

AMERICAN UNIVERSITY OF BEIRUT

PRE-POST NATAL FITNESS

BY

SARAH FOUAD NAJEM

UNDERGRADUATE SENIOR PROJECT

IN

GRAPHIC DESIGN

DEPARTMENT OF ARCHITECTURE AND DESIGN

MAROUN SEMAAN FACULTY OF ENGINEERING AND ARCHITECTURE

DATE OF THESIS FINAL PRESENTATION: THURSDAY, 14 MAY, 2020

Appendix 3: GDRP Thesis Approval Form

AMERICAN UNIVERSITY OF BEIRUT
UNDERGRADUATE SENIOR PROJECT
IN
GRAPHIC DESIGN
SUBMITTAL FORM

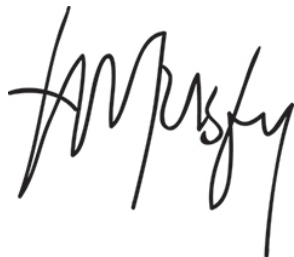
PRE-POST NATAL FITNESS

by
SARAH FOUAD NAJEM

FINAL YEAR THESIS PROJECT- 407 GD 2020
2020 SPRING

ADVISOR: LEILA MUSFY

Approved by Thesis Advisor:



[Signature]

Leila Musfy | Professor

[Full Name, rank]

Department of Architecture and Design

Date of Thesis final presentation: Thursday, 14 May, 2020

Appendix 1: Project Release Form

AMERICAN UNIVERSITY OF BEIRUT

THESIS, DISSERTATION, PROJECT RELEASE FORM

Student Name: NAJEM SARAH FOUAD
Last First Middle

- ArDT Project (Architecture Design Thesis)
- GDRP Project (Graphic Design Research Project)

I authorize the American University of Beirut to: (a) reproduce hard or electronic copies of my project; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes.

I authorize the American University of Beirut, to: (a) reproduce hard or electronic copies of my project; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes

- after : **One year from the date of submission of my capstone project.**
 Two years from the date of submission of my capstone project.
 Three years from the date of submission of my capstone project.



May 27, 2020

Signature

Date

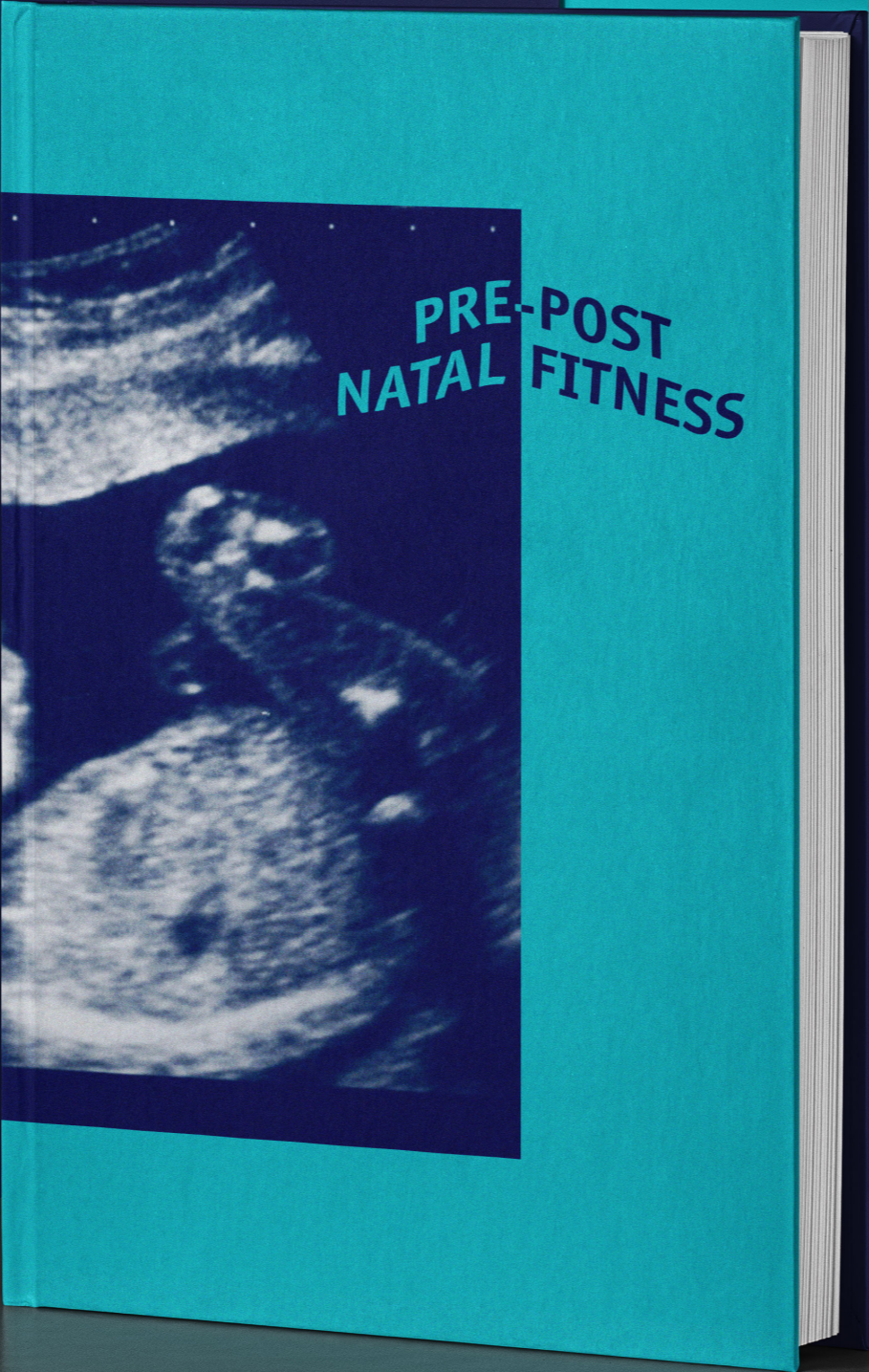
This form is signed when submitting the thesis, dissertation, or project to the University Libraries.

ABSTRACT

Examining the effects of exercise on women and their babies, this publication provides guidelines for exercise plans that safely fulfill a mother's needs during different phases of pregnancy, answering such questions as, **How does exercise benefit the mother? How does exercise affect growth of the fetus? What is the effect of exercise on milk production? Does exercise limit weight gain during pregnancy? What is the right amount of exercise? What are the dos and don'ts of exercising when pregnant? When should exercise be avoided? How late into pregnancy can you exercise? and What should be the exercise regimen after giving birth?** It includes the latest scientific information on staying fit during pregnancy and emphasizes appropriate exercises. Moreover, this publication thoroughly describes the changes that happen to the mother while she's pregnant and how both she and the child can benefit through exercise.

TABLE OF CONTENT

Title Page	p1
Thesis Approval Form	p2
Release Form	p3
Abstract	p4
Content	p5
Documentation	p27



**PRE-POST
NATAL FITNESS**

This publication is for information purposes only. The material herein represents training, health and nutrition literature and information as summarized by the authors. The information contained herein is not intended to replace the advice of health care professionals. No part of this publication is intended to provide medical advice on personal health matters which should be obtained directly from a physician.

This publication will help you be able to:

//List the benefits and potential risks for exercise during pregnancy for both the mother and unborn baby.

//Explain the important physiological and biomechanical changes that occur in the course of a woman's pregnancy and how those changes affect the performance of exercise.

//Describe basic nutritional requirements for pregnancy and the postpartum period.

//Know basic information on the psychological changes that may occur during pregnancy and the postpartum period and how exercise might play a role in relieving psychological symptoms.

//Describe the research pertaining to both the mother and fetus relating to exercise during pregnancy and the postpartum period.

//Give basic information on the psychological changes that may occur during pregnancy and the postpartum period and how exercise might play a role in relieving psychological symptoms.

