *et al.* (2017) conducted a study to compare the risk factors between gestational hypertension and preeclampsia. In their study, they found that folic acid supplementation was an effective preventative measure, but only for early onset preeclampsia (Shen *et al*., 2017). Similarly, calcium supplementation in high doses may also help to reduce the risk of preeclampsia (WHO, 2018).

2.4.4 Diet

Danielewicz *et al*. (2017) highlighted that too many calories consumed during pregnancy can be associated with preeclampsia, miscarriage, and diabetes. Diet may be an effective way to manage milder conditions during pregnancy because adherence to a good quantity of high-quality foods that contain necessary macro- and micronutrients may help promote proper development of the foetus (Danielewicz *et al.,* 2017). One diet specifically aimed to reduce BP and lipid profiles in individuals is the Dietary Approaches to Stop Hypertension (DASH) diet (Wiertsema *et al*., 2021). In this diet, it is recommended to increase the intake of fruits, vegetables, nuts, grains, seeds, legumes, and low-fat dairy products and reduce the intake of sodium, sugar, and animal proteins (Wiertsema *et al*., 2021). Wiertsema *et al.* (2021) conducted a study on normotensive, low-risk pregnant women, and found that the DASH diet may positively affect oxidative stress and the renin-angiotensin-aldosterone system by reducing sodium intake. They also found that DBP was lower in mid-pregnancy amongst those with a higher maternal adherence to the DASH diet.

Furthermore, the offspring to mothers who acquired all their correct macronutrients from their diet are also at a lower risk for the development of cardiovascular diseases later in life (van Elten, *et al*., 2019). In a review article by van Elten, *et al*., (2019) evidence suggested that there was a positive association between increased maternal carbohydrate intake during pregnancy and a higher BP in offspring, while higher protein intake was associated with reduced carotid intima-media thickness. This highlights the fact that diet can affect the cardiovascular health of the offspring.

2.4.5 Physical Activity

Physical activity can also improve foetal health (May, *et al*., 2010). Results from a study by May, *et al*., (2010) have shown that regular maternal exercise during pregnancy was associated with lowered foetal HR and heart rate variance. Exercise has been shown to lower the risk for cardiovascular disease risk and hypertension and decrease BP for non-pregnant women (May, *et al*., 2010). During pregnancy, aerobic activity might be beneficial by potentially lowering the risk of gestational hypertension when a woman begins early on in pregnancy (Magro-Malosso *et al*., 2017). However, aerobic activity is not always recommended during pregnancy and according to Chobanian *et al.,* (2003) it should be limited if there is concern about placental blood flow for hypertensive pregnant women. Essentially, both pregnant and non-pregnant individuals could benefit from physical activity as it may help to reduce oxidative stress and inflammation (Chawla & Anim-Nyame, 2015).

2.5 Stress and the Cardiovascular System

The complex adaptations that occur in the maternal cardiovascular system to facilitate pregnancy highlight the body's desire to maintain a certain level of balance. However, pregnancy also involves many other stressors, such as work-related stress, stress specific to pregnancy as well as financial stress (Higgins *et al*., 2002; Lobel *et al*., 2008; Taylor *et al*., 2021). Essentially, maternal stress can diminish blood flow and oxygen to the foetus and affect foetal development (Curtis *et al*., 2012).

Evidence suggests that maternal stress can result in babies being delivered earlier and, or, with low birth weight (Lobel *et al*., 2008). In non-pregnant individuals unmanaged stress can increase one's risk for CVD and hypertension (Chu *et al*., 2021). During pregnancy, psychological and psychosocial stress, as well as worry, may lead to hypertensive conditions such as preeclampsia (Yu *et al*., 2013; Krishnamurti *et al*., 2019; Thilaganathan & Kalafat, 2019).

This section provides an overview of the effect of stress on the cardiovascular system, together with mental and external stressors that may arise to disrupt the psychological well-being of a pregnant woman.

2.5.1 Defining Stress

To understand stress, it is also important to understand homeostasis and how it correlates with health and disease (Billman, 2020). According to Billman (2020), homeostasis is defined as the process of self-regulation to maintain stability through changes in external conditions and circumstances. Stress, therefore, involves an external "*stressor*" or "*stimulus*" that disrupts homeostasis, which then initiates a stress response to re-regulate the biological system (Chu *et al.*, 2021). This response is frequently termed "fight or flight" and describes sympathetic nervous system activation, together with the physiological changes that take place (Isgut *et al*., 2016; Kim *et al*., 2018). If the exposure to stress is experienced as repetitive, severe, or prolonged, the stress response can become ineffective and detrimental (Chu *et al*., 2021), which may result in diseases such as those seen in the cardiovascular system (Yaribeygi *et al*., 2017).

2.5.2 The Cardiovascular System's Response to Stress

Response to stress depends on an individual's capacities to cope with the stressor (Yaribeygi *et al*., 2017). An immediate reaction of the cardiovascular system to a stressful event involves a sympathetic response which includes an increase in the strength of heart contractility, vasodilation of the skeletal muscle arteries, an increase in HR, BP, CO, and SV, as well as blood flow redirection to the large muscles (Schneiderman *et al*., 2005; Yaribeygi *et al*., 2017; Chu *et al*., 2021). This redirection of blood flow to large muscles during stressful times could explain the association between anxiety and reduced blood flow to the uterus (Teixeira *et al*., 1999), which might explain the link between maternal stress and low birth weight (Teixeira *et al*., 1999; Isgut *et al*., 2016) or disease in children later on (Isgut *et al*., 2016).

Since pregnancy is already associated with physiological changes to the cardiovascular system, stress can further affect maternal hormone balance and the immune system (Isgut *et al*., 2016), essentially disrupting the intrauterine environment (Teixeira *et al*., 1999; Teixeira *et al*., 2005; Sandman *et al*., 2011, Isgut *et al*., 2016). Stress-associated hormones include cortisol and adrenaline (Devraj *et al*., 2021). In a normal pregnancy, cortisol levels can rise 300% above non-pregnant levels (Bärebringa *et al*., 2019). Cortisol assists with BP regulation (Quinkler & Stewart, 2003) and abnormally elevated levels of cortisol and anxiety are associated with a higher risk for preeclampsia (Bärebringa *et al*., 2019; van Esch *et al*., 2020). For non-pregnant individuals, prolonged stress may result in consistently high BP levels, which can cause the heart to work harder, for longer periods (Schneiderman *et al*., 2005; Chu,*et al*., 2021).

2.5.3 Work-related Stress during Pregnancy

For non-pregnant individuals, work-related stress may put one at risk for CVD, specifically in terms of elevated SBP and increased HR (Vrijkotte *et al*., 2000). During pregnancy, a woman may be at risk for developing preeclampsia if she works during gestation (Higgins *et al*., 2002; Yu *et al*., 2013). Further evidence suggests that women who work long hours during pregnancy are associated with unfavourable pregnancy outcomes (Jansen *et al.*, 2010).

Yu *et al. (*2013) conducted a study that included 4 314 pregnant women with the aim of evaluating the relationship between preeclampsia risk, life stress, perceived stress during pregnancy and chronic hypertension. They found that women with preeclampsia experienced higher levels of general life stress and perceived stress during pregnancy. Furthermore, those with preeclampsia were found to have higher work-related stress during the first and second trimesters when compared to pregnant women without preeclampsia. (Yu *et al*., 2013). Even if a pregnant woman does not work throughout her pregnancy, there are already bodily adaptations that are putting her under physical stress. The mental and emotional aspects of pregnancy may put a pregnant woman under pregnancy-related conditions, such as pregnancy-specific stress (PSS) *(Curtis et al*., 2012; Lobel *et al.*, 2008), sleep disturbances (Özkana & Rathfisch, 2018) and discomfort (Ray-Griffith *et al*., 2018).

2.5.4 Pregnancy-Specific Stress and Discomforts

PSS refers to the stress, fears and worries that are directly associated with pregnancy (Lobel *et al*., 2008). Other forms of stress that are specific to pregnancy could also be physical discomforts that arise to accommodate the growth of the foetus (Lobel *et al*., 2008; Ray-Griffith *et al*., 2018). A pregnant woman may therefore experience discomforts such as headaches, chronic lower back pain, pelvic pain (Ray-Griffith *et al*., 2018), and sleep disturbances (Hutchison *et al*., 2012). Physical discomforts, such as sleep disturbances, can contribute to the development of preeclampsia and postnatal depression for instance.

Adjusting to the physical changes associated with pregnancy as well as the maternal concerns about pregnancy, labour and delivery together with concerns regarding the health of the child, are all considered forms of PSS (Lobel *et al*., 2008; Isgut *et al*., 2016). Anxiety and depression can also occur during pregnancy (Rochat, *et al*., 2011; Dennis *et al*., 2017; Xian *et al*., 2019). Prenatal anxiety and depression prevalence amongst all trimesters in pregnancy has been reported to range from 18.2%–24.6%, and 7.4%–12.8% respectively (Xian *et al*., 2019).

According to a systematic review and meta-analysis of the prevalence of antenatal and postnatal anxiety by Dennis *et al*. (2017), it was found that self-reported anxiety was highest in the third trimester (25.6%), lowest in the first trimester (18.2%) and 19.1% in the second trimester. Dennis *et al*. (2017) found that anxiety symptoms were prevalent in 15.0% of women 1–24 weeks after giving birth. In contrast to these findings by Dennis *et al*. (2017), George *et al*. (2013) found that 18.8% of the pregnant women in their study experienced severe anxiety symptoms prior to birth which then increased to 20.2% experiencing anxiety symptoms after birth.

In South Africa, postnatal depression rates range between 20% and 30% (Osuna, *et al*., 2023). This might be due partner violence, lack of partner support, poverty, an increased risk for HIV (human immunodeficiency virus), (Rochat, *et al*., 2011) early pregnancy (Duby, *et al*., 2021) and inadequate nutritional intake (Osuna, *et al.,* 2023). Rochat, *et al*., (2011) investigated the prevalence of antenatal depression on 109 pregnant women in their third trimester in rural South Africa and found that 47% of the participants reported having depression. Of those that reported having depression, both

HIV positive (53%) and HIV negative (47%) women were at risk. Similarly, Redingera, *et al*., (2020) conducted a study on antenatal depression and anxiety in urban South Africa and found that depression and anxiety rates were high during pregnancy, (24–28%) and (14–18%) respectively. According to the results by Redingera, *et al*., (2020), if depression was prevalent early on during pregnancy, it would continue during gestation, while anxiety would increase. According to the results from a study by Osuna, *et al*., (2023) regarding depression in Johannesburg, South Africa, the prevalence rates of perinatal depression amongst the 242 participants were lowest at about 36 weeks of gestation (17%) and highest at 6 months postpartum.

Both high-income and low- and middle-income countries have risks for experiencing stressors during gestation (Redingera, *et al*., 2020). These include a previous history of mental illness, lack of support, as well as complications during pregnancy (Redingera, *et al*., 2020). However, women of low- and low- and middle-income countries may be at a higher risk for developing antenatal depression than those of high-income countries (Rochat, *et al*., 2011; Osuna, *et al*., 2023) since estimated rates of around 9% for perinatal depression in high-income countries compared to prevalence rates up to 50% in low- and middle-income countries (Osuna, *et al*., 2023). This may be due to increased exposure to violence, HIV, extreme poverty, which are unique to such areas (Redingera, *et al*., 2020). Essentially, the process of pregnancy and then raising a child, involves enormous costs that may create stress that is familial (Redingera, *et al*., 2020), financial and medical (Taylor *et al*., 2021).

2.5.5 Financial and Medical Stress

Taylor *et al.* (2021) explored financial difficulties among pregnant and postpartum women in the United States between 2013 and 2018. They found that of the 3 509 peripartum women who participated in the study, 24.2% of them reported unmet health care due to cost, 60% reported that health care was unaffordable, and general financial stress was reported by 54% (Taylor *et al*., 2021).

In a study by Henderson (1994), an association between prenatal care and positive birth outcomes was discovered. Henderson (1994) demonstrated that there were fewer low birth weight and prematurity incidences when a woman received prenatal care during her pregnancy. The study also highlighted that prematurity and low birth weight in infants could put the mother and baby at risk for Intensive Care Unit transfer and higher medical costs — making prenatal care a more cost-saving approach in the long run (Henderson, 1994). However, as reported by Taylor *et al.* (2021), not all pregnant women can afford conventional health care, despite its positive effects on birth outcome (Henderson, 1994). This makes mind-body practices a potentially viable and cost-effective option as a form of prenatal care.

2.6 Mind-body Practices and Yoga Nidra

Mind-body practices include yoga, meditation, mindfulness, and relaxation techniques (Dossett *et al*., 2020), such as yoga nidra, and may be effective mechanisms for coping with stress, stress-related complications and improving the cardiovascular functioning of the foetus and the mother (Saraswati, 2012; Curtis *et al*., 2012; Kusaka *et al*., 2016; Hamdiah *et al*., 2017). Furthermore, yoga nidra is cost-effective (Ferreira-Vorkapic *et al*., 2018) with no reported side-effects (Rani *et al*., 2011).

In this section, we explore the benefits of mind-body practices during pregnancy and provide an overview of yoga nidra, together with a definition and outline of the practice, its therapeutic applications, and its potential to promote relaxation and improve cardiovascular functioning during pregnancy.

2.6.1 Mind-body Practices

Mind-body techniques done during gestation may help reduce anxiety in the mother during pregnancy (Teixeira *et al*., 2005) and labour (Mohyadin *et a*l., 2020), reduce stress (Kusaka *et al*., 2016; Bauer *et al*., 2021; Hamdiah *et al*., 2017), and assist women with high-risk pregnancies (Rakhshani *et al*., 2012). These practices may also help to activate the parasympathetic nervous system, which opposes the sympathetic nervous response of “fight and flight” (Isgut *et al*., 2016; Hayase & Shimada, 2018; Hamdiah *et al*., 2017; Kim *et al*., 2018).

Results from a study by Hayase & Shimada (2018) indicated that practicing yoga during pregnancy can help activate the parasympathetic nervous system, assist with nighttime sleep, and lower stress levels. Both Hayase & Shimada (2018) and Kusaka *et* *al.* (2016) found similar results regarding yoga being able to lower salivary alpha-amylase levels, thus indicating stress reduction. Further stress reduction from yoga was discovered in a study by Hamdiah *et al.* (2017) which found that yoga was able to assist with lowering foetal HR as well as maternal anxiety and SBP.

Rakhshani *et al*. (2012) studied the effects of yoga on women with high-risk pregnancies. Women were recruited based on the presence of any risk factors associated with developing pregnancy complications (*i.e.,* history of previous pregnancy complications, family history, age, obesity, and twin pregnancies). In their study, it was found that 28 sessions of yoga between 13–and 28–weeks' gestation reduced the occurrence of preterm birth, intrauterine growth retardation, gestational diabetes, preeclampsia and PIH (Rakhshani *et al*., 2012).

Urech *et al* (2010) observed the effects of different relaxation techniques done during pregnancy. Their study found that a guided imagery relaxation technique was effective in inducing self-reported relaxation and lowering HR. Bauer *et al.* (2021) had similar findings in that different relaxation techniques were an effective way to reduce stress during pregnancy. Yoga nidra is a mind-body practice that helps to encourage a high level of relaxation (Pandi-Perumal *et al*., 2022). It is typically performed at the end of a yoga class but can also act as a stand-alone practice.

2.6.2 Yoga Nidra

Although similar in name, yoga nidra differs from yoga. It is important to make this distinction because the practice of yoga nidra can often be misunderstood and confused with yoga. Yoga, and more specifically, the yoga classes taught today, typically include physical movement through postures (known as Asana), breathwork (known as Pranayama) (Siu *et al*., 2015) and an ending supine position for relaxation (known as Shavasana). Yoga nidra, on the other hand, does not involve any physical movement or activity and is typically done in Shavasana (Pandi-Perumal *et al*., 2022). This practice can be done at the end of a yoga class or as a stand-alone practice for relaxation. The lack of physical movement makes yoga nidra an accessible practice for pregnant women, regardless of their hypertensive status.

Yoga nidra consists of two Sanskrit words, “yoga”, which translates to “union” or “awareness” and “nidra”, which translates to “sleep” (Datta *et al*., 2017). Yoga nidra is described by Saraswati (2012) as a methodical way of reaching an “aware sleep state” whereby one experiences relaxation on mental, emotional, and physical levels. Pandi-Perumal *et al*. (2022) gave a similar definition and explain that the goal of yoga nidra is to encourage a state of “profound relaxation” that is unlike sleep as one is still aware of their surroundings. Parker *et al*. (2013) suggested in their article that the definition of yoga nidra should include more specific physiological parameters such as brain wave states. The article proposed that yoga nidra be defined in terms of demonstrating similar symptoms to those of deep, non-REM (rapid eye movement) sleep with the presence of delta brain waves while remaining fully awake.

Despite the subtle and varying definitions of yoga nidra, Saraswati (2012), Pandi-Perumal *et al*. (2022) and Parker *et al*. (2013) all have basic commonalities in that they define yoga nidra in terms of sleep, relaxation, and the fact that one remains fully aware or conscious of their surroundings during the practice.

2.6.2.1 Outline of Practice

A typical session of yoga nidra has a distinct method that separates it from simply being meditation or relaxation and can thus make it universally applicable. This distinct method allows individuals to practice and essentially progress in their experience of relaxation.

The amount of practice one has in yoga nidra plays a role in the depth of relaxation one experiences (Parker *et al*., 2013). This means that individuals may only reach deeper levels of relaxation after continued practice. Furthermore, the length of the session and outline of the practice may need to be adapted to suit the level of experience of the individual, so that they can still benefit, without training.

Throughout the practice, there is a shift between active and passive phases of mental activity as one is encouraged to follow the instructions provided by the practitioner and actively engage in the instructions (e.g., counting breaths). A beginner-friendly session could be outlined as follows (Saraswati, 2012; Pandi-Perumal *et al*., 2022):

1. Preparation.
2. Stating a resolve (goal or affirmation).
3. Rotation of consciousness (mental body scan without physical movement).
4. Breath awareness and breath counting.
5. Awareness of sensations (lightness or heaviness, cold or warm, etc.).
6. Re-state resolve.
7. End practice by externalising awareness.

Other activities that can be included in the yoga nidra practice are inner space awareness (Saraswati, 2012), reciting poetry or reading stories (Saraswati, 2012; Lusk, 2015) or using the imagination with visualisations (Saraswati, 2012; Lusk, 2015, Dinsmore-Tuli & Tuli, 2022). One may also choose to engage in rotation of consciousness alone, or with breath awareness, as a short practice for working individuals (Saraswati, 2012).

2.6.2.2 Therapeutic Applications

Most research regarding yoga nidra has been conducted on non-pregnant populations, with pregnant women even being excluded from yoga nidra research trials (Monika *et al.* 2012; Devraj *et al*. 2021). This limited research might be because pregnant women are often excluded from research studies as they are termed a “scientifically complex” population (The American College of Obstetricians and Gynecologists, 2015). Despite this, yoga nidra has been investigated to effectively manage various psychological and physiological conditions amongst non-pregnant individuals (Datta *et al*. 2017; Vaishnav *et al*. 2018; Moszeik *et al*. 2022).

Vaishnav *et al*. (2018) investigated the effects of yoga nidra in adolescents (between 13–15 years of age) in a school setting. The adolescents reported experiencing feelings of happiness, lowered stress levels, and improved psychological well-being. Psychological well-being was described in terms of vitality, self-control, positive mood, as well as levels of anxiety and depression (Vaishnav *et al*., 2018). Ferreira-Vorkapic *et al.* (2018) also found that yoga nidra was effective in reducing anxiety and stress levels in college professors when compared to a control group. Furthermore, in a case report by Datta *et al*. (2017), it was found that after a yoga nidra intervention, the two patients presenting with insomnia experienced improvements in scores pertaining to depression, stress, and anxiety as well as quality of sleep and severity of insomnia. However, research regarding yoga nidra appears to investigate the effects of long yoga nidra practices ranging from 35–50 minutes in duration (Monika *et al*., 2012; Ferreira-Vorkapic *et Neal*., 2018; Devraj *et al*., 2021) despite the possibility of shorter practices (Saraswati, 2012). A study by Moszeik *et al*. (2022) found that just 11 minutes of yoga nidra improved the quality of sleep, sense of well-being and stress levels of a large population sample (n = 341).

Both Rani *et al.* (2016) and Monika *et al.* (2012) found that there were positive psychological and physiological changes after yoga nidra sessions for women with menstrual complications. In these cases, yoga nidra, as an intervention, showed improvement in anxiety, depression, and positive well-being, together with reductions in HR readings, respiratory rate, SBP and DBP readings (Monika *et al*., 2012; Rani *et al*., 2016). Similarly, in a pilot study by Devraj *et al*. (2021) on the BP, HS-CRP, and lipid profiles of hypertensive subjects, significant reductions in SBP, DBP and MAP were found in the yoga nidra group when compared to the control group.

To the best of our knowledge, limited research is available that examines the effects of yoga nidra alone on the cardiovascular well-being of pregnant women. The above evidence regarding the therapeutic applications of yoga nidra suggest that a short practice of yoga nidra could have the same therapeutic benefits for pregnant individuals as for non-pregnant ones.

2.7 Conclusion

Pregnancy involves a complex adaptation process to facilitate the growth and development of a baby. The complex changes that take place in the maternal cardiovascular system as a result of pregnancy highlight the body's desire to maintain a level of homeostasis. As the maternal body changes to help provide blood to her organs and the growing foetus, the intense physical stress on the cardiovascular system can put the mother at risk for developing cardiovascular complications, which also puts the foetus at risk for developmental problems from birth and into childhood. During pregnancy, the recognition of the life-changing event of having a child, together with fears, anxieties, and financial expenses specific to pregnancy, might create a psychological strain that manifests in the form of stress.

This literature review highlights the relevance of mind-body practices as they are inexpensive, accessible, safe, and stress-reductive in the context of preventing unfavourable cardiovascular changes that accompany pregnancy. We aim to explore whether a practice such as yoga nidra can be used to encourage a state of relaxation and essentially reduce the risk of BP and HR complications during pregnancy.

Chapter Three:

Methodology

3.1 Introduction

This methodology chapter outlines the research methods that guided this study. It provides information regarding the study design, setting, population, sample, inclusion and exclusion criteria, and procedures pertaining to the intervention and cardiovascular measures. It also includes study limitations and ethical considerations. The quality criteria and statistical analysis are also discussed to provide a framework for a valid and reliable analysis of the results.

3.2 Study Design

The study was a pre-test, post-test intervention involving participation in a single yoga nidra session. The purpose of the intervention was to investigate the effect that a single session of yoga nidra may have on the cardiovascular system of the participants, specifically, blood pressure (BP) (systolic blood pressure [SBP] and diastolic blood pressure [DBP], mmHg) and heart rate (HR) (beats per minute [bpm]) when compared to sitting. Based on self-reported data, the study was conducted on apparently "healthy" pregnant women who were over the age of 18 and at gestation of > 13 weeks (see the inclusion and exclusion criteria in Section 3.4.1 below).

The entire session took between 60–75 minutes, depending on the number of participants at each session. A session included three cardiovascular measurements: a baseline measurement upon arrival (M1), a post-sitting measurement (M2) and a post-yoga nidra measurement (M3). The experimental procedure is explained in detail in Section 3.6 below.

3.3 Study Setting

The study was conducted at four main sites in the regions of Tshwane and Johannesburg, namely, YogaSteps Studio in Moreleta Park, Midwives Exclusive in Rietondale, Shakti Yoga Therapy Centre in Sandton, and Flex Pilates Studio in Benoni. Following recruitment, potential participants were consulted to arrange an appropriate appointment at either of the four sites.

3.4 Study population, sample, and recruitment

The study population were adult pregnant women living in the regions of Tshwane, Johannesburg, and Benoni, Gauteng. There is no register of pregnant women publicly available; thus, without a sample frame, non-probability sampling techniques were employed to draw a sample from the population. Convenience sampling was utilised by conducting face-to-face recruitment at clinics, hospitals and antenatal classes in the Tshwane and Johannesburg regions (Table 3.1).

Table 3.1: An overview of places visited and points of contact for participant recruitment.

Point of Contact	Location	Method of Recruitment
Midwives Exclusive	Tshwane	Hand out flyers, recruitment from online antenatal classes, and a public post for recruiting volunteers on their Facebook page.
City View Birthing Retreat	Tshwane	Hand out flyers and point of contact to email notifications to potential participants.
Cuddles and Grace	Tshwane	Hand out flyers and recruitment from antenatal classes.
Genesis	Johannesburg	Hand out flyers and recruitment from antenatal classes.
Parentwood	Tshwane	Hand out flyers and recruitment from antenatal classes.
Fit4Two	Tshwane	Hand out flyers and point of contact to regularly notify potential participants.
Yoga Connection	Tshwane	Hand out flyers.
Escape Yoga Studio	Tshwane	Hand out flyers.
Shakti Yoga Therapy Centre	Johannesburg	Point of contact.
YogaSteps Studio	Tshwane	Hand out flyers and point of contact.
Karien Camphor	Tshwane	Hand out flyers and recruitment from antenatal classes.
Facebook Posts	"People who live in Pretoria East" group, "SA Psychologists Resources and Discussion" group and on the researcher's personal page	Public post for recruiting volunteers.
KASI School	Tshwane	Public post for recruiting volunteers.
Lyceé Jules Verne	Tshwane	Hand out flyers.
Pretoria East Hospital	Tshwane	Hand out flyers.
Babi Baby Clinic	Tshwane	Hand out flyers and recruitment from antenatal classes.
Wilgers Medical Consortium	Tshwane	Hand out flyers.

Furthermore, voluntary response sampling was used by recruiting through social media and flyers. Snowball sampling, otherwise known as *chain-referral-sampling* (Alkassim *et al.*, 2015) was also used. This sampling technique describes how the researcher used her initial points of contact to recruit via a referral process (Parker *et al*., 2020).

Interested women were invited to contact the researcher via email or cell phone. Alternatively, the potential participants provided their contact details on a sign-up sheet when the researcher visited their antenatal classes. Volunteers completed either an online form via Google Forms or a hard-copy pre-screening form (Appendix 4) at the research site to determine their eligibility for the study according to the inclusion and exclusion criteria explained below.

3.4.1 Inclusion and exclusion criteria

The inclusion criteria for this study were women with a confirmed single pregnancy 18 years or older and above 13 weeks gestation. Women were recruited after their first trimester of pregnancy because this trimester is associated with a high prevalence of miscarriage which makes women more likely to keep pregnancy a secret until after their 12-week scan (Lou, *et al*., 2017). We therefore decided to exclude women in the first trimester of pregancy due to this increased risk of miscarriage and because they might be less likely to volunteer for participation in a research study as a result of wanting to remain quiet about pregnancy until the 13th week.

Additionally, the participants needed to be willing to attend a yoga nidra session and dedicate a maximum of 75 minutes to the study at an agreed study site. Women were excluded from the study if they had a serious mental or physical condition (such as schizophrenia or epilepsy) or were diagnosed with hypertension during their pregnancy, or cardiovascular disease, or had a previous pregnancy with hypertension.

The women who participated in this study were therefore apparently “healthy” at the time of recruitment. The term “healthy” here refers to the self-reported data obtained from the participants who were not known to have conditions that might affect their BP and HR readings on the measurement days, and who met the inclusion and exclusion criteria of this study. This definition of the term “healthy” was similarly specified by Loerup, *et al*., (2019) who only incorporated "healthy" pregnant women for analysis in their systematic review and meta-analysis.