Written by: Patrick Bejjani and Sarah Najem

Designed by: Sarah Najem

INTRODUCTION

Examining the effects of exercise on women and their babies, this publication provides guidelines for exercise plans that safely fulfill a mother's needs during different phases of pregnancy, answering such questions as, **How does exercise benefit the mother? How does exercise affect growth of the fetus? What is the effect of exercise on milk production? Does exercise limit weight gain during pregnancy? What is the right amount of exercise? What are the dos and don'ts of exercising when pregnant? When should exercise be avoided? How late into pregnancy can you exercise? and What should be the exercise regimen after giving birth?** It includes the latest scientific information on staying fit during pregnancy and emphasizes appropriate exercises. Moreover, this publication thoroughly describes the changes that happen to the mother while she's pregnant and how both she and the child can benefit through exercise.



TABLE OF CONTENT

Pregnancy	P 08
Special consideration and contraindications	P 10
Physiological changes	P 18
Biomechanical consideration	P 20
Exercise techniques	P 24
Nutritional Considerations	P 32
Psychological Considerations	P 36



PREGNANCY AND EXERCISE

Benefits of exercising during pregnancy

In 2002, the American Congress of Obstetricians and Gynecologists (ACOG) recommended pregnant women to **exercise for 30min or more daily doing moderate-intensity physical activity**; a statement that was reassured by the same nonprofit organization (ACOG) in 2009 (Skinner, J., Bryant, C., Merrill, S., Green, D. 2015). Note that it is crucial for pregnant women to **inform and discuss the exercise routine they are willing to perform with their medical doctor to get a medical clearance** which must be presented to their personal trainer before starting their workout routine.

Exercise for pregnant women cleared by their medical doctors to undergo physical activity can **improve both their cardiovascular and muscular fitness reducing their risk of cardiovascular problems, fatigue and lower back pain; helping them gain healthy weight during pregnancy and losing this weight back after delivery (postpartum)**. Studies had also proven that physical activity decreases the risk of gestational diabetes (increased blood sugar levels during pregnancy), preeclampsia (combination of hypertension and proteinuria during pregnancy), cesarean section procedures, insomnia, heartburn, constipation, leg cramps and anxiety/depression (Skinner, J., Bryant, C., Merrill, S., Green, D. 2015).

Participation rate

The change in the exercise guidelines and physicians recommendations has increased the rate of participation of pregnant women in regular physical activity, where **42% to 66% of pregnant women engage in some form of regular leisure-time physical activity** (20% adhere to a physician – recommended level of exercise)(Shivakumar et al., 2011; Evenson, Savitz, & Huston, 2004); however, only 3 to 15% of pregnant women were meeting guidelines compared with 24 to 26% of non-pregnant women (Currie et al., 2013)

SPECIAL CONSIDERATIONS

Maternal Exercise & Fetal Response

Theoretical Concerns Surrounding Maternal Exercise:

//The selective redistribution of blood flow away from the fetus during regular or prolonged exercise in pregnancy.

//Transient Hypoxia resulting in fetal tachycardia and increase in fetal blood pressure.No reports to link such adverse event.

//Intrauterine growth restriction due to strenuous physical activity. Studies are inconclusive. It has been reported that participating in moderate to high intensity P.A. have a higher risk than light to moderate intensity P.A.

Special Considerations

The health concerns affecting both the pregnant women and the fetus/child get worse as the BMI values of the future mother to be rises

Even though physical activity is proven to be effective during and after pregnancy, there are some cases that require special considerations since they may cause negative health consequences on the pregnant women and the unborn child. For this reason, any of the following special considerations: **gestational diabetes mellitus, preeclampsia and/or maternal obesity**, can impose changes on the course of a pre and postnatal exercise program.

Gestational Diabetes Mellitus (GDM)

The increase in blood glucose levels (hyperglycemia) or glucose intolerance that affects the pregnant women during their pregnancies.

Gestational diabetes mellitus is becoming one of the most common medical complications of pregnancy (Hopkins, S., & Artal, R. 2013). Although it usually resolves after delivery, if not treated, it can prevail as type 2 diabetes mellitus affecting the mother later in her life,

jaundice (yellow discoloration of the newborn's skin and eyes due to excessive bilirubin pigmentation)

it can also increase the risk of hypertension, preeclampsia and cesarean section delivery. Regarding the baby's future health, untreated GDM can lead to macrosomia (figure 1), acute breathing difficulty, jaundice along with hypoglycemia. Gestational diabetes mellitus (GDM) can be due to either a family history of GDM or Diabetes mellitus type 2, maternal obesity, increased maternal age of equal or more than 35, hypertension, sedentary lifestyle and poor nutrition (Padayachee, C., & Coombes, J. S. 2015). Due to its detrimental effects on the health of both the pregnant women/mother to be and the fetus/newborn baby, in addition to the fact that some of the most important risk factors leading to GDM are maternal obesity and sedentary lifestyle; medically cleared prenatal exercise plays a crucial role in both preventing and treating GDM (American College of Sports Medicine, 2014).

Preeclampsia

A serious disorder that can affect several body systems, preeclampsia is referred as a medical disorder usually diagnosed after 20 weeks of pregnancy and characterized by the combination of maternal persistent hypertension of >140/90 mmHg and proteinuria of >300mg protein present in maternal urine over a period of 24 hours.

Risk factors of preeclampsia include **maternal obesity, increased maternal age, renal problems, pre-existing hypertension, previous preeclampsia, family history of preeclampsia, first pregnancy and multiple pregnancies** (English, F. A., Kenny, L. C., & McCarthy, F. P. 2015). Beside being directly responsible of several maternal deaths annually, preeclampsia can lead to several complications

including fetal death, fetal growth retardation, premature delivery, along with maternal cardiac, cerebrovascular and renal disorders (Skinner, J., Bryant, C., Merrill, S., Green, D. 2015). While the one and only cure being premature delivery after stabilizing the condition, preeclampsia can be prevented and managed by several ways including physical activity that must be closely monitored by the mother's physician (Bezerra Maia e Holanda Moura, S., Marques Lopes, L., Murthi, P., & da Silva Costa, F. 2012); a study conducted in 2006 had successfully proven that exercise can prevent and help in the management of preeclampsia by enhancing placental vascularization improving fetal growth along with antioxidant defense mechanisms and reducing inflammation

Maternal Obesity

Alarmingly, and due to the emergence of cheaper high caloric non healthy food combined with a overall decrease in the amount of physical activity, overweight and obesity is increasing worldwide and affecting pregnant women either prior or after conception. Maternal obesity imposes several concerns on the health of the pregnant mother, in addition to the health and development of her fetus/child.

Maternal obesity is defined as having a high body mass index BMI (BMI 25-30 kg/m², Overweight, BMI > 30 kg/m², Obese, and BMI > 40 kg/m², Severely obese)

The health concerns affecting both the pregnant women and the fetus/child get worse as the BMI values of the future mother to be rises. **These adverse health outcomes include: congenital anomalies (neural tube defect: birth defect of the brain and spinal column;**

omphalocele: abdominal organs protrude outside of the abdominal wall; and congenital heart disease), preterm birth, macrosomia, higher risk of childhood obesity which in turn increases the risk of several medical problems, shoulder dystocia (when the newborn's shoulder gets stuck behind the mother's pubic bone causing labor difficulties), gestational diabetes mellitus, preeclampsia, higher risk of C-section delivery which in turn increases the risk of excessive operational blood loss, wound infection and stillbirth (death of the fetus). Finally maternal obesity makes it much harder for the mother to lose weight after delivery which can lead to several health problems such as diabetes, hypertension, cardiovascular diseases... (ACOG, 2015). Exercise and proper nutrition play an effective role in fighting maternal obesity; however it is mandatory for the certified medical exercise specialist to follow the recommendations of the physician since pregnant women must gain weight during their pregnancy. The following table lists all the recommendations for weight gain during pregnancy issued by the institute of medicine and modified by the American council of obstetricians and gynecologists (ACOG, 2013).