3.5 Sample Size

To estimate the sample size required, an a priori power analysis was performed using G*Power 3.1.9.4 (Faul *et al*., 2009) to reach a power (1-β) of 0.8, effect size (*f*) of 0.25 and an alpha error probability of 0.05 for an ANOVA repeated measures *F*-test, with three measurements. The result indicated that the sample size should include a minimum of 28 participants.

3.6 Experimental Procedure and Data Collection

Interested volunteers received the participation information sheet and consent form prior to the data collection session (Appendix 6) so that they could peruse it in their own time. They then completed the pre-screening form via a Google Form or a hard copy on-site (Appendix 4). The researcher answered any questions the participants may have had.

Once written consent was given, baseline BP and HR (M1) were measured (in triplicate), followed by a sitting (passive relaxation) period of 15 minutes. At the end of the sitting period, a second BP and HR (M2) reading was recorded (in triplicate). Thereafter, participants were free to resume regular activity or walk around during a washout period, also of 15 minutes. After the washout period, participants were made comfortable in their seated position and participated in the 15-minute yoga nidra session (active relaxation), after which a final (M3) recording (in triplicate) was taken (Figure 3.1). More detail on the procedures for collecting the cardiovascular data is provided in Section 3.6.2 below.

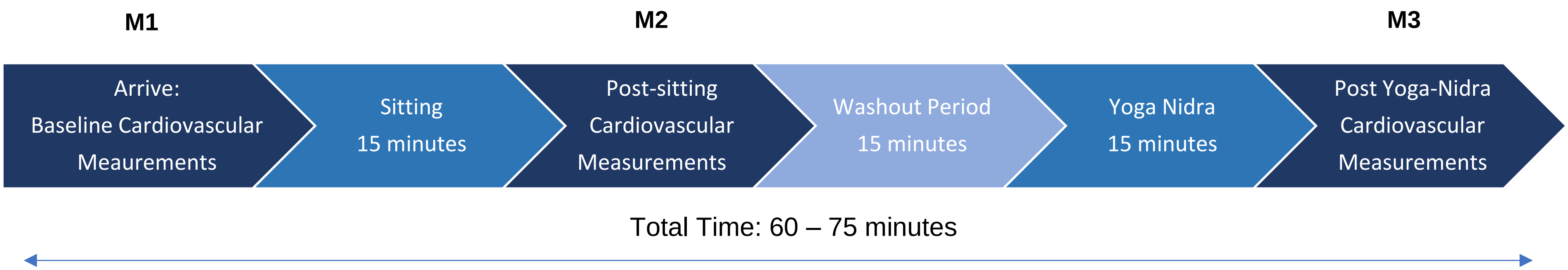

Figure 3.1: Flow chart describing the session layout.

M1 (baseline cardiovascular measurement); M2 (post-sitting cardiovascular measurement); M3 (post-yoga nidra cardiovascular measurement)

3.6.1. Outline of Sessions

Below is an explanation of the sessions, as provided in Figure 3.1. The 15-minute duration of the time intervals was determined based on the shortest yet equally effective time; the participants could be expected to take part in the study — both during the interval periods and in the totality of the study. The minimum time for the possibility of an effective yoga nidra was determined based on other literature. Results from other studies showed that 10 minutes (Urech *et al*., 2010), 11 minutes (Moszeik *et al*., 2022), 15 minutes (Teixeira *et al*., 2005) and 20 minutes (Anjana *et al.,* 2022) of yoga nidra, or active relaxation, was effective in providing measurable results after a yoga nidra practice. Based on this, 15-minute intervals were decided upon.

3.6.1.1 Sitting

During this period, the pregnant women were asked to sit quietly for 15 minutes, which is considered passive relation. The researcher exited the room so as not to be a distraction. During this time, the demographic data were filled out, and women were allowed to peruse reading material provided by the researcher. The use of phones was not encouraged as participants might have read messages or observed content on social media that could have caused undesirable distress.

3.6.1.2 Washout Period

For 15 minutes, women were allowed to assume regular activity by standing outside, walking around the premises, going to the bathroom, and talking to the researcher or other participants.

3.6.1.3 Yoga Nidra

Yoga nidra is typically done in a supine position known as Shavasana. However, it is not advised that pregnant women lay in the supine position for extended periods from 20 weeks gestation due to the pressure of the uterus on the vena cava (Rossi *et al*., 2011). Thus, a modification was made to the conventional yoga nidra methodology where participants remained seated in their chairs and were made comfortable for relaxation using cushions, props, and blankets. Once the participants were made comfortable, the 15-minute yoga nidra (active relaxation) was provided at each session by the researcher as per the following format:

1. Preparing the body for relaxation: The participant was asked to listen to sounds and become aware of their body, baby, and breathing.
2. Stating a resolve: This is a basic statement, formulated and then said mentally, by the participant that is personal to them. It is said in the present tense and helps to set the tone for yoga nidra. The example resolve provided was, "*I am calm in all that I do."*
3. A body scan/rotation of consciousness: Each participant was guided through the body according to the same format, whereby each body part is named. It was explained to the participant that they should try not to make any movements but rather allow their awareness to move around the body as each part is named.
4. Breath awareness: The participant was asked to become aware of the breath and enter a breathing practice of mentally counting breaths backwards from 10 to 1 in the following fashion: *breath rises, 10; breath falls, 10; breath rises, 9; breath falls, 9; and so on.*
5. Awareness of sensations and paradoxes: The participant was asked to generate the sensations of heaviness followed by the sensation of lightness — again without physical movement. It was encouraged that the feeling of heaviness is associated with relaxation and a sense of letting go of muscular tension. The feeling of lightness contrasted the feeling of heaviness with a feeling of weightlessness and experiencing the release of tension.
6. Stating resolve: The participant was asked to state the same resolve made at the beginning of the yoga nidra practice, and in the exact words, three times mentally.
7. Externalise awareness: The participant was asked to gently externalise their awareness by listening to sounds and becoming aware of the room, body, and baby.

The general formats to use for a yoga nidra practice are outlined in Saraswati (2012), Lusk (2015) and Dinsmore-Tuli and Tuli, (2022). Appendix 7 provides the links to a series of yoga nidra relaxations created by the researcher and given to the participants after they partook in the study.

3.6.2. Cardiovascular Measures

The dependent variables in the study were the cardiovascular readings of the participants, which included SBP and DBP (mmHg), mean arterial pressure (MAP) (mmHg), pulse pressure (PP) (mmHg), and heart rate (HR) (bpm). An OMRON HEM-7280T-E device (OMRON Healthcare, Kyoto, Japan) was used to measure each participant's BP and HR. PP was calculated as SBP – DBP, and MAP was calculated as MAP = DBP + 1/3(SBP – DBP) or MAP = DBP + 1/3 (PP).

BP and HR were measured in a seated position with an arm cuff of adequate size placed on the left arm at heart level (Regitz-Zagrosek *et al*., 2018). Feet were placed on the ground, uncrossed. Three readings were taken on the measurement days with no waiting period between readings. An average of the second and third readings was used for the final assessment per the guidelines outlined by Beaney *et al*. (2019).

3.6.3. Covariates

Characteristics of the participants were obtained to acquire more information about potential covariates. Self-reported height (metres [m]) and weight (kilograms [kg]) were obtained, and body mass index (BMI) was calculated as weight divided by height squared (kg/m^2). Subjective stress levels were collected by asking participants to rate their level of stress concerning work and daily living from 1–5, with a rating of five being the highest (Appendix 5).

Participants were also asked to record their maternal age as well as their current gestational age on the day of data collection (determined from a previous gynaecological visit or obtained from applications on their smartphones) and their gestational age at their most recent scan. There was often a few weeks' difference between the gestational age at their most recent scan and their gestational age on the day of data collection. For this reason, the gestational age on the day of data collection was used in the results.

3.6.4. Sociodemographic Data

Sociodemographic data was collected using a questionnaire (Appendix 5) to record ethnicity, age, obstetric history, familiarity with yoga nidra and lifestyle factors such as smoking and activity level (sedentary, moderately active, or active). The employment setting of each participant was also collected in the form of “home”, “office”, or “other” to gain insight into the type of work each participant engaged in. Furthermore, each participant was asked to explain a typical week in terms of stress to give more insight into their daily routine and living.

3.7 Scientific Rigour

This section presents an overview of the overall rigour of the study as well as its validity and reliability.

3.7.1 Reliability

Reliability refers to effectively replicating the results when the research is performed numerous times under the same circumstances and conditions (Middleton, 2019), essentially creating *consistency* in the results (Middleton, 2019; Heale & Twycross, 2015). According to Heale and Twycross (2015), the test-retest method achieves stability. Stability ensures reliability as each participant uses the same instrument multiple times under similar conditions. A statistical comparison is then made between each of the results from the participants to ensure that the instrument is reliable (Heale & Twycross, 2015).

In this study, cardiovascular measurements were obtained in triplicate at each relevant time interval. The 15-minute periods during the sessions (Figure 3.1) were monitored using a stopwatch on the researcher’s phone to ensure reliability. For the cardiovascular measurements, the same set of instruments and equipment were used for each participant. An average of the second and third readings was determined from the results using Microsoft Excel. Furthermore, the same reading material was provided for the participants during the sitting period. The women were allowed to perform similar activities during the washout, and the same yoga nidra outline was used for each participant during the yoga nidra period.

3.7.2 Validity

Validity refers to the accuracy with which a study measures what it is supposed to (Heale & Twycross, 2015). It is evaluated by observing how well the results correspond to the matching theories and concepts as performed in other, similar research (Middleton, 2019; Heale & Twycross, 2015). There are three types of validity: construct validity, content validity, and criterion validity (Heale & Twycross, 2015).

Uniformity and homogeneity in instruments are essential aspects of construct validity (Heale & Twycross, 2015). Construct validity was adhered to in this study in terms of how well the instrument measured what it was intended to measure (Heale & Twycross, 2015). Homogeneity was maintained by ensuring that the instrument used measured the same construct throughout the study. All participants were seated for the sitting and yoga nidra sessions, and the participant remained in her same chair for the period of sitting and yoga nidra. The manufacturers of the instruments used to measure BP and HR have ensured validity amongst their instruments through protocols and assessments (Beaney *et al.*, 2019).

Regarding the intervention, the same yoga nidra outline was repeated for all participants (as described in Section 3.6.2.3) to ensure consistency and stability. In terms of validity, the yoga nidra script was inspired by other literature (Saraswati, 2012; Lusk, 2015; Dinsmore-Tuli & Tuli, 2022) and used by the researcher personally in her capacity as a professional yoga instructor.

Furthermore, comparatively similar scripts to the one used in this study have also been outlined in Saraswati, (2012) Lusk, (2015) and Dinsmore-Tuli and Tuli (2022), with the use of a body scan, breath counting and pairing of opposites. Saraswati (2012), Lusk (2015) and Dinsmore-Tuli and Tuli (2022) all highlight the importance of pairing opposites, which was included in this script. Saraswati (2012) also provides a brief outline of a short yoga nidra script that can be used as an accessible way to provide a break from work and is accessible to beginners.

Parker *et al*. (2013), describe various levels of practice for yoga nidra, with more advanced levels being accessible to individuals, the deeper they can go regarding slower brainwave states. Since the general population participating in the study may not be familiar with the practice of yoga nidra, a relatively neutral and beginner-friendly script was chosen. The visualisation component that is often included in a yoga nidra practice was omitted to remain within the 15-minute time constraints and to evoke the least emotional response. From personal accounts, the subjectivity of visualisations can affect the yoga nidra experience. The primary focus was, therefore, on stillness and relaxation.

3.7.3 Overall Rigour

Instrument validity and reliability are important aspects of proper measurement and data collection, which facilitates the overall rigour of the study. Furthermore, rigour was adhered to by maintaining as close to a 15-minute interval period for each session as possible. Each participant followed a similar format when attending measurement sessions, regardless of the setting, with respect to filling out forms, reading materials provided for, sitting, washout time intervals, and the yoga nidra used for relaxation.

3.8 Statistical Analysis

Data was captured on hardcopy questionnaires for the sociodemographic and covariate variables. BP and HR measurements were captured on paper (and attached to the consent form) or captured directly onto the consent form. All data was then transferred to electronic data sheets on Microsoft Excel.

Data were checked for correctness by reviewing minimum and maximum values. From the data sheets on Microsoft Excel, data was transferred to IBM SPSS Statistic Program version 28 (IBM Corp., NY, USA) for statistical analysis. Microsoft Excel, Word, and PowerPoint were used to represent the data visually. Data was also checked for normal distribution and outliers using the test for normality via SPSS.

Descriptive SPSS analysis was conducted to gather the mean and standard deviation of the participants' sociodemographic characteristics (Table 4.1 of Chapter Four). Results were further analysed through inferential methods for explanatory purposes, namely according to gestational and maternal age.

Dependent *t*-tests were performed to compare readings between baseline, sitting and yoga nidra amongst all the participants. Participants were also grouped according to maternal and gestational age. Further dependent *t*-tests were performed to compare the readings between women in the second and third trimesters. Repeated measures ANOVA (RM-ANOVA) was used to investigate the effect of the interventions while considering maternal and gestational age as covariates (Field 2009). The Bonferroni post hoc test was conducted to determine which specific means differed. The data was tested to see if assumptions were met, namely dependent observations, normally distributed data, and sphericity. All assumptions were met except for a few cases of sphericity. In those cases, the Greenhouse-Geisser was reported (Field 2009). Two models of RM-ANOVA results were conducted. The first one was an unadjusted model that investigated the yoga nidra results without accounting for maternal or gestational age. The second one was an adjusted model that investigated yoga nidra results when adjusting for maternal and gestational age.

Table 3.2 below summarises the data analysis procedures used according to each objective of the study together with the study variables and data analysis procedures.