Contraindications and Risk Factors

Although exercise is proven to have several health benefits as discussed previously; theoretically, there are some medical concerns that must be addressed which imposes absolute and relative contraindications to exercise in case of a complicated pregnancy. **The first concern is the redistribution of blood flow that occurs whenever a person exercises;** in the case of a pregnant woman, this might lead to less flow of blood and less oxygen and nutrients reaching the fetus interfering with his/her development. This condition can lead to maternal edema and hypertension as well. Studies has shown that the best way to avoid these complications is by adopting aquatic exercise as the preferable method of aerobic training since the hydrostatic pressure of the water inside the pool helps preventing maternal edema and hypertension while preventing the shunting of blood away from the fetus (Da Silva et al. 2013). **Secondly, low levels of oxygen leads to fetal tachycardia and hypertension,** a defensive mechanism allowing the fetus for

better gas exchange of oxygen and carbon dioxide across the placenta in a way to fight hypoxia. However, studies have shown that exercise (even if it reaches 84% of maximal heart rate) does not lead to any of these effects and can be well managed by both the pregnant women and the fetus (Szymanski & Satin, 2012). **Thirdly, in the previous years, there were some concerns related to the negative effect of exercise on fetal growth restriction;** however, a recent study conducted in 2013 showed that moderate-intensity exercise has no effect on fetal growth (Tomic et al. 2013); note that this study did not involve high-intensity exercise.

Based on the possible risks of exercise on complicated pregnancies, the American council of obstetricians and gynecologists (ACOG) has declared absolute and relative contraindications to exercise during pregnancies (Evenson, K. R., Barakat, R., et al. 2014)

Note: Risk of activities requiring balance is relative to maternal weight gain and morphologic changes; some activities may be acceptable early in pregnancy but risk later on.

Examples of safe and unsafe physical activities during pregnancy

The following activities are safe to initiate or continue:

- //Walking
- //Swimming
- //Stationary cycling
- //Low-impact aerobics
- //Yoga, modified
- //Pilates, modified
- //Running or jogging
- //Racquet sports
- //Strength trainingg

The following activities should be avoided:

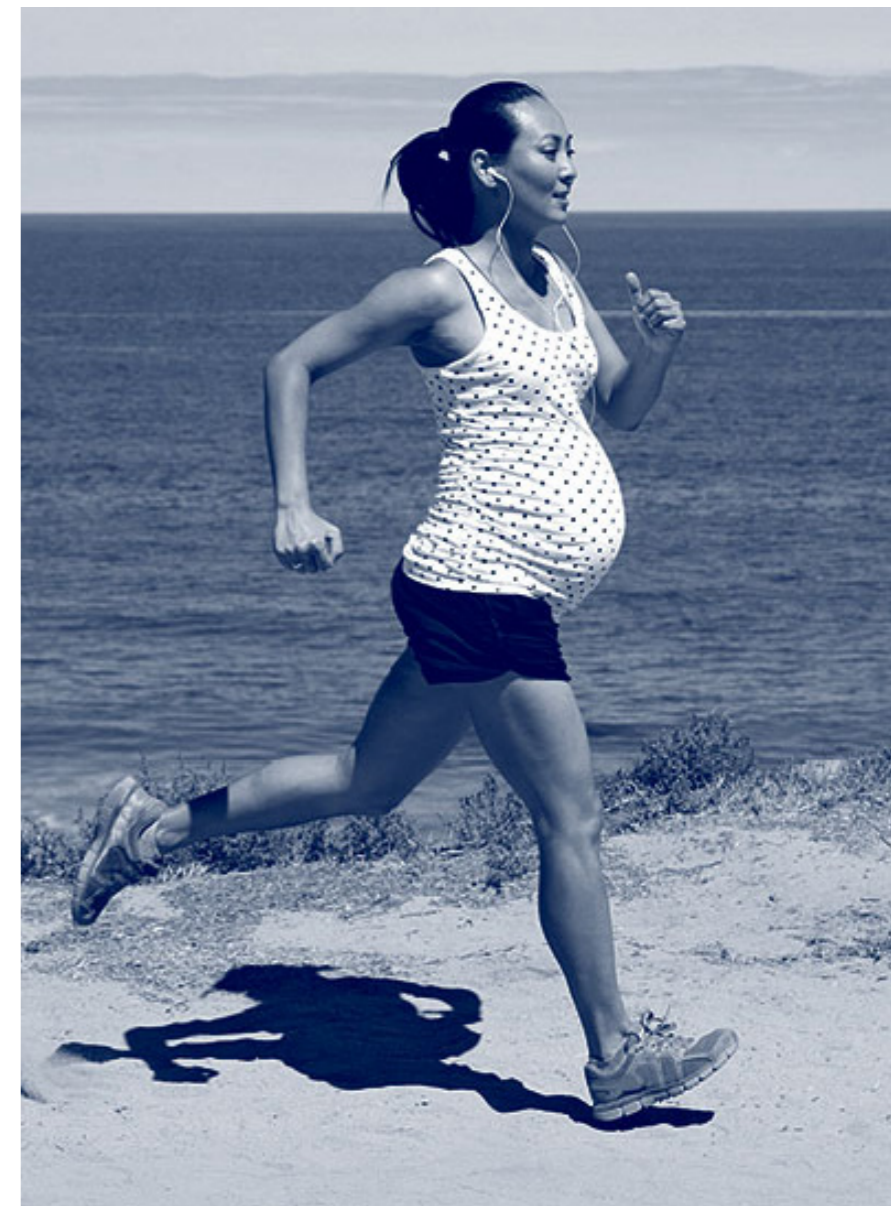
- //Contact sports (eg. ice hockey, boxing, soccer, and basketball)
- //Activities with a high risk of falling (downhill, snow skiing, water skiing, surfing, off-roading cycling, gymnastics, and horseback riding)
- //Scuba diving
- //Sky diving
- //Hot yoga or hot Pilates

In women with uncomplicated pregnancies in consultation with an obstetric care provider.

Yoga positions that result in decreased venous return and hypotension should be avoided as much as possible.

In consultation with an obstetric care provider, running, or jogging, racquet sports, and strength training, may be safe for pregnant women who participated in these activities regularly before pregnancy.

Racquet sports wherein a pregnant woman's changing balance may affect rapid movement and increase the risk of falling should be avoided as much as possible.





Absolute Contraindications

- //Hemodynamically significant heart disease
- //Restrictive lung disease
- //Incompetent cervix/cerclage
- //Multiple gestation at risk for premature labor
- //Premature labor during the current women with persistent second or third trimester bleeding or placenta preiva after 26 weeks of gestation (ACOG, 2002)

Relative Contraindications

- //Morbid obesity (100 pounds (45 kg) over ideal weight, a BMI of > 40 kg/m² or BMI > 35 kg/m² and experiencing obesity related health conditions such as high blood pressure or diabetes
- //Extreme underweight (BMI <12 kg/m²)
- //Severe anemia
- //Unevaluated maternal cardiac arrhythmia
- //Chronic bronchitis
- //Orthopedic limitations
- //History of extreme sedentary lifestyle
- //Intrauterine growth in the current pregnancy
- //Heavy smoking habit
- //Poorly controlled hypertension
- //Seizure disorder
- //Hyperthyroidism

Signs to Terminate Exercise

In case of the following signs and symptoms immediately terminate exercise and follow up with a physician:

- //Vaginal bleeding
- //Dyspnea prior to exertion
- //Dizziness
- //Headache
- //Chest Pain
- //Muscle weakness
- //Calf pain or swelling
- //Preterm labor
- //Decreased fetal movement
- //Amniotic fluid leakage (ACOG, 2002)

Lastly, the American Council of Obstetricians and Gynecologists had also tested and published the types of activities that are recommended to pregnant ladies due to their various exercise benefits (discussed in the “health benefits” section of this chapter), and the types of activities that are contraindicated due to the high risk they pose on the health of the pregnant mother and her fetus/child (ACOG. 2015, reaffirmed 2017).



PHYSIOLOGICAL CHANGES DURING PREGNANCY

Several physiological changes occur to the pregnant woman's body during the 38 weeks of pregnancy in order to accommodate and nurture the developing fetus for a healthy gestation and an uncomplicated delivery. **These changes are caused by the pregnant woman's endocrine system through hormones affecting her musculoskeletal, cardiovascular, respiratory and many other systems;** changes that must be acknowledged to maintain safe and effective physical activity throughout pregnancy.

Note that each and every one of these changes is completely normal and should resolve after delivery in all uncomplicated pregnancies.

Musculoskeletal System

One of the most noticeable changes that occur to the pregnant woman's body affects her musculoskeletal system. First, every pregnancy is accompanied by weight gain causing the build-up of extra pressure and mechanical stress on the joints leading to a discomfort at the level of previously normal joints, and an increased damage and injury risk on previously unhealthy joints. Second, the fact that the fetus develops in the female uterus at the level of the abdominal area shifts the pregnant lady's center of gravity upward and out putting an additional stress on the joints of the spine, pelvis, hip, knees and ankles; this posture change also leads to a decrease in balance and an increased risk of recurrent falls. Third, the increased production of relaxin and progesterone (Skinner, J., Bryant, C., Merrill, S., Green, D. 2015) to enlarge the uterine cavity and to loosen the sacroiliac and pubic symphysis ligaments will also lead to the softening of other ligaments especially at the lumbar area predisposing the pregnant mother to a higher risk of both sprain and strain injuries along with lordotic posture and lower back pain

Cardiovascular System

Several changes in the cardiovascular system take place during pregnancy. **Relaxin**, along with other hormones released throughout pregnancy causes the relaxation of the vascular smooth muscles or vasodilation decreasing both systolic and diastolic blood pressure (which leads to several symptoms including fatigue, lightheadedness, and nausea...) in addition to a decrease in the venous return. To correct this decrease in blood circulating back to the heart, the pregnant female's endocrine system releases hormones preventing salt and water excretion by the kidneys increasing the blood and plasma volume, heart rate and cardiac output in order to increase blood flow towards the tissues to meet their higher needs during pregnancy. The decreased urination also leads to an accumulation of extracellular fluid and possible lower limb edema.

Note that cardiac output increases gradually during the 1st and 2nd trimesters and plateaus after the 20th week till delivery

This increase in cardiac output is related to an increase in both heart rate and stroke volume. Blood pressure decreases in the 1st and 2nd trimesters to increase again gradually midway through the 3rd trimester reaching prepregnancy values (Hall, M. E., George, E. M., & Granger, J. P. 2011). All of these normal hemodynamic changes aim to improve the delivery of oxygen and nutrients to the baby and the mother especially during physical activity of the pregnant woman. Every certified medical exercise specialist must be aware of these changes and act accordingly: due to the fluctuations in the heart rate response, the intensity of **the exercises should be assessed via the RPE method (ratings of perceived exertion)**. Supine positions and motionless standing both decrease cardiac output especially during the 2nd and 3rd trimesters and must be avoided during workout.

Respiratory System

During pregnancy, the respiratory system undergoes changes as well. There are both biochemical and mechanical variations affecting the lungs function improving oxygen delivery to the fetus. On the biochemical level, the elevated estrogen and progesterone has a bronchodilator effect in addition to the fact that it increases the brain's respiratory center sensitivity for carbon dioxide stimulating **hyperventilation** and improving oxygen uptake along with carbon dioxide elimination. Mechanically, the enlarged uterus displaces the diaphragm upward (around 5cm) lengthening its muscular fibers allowing it to produce more tension creating extra space for the lungs to get filled with air. These changes increases the amount of gas exchange at the level of the alveoli with each breath (tidal volume) enabling more oxygen to reach both maternal and fetal tissues.

Hyperventilation is a condition in which you start to breathe very fast

Thermoregulatory System

An improvement in the ability of the pregnant woman to dissipate heat and regulates its body temperature is noticeable. During pregnancy, the increased amounts of blood reaching the skin (elevated cardiac output as mentioned in the cardiovascular system changes earlier in this chapter) allows for direct heat exchange with the atmospheric air or heat loss. Similarly, additional heat loss is detected with the increase in gas exchange with each breathe (elevated tidal volume as mentioned in the respiratory system changes earlier in this chapter) through expiration.

Note that fetal body temperature is 1 degree Celsius higher than the maternal body temperature.

This indicates that the exercising pregnant women must stay hydrated (in order to keep the blood volume and blood flow high) and avoid training in hot and/or humid environment otherwise she will face higher risks of hyperthermia which is scientifically proven to increase the risk of fetal neural tube defects (defects affecting the spine, spinal cord and/or brain of the fetus during the 1st month of pregnancy) (Skinner, J., Bryant, C., Merrill, S., Green, D. 2015).



BIOMECHANICAL CONSIDERATIONS

Understanding the Biomechanical Changes

During 10th to 12th week of pregnancy, production of the hormone relaxin significantly increases, allowing the pelvis to accommodate the enlarging uterus and weakening the static support in the lumbar spine (Aldabe et al., 2012). Advancing pregnancy produce a forward shift in the COG, anterior pelvic tilt, increase in lumbar lordosis, thoracic kyphosis.

Lower Back & Posterior Pelvic Girdle Pain

Exercise appropriate for pregnant women with lumbar pain include:

//Mobility and stretching movements that emphasize relaxing and lengthening the back extensors, hip flexors, scapular protractors, shoulder internal rotators and neck flexors

//Strengthening should focus on the abdominal, gluteal, scapular retractors and external rotators.

//The hypothetical origin of SI joint dysfunction during pregnancy focus on decreased stability of the pelvic girdle.

//Muscles may act to stabilize the SI joint include:

Internal and external obliques

Latissimus Dorsi

Erector Spinae (multifidus especially)

Gluteus Maximus

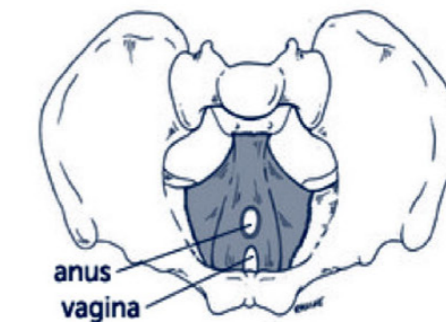
//Increasing muscular strength and endurance in these muscles may benefit women with prenatal pelvic pain

(Aldabe et al., 2012)

The hormone relaxin significantly increases, allowing the pelvis to accommodate the enlarging uterus and weakening the static support in lumbar spine

Pubic Pain

Normally the pre-pregnancy width of the pubic symphysis is 0.5mm, as pregnancy progress it continues to widen to maximum of 12mm. The irritation of the pubic symphysis caused by increased motion at the joint is called symphysisitis. Therefore, avoid weightbearing activities that intensity pain, physician evaluation, physical therapy and pubic belt may be prescribed (Soulтанakis, Artal, & Wiswell 1996).



Diastasis Recti

It is a partial or complete separation between the left & right sides of the rectus abdominis muscle, commonly seen after multiple pregnancies. Three main factors contributing to Diastasis Recti:

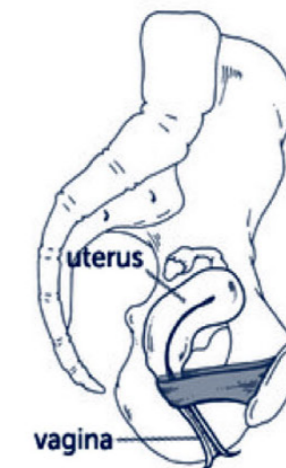
//Maternal hormones

//Mechanical stress with the abdominal cavity

//Weak abdominal muscles

According to research exercise during the prenatal period reduce the presence by 35% (Benjamin, van de Water, & Peiris, 2013).

levator ani



Stress Urinary Incontinence

It is the involuntary loss of urine that occurs with physical exertion and a raise in abdominal pressure. We can identify the following risk factors:

//Multiple Pregnancies

//Vaginal delivery

//High infant birth weigh (>3.7kg)

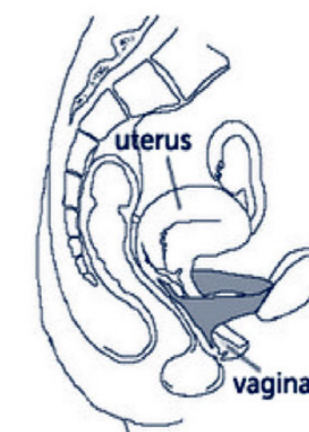
//Large infant cranial circumference (>35.1cm)

//High maternal weight during pregnancy (>13kg)

//Tearing the perineum during delivery

(Sangsawang & Sangsawang, 2013)

pubovaginalis



It is believed that training the pelvic floor muscles with exercises such as the kegel might help reduce it effect or prevent its occurrence; however, this topic is still debatable by literature

spincter urethrae



BODYWEIGHT SQUAT

Step 1

Starting Position: Begin standing with your feet slightly wider than hip-width, with the toes turned slightly outwards with your hands by your sides so the palms facing inwards. Depress and retract your scapulae (pull the shoulders down and back).