Table 3.2: Study objectives, variables, and data analysis procedures

Study Objectives	Variables	Instruments	Statistical Analysis
To describe the blood pressure (BP) (systolic blood pressure [SBP] and diastolic blood pressure [DBP], mmHg) and heart rate (HR) (bpm) of pregnant individuals immediately after a 15-minute yoga nidra session.	Post-yoga nidra HR (bmp), SBP (mmHg), and DBP (mmHg).	Questionnaire Calibrated BP instrument.	Descriptive statistics (means, standard deviation, and frequencies)
To compare the effects of yoga nidra on BP (SBP and DBP, mmHg) and HR (bpm) before and after the 15-minute yoga nidra session to baseline readings and sitting.	Baseline HR (bmp), SBP (mmHg), DBP (mmHg), mean arterial pressure (MAP) (mmHg), and pulse pressure (PP) (mmHg). Post-sitting HR (bpm), SBP (mmHg), DBP (mmHg) BP (mmHg), MAP (mmHg), and (PP) (mmHg). Post-yoga nidra HR (bmp), SBP (mmHg), DBP (mmHg), MAP (mmHg), and PP (mmHg).	Calibrated BP instrument. Data Sheets.	Descriptive statistics Dependent *t*-tests. Analysis of covariance.
To investigate whether any relationships exist between yoga nidra and the change in cardiovascular measures (BP and HR) in pregnant women using correlations.	Variables HR (bmp), SBP (mmHg), DBP (mmHg). Independent Variables (Figure 3.1) Baseline cardiovascular measurement (M1). Post-sitting cardiovascular measurement (M2). Post-yoga nidra cardiovascular measurement (M3).		Cardiovascular measurements Repeated measures ANOVA (RM-ANOVA).

	Model 1 Baseline as an independent variable (no covariates).		
	Model 2 Baseline as an independent variable + gestational age (weeks) + maternal age (years).		

3.9 Limitations

The study was conducted on pregnant women > 13 weeks gestation. This means that the fluctuating BP that occurs throughout pregnancy might have had unforeseen effects on the results obtained from the study (Morton, 2021). Furthermore, seasonal temperature variations, weather conditions (e.g., thunder), day of the week, time of the day, and variations in the study site may have also affected the measurement results. Study site variations included props, chairs, surroundings, and number of participants present in each session. Despite this, the same measures were taken at each separate study site to limit variations as much as possible.

The study was conducted in Gauteng and is therefore only applicable to people from the area. It cannot be indicative of the South African population, nor can it be generalised to the greater population as a small sample size was used. There were no exclusion criteria for ages above 18 years, race, smoking, number of prior pregnancies, or a family history of cardiovascular complications as the study focussed on whether the volunteer presently had hypertension or had experienced hypertensive complications in a previous pregnancy.

Participants were recruited on a volunteer basis, which could have been subject to a few influencing factors and placed the study at risk of self-selection bias. Firstly, the study took place during and just after the COVID-19 pandemic, meaning that there were uncertain conditions surrounding recruitment, and pregnant women may have felt uneasy about volunteering to participate. This also affected the researcher's ability to distribute flyers and have face-to-face visits. Secondly, participants were recruited from areas where the researcher was permitted to attend antenatal classes, meaning there were limitations on the access to pregnant women for recruitment. Word-of-mouth and social media also played a role in recruiting participants, and as a result, the researcher cannot rule out self-selection bias.

Another limitation of this study is that some literature points to yoga nidra being a "state" of brain wave activity that mimics that of non-REM (rapid eye movement) sleep (Parker *et al*., 2013). This study focused primarily on a single script of yoga nidra being used for the participants, as well as their cardiovascular response to that specific script. To fully assess the level of brainwave activity, electroencephalography and positron emission tomography are recommended by Parker *et al.* (2013). It is, therefore, not known if all the participants experienced the same level of rest during the yoga nidra script practice, and it is also unknown if a different script would have had differing results.

Despite these limitations, this study was performed under strict conditions and is the first study to highlight the potential effectiveness of a short yoga nidra study on the cardiovascular system of pregnant women. Since pregnancy is a physically and psychologically demanding time, coupled with more women working during gestation, this study shows that only 15 minutes of yoga nidra are needed to be included in one's busy day.

3.10 Ethical Considerations

3.10.1 Ethical Clearance

Ethical clearance was obtained from the University of South Africa, College of Agricultural and Environmental Sciences (CAES), Health Research Ethics Committee (HREC); 2021/CAES_HREC/021 (Appendix 1).

3.10.2 Informed Consent

The researcher explained the research study to volunteers showing interest in the study, including the requirements of the participants as well as the fact that the participants can withdraw from the study at any time and without concern or consequence. Consent forms (Appendix 6) were sent to the interested participants prior to the sessions via WhatsApp or email. The contents were explained to them on the measurement days and then handed to them for signing. The research was conducted according to the ethical principles as outlined in the Declaration of Helsinki (World Medical Association Declaration of Helsinki, 2013)

Participants were able to ask as many questions as they needed during the recruitment consent procedure and throughout the study. The participants were allowed to withdraw at any time without consequence.

3.10.3 Data Storage

All consent forms, questionnaires and personal information were treated with confidentiality. The hard copies were stored by the researcher in locked cabinets in Tshwane, Gauteng, for a maximum of five years after the study had been completed. All necessary documents were scanned, and the digital copies were stored in password-protected files on a flash drive and the Microsoft Cloud under the personal account of the researcher for a maximum of five years.

3.10.4 Participant Safety

Due to the nature of the relaxation practice, the participants were informed about comfortable seating positions and signs to look out for that indicate that the participant should stop — typically in the form of discomfort. Although it is encouraged that people remain as still as possible while practising yoga nidra, comfort was encouraged at all times. At the sessions, the participants were in secure premises, and the doors were closed or locked to ensure no disturbance during the sessions.

The researcher is a qualified yoga and yoga nidra teacher with seven years of teaching experience and over ten years of personal practice. No participants had any health-related concerns, reported adverse side effects, or had to be referred to a healthcare practitioner.

3.11 Conclusion

Reliable and valid research requires thorough investigations. Adherence to established experimental designs and data collection methods can ensure higher-quality results. Despite limitations, this study maintained a level of homogeneity amongst settings, adhered to inclusion and exclusion criteria for participants, had an adequate sample size for statistical analysis and used scientifically approved instruments for data collection. The study also gained ethical clearance before commencement, and participant safety was a concern throughout.

Chapter Four:

Results and Discussion

4.1 Introduction

This study investigated the effects of yoga nidra (active relaxation) and sitting (passive relaxation) on the cardiovascular system of pregnant women in their second and third trimesters in Gauteng, South Africa. As described in Chapter Three, the entire session took between 60–75 minutes, depending on the number of participants at each session. A session included three cardiovascular measurements: a baseline measurement upon arrival (M1), a post-sitting measurement (M2) and a post-yoga nidra measurement (M3) (Figure 3.1). This chapter presents the results, followed by a discussion of the findings.

4.2 Sociodemographic Characteristics

In total, 32 women enrolled in the study; however, one participant was excluded based on exclusion criteria, namely the use of antihypertensive medication. Therefore, the study included 31, non-smoking participants, with a mean age of 31.6 (± 4.46) years, and a mean gestational age of 28.7 (± 6.15) weeks. Most participants were of white ethnicity (80.6%, n = 25), primigravida (77.4%, n = 24) and new to yoga nidra (83.9%, n = 26). Self-reported lifestyle factors revealed that most women were moderately active (67.7%, n = 21) with a mean body mass index (BMI) of 27.2kg/m^2 (± 4.74) and medium stress levels (64.5%, n = 20). The characteristics of the participants are summarised in Table 4.1 below.

Table 4.1: Participants' sociodemographic characteristics

Characteristic		Mean	±SD		n (%)
Gestational Age (weeks)		28.68	±6.15	< 28 weeks	14 (45.2)
				≥ 28 weeks	17 (54.8)
Age (years)		31.55	±4.46	< 30 years	15 (48.4)
				≥ 30 years	16 (51.6)
BMI (kg/m^2)		27.19	±4.74		
		n	**(%)**		
Employment Setting					
Home		15	(48.4)		
Office		7	(22.6)		
Other/Both		9	(29.0)		
Stress Levels					
Low	1	3	(9.7)		
	2	2	(6.5)		
	3	20	(64.5)		
	4	6	(19.4)		
High	5	-	-		
New to Yoga Nidra		26	(83.9)		
Primigravid		24	(77.4)		
Activity Level					
Sedentary		4	(12.9)		
Moderate Activity		21	(67.7)		
Active		6	(19.4)		
Ethnicity					
Indian		1	(3.2)		
Caucasian/White		25	(80.6)		
Black/African		5	(16.1)		

Body mass index (BMI) (kg/m^2), standard deviation (SD), and number of participants (n) (n=31).

In this study, slightly more than half of the women were in their third trimester (54.8%, n = 17). In healthy pregnancies, blood pressure (BP) varies amongst trimesters. There is a decrease in BP during the second trimester with a slight increase in the third (Kintiraki *et al*., 2015) as BP readings start to reflect pre-pregnancy values (Gaillard *et al*., 2011). It is important to make this distinction between trimesters to account for possible variations in cardiovascular readings when interpreting the results of this study.

More than three-quarters of the women (77.4%) were primigravid. Women having their first pregnancy are at a higher risk of preeclampsia than during succeeding pregnancies (Morris *et al*., 2015). The interval time between pregnancies also affects this risk; however, the high risk of the first pregnancy when compared to the second suggests that a woman's body undergoes certain adaptations between a primigravida and multigravida (Morris *et al*., 2015).

According to Khalil *et al*. (2013), advanced maternal age (≥ 40 years) is considered a risk factor for developing adverse pregnancy outcomes. The mean age for our study population was 31.55 (SD ± 4.46) years, and no participants were older than 40 years old, indicating that this sample was not likely at risk for adverse effects associated with higher maternal age.

The mean BMI was 27.2kg/m^2 (SD ± 4.74) among the participants; however, due to pregnancy weight gain (Kominiarek & Peaceman, 2017) the BMI during the second and third trimesters cannot be interpreted accurately. Even so, excessive weight during gestation has been associated with poor pregnancy outcomes. According to Sibai *et al*. (1997), a BMI > 34 kg/m^2 from the early second trimester is associated with an increased risk for the development of preeclampsia during pregnancy. Since most participants were in their late second or third trimester (Table 4.3), there is no evidence of a concerningly high BMI in this sample.

A large proportion of the participants reported working from home (48.4%, n = 15) and having moderate stress levels (64.5% reported three out of five, with five being the most stressed). This finding suggests that despite working from home, most women were experiencing moderate levels of stress at the time of the research intervention.

The majority (83.9%) of participants reported being new to yoga nidra. Parker *et al*. (2013) suggest more experienced yoga nidra practitioners could reach deeper states of relaxation. This suggests that the participant's level of yoga nidra practice could have affected their ability to relax during the sessions.

Most participants reported being either moderately active (67.7%) or active (19.4%). Lowered resting heart rate (RHR) is associated with engaging in physical activity (Reimers *et al*., 2018; Rowan *et al*., 2022). In a meta-analysis by Cai *et al*. (2020), there was "high-certainty evidence" that regular physical activity lowered the RHR of pregnant individuals compared to pregnant women who did not engage in physical activity. Rowan *et al.* (2022) also found improvements in RHR as well as heart rate variability (HRV) for a small sample of pregnant women that engaged in physical exercise throughout gestation. Furthermore, exercise during pregnancy is associated with a lowered risk of gestational hypertension (Magro-Malosso *et al*., 2017), and a reduction in BP (Cai *et al*., 2020).

Our study population was mostly of white ethnicity (80.6%). Ethnic differences among pregnant women have been revealed as risk factors for developing preeclampsia (Ghosh *et al*., 2014). According to Ghosh *et al*. (2014), black ethnicity can put a pregnant woman at higher risk for cardiovascular disease than other racial groups. The link could be associated with the racial and ethnic differences that are prevalent for non-pregnant individuals (Ghosh *et al*., 2014).

4.3 Cardiovascular Outcomes

For the purposes of clarity when interpreting the following cardiovascular results, please refer to the diagrammatic representation of the intervention and three measurements shown in Figure 3.1 in Chapter Three. Briefly, upon arrival, the baseline, M1, was taken. M2 was taken after participants remained seated (passive relaxation) for 15 minutes. Participants then had a washout period for 15 minutes before returning to take part in a 15-minute yoga nidra session (active relaxation), after which M3 was taken.

In this section, the cardiovascular results are reported and discussed in terms of baseline, post-sitting, and post-yoga. With the above-mentioned overview as well as Figure 3.1 in mind, the mean values are given below (Figure 4.1) at each time point. The dependent *t*-test comparison of cardiovascular results after each intervention is presented in Table 4.2, with a discussion in Section 4.3.1.