Step 2

Stiffen your core and abdominal muscles (“bracing”) to stabilize your spine. Hold your chest up and out, tilt your head slightly up, shift your weight back into your heels while pushing your hips towards the wall behind you.

Step 3

Downward Phase: Start the downward phase by first shifting your hips backwards then downwards to create a hinge-like movement at your hips and knees simultaneously. As you lower your hips the knees will then start to shift forward slowly, but try to control the amount of forward translation (movement) of the tibia (shinbone). Maintain tension in the core muscles (continue bracing) and attempt to keep your back flat.

Step 4

Continue to lower yourself until your thighs are parallel or almost parallel with the floor, until your heels begin to lift off the floor, or until your torso begins to round or flex forward. Monitor your feet, ankles and knees, ensuring that the feet don't move, the ankles do not collapse in or out and the knees remain aligned over the second toe.



Step 5

From the Lowered Position: the knees should continue to remain aligned over the second toe and body weight should be evenly distributed between the balls and heels of the feet. From the side, the position of the tibia (shinbone) and torso should be parallel with each other and the low back should appear flat or showing the beginning of some rounding.

Step 6

Upward Phase: While maintaining your back, chest and head-up position, exhale and extend the hips and knees by pushing your feet into the floor through your heels. The hips and torso need to rise together while keeping the heels flat on the floor and knees aligned over the second toe. Continue extending until you reach your starting position.

Think about inhaling on the way down and exhaling while exerting on the way back to the initial standing position.

while maintaining a neutral wrist position, and keep your head aligned with your spine while avoiding any arching your low back.

Step 3

Continue pressing until your elbows are fully extended, but not locked. Your shoulder blades should continue to make contact with the backrest and not round or bend forward. Pause momentarily then gently allow your elbows to flex (bend) in a slow, controlled manner while returning your hands back towards the starting position. Repeat the movement.



Exercise Variation: To increase the exercise intensity, perform the following variations: Perform unilateral (one arm at a time) presses

CHEST PRESS

Step 1

Stand with feet shoulder width apart. Grasp the handles with palms facing down, with the band portion behind you and the band is positioned no deeper than chest level (level with the front of your chest). Grasp the band firmly with a full grip (thumbs clasped around the handles) and maintain a neutral wrist position (i.e., wrists in line with your forearms). Position your feet firmly on the floor or on the foot rests to stabilize your body. Stiffen (“brace”) your abdominal muscles to stabilize your spine. Maintain the natural arch in your low back and avoid arching your back throughout the exercise. Depress and retract your scapulae (pull shoulders back and down) and attempt to hold this position throughout the exercise.

Step 2

Gently exhale and slowly perform a pressing movement, extending your elbows in front,

Very frequently individuals will press the band to a point where the shoulder blades round themselves forward and move off the backrest. This promotes instability within the muscles that hold the shoulder blades to the ribcage. While this “push-plus” movement is considered an advanced movement, focus initially on pressing while keeping your shoulder blades flat and firmly positioned against the backrest.

LATERAL LUNGE

Step 1

Stand with the feet hip-width apart holding one dumbbell in each hand with the palms facing each other.

Step 2

Step directly to the right, keeping the right foot parallel to the left as it hits the ground,

and push the right hip back while reaching for the right foot with both hands on either side of the right leg.

Step 3

To stand up, push the right foot into the floor while pulling the body back to the center with the inside of the left leg.



HIGH ROW

Step 1

Stand with the feet hip-width apart, the hips straight, the back tall, and the knees slightly bent. Place the cable pulley at about shoulder-height, attach a rope handle, and hold one end of the rope in each hand with the palms facing down.

Step 2

Turn to face the machine. Lift the chest up and pull the elbows back until the hands are right in front of the shoulders, then pause for 2-3 seconds.

Step 3

Slowly straighten the arms to return the weight to the starting position.



SHOULDER PRESS

Step 1

Place a barbell in a rack at about shoulder-height. Grip the bar with the hands about shoulder-width apart and the palm facing the ceiling.

Step 2

Dip under the bar to bring it off the rack letting it rest across the top of the shoulders so that the palms are facing the ceiling and the elbows are pointed straight ahead. Step back, keeping the back straight and tall and press the barbell directly overhead.

Step 3

Slowly return the weight to the shoulders and repeat for the desired number of reps.



LATERAL RAISE

Step 1

Starting Position: Stand holding dumbbells in your hands with a closed, neutral grip (thumbs around the handles and palms facing your body). Position the dumbbells alongside your thighs with your elbows extended or holding a slight bend. Assume either a split-stance position to stabilize your body or position your feet slightly wider than hip-width apart.

Step 2

Stiffen your torso by contracting your abdominal and core muscles ("bracing"), and depress and retract your scapulae (pull your shoulders down and back), maintaining this position throughout the exercise. Your head position should be aligned with your spine.

Step 3

Upward Phase: Exhale and slowly raise the dumbbells up and out to your sides. Your elbows and upper arms should rise together and be slightly ahead of your forearms and dumbbells. As your arms move past 60 - 70 degrees (nearing shoulder level), rotate them slightly upwards so that the front edge of the dumbbells point slightly upwards. Continue raising the dumbbells until your arms are level with your shoulders and approximately parallel with the floor. Maintain your torso erect (no arching your low back) and neutral wrist position (avoid flexion and extension of your wrists).

Step 4

Downward Phase: Inhale and gently lower the dumbbells back towards your starting position keeping your elbows slightly extended and holding the neutral grip position. Maintain your foot, torso, shoulder and wrist positions while lowering the dumbbells and rotating them slightly downwards as your arms pass that 60-70 degree mark.

As this exercise traditionally positions the arms into internal rotation during the lift, the slight external rotation initiated at the 60-70 degree mark may reduce potential impingement in the shoulder joint.



FRONT RAISE

Step 1

Starting Position: Stand holding dumbbells in front of you thighs using a closed, pronated grip (thumbs around the handles and palms facing your thighs). Position the dumbbells lightly touching the fronts of your thighs

with your elbows extended or holding a slight bend. Assume either a split-stance position to stabilize your body or position your feet slightly wider than hip-width apart.

Step 2

Stiffen your torso by contracting your abdominal/core muscles ("bracing"), and depress and retract your scapulae (pull your shoulders down and back), maintaining this position throughout the exercise. Your head position should be aligned with your spine.

Step 3

Upward Phase: Exhale and slowly raise the dumbbells up in front of your body. Your elbows and upper arms should rise together and be slightly ahead of your forearms and dumbbells. As your arms move past 60 - 70 degrees (nearing shoulder level), slowly rotate them upwards somewhat so that the inside edge of the dumbbells point slightly upwards. Continue raising the dumbbells until your arms are level with your shoulders and approximately parallel with the floor. Maintain an erect torso (no arching of your low back) and neutral wrist position (avoid flexion and extension of your wrists).



Step 4

Downward Phase: Inhale and gently lower the dumbbells back towards your starting position keeping your elbows slightly extended. Maintain your foot, torso, shoulder and wrist positions while lowering the dumbbells and rotating them slightly inwards as your arms pass that 60-70 degree mark.