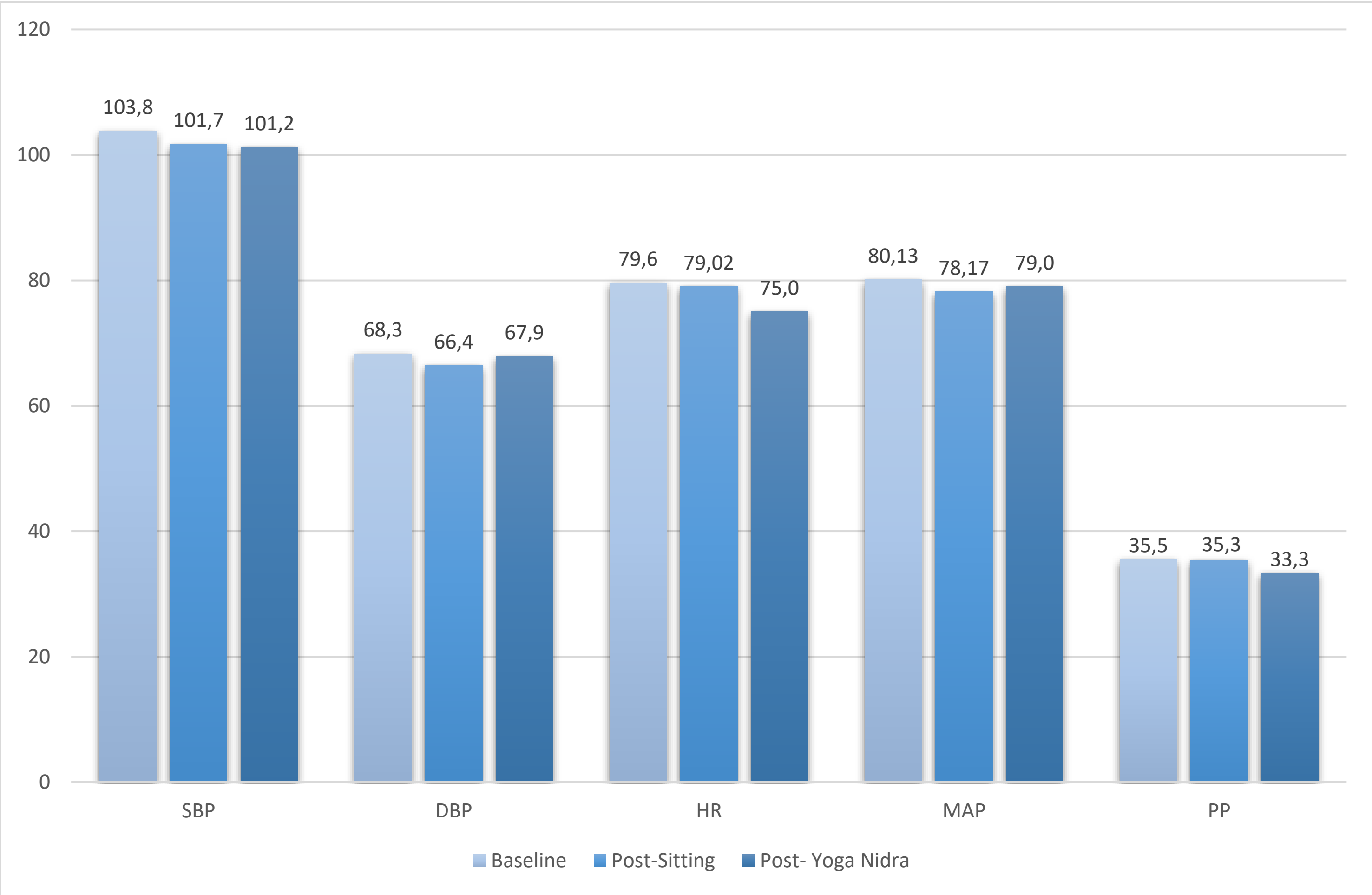

Figure 4.1: Mean systolic and diastolic blood pressure (SBP and DBP), heart rate (HR), mean arterial pressure (MAP) and pulse pressure (PP) values at different timepoints (baseline, post-sitting and post-yoga nidra).

Systolic blood pressure (SBP) (mmHg); diastolic blood pressure DBP (mmHg); heart rate (HR) (beats per minute [bpm]); blood pressure (BP) (mmHg); number of participants (n); mean arterial pressure (MAP) (mmHg); and pulse pressure (PP) (mmHg).

Table 4.2: Dependent *t*-test comparing cardiovascular measures at baseline, post-sitting, and post yoga nidra for pregnant women.

Variables	Baseline		Post-Sitting				Baseline		Post Yoga Nidra				Post-Sitting		Post Yoga Nidra		
n = 31	Mean	±SD	Mean	±SD	p-value		Mean	±SD	Mean	±SD	p-value		Mean	±SD	Mean	±SD	p-value
SBP	103.8	±8.53	101.7	±8.79	**0.003**	**SBP**	103.8	±8.53	101.2	±8.20	**0.006**	**SBP**	101.7	±8.79	101.2	±8.20	0.606
DBP	68.3	±6.93	66.4	±6.57	**0.014**	**DBP**	68.3	±6.93	67.9	±6.83	0.666	**DBP**	66.4	±6.57	67.9	±6.83	0.112
HR	79.6	±12.2	79.02	±11.5	0.514	**HR**	79.6	±12.2	75.0	±10.98	**< 0.001**	**HR**	79.02	±11.5	75.0	±10.98	**< 0.001**
MAP	80.16	6.63	78.19	6.66	**0.003**	**MAP**	80.16	6.63	79.04	6.85	0.158	**MAP**	78.19	6.66	79.04	6.85	0.325
PP	35.32	7.98	35.31	7.32	0.793	**PP**	35.32	7.98	33.31	6.11	**0.023**	**PP**	35.31	7.32	33.31	6.11	**0.018**

Standard deviation (SD); systolic blood pressure (SBP) (mmHg); diastolic blood pressure DBP (mmHg); heart rate (HR) (beats per minute [bpm]); mean arterial pressure (MAP) (mmHg); pulse pressure (PP) (mmHg); and number of participants (n).

4.3.1 Baseline Cardiovascular Measurements

Mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were within normal ranges (SBP ≤ 140 mmHg and DBP ≤ 90 mmHg) and remained so for the duration of the study (Figure 4.1 and Table 4.2). Other indicators of cardiovascular risks are mean arterial pressure (MAP) (Cnossen *et al*., 2008) and pulse pressure (PP) (Thadhani *et al*., 2001).

First and second-trimester MAP values are considered reliable indicators for developing preeclampsia (Cnossen *et al*., 2008; Emiija & Vladimir, 2011) as well as early pregnancy PP values (Thadhani *et al*., 2001). Our study showed mean baseline MAP and PP values of 80.1 mmHg and 35.5 mmHg, respectively. According to Cnossen *et al*., (2008) second trimester MAP readings of 90 mmHg or more showed a positive likelihood for the development of preeclampsia. Furthermore, our mean PP values were not higher than 40 mmHg, which is an indicator for the risk of developing gestational hypertension or preeclampsia according to Thadhani *et al*., (2001). The MAP and PP baseline readings obtained from our study may therefore indicate that our population was at a low risk for the development of cardiovascular complications.

According to previous research, the average HR is around 85 bpm by the end of gestation (Hunter & Robson, 1992; Loerup *et al*., 2019). Our cohort was within the expected range for their stage of pregnancy (79.6 bpm at baseline), which may have also been influenced by the activity levels of the participants. RHR is a strong indicator for the development of cardiovascular diseases (Palatini, 2021; Reimers *et al*., 2018). In a review article by Palatini (2021), evidence from several studies suggested that a persistently high RHR of > 80 bpm for non-pregnant individuals puts them at a greater risk for developing cardiovascular diseases. During pregnancy, persistently high RHR is monitored with discretion due to the vast HR range (68–115 bpm), with further investigation necessary to evaluate whether a persistently high maternal RHR is pathological (Coad & Frise, 2021). Furthermore, HR is an indicator of parasympathetic or sympathetic activity (Kim *et al*., 2018). Parasympathetic activity often shows physiologically with a reduction in HR, while sympathetic activity shows with an increase in HR (Isgut *et al*., 2016; Kim *et al*., 2018)

4.3.2 Cardiovascular Measurements Post-Interventions

Dependent *t*-tests revealed that SBP values were significantly lower post-sitting ($p = 0.003$) and post-yoga nidra ($p = 0.006$) when compared to baseline (Table 4.2). DBP and MAP values were significantly lower post-sitting ($p = 0.014$ and $p = 0.003$, respectively) and not post-yoga nidra. HR ($p < 0.001$) and PP results ($p = 0.023$) were significantly lower post-yoga nidra when compared with baseline, which was not seen post-sitting. PP and HR showed similar trends in that they were both significantly lower post-yoga nidra when compared with sitting ($p=0.018$ and $p<0.001$, respectively).

Essentially, the difference between post-sitting and post-yoga nidra results in HR was significant ($p < 0.001$) in two incidences. Firstly, when comparing the difference between baseline HR readings (79.6 bpm) and post-yoga nidra (75.0 bpm), and secondly, when comparing the post-yoga nidra and post-sitting (79.0 bpm) results.

Reasons for the significant drop in SBP, DBP and MAP post-sitting may be related to an orthostatic hypotensive response that can arise in elderly individuals who have altered BP governing mechanisms and autonomic dysfunction (Gupta & Lipsitz, 2007). Since pregnancy affects the cardiovascular system in numerous ways, such as those provided in Chapter Two, the 15 minutes of sitting may have caused a significant lowering of BP and not HR. Participants were in a state of passive relaxation when they were sitting. This finding is in line with other studies that suggest that there is a different response between passive and active relaxation (Teixeira *et al*., 2005; Urech *et al*., 2010).

Studies by Teixeira *et al*. (2005) and Urech *et al*. (2010) found that active and passive relaxation methods provide differing endocrine results, namely adrenaline, noradrenaline (Teixeira *et al*., 2005), cortisone, norepinephrine, epinephrine and the adrenocorticotropin hormone (Urech *et al*., 2010). These findings propose differences in physiological responses when it comes to the form of relaxation experienced. Teixeira *et al.* (2005), and Urech *et al.* (2010) both made use of what they termed “passive” and “active” relaxation. Active relaxation involves the use of a narrative guided by a specialist with the use of a narrative (Teixeira *et al*., 2005), or guided imagery (Urech *et al*., 2010), which is similar to our yoga nidra intervention. Passive relaxation involves sitting quietly (Urech *et al*., 2010) or sitting quietly with a magazine in a comfortable chair (Teixeira *et al*., 2005), which is similar to our sitting intervention. A difference between these studies and ours was the time intervals; Teixeira *et al*. (2005) used 45 minutes for the relaxation, while Urech *et al*. (2010) used 10 minutes, whereas ours used 15 minutes. Both Teixeira *et al*. (2005) and Urech *et al*. (2010) provided similar results as our study in that that they reported lowered HR readings after active relaxation when compared to passive.

During pregnancy, there is an activation of sympathetic activity, which could affect a pregnant woman's autonomic balance and cause a decrease in HRV (van der Zwan *et al*., 2019). Active relaxation (such as yoga nidra) is said to initiate parasympathetic nervous system activity (Teixeira *et al*., 2005; Urech *et al*., 2010). In the above-mentioned study conducted by Urech *et al*. (2010), it was found that active relaxation had a more significant effect on lowering HR when compared with passive relaxation (such as sitting). Lowered HR was explained by Isgut *et al*. (2016) and Kim *et al*. (2018) as an indicator for parasympathetic activity. Similarly, Teixeira *et al*. (2005) found that passive and active relaxation both had lowering effects on HR during pregnancy, with active relaxation also having a greater effect.

Yoga nidra, or "yogic sleep" (Saraswati, 2012), is a practice that alters an individual's brainwave states to mimic those of non-REM (rapid eye movement) sleep while one remains cognisant of their surroundings (Parker *et al*., 2013). The autonomic nervous system assists with regulating cardiovascular functions throughout the various sleep stages (Tobaldini *et al*., 2013). According to the results of a study by Somers *et al*. (1993), it has been established that a decline in sympathetic-nerve activity, HR and BP values occurs during non-REM sleep.

4.4 Maternal and Gestational Age Group Comparisons Variates

Gestational age (number of weeks pregnant) and maternal age (years of age) are well-known factors that affect the cardiovascular system during pregnancy (Gaillard *et al*., 2011; Cooke & Davidge, 2019; de Haas *et al*., 2022). Typically, second and third-trimester BP readings differ immensely, with higher readings during the third trimester than the second (de Haas *et al*., 2022). Furthermore, increased maternal age is said to be associated with less vascular compliance (Gaillard *et al*., 2011). It is, therefore, imperative to consider these covariates in our participants' cardiovascular results. We performed dependent *t*-tests to compare the readings between women who were younger than 30 and those who were older (Figure 4.2) and to compare readings between the second and third trimesters (Figure 4.3). We then conducted repeated measures ANOVA (RM-ANOVA) (Table 4.2) to further investigate the difference in results between interventions while considering maternal and gestational age as covariates.

4.4.1 Maternal Age

As is depicted in Figure 4.2, there were no significant differences in any of the cardiovascular readings between women who were younger than 30 and those who were older. Since our population was relatively young (mean age of 32 years), in comparison to what is considered "advanced maternal age", and with no participants over 40 years, our findings are in line with previous literature (Gaillard *et al*., 2011; Cooke & Davidge, 2019).

According to Cooke and Davidge, (2019), the criteria that define the term "advanced maternal age" is not generally agreed upon. In their review article, it was said that previously, ≥ 35 years was considered advanced maternal age; however, with recent technologies, advanced maternal age is now thought to be over 40 years. Gaillard *et al*. (2011), investigated the effects of maternal age on BP and found that older maternal age during pregnancy had only slight effects on BP readings. They also found slight variations in BP readings between second and third trimester results, but the differences in BP were still within normotensive ranges.