Traditionally, this exercise positions the arms into internal rotation during the lift, so the slight external rotation initiated at the 60-70 degree mark may reduce potential impingement in the shoulder joint.

SIDE PLANK

Step 1

Starting Position: Lie on your right side on an exercise mat with your left leg lying directly over your right leg and bend your knees to a comfortable position. Raise your upper body to support yourself on your right arm, your right elbow should bend to 90 degrees and be positioned directly under your shoulder. Align your head with your spine and keep your hips and lower knee in contact with the exercise mat.

Step 2

Upward Phase: Exhale, gently contract your abdominal / core muscles to stiffen your spine and lift your hips off the mat, but keeping contact with your knee, and head aligned with your spine.

Step 3

Lowering Phase: Inhale and gently return yourself to your starting position.

Step 4

Exercise Variation: You can increase the exercise intensity by increasing the length of time you are in the raised position.



HAY BALER

Step 1

Standing with legs about hip-width apart, step one foot forward flat on the ground and the other leg back behind the body on the ball of

the foot. Hold the medicine ball in both hands near the hip of the leg that is behind.

Step 2

Twist through the chest and shoulders to bring the ball across the body and over the opposite shoulder, keeping both arms straight for the whole movement. When finished with one side, switch to the other side.



BICEP CURL

Step 1

Hold the barbell with both hands facing up so the wrists, elbows, and shoulders are in a straight line about shoulder-width apart.

Step 2

Lift the barbell toward the shoulders while bending the elbows and keeping them next to the middle of the body.

Step 3

Slowly lower the weight to return to the starting position. Keep chest still, using just the arms for the movement.



BIRD-DOG

Step 1

Starting Position: Kneel on an exercise mat or floor, positioning your knees and feet hip-width apart, with your feet dorsi-flexed (toes pointing towards your body).

Step 2

Slowly lean forward to place your hands on the mat, positioning them directly under your shoulders at shoulder-width with your fingers facing forward. Reposition your hands and knees as necessary so that your knees are directly under your hips and hands are directly under your shoulders.

Step 3

Stiffen your core and abdominal muscles to position your spine in a neutral position, avoid any excessive sagging or arching.

Step 4

Upward Phase: This exercise involves simultaneous movement of your leg and contralateral (opposite) arm. This exercise is best performed facing a mirror. **Hip Extension:** Slowly extend your left hip (raise and straighten the knee) attempting to extend it until it is at, or near parallel, to the floor without any rotation in the hip. Your goal is to keep both hips parallel to the floor. The use of a light bar placed across the hips, parallel to the waistline of your pants, provides visual feedback to hip rotation and what corrections are needed.

Step 5

Shoulder flexion: Slowly flex your right arm (raise and straighten the arm) attempting to raise it until it is at, or near parallel, to the floor without any tilting at the shoulders. Your goal is to keep the both shoulders parallel to the floor. The use of a light bar placed across the shoulders provides visual feedback to shoulder rotation and what corrections are needed. Your head should remain aligned with the spine throughout the movement.

Step 6

The degree of hip extension and shoulder flexion is determined by the ability to control against movement in the low back. As the leg is raised, individuals may witness an increase in lumbar lordosis (low back sagging). Only raise the limbs to heights where the low back position can be maintained through the combined actions of the core and abdominal muscles.

Step 7

Downward Phase: Gently lower yourself back to your starting position and repeat with the opposite limbs.

The bird-dog is an excellent exercise to train the body how to stabilize the lumbar spine (low back) during upper and lower extremity movement. Never exceed your body's capacity to control movement in the low back.





NUTRITIONAL CONSIDERATIONS

Introduction

During pregnancy and breastfeeding lifestyle and dietary habits are critical determinants of health of both mother and fetus. Starting from the preconceptional period, maternal nutrition is crucial to ensure the maternal well-being and pregnancy outcomes, as well as ensuring long term health of the offspring. In fact, current scientific literature highlights that the first 1000 days of life starting from conception plays an important role in the prevention of non-communicable diseases (NCDs) in adulthood (1). Moreover, certain maternal conditions such as obesity prior to pregnancy and excessive weight gain during pregnancy are associated with adverse pregnancy outcomes and influences negatively child's health in its early life (2). Breastfeeding, "the gold standard" of infant feeding has also a critical role in infant health outcome. It is well known that it saves and improves the quality of life (3).

Optimizing nutrition prior and during pregnancy and promoting breastfeeding are critical interventions to reduce chronic disease risk later in life.

Appropriate weight gain and consumption of an adequate healthy diet are two key components of a health-promoting lifestyle during pregnancy. The optimal supply of nutrients and oxygen from the mother to the developing fetus is required to achieve appropriate fetal growth and development. During pregnancy, the total energy needs are increased because of the increased maternal metabolism, blood volume and red cell mass expansion by 50%, and the delivery of nutrients to the fetus (4).

Energy Expenditure during Pregnancy

A total of **80,000 kcal** is needed to support a full-term pregnancy to account for increased maternal metabolism and fetal growth. Thus, caloric intake should increase by about **300**

kcal/day during pregnancy (the mean pregnancy duration is 250 days) (5). The Institute of Medicine 2002, advise no additional calories for the first trimester, addition of 340 Kcal/day for the second trimester and 452 kcal/day in the third trimester. However, there are factors that affect caloric requirements such as woman's age, preconception BMI, and activity level. **Therefore, caloric intake must be individualized.**

Macronutrient needs

Protein

To ensure the full-term delivery of a healthy newborn, adequate dietary protein is crucial during pregnancy. Protein needs increases progressively throughout pregnancy to maintain maternal tissues and fetal growth, particularly during the third trimester. Thus, guidelines agree on increasing protein requirements during pregnancy, especially during the second and third trimester to ensure the extra 21 grams needed for maternal tissues and fetal growth (6). Protein recommendation for non-pregnant women is 0.8g of protein/kg/day. However, according to the 2002 DRI for pregnant women, **the amount of protein recommended is 1.1g of protein/kg/day, or an extra 25 g/day to meet the requirements of pregnancy.** Insufficient energy and protein intake during pregnancy may be associated with preterm birth and have several adverse effects on both mother and fetus (7).

Carbohydrates

Glucose is the main energy substrate for fetal rapid growth and development and is transmitted in a regular from mother to fetus (8). It should be available to the fetus at all times to ensure his normal growth. **The recommended daily allowance (RDA) for pregnant women is 175 g/day** whereas the RDA for non-pregnant women is 130 g/day. Moreover, adequate fiber supply is important during pregnancy; it helps in reducing constipation which is a common side effect of pregnancy. The DRI for fiber during pregnancy is 28 g/day. Fiber rich foods include whole-grain

bread and cereals, fresh fruits and vegetables and legumes.

Furthermore, during pregnancy adequate carbohydrate intake is crucial for an active pregnant woman. Indeed, pregnant women use carbohydrates at a higher rate during exercise than do non-pregnant women (9). Studies have shown that there is preferential use of carbohydrates during anaerobic exercises such as non-weight bearing exercise during pregnancy (10).

Fats

During pregnancy, the quality of fats is more important than their total quantity. In fact, PUFA Polyunsaturated fatty acid are of utmost importance; they play a critical role in fetal development and infant growth. Eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA), and docosahexaenoic acid (DHA) are typically referred to as n-3 long-chain PUFA. Many systematic reviews revealed a positive impact of maternal intake and status of n-3 long-chain PUFA during pregnancy and lactation on maternal, infant, and child health.

Of these n-3 long-chain PUFA, DHA is of greatest importance. Indeed, it is the main PUFA in the human brain and retinal rods and, thus, is critical for optimal fetal neurodevelopment. Several literatures supported the benefits of DHA for the fetus and overall infant health and maternal health (14) (15).