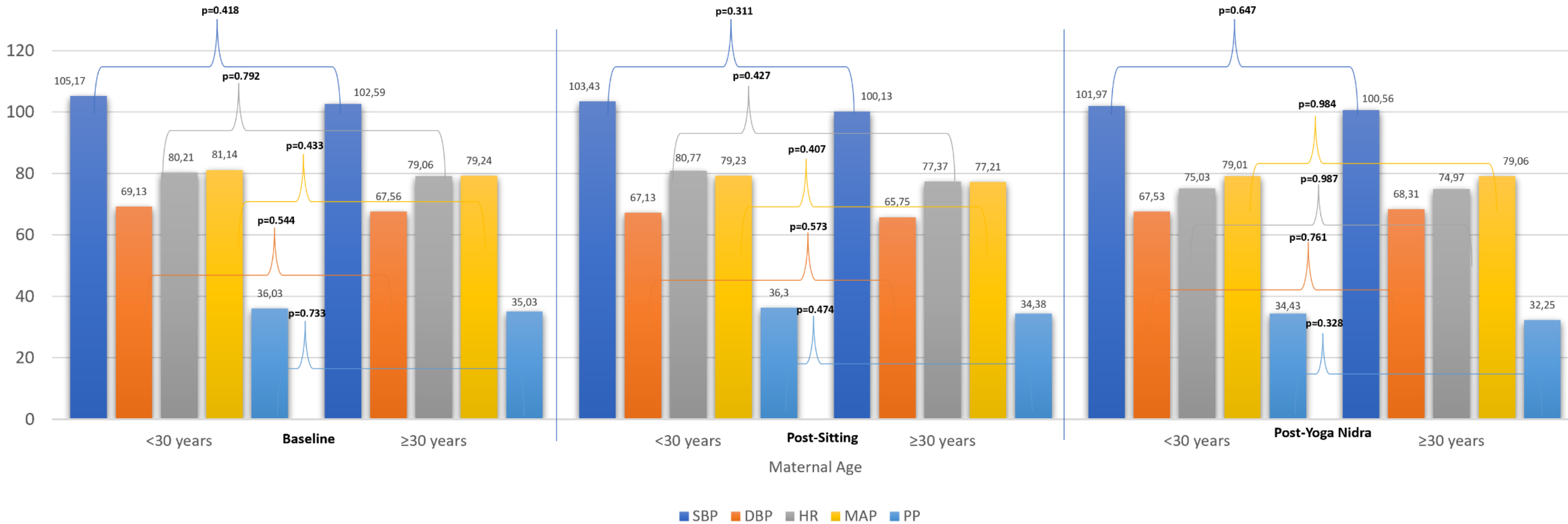

Figure 4.2: Dependent *t*-test results of cardiovascular measures of women between < 30 and ≥ 30 years and older at baseline, post-sitting, and post-yoga nidra.

Systolic blood pressure (SBP) (mmHg); diastolic blood pressure (DBP) (mmHg); heart rate (HR) (bpm); blood pressure (BP) (mmHg); the number of participants (n); mean arterial pressure (MAP) (mmHg); and pulse pressure (PP) (mmHg).

4.4.2 Gestational Age

From our study (Figure 4.3) baseline, SBP, DBP, HR, and MAP readings were highest for women in their third trimester when compared to women in their second. Dependent *t*-tests revealed that SBP readings were borderline significant ($p = 0.061$) at baseline, and DBP and MAP readings were significantly different ($p < 0.001$) amongst the trimesters at these timepoints. PP readings were lowest in the third trimester when compared to the second. This trend remained the same throughout the study.

Despite interventions, DBP readings remained significantly different amongst trimesters throughout the study at the different time points (baseline, $p < 0.001$; post-sitting, $p = 0.002$; post-yoga nidra, $p = 0.003$). MAP readings showed the same trend as DBP values with significantly different results between trimesters across all time points (baseline, $p < 0.001$; post-sitting, $p = 0.002$; post yoga nidra, $p = 0.002$).

When values were compared across interventions, DBP and MAP readings were both lowest after sitting in the second and third trimesters. SBP, HR and PP were lowest after yoga nidra. SBP readings in the second trimester showed more variability from baseline (100.64 mmHg; SD ± 5.716) to post-sitting (98.04 mmHg; SD ± 6.47) and post-yoga nidra (97.5 mmHg; SD ±4.94) across the study when compared with women in their third trimester (baseline: 106.47 mmHg; SD ± 9.903, post-sitting: 104.76 mmHg; SD ± 9.69, post-yoga nidra: 104.32 mmHg; SD ± 9.38).

A possible explanation for more variability in SBP in the second trimester compared with the third could be that there is a differing SBP against the arteries during a ventricular contraction (Rehman & Nelson, 2021). Women in their second trimester could be under less arterial strain than women in their third trimester as arterial pressure increases from the third trimester, together with BMI, blood volume and heart alterations (Sanghavi & Rutherford, 2014).

Under normal physiological conditions, women have different cardiovascular experiences at different stages of gestation. There is a decrease in BP during the second trimester with a slight increase in the third (Kintiraki *et al*., 2015; de Haas *et al*., 2022). The decrease in BP values during the second trimester could result from a decrease in maternal systemic vascular resistance, together with the other haemodynamic changes that occur during pregnancy (Kintiraki *et al*., 2015). This trend in BP values across trimesters was also observed in our study and consistent with previous research, where HR increases steadily throughout pregnancy and peaks during the third trimester (Sanghavi & Rutherford, 2014). Increasing HR could be because of increased sympathetic activity and having to adapt to the increase in fluid during pregnancy (Taranikanti, 2018).

Despite the observable difference amongst timepoints, HR readings were not significantly different between the second and third trimesters at any point of the study, which suggests that they followed a similar trend and gives reason to suggest that the participants may have experienced a reduction in HR irrespective of any covariates, such as maternal or gestational age. To further investigate this finding, we performed an RM-ANOVA to determine the effects of different interventions (15 minutes of sitting and 15 minutes of yoga nidra) on SBP, DBP and HR while accounting for gestational and maternal age. These results are presented and discussed below in Section 4.5.3.

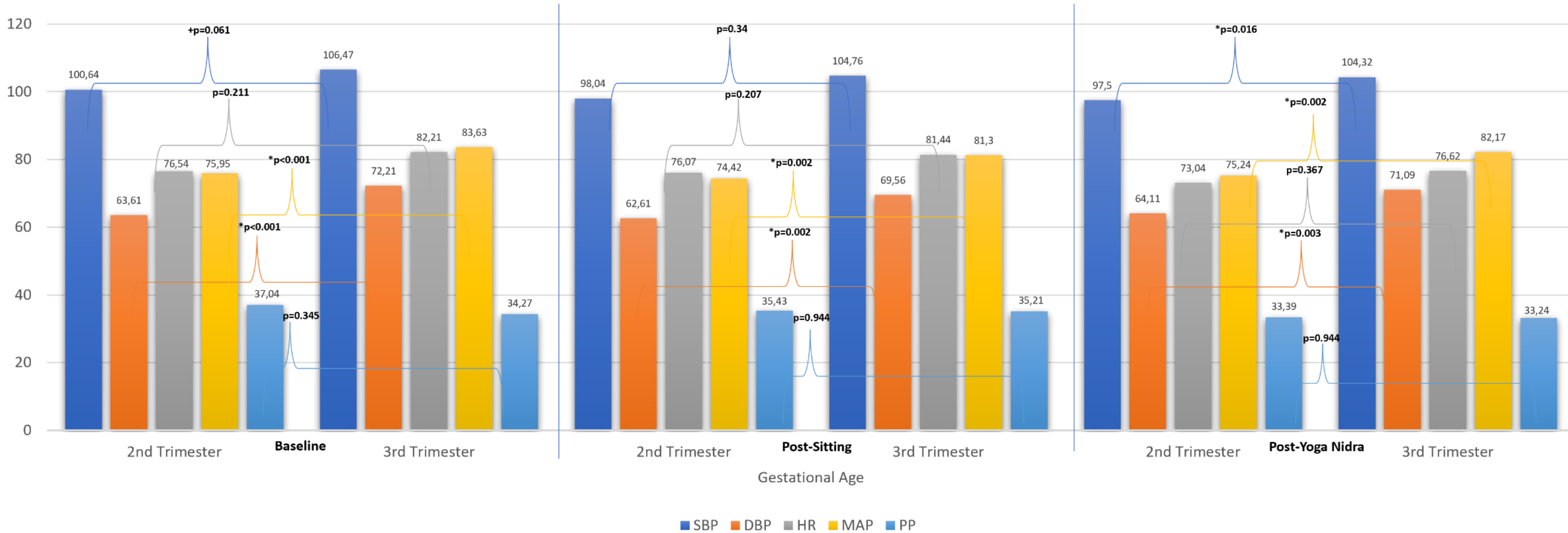

Figure 4.3: Dependent *t*-test results on cardiovascular measures of women in their second and third trimesters at baseline, post-sitting, and post yoga nidra

Systolic blood pressure (SBP) (mmHg); diastolic blood pressure (DBP) (mmHg); heart rate (HR) (bpm); blood pressure (BP) (mmHg); number of participants (n); mean arterial pressure (MAP) (mmHg); and pulse pressure (PP) (mmHg).

Second trimester, 13 - 28 weeks gestation; Third trimester, ≥ 28 weeks gestation.

* Represents significance amongst trimesters ($p < 0.05$).

+ Represents borderline significance amongst trimesters (close to $p = 0.05$)

4.4.3 Repeated Measure ANOVA Results

The purpose of conducting an RM-ANOVA was to assess the results across the two interventions (sitting and yoga nidra). *T*-tests revealed that HR and PP values lowered significantly after yoga nidra. Therefore, an RM-ANOVA determined if one of the covariates discussed above (maternal and, or gestational age, or both) was more responsible for the change. Two types of RM-ANOVA results were obtained. The first one was an unadjusted model that investigated the yoga nidra results without accounting for maternal or gestational age. The second RM-ANOVA investigated the yoga nidra results when adjusting for maternal and gestational age (adjusted model). The results from Table 4.3 below will be presented and discussed.

Table 4.3: Repeated measures ANOVA comparing baseline, post-sitting, and post-yoga nidra cardiovascular results for all pregnant women.

Variables	**Baseline**		**Post-Sitting**		**Post-Yoga Nidra**		**Unadjusted Model**			**Adjusted Model**		
n = 31	Mean	±SD	Mean	±SD	Mean	±SD	df	F	p-value	df	F	p-value
SBP	103.8	±8.67	101.7	±8.93	101.2	±8.33	2.0	5.51	**0.006**	2.0	0.75	0.477
DBP	68.3	±7.04	66.4	±6.68	67.9	±6.94	2.0	2.56	0.086	2.0	0.77	0.468
HR	79.6	±12.4	79.02	±11.7	75.0	±11.16	1.7	12.14	**< 0.001**	1.6	1.03	0.352
MAP	80.2	6.63	78.2	6.66	79.0	6.85	2.0	3.49	**0.037**	2.0	0.91	0.409
PP	35.3	7.98	35.3	7.32	33.3	6.11	2.0	4.23	**0.019**	2.0	0.24	0.792

Standard deviation (SD); systolic blood pressure (SBP) (mmHg); diastolic blood pressure (DBP) (mmHg); heart rate (HR) (bpm); mean arterial pressure (MAP) (mmHg); pulse pressure (PP) (mmHg), and number of participants (n).
Unadjusted model: no account for maternal and gestational age
Adjusted Model: Adjusted for maternal and gestational age as covariates.

The post hoc test results using the Bonferroni correction in the unadjusted model show that SBP, HR, MAP and PP at baseline (103.81 mmHg; 79.6 mmHg; 80.2 mmHg and 35.3 mmHg, respectively) was significantly different to that after 15 minutes of yoga nidra ($p = 0.006$; $p < 0.001$; $p = 0.037$; $p= 0.019$, respectively). The difference in DBP after yoga nidra was not significant (df = 2, $F= 2.56$, $p = 0.086$). Although valuable drops were seen from baseline, MAP results were of borderline significance (df = 2, $F= 3.49$, p

= 0.04). Furthermore, it must be noted that the significance in the above-mentioned values, and specifically in HR ($p < 0.001$), was observed without adjusting for any covariates.

Accounting for maternal and gestational age using the Greenhouse-Geisser estimate for HR in the adjusted model (Table 4.3) showed no significant effect from the interventions, implying that any effect shown in the unadjusted model is explained by the covariates. The mean baseline HR readings were 75.7 bpm and 81.8 bpm for women in their second trimester and third trimester respectively (Table 4.4 and Figure 4.4). After yoga nidra, there was a reduction in HR for women in the second trimester to 72.6 bpm (95% CI 65.97, 79.19) and 76.5 bpm (95% CI 70.69, 82.36) for women in the third trimester. Despite the second trimester mean HR being lower post-yoga nidra than the third trimester mean HR value (Table 4.4 and Figure 4.4), upon further investigation into pairwise comparisons and multivariate test results, women in their third trimester of pregnancy had a significant reduction in HR (df = 2, F = 7.78, $p = 0.002$), while those in their second trimester did not. Instead, the HR of women in their second trimester dropped to values that were borderline significant (df = 2, F = 2.96, $p = 0.069$) (Table 4.4). This finding suggests that women in their third trimester of pregnancy accounted for the significance in HR as seen in the unadjusted model (Table 4.3).

Table 4.4: ANOVA multivariate test results comparing heart rate (HR) at baseline, post-sitting, and post yoga nidra for pregnant women in the second and third trimesters.

Trimesters	**Baseline**		**Post-Sitting**		**Post Yoga Nidra**		**Adjusted Model**		
n = 31	Mean	±SD	Mean	±SD	Mean	±SD	df	F	p-value
Second Trimester	75.7	±3.47	76.7	±3.25	72.6	±3.22	2.0	2.96	*0.069*
Third Trimester	81.8	±3.07	80.9	±2.87	76.5	±2.85	2.0	7.87	**0.002**

(HR) (bpm); number of participants (n), and second trimester < 28 weeks, n = 14, Third trimester ≥ 28weeks; n = 17

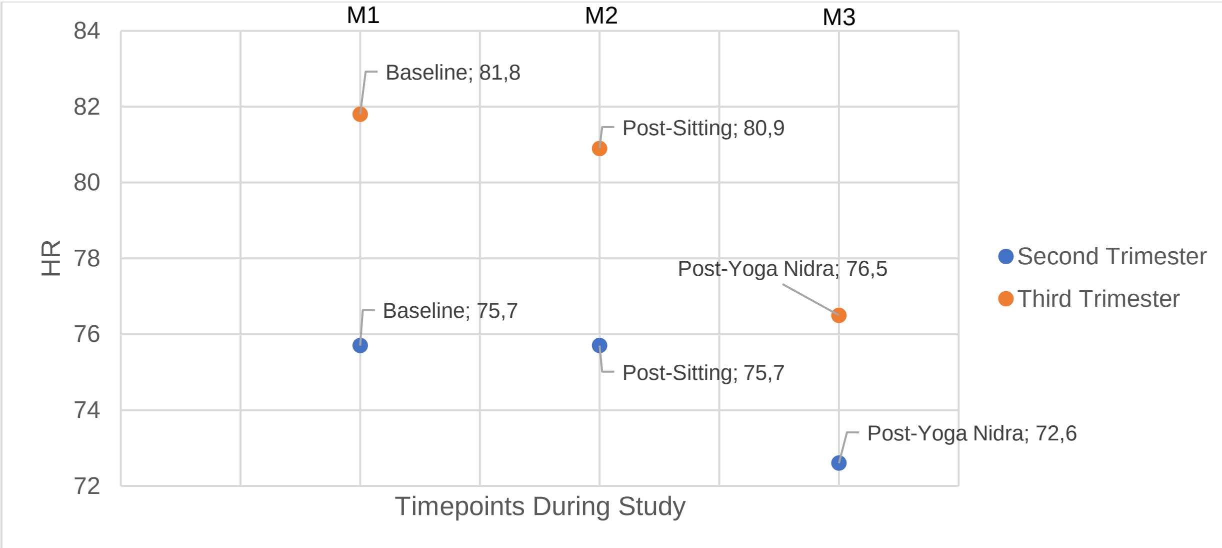

Figure 4.4: Trend in mean heart rate (HR) amongst women in the second and third trimesters at the various timepoints in the study.

Second trimester, < 28 weeks gestation; Third trimester ≥ 28weeks gestation; and heart rate (HR) (bpm); M1 (baseline cardiovascular measurement); M2 (post-sitting cardiovascular measurement); M3 (post-yoga nidra cardiovascular measurement)

A possible explanation for this could be that the third trimester is a physiologically demanding time as most of the physical changes that occur throughout pregnancy reach their peaks (Sanghavi & Rutherford, 2014) together with the uterus being at its largest (Özkana & Rathfisch, 2018). This trimester is associated with more physical discomfort (Hutchison *et al*., 2012; Özkana & Rathfisch, 2018), difficulty breathing and more frequent urination (Özkana & Rathfisch, 2018; Azwarda *et al*., 2021). The third trimester is also associated with poor sleep quality, difficulty falling asleep, and lowered sleep duration (Hutchison *et al*., 2012; Özkana & Rathfisch, 2018; Azwarda *et al*., 2021). These massive changes that occur before labour, together with a poorer quality of sleep, could make women in their third trimester more psychologically and physiologically receptive to relaxation when compared to women in their second trimesters.

In a study by Bauer *et al.* (2021), gestational age also influenced their results after an acute relaxation intervention. Unlike our study, their participant population only included women in their third trimester (between 30– and 40–weeks' gestation). They found that relaxation significantly reduced perceived stress levels in the earlier stages of the third trimester, when compared with women in the later stages. This provides interesting insight into the influence that gestational age might have on the ability of a pregnant women to relax.

Based on the results from our study, yoga nidra could be recommended for women during the third trimester to activate the parasympathetic nervous system, lower HR and prepare for labour and birth. Since yoga nidra is an in-depth relaxation practice, it might also be able to provide relief from poor sleep quality (Özkana & Rathfisch, 2018) and high stress levels (Bauer *et al.,* 2021) associated with the final stages of pregnancy.

4.5 Conclusion

Results from this study revealed SBP, DBP and HR alterations after 15-minute periods of sitting and yoga nidra, separately, when compared to baseline. Results from dependent *t*-tests showed that SBP readings significantly lowered after sitting ($p = 0.003$) and yoga nidra ($p = 0.006$). DBP and MAP readings lowered significantly post-sitting ($p = 0.014$ and $p = 0.003$, respectively) and not post-yoga nidra. PP and HR significantly reduced post-yoga nidra (PP $p = 0.18$; HR $p < 0.001$) and not post-sitting. RM-ANOVA was used to investigate influences of maternal and gestational age on the cardiovascular measurements.

The results from the unadjusted model were lost after adjusting for both maternal and gestational age. Therefore, in this sample, maternal and gestational age were the drivers of the effects on BP. However, there was a significant reduction in HR and not BP. HR significantly reduced ($p = 0.002$) from 81.8 bpm at baseline to 76.53 bpm, 95% CI (70.69, 82.36) after yoga nidra, among women in the third trimester, and a borderline significance ($p = 0.069$) in HR reduction (75.7 bpm at baseline to 72.6 bpm post-yoga nidra) for women in their second trimester. These findings highlight the potential that yoga nidra could have on activating the parasympathetic nervous system and lowering HR during the third trimester.

Chapter Five:

Conclusion and Recommendations

5.1 Introduction

This chapter integrates and summarises the previous sections found in the dissertation by providing overviews of the background, purpose and a summary of findings concerning the study objectives, recommendations for future research and the study's limitations. A conclusion is drawn at the end to integrate the research study within the context of maternal health.

5.2 Background

Hypertension during pregnancy is both a national and international concern, accounting for 14% of maternal deaths both worldwide between 2003 and 2009 (Say *et al*., 2014), and in South Africa between 2008 and 2010 (Moodley, 2011). The changes that occur during pregnancy can make it a considerably demanding time, especially regarding the maternal cardiovascular system (Sanghavi & Rutherford, 2014) and levels of stress (Lobel *et al*., 2008). Research shows that relaxation techniques can significantly reduce self-reported maternal stress (Urech *et al*., 2010; Bauer *et al*., 2021) and lower heart rate (HR) (Urech *et al*., 2010) when done during pregnancy. Yoga nidra is an in-depth relaxation technique (Saraswati, 2012) that has previously been shown to assist with insomnia (Datta *et al*., 2017), diabetes (Amita *et al*., 2009), blood pressure (BP) (Monika *et al*., 2012; Devraj *et al*., 2021), menstrual irregularities (Rani *et al*., 2011) as well as anxiety and depression in adolescents (Vaishnav *et al*., 2018) and adults (Ferreira-Vorkapic *et al*., 2018). These findings give yoga nidra the potential to be a cost-effective (Ferreira-Vorkapic *et al*., 2018) form of prenatal care, with no side-effects (Rani *et al*., 2011) that is accessible for pregnant women.

5.3 Purpose of Research

This study aimed to investigate the effects of a single 15-minute yoga nidra practice on the BP (systolic [SBP] and diastolic [DBP]), mmHg) and HR (beats per minute [bpm]) of pregnant women in Gauteng, South Africa.

5.4 Summary of Findings in Relation to Study Objectives

To guide the research, the study design and data collection procedures were structured around three objectives indicated and summarised in Sections 5.4.1 to 5.4.3 below.

5.4.1 Objective One: To describe the blood pressure (systolic and diastolic, mmHg) and heart rate (bpm) of pregnant individuals immediately after a 15-minute yoga nidra session.

Measurement 1 (M1) results revealed that the participants were within normal BP and HR ranges (Hunter & Robson, 1992; Loerup *et al*., 2019; Magee *et al*., 2022), indicating no signs of hypertension or hypertensive predisposition at the point of participation, which were expected since individuals without hypertension were recruited. Measurement 3 (M3) results showed that 15 minutes of yoga nidra had significant effects on SBP ($p = 0.003$) and HR ($p < 0.001$). After yoga nidra, the mean SBP results reduced by 2.6 mmHg, while the mean HR reduced from 79.6 bpm (baseline) to 75.0 bpm (post-yoga nidra).

5.4.2 Objective Two: To compare the change in blood pressure (systolic and diastolic, mmHg) and heart rate (bpm) after two different sessions: 15 minutes of sitting and a 15-minute session of yoga nidra.

Both sitting and yoga nidra had significant effects on BP and HR. Sitting significantly reduced mean SBP, 103.8 mmHg at baseline to 101.7 mmHg ($p = 0.006$), as did yoga nidra, 103.8 mmHg at baseline to101.2 mmHg ($p = 0.003$). There was no significant difference amongst post-sitting and post-yoga nidra SBP values. DBP reduced significantly ($p = 0.014$) post-sitting (66.4 mmHg) when compared with baseline (68.3 mmHg) and not after yoga nidra (67.9 mmHg). HR reduced significantly ($p < 0.001$) from 79.6 bpm (baseline) to 75.0 bpm (post-yoga nidra) but not after sitting (79.02 bpm). The difference between post-sitting and post-yoga nidra HR readings was significant ($p < 0.001$).

5.4.3 Objective Three: To investigate whether any relationships exist between yoga nidra and the change in cardiovascular measures, blood pressure (systolic and diastolic, mmHg) and heart rate (bpm), in pregnant women.

Dependent *t*-tests revealed that yoga nidra significantly lowered HR ($p < 0.001$) and SBP ($p = 0.003$) and sitting significantly reduced DBP ($p = 0.014$) and SBP ($p = 0.006$) readings. When comparing post-sitting and post-yoga nidra values, HR was significantly different ($p < 0.001$) as a result of yoga nidra, while SBP and DBP values were not. The change in cardiovascular measures may have been due to covariates such as maternal and gestational age. The results from the unadjusted model were lost after adjusting for both maternal and gestational age. Findings rather revealed that there was no HR or BP changes after adjusting for maternal age, while changes in HR alone were found when adjusting for gestational age. Yoga nidra significantly affected the HR of pregnant women in their third trimester of pregnancy (df = 2, F = 7,78, $p = 0.002$).

5.5 Limitations

The study contained a small sample size (n = 31), limited to pregnant women (> 13 weeks gestation) in Gauteng, South Africa and is not representative of the South African population. Maternal age, gestational age, and BMI can affect the cardiovascular system during pregnancy (Gaillard *et al*., 2011; Cooke & Davidge, 2019; de Haas *et al*., 2022). Although maternal and gestational age were accounted for, there may have been unforeseen influences that we are unaware of. This may have been because of the small number of participants in their second trimester (n = 14) and third (n = 17), or otherwise. BMI was not included as a covariate in this study because pre-pregnancy weight could not be obtained from all the participants as some women were not aware of their weight prior to pregnancy. Therefore, gestational weight gain could not have been accounted for and BMI might have had unforeseen effects on the results of the study.

Four different session sites were used, and these may have had unknown influences on the consistency of the results. The study took place over an extended period and on different days, which may have led to inconsistencies in outdoor or indoor temperatures and other weather factors (such as thunderstorms), which may have affected how the participants experienced the yoga nidra. The day of the week and time of day could have also influenced BP and HR measures. However, all our data collection was completed indoors, and when at the same venue, the study was performed under similar conditions in an effort to minimise environmental impact as far as possible and provide consistency.

The majority of the participants (83.9%) were new to yoga nidra, which may have influenced the ability of the participants to relax and feel familiar with the practice. However, our results still show a favourable drop in heart rate despite any possible unfamiliarity with the practice. Furthermore, finding suitable days and times for participation meant that some participants were alone at their session, while others were in pairs or groups of three, which could have affected the results. Despite this, there was an adherence to 15-minute intervals for sessions and the washout period, and two BP monitoring devices were available to make measurement timings as consistent as possible.

Recruitment procedures could have hindered volunteer response because recruitment was conducted during and directly after the COVID-19 pandemic. Furthermore, the researcher only had access to places that gave her permission, which may have resulted in self-selection bias as the participants selected themselves to be part of the study. This hinders the ability for randomisation and generalisation of the results. Nonetheless, all ethical practices were followed in accordance with human research, and participants had a pleasant experience taking part in this important research project.

5.6 Recommendations

Small sample sizes (< 40 participants), as seen in this study, are prevalent in other acute relaxation research (Urech *et al*., 2010; Bauer *et al*., 2021) with very little evidence of research for prenatal yoga nidra, specifically. It can, therefore, be recommended that similar research be conducted on larger sample sizes and in the same setting for the duration of the study on the same day, if possible.

Since more than 80% of the participants were new to yoga nidra, potential participants could receive a yoga nidra recording to listen to prior to the session so that they are familiar with the practice on the day of the research. This familiarity could prevent any anxiety that might occur with regards to the participants being uncertain about what to expect from the relaxation practice, and yoga nidra. Because it is unclear as to what extent being new to the practice of yoga nidra could influence one's ability to relax completely, two research sessions could be done a month apart, with homework provided in between to see if practising yoga nidra had any effects on results after a period of practice. Randomised controlled trials are the gold standard to determine the effect of an intervention, and such studies would be necessary to confirm our results.

Future studies can use an electrocardiogram to investigate the HR variability of individuals throughout the sitting and yoga nidra interventions. From this, participants can be encouraged to stay after the yoga nidra practice to observe the point when HR levels increase. Other longitudinal studies (± 12 weeks duration) can also be implemented to observe if yoga nidra has any lasting effects on HR levels throughout gestation. Future studies could also use electroencephalography and positron emission tomography to observe brainwave activity.

5.7 Conclusion

Resting heart rate is considered a good indicator of autonomic nervous system tone and parasympathetic activity. This study investigated the effects of a form of active relaxation method called yoga nidra on the cardiovascular system of pregnant women. Our findings demonstrate a significant reduction in HR when compared with sitting and baseline measurements of women, more specifically in their third trimester of pregnancy. This lowered HR, which was not observed post-sitting, indicates parasympathetic activation after yoga nidra. The third trimester of pregnancy is associated with the most physical discomfort and poor quality of sleep when compared with other trimesters due to the size of the foetus. The results from this study indicate that yoga nidra could be recommended during the third trimester to assist with lowering HR and activating the parasympathetic nervous system during the final stages of pregnancy.