DHA and EPA can only be obtained from dietary sources. The richest sources of these fatty acids are seafood and fish oil supplements. Vegetable oils and flax seed oil do not contain directly EPA and DHA, they contain ALA that needs to be converted to EPA and DHA to become biologically active. According to US Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) **pregnant woman should consume 2 to 3 serving of seafood per week to optimize pregnancy outcomes (16).** The 2015–2020 Dietary Guidelines for Americans states that pregnant or lactating women should consume 8–12 ounces of low mercury fish every week, such as salmon, sardines, and trout.



Micronutrients needs

Micronutrient requirements during pregnancy increase more than those of macronutrients. They play a crucial physiological role in pregnancy.

Insufficient intakes influence fetal development and can have significant consequences for the mother.

A pregnant woman should make sure to get enough of each vitamin/mineral and not to exceed the daily maximum for each vitamin/mineral.

Folic acid

Folate requirements are greater in pregnancy than in the non-pregnant state in order to support rapid cell growth in the fetus and placental development. Women should be advocated to maintain a healthy folate-rich diet.

Rich sources of folate include dark-green leafy vegetables, orange juice, legumes and fortified foods such as bread and cereals.

Dietary supplementation with folate for women planning a pregnancy or recently pregnant is recommended. In fact, folic acid supplementation taken prior to conception has long been known to decrease the risk of neural tube defects (NTDs) in the newborn (17). According to the U. S. Public Health Service and CDC, **women of childbearing age are recommended to take 400 micrograms of folic acid daily (18).**

Iron

During pregnancy, iron requirement gradually increases until the third month, in parallel with the accumulation in fetal tissues. **Insufficient intakes during pregnancy may affect growth and development of the fetus, and are associated with increased risk of preterm delivery, low birth weight and post-partum hemorrhages (20).** Moreover, recent studies presented an association between inadequate

iron intakes during pregnancy and increased cardiovascular risk for the offspring later in adult life (21). **According to the Center for Disease Control and Prevention and the WHO it is advised that iron intake for all pregnant women is 27 mg per day.** Iron supplementation is often recommended to meet the iron needs of both mother and fetus, and to optimize pregnancy outcomes (19) (20).

Calcium

During pregnancy there is no need for additional calcium intake since its intestinal absorption increases (22). According to World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO), **pregnant women are recommended to consume 1200 mg/day of calcium (23).** Several adverse effects in both the mother and the fetus occur in case of inadequate calcium consumption during pregnancy, such as: **Osteopenia, poor fetal mineralization, muscle cramping, low birth weight and delayed fetal growth (24).** Adequate calcium intake through calcium-rich foods should be promoted. However, when calcium intake is low, calcium supplementation is recommended. Numerous studies have suggested that calcium supplementation during pregnancy decreases the risk of pre-eclampsia, especially among pregnant woman with high risk of hypertension (24).

Gestational weight gain

There are notably two key parameters that influences pregnancy outcome and offspring birth weight: pre-pregnancy body mass index (BMI) and gestational weight gain (GWG) (25). In fact, these two are known to be predictors of the maternal nutritional status. Healthier offspring and maternal outcomes were shown with adequate pre-pregnancy weight and gestational weight gain (26).

The weight gain during pregnancy is ~8 kg which accounts for the fetus, the placenta, amniotic fluid volume, breast tissues and uterus, interstitial fluid and blood volume.

Gradually, maternal adipose tissue increase serving as an energy reserve for pregnancy and lactation. If weight gain is less than 8Kgs this indicates that existing maternal adipose and protein stores will be catabolized in order to support the pregnancy. The last recommendations of pregnancy weight gain according to different BMI categories has been released in 1990.

Excessive gestational weight gain

Excessive gestational weight gain (GWG) is a public health concern in both developed and developing countries. Women who gain weight in excess of current recommendations during pregnancy have a higher risk to develop pregnancy complications such as **gestational diabetes mellitus (27)** and also **increases their likelihood to remain overweight postpartum.** Moreover, they increase the risk of delivering a baby by caesarean section (28) and put their child at a greater risk of childhood overweight or obesity (29).

Inadequate gestational weight gain

Deficiencies of calories and macronutrients during pregnancy is just as harmful as their excess.

Low gestational weight gain is considered to be an independent predictor of negative pregnancy outcomes. In fact, studies have found that it is positively associated with preterm birth and increased risk of low birth weight (30) (31).

Nutrition during lactation

Breast milk is considered the “gold standard” for infant feeding. The World Health Organization, the American Academy of Pediatrics, the Academy of Breastfeeding Medicine and the American Congress of Obstetricians and Gynecologists all support this statement. According to the American Academy of Pediatrics, exclusive breastfeeding should be recommended for the first 6 months and breastfeeding at least through the first year of life (39). Mother’s energy needs and nutritional

requirements increases during lactation to ensure milk production. **In fact, the energy content of the milk is 67 Kcal/100 mL (40).** **Thus, during the first 6 months’ breastfeeding women requires 500 additional Kcal/day (41).** Lactating women usually lose 0.5 to 1 Kg/month.

During lactation, carbohydrates are important to support adequate energy level and to provide enough calories in the diet for milk production. **Thus, the RDA of breastfeeding women for carbohydrate is 210 g/day.**

As for protein intake during exclusive breastfeeding, it should be increased by 21 g/day in the first semester and 14 g/day later, if breastfeeding is continued throughout the year (43).

The American Academy of Pediatrics advices breastfeeding women to consume **one to two servings of fish per week** to assure a sufficient amount of DHA in breast milk (44). Indeed, the DHA is critical in the first months for the newborn psychomotor neurodevelopment. However, **the overall intake of fat during breastfeeding is not necessary to change (45).**

Exclusive breastfeeding should be recommended for the first 6 months and breastfeeding at least through the first year of life

PHYSIOLOGICAL CONSIDERATIONS

Physiological changes following pregnancy

Similarly to the changes occurring throughout pregnancy, the physiological changes that take place following pregnancy are related to the endocrine system as well. In fact all of the hormones that get excessively secreted during pregnancy return to prepregnancy levels after delivery resulting in some physiological variations affecting the musculoskeletal, respiratory and cardiovascular systems.

Although the maternal hormones secreted throughout pregnancy will decrease to return to its prepregnancy levels; the effects of these hormones like relaxin for example takes some time to subside.

The softening of the pregnant woman's body joints during the period of pregnancy can take up to eight months postpartum to subside.

Another postpartum variation affecting the musculoskeletal system is the possible development of rounded shoulders (kyphosis) that is highly related to lactation. During lactation the mother holds her baby in a specific way to help him/her reach for her breasts adopting a forward-rounded shoulders position that gets repeated daily for a period of several months. This increases the risk of abnormal posture which gets aggravated by the fact that lactation is associated with an increase in breasts weight. Another area of concern after pregnancy is tightening pelvic floor muscles (levator ani, pubovaginalis and sphincter urethrae) that must go in parallel with tightening the abdominal core muscles via kegel exercises along with pelvic tilts; exercises that should be of light intensity at first and progress slowly and gradually in order to avoid any compression affecting the abdominal wall and/or the pelvic floor.

Female pelvic floor muscles

Both the cardiovascular and respiratory systems undergo changes postpartum as well. The increase in cardiac output, heart rate, stroke volume, plasma and blood volume that take place during pregnancy decrease gradually after delivery to finally reach its prepregnancy levels within six to eight weeks. The increased tidal volume that occurred during pregnancy will also return to its normal prepregnancy levels within six to twelve weeks after delivery (*Skinner, J., Bryant, C., Merrill, S., Green, D. 2015*).

Due to all of these postpartum physiological changes affecting the mother's body, it is recommended that postpartum exercise programs start slowly and progress gradually. It is advised that exercise during the first six weeks after delivery should be guided to help the mother regain some sense of control over her body muscles and joints; for the remainder of the first year after delivery, the exercise program should target maternal physical fitness. However, if the delivery was either complicated or by C-section, the ACSM declared back in 2014 that the mother should consult her physician before returning to physical activity eight to ten weeks after delivery (*Skinner, J., Bryant, C., Merrill, S., Green, D. 2015*).

Psychological Consideration

Pregnancy is associated with increased psychological distress for some women, which may include anxiety and depression.