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Appendix 1

Ethical Clearance

UNISA university of south africa

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 10/10/2022

NHREC Registration # : REC-170616-051
REC Reference # : 2021/CAES_HREC/021
Name : Ms CJ Taylor
Student #: 64062740

Dear Ms Taylor

Decision: Ethics Approval Renewal after First Review from 06/10/2022 to 30/09/2023

Researcher(s): Ms CJ Taylor
64062740@mylife.unisa.ac.za

Supervisor (s): Dr C Myburgh
Caitlynd.Myburgh@kingsu.ca; 011-471-2819

Working title of research:
The effects of yoga nidra on the cardiovascular system of pregnant women

Qualification: MSc Life Science

Thank you for the submission of your yearly progress report to the Unisa-CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is renewed for one year, and remains renewable on a yearly basis upon submission of a progress report. **Failure to submit the progress report will lead to withdrawal of the ethics clearance until the report has been submitted.**

Furthermore, the following amendment is approved:

1. Change to data collection after a single session of yoga nidra, rather than collection over a three month period.

The researcher is cautioned to adhere to the Unisa protocols for research during Covid-19.

Due date for next progress report: 30 September 2023

The progress report form can be downloaded from the college ethics webpage:

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https://www.unisa.ac.za/sites/corporate/default/Colleges/Agriculture-&-Environmental-Sciences/Research/Research-Ethics

*The **medium risk application** was originally **reviewed** by the UNISA-CAES Health Research Ethics Committee on 11 February 2021 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
8. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

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> *Note:*
> *The reference number* ***2021/CAES_HREC/021*** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof MA Antwi
Chair of UNISA-CAES Health REC
E-mail: antwima@unisa.ac.za
Tel: (011) 670-9391

Prof SR Magano
Executive Dean: CAES
E-mail: magansr@unisa.ac.za
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Appendix 2

Turnitin Report

turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Cassandra Jayne Taylor
Assignment title:	Complete dissertation/thesis Final
Submission title:	64062740 MSc Dissertation Final
File name:	TII_Final_Submission_64062740_C.Taylor_MSc_Dissertation.d...
File size:	2.32M
Page count:	119
Word count:	25,259
Character count:	144,528
Submission date:	09-Nov-2023 05:37PM (UTC+0200)
Submission ID:	2222862906

THE EFFECT OF YOGA NIDRA ON THE CARDIOVASCULAR
SYSTEM OF PREGNANT WOMEN

by

CASSANDRA TAYLOR

Student Number:

64062740

Submitted in accordance with the requirements

for the degree of

MASTER OF LIFE SCIENCE

in the

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

DEPARTMENT OF LIFE AND CONSUMER SCIENCES

at the

UNIVERSITY OF SOUTH AFRICA

Supervisor:

DR C. MYBURGH

Co-supervisor:

DR E.A. SYMINGTON

November 2023

Appendix 3

Language Editing Certificate

HAZELHURSTINC

Proofreading and Editing Services

CERTIFICATE

This certificate confirms that the dissertation listed below was proofread and edited for spelling, grammar, punctuation, as per the client's brief.

THE EFFECT OF YOGA NIDRA ON THE CARDIOVASCULAR SYSTEM OF PREGNANT WOMEN

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Certificate Number: Haz002_01

Date Issued: 6 November 2023

Issued by: Olivia Hazelhurst

HazelhurstInc Proofreading and Editing Services

Email: hazelhurstinc@gmail.com Telephone: 074 505 8654

Certified Professional Proofreaders and Editors. Bachelor of Arts, University of Pretoria / Knowadays LTD (Certified CPD Training Provider)

Appendix 4

Volunteer Pre-Screening Form

Pre-screening form for participation in the study:

Characteristics:	**Answer:**	
Number of weeks pregnant:		
Age:		
Yes/No Questions:	**Yes**	**No**
Diagnosed with hypertension or cardiovascular disease?		
Have a severe mental or physical condition you feel may prevent you from participating? (Such as schizophrenia or epilepsy)		
Have had a previous pregnancy where you were diagnosed with pre-eclampsia or any other cardiovascular disease?		
Have any serious health conditions you feel may prevent you from participating in yoga nidra?		
Willing to participate in a 45 – 60min session that includes 4 blood pressure measurement readings, weight, and height measurements as well as a yoga nidra relaxation?		
Pregnant with a single child (not twins, etc)		

Appendix 5

Sociodemographic Questionnaire

Revised Sociodemographic Questionnaire:

Sociodemographic & necessary information form for participation in the study once the participant has passed the pre-screening form:

Please fill in the following information:	
Participant Number:	
Email:	
Ethnicity:	
Number of pregnancies prior to current one:	
Gestation at recent scan:	________ weeks; _________ days
Weight:	
Height:	
Please circle one of the following options:	
Type of work:	Office Home Other
Stress levels:	(5 is the highest): 1 2 3 4 5
Activity levels:	sedentary moderately active active
Would you consider yourself a regular smoker within the last 3 months?	Yes No
New to yoga nidra:	Yes No
In the space below, please try to describe a typical week (stress-wise) for you:	

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Appendix 6

Participant Consent Form

UNISA university of south africa

RESEARCH INFORMATION DOCUMENT & CONSENT FORM

PARTICIPANT INFORMATION SHEET

Ethics clearance reference number:
Research permission reference number:

Title: The Effect of Yoga Nidra on the Cardiovascular System of Pregnant Women: a randomized controlled trial

Dear Potential Research Participant

Thank you so much for your interest in being part of this research study. My name is Cassandra Taylor. I have been teaching yoga for nearly 5 years and it is a joy to share this practice with children and adults alike. What drew me to yoga were the noticeable benefits a regular practice had on my mind, body, and emotions. This has inspired me to teach and further my studies in conducting research to see the effects that yoga can have on individuals.

Dr Caitlynd Myburgh and Dr Elize Symington (lecturers in the Department of Life and Consumer Sciences) will be my supervisors as I study towards a Master of Science (MSc) in Life Sciences, at the University of South Africa (UNISA). The study is aimed to see the effects that yoga/yoga nidra may have on the cardiovascular system of women during pregnancy.

Please familiarise yourself with the information contained within this document. If you are happy with it and would like to participate, you can fill in the information of the documents titled, "Participant Pre-screening Form" and "Consent to Participate in the Study".

If you have concerns about the way in which the research will be conducted, you may contact:

- My supervisor: Dr. Caitlynd Myburgh on 011 471 2819 or email: vzylc1@unisa.ac.za.
- My co-supervisor: Dr. Elize Symington on 011 471 3438 or email: syminea@unisa.ac.za.
- The research ethics chairperson of Prof MA Antwi via email: antwima@unisa.ac.za

Please contact me on casstayloryoga@gmail.com or 076 457 5700 for any queries. It is hoped that by participating in this study, that it will be an uplifting experience for you and your growing family.

Warm regards
Cassandra

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Purpose of study:

Hypertension and hypertensive related conditions can put a pregnant mom and her baby at risk for experiencing unfavourable conditions related to health and wellbeing – either during pregnancy or later in life. The number of recorded pregnancies that experience hypertension is increasing.

Yoga has been known to have calming effects for the mother, while promoting a favourable environment for an unborn baby - these two factors can set the stage for healthy long-term growth and development.

This study will be conducted to see if *yoga nidra* could act as an effective modality for the management of a pregnant woman's cardiovascular system during pregnancy.

About Y*oga Nidra*:

Yoga is an ancient practice that aims to bring harmony to the body, mind and emotions. It does this through physical postures, breathing practices and relaxation.

Yoga nidra is a form of conscious relaxation where an individual is guided through a series of instructions that take them into a deep state of rest and relaxation.

This state and be nourishing, rejuvenating and uplifting for the whole body. Typical *yoga nidra* sessions include a body scan, breath awareness and awareness of sensations (heaviness/lightness) or a guided visualization (walk to a park, calm ocean etc.)

Sometimes there are questions with regards to religion and yoga, but this study will be kept neutral and suitable for all faiths with focus on stillness, calmness and peace.

Requirements:

- Willingness to do yoga & yoga nidra each week for 12-weeks
- 18 years or older
- Between 14 and 18 weeks pregnant to participate in the study
- Access to email and internet
- Access to transport for blood pressure reading meetings
- Living within the Pretoria area/willing to travel to Pretoria for blood pressure readings

Reasons for Participation:

- Chance to participate in a novel research study and contribute to yoga-related research
- Regular blood pressure readings
- Regular heart rate monitoring
- Opportunity to meet other moms-to-be
- Access to free yoga nidra classes and general prenatal advice

Voluntary Participation:

- Participation of the study is on a voluntary basis and will begin after you sign a consent form.

- All the study protocols will be explained to you in detail and you will be able to ask any questions throughout the duration of the study.

Ethics approval:

- This study has received ethics approval from the Research Ethics Review Committee of the College of Agriculture and Environmental Sciences, UNISA. A copy of the approval letter can be obtained from the researcher on request.

Withdrawal from the Study:

- Should you at any time wish to leave the study, you are free to do so, without any consequences.

How it will Work:

- You will be randomly assigned into one of two groups, either the control group or the experimental group. This will be done on the first day of meeting when we do our initial blood pressure and heart rate measurements. You will draw a number from a box and that will be your assigned group.
- Once you have joined your group, you will receive your weekly tasks. Both groups will receive general prenatal advice. The experimental group will receive the *yoga nidra* recordings to do during the study and the control group will only receive them after a 12-week period.
- You will be given two *yoga nidra* recordings to do each week and they can be done at any time you find most convenient to you. You will be given an online timetable where you can make a cross on the day and time you did the recordings. This can also help you plan your week in advance.
- Cardiovascular readings will need to be taken every 3 weeks for observation at times/days decided in advance.

(Please see the diagram explaining the outline of the experiment at the back of this document)

Data Collection and Confidentiality:

- Data will be collected from the Google Docs as well as the private meetings for cardiovascular measurements.
- Data will be kept in a retrieval system for up to 5 years, after which all documents (recorded in hard copies or on the computer) will be disposed of appropriately.
- Your participation in the study will always be handled with the most confidence, including in the final publication.
- Your contact details will be required in your consent form so that you can receive the recordings to be sent via email and notifications for your cardiovascular measurement appointments.
- The nature of the cardiovascular measurement days will mean that you may meet other people who are also participating in the study, this means that your identity

cannot be kept completely confidential. Should you wish to remain anonymous to other individuals, readings can be done privately. However, communal meetings allow for an opportunity for you to meet other moms-to-be who may be able to share in some of your pregnancy experiences.

General Precautions:

- There are no known side effects of practicing yoga nidra, however, should any discomfort be experienced, one can stop the recording/discontinue altogether.
- The yoga exercises will be basic and suitable for all levels of fitness, flexibility and strength, but if you are unsure, you can visit your health-care provider or seek medical advice before beginning the yoga programme.
- If discomfort is experienced, it is advised to discuss it with Cassandra and you are welcome to discontinue the practice at any time.

Conclusion:

Yoga has been shown to be beneficial for individuals, but very few studies have looked at the effects of *yoga nidra* on the cardiovascular system of pregnant women. By participating in this study, you will be making a valuable contribution to the fields of research pertaining to pregnancy, hypertension, yoga and *yoga nidra*.

CONSENT TO PARTICIPATE IN THIS STUDY

I, __________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

Important information:
The nature of yoga nidra is to be rejuvenating. While we cannot guarantee your safety completely because the participation is online and in your own home, it is asked that you use discretion with regards to your participation. This means:

- Knowing that you should do the recordings in a calm and comfortable environment
- Let other family members/friends know what you are doing (in case you fall asleep)
- Not doing yoga in an unsafe environment (where there is lots of furniture/slippery or unsteady surfaces)
- Only practice yoga nidra in a comfortable position that is safe (e.g. not in the bath or while driving)
- Should you start to feel any discomfort, you may stop at any time and are under no obligations whatsoever to participate/continue participation

As the signee, by signing the document, I acknowledge that I have read all the information given and understand the following:

- I have read (or had explained to me) and understood the study as explained in the information sheet.
- I have had sufficient opportunity to ask questions and am prepared to participate in the study.
- That I will use my personal judgement to ensure that I do not unduly strain my body or cause personal injury when choosing a relaxation posture.
- That I am responsible for my body and assume any risks of injury/accidents or loss/damage of property to myself while participating in the yoga videos.
- If I feel unsure about participating in the research study, I know to consult a medical practitioner for further approval.
- I give Cassandra Taylor full permission to use the data collected from the Google Docs and from the cardiovascular measurement days for the purpose of her research.
- I will not redistribute or use any of the materials provided by Cassandra and the research team for commercial purposes, or for any means without prior permission.
- I have, of my own free will, agreed to participate in the research on the effects of yoga nidra on the cardiovascular system of pregnant women.
- That I can withdraw myself and my data from the study at any time.
- I have had sufficient opportunity to ask questions and am prepared to participate in the study.

- I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.
- I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).
- I agree to the recording of my blood pressure and heart rate at five time points, as well as to body measurements and to answer the necessary questionnaires at enrolment.
- I have received a signed copy of the informed consent agreement.

Participant Name & Surname…………………………………………… (please print)

Participant Signature…………………………………………… Date…………………

Researcher's Name & Surname…………………………………………… (please print)

Researcher's signature…………………………………………… Date…………………

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Appendix 7

Yoga Nidra Links

Yoga Nidra Outline.m4a

Prenatal Yoga Nidra 1 - Awareness of Sensations.mp4

Prenatal Yoga Nidra 2 - Breath Counting.mp4

Prenatal Yoga Nidra 3 - Heart-Baby Breathing.mp4

Prenatal Yoga Nidra 4 - Skin Awareness.mp4

Prenatal Yoga Nidra 5 - Belly Breath Counting.mp4

Prenatal Yoga Nidra 6 - Sitting Beside a Stream Visualisation.mp4

Prenatal Yoga Nidra 7 - Loving Kindness Contemplation.mp4

Prenatal Yoga Nidra 8 - Organ Awareness.mp4

Prenatal Yoga Nidra 9 - Sinking into Stillness.mp4

Prenatal Yoga Nidra 10 - The Dust that Dances.mp4

Prenatal Yoga Nidra 11 - Image Visualisation.mp4

Prenatal Yoga Nidra 12 - Softness.mp4