Antenatal depression has estimated prevalence rate 10 to 13%. Exposing pregnant women to poor self-care, premature labor, low birth weight, longer hospital stays, and compromise mother child bonding. Moreover, it's a predictor of postpartum depression.



REFERENCES

- American Council on Exercise (2015). *Medical Exercise Specialist Manual*. San Diego, Calif.: American Council on Exercise.
- ACOG Committee Opinion No. 650: Physical Activity and Exercise During Pregnancy and the Postpartum Period. (2015). *Obstetrics and Gynecology*, 126(6), e135-142. <https://doi.org/10.1097/AOG.0000000000001214>
- Adair L.S. Long-term consequences of nutrition and growth in early childhood and possible preventive interventions. *Nestlé Nutr. Inst. Workshop Ser.* 2014;78:111-120.
- Alwan N.A., Cade J.E., McArdle H.J., Greenwood D.C., Hayes H.E., Simpson N.A. Maternal iron status in early pregnancy and birth outcomes: Insights from the Baby's Vascular health and Iron in Pregnancy study. *Br. J. Nutr.* 2015;113:1985-1992. doi: 10.1017/S0007114515001166.
- American College of Obstetricians and Gynecologists (2013). *Practice Bulletin No. 137: Gestational diabetes mellitus*. *Obstetrics & Gynecology*, 122, 2, 406-416.
- American College of Sports Medicine (2018). *ACSM's Guidelines for Exercise Testing and Prescription (10th ed.)*. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins.
- Artal R, Lockwood CJ, Brown HL. Weight gain recommendations in pregnancy and the obesity epidemic. *Obstet Gynecol* 2010; 115:152
- Artal R, Masaki DI, Khodiguian N, et al. Exercise prescription in pregnancy: weight-bearing versus non-weight-bearing exercise. *Am J Obstet Gynecol* 1989;161:1464-9.
- Artal R, O'Toole M., (2003), Guidelines of the American College of Obstetricians and Gynecologists for exercise during pregnancy and the postpartum period. *British Journal of Sports Medicine*, 37:6.
- Berti C., Cetin I., Agostoni C., Desoye G., Devlieger R., Emmett P.M., Ensenauer R., Hauner H., Herrera E., Hoesli I., et al. Pregnancy and infants' outcome: Nutritional and metabolic implications. *Crit. Rev. Food Sci. Nutr.* 2016;56:82-91. doi: 10.1080/10408398.2012.745477
- Bezerra Maia e Holanda Moura, S., Marques Lopes, L., Murthi, P., & da Silva Costa, F. (2012). Prevention of Preeclampsia. *Journal of Pregnancy*, 2012. <https://doi.org/10.1155/2012/435090>
- Cetin I., Berti C., Mandò C., Parisi F. Placental iron transport and maternal absorption. *Ann. Nutr. Metab.* 2011;59:55-58.
- Choi J, Fukuoka Y, Lee JH. The effects of physical activity and physical activity plus diet interventions on body weight in overweight or obese women who are pregnant or in postpartum: a systematic review and meta-analysis of randomized controlled trials. *Prev Med.* 2013;56:351-64.
- Clapp, J.F. & Cramm, C. (2012). *Exercising Through Your Pregnancy (2nd ed.)* Omaha, Nebr.: Addicus Books, Inc.
- Currie, S. et al. (2013). Reducing the decline in physical activity during pregnancy: A systematic review of behavior-change interventions. *PLoS One*, 8, 6, e66385.
- Da Silva, J.R. et.al. (2013). Effects of an aquatic physical exercise program on glycemic control and perinatal outcomes of gestational diabetes: Study protocol for a randomized controlled trial. *Trials*, 14, 390.
- Davis RR, Hofferth SL. The association between inadequate gestational weight gain and infant mortality among U. S. infants born in 2002. *Matern Child Health J.* 2012;16:119-24.
- De Wals P, Tairou F, Van Allen MI, et al. Reduction in neural-tube defects after folic acid fortification in Canada. *N Engl J Med.* 2007; 357:135-142
- Dieterich, C. M., Felice, J. P., O'Sullivan, E., & Rasmussen, K. M. (2013). Breastfeeding and Health Outcomes for the Mother-Infant Dyad. *Pediatric Clinics of North America*, 60(1), 31-48. <http://doi.org/10.1016/j.pcl.2012.09.010>
- Effects of Resistance Training on Fatigue-Related Domains of... : *Psychosomatic Medicine*. (n.d.). Retrieved May 31, 2018, from https://journals.lww.com/psychosomaticmedicine/Abstract/2018/04000/Effects_of_Resistance_Training_on_Fatigue_Related.11.aspx
- English, F. A., Kenny, L. C., & McCarthy, F. P. (2015). Risk factors and effective management of preeclampsia. *Integrated Blood Pressure Control*, 8, 7-12. <https://doi.org/10.2147/IBPC.S50641>
- Evenson, K. R., Barakat, R., Brown, W. J., Dargent-Molina, P., Haruna, M., Mikkelsen, E. M., ... Yeo, S. (2014). Guidelines for Physical Activity during Pregnancy: Comparisons From Around the World. *American Journal of Lifestyle Medicine*, 8(2), 102-121. <https://doi.org/10.1177/1559827613498204>
- Guidelines for perinatal care. 7th American Academy of Pediatrics and the American College of Obstetricians and Gynecologists; Washington, DC: 2012.
- Hall, M. E., George, E. M., & Granger, J. P. (2011). The Heart During Pregnancy. *Revista Espanola de Cardiologia*, 64(11), 1045-1050. <https://doi.org/10.1016/j.recesp.2011.07.009>
- Harris ST, Liu J, Wilcox S, et al. Exercise during pregnancy and its association with gestational weight gain. *Matern Child Health J.* 2015;19(3):528-37.
- Hedderson MM, Gunderson EP, Ferrara A. Gestational weight gain and risk of gestational diabetes mellitus. *Obstet Gynecol.* 2010;115:597-604.
- Herring SJ, Nelson DB, Davey A, et al. Determinants of excessive gestational weight gain in urban, low-income women. *Womens Health Issues.* 2012;22(5):e439-46.
- Homko CJ, Sivan E, Reece EA, et al. Fuel metabolism during pregnancy. *Semin Reprod Endocrinol* 1999;7:119-25.
- Hopkins, S., & Artal, R. (2013). Exercise and the Risk of Gestational Diabetes Mellitus. (n.d.). Retrieved November 5, 2018, from <http://www.medscape.com/viewarticle/814112>
- Horvath, A., Koletzko, B., and Szajewska, H. 2007. Effect of supplementation of women in high-risk pregnancies with long-chain polyunsaturated fatty acids on pregnancy outcomes and growth measures at birth: a meta-analysis of randomized controlled trials. *Br. J. Nutr.* 98(2): 253-259.
- Imhoff-Kunsch, B., Briggs, V., Goldenberg, T., and Ramakrishnan, U. 2012. Effect of n-3 long-chain polyunsaturated fatty acid intake during pregnancy on maternal, infant, and child health outcomes: a systematic review. *Paediatr. Perinat. Epidemiol.* 26(Suppl. 1): 91-107.
- Jiang, H., Qian, X., Li, M., Lynn, H., Fan, Y., Jiang, H., ... He, G. (2012). Can physical activity reduce excessive gestational weight gain? Findings from a Chinese urban pregnant women cohort study. *The International Journal of Behavioral Nutrition and Physical Activity*, 9, 12
- Jiang, H., Qian, X., Li, M., Lynn, H., Fan, Y., Jiang, H., ... He, G. Can physical activity reduce excessive gestational weight gain? Findings from a Chinese urban pregnant women cohort study. *The International Journal of Behavioral Nutrition and Physical Activity*, 2012 ;9-12
- Kaiser L.L., Allen L. Position of the american dietetic association: Nutrition and lifestyle for a healthy pregnancy outcome. *J. Am. Diet. Assoc.* 2002;102:1479-1490. doi: 10.1016/S0002-8223(02)90327-5.
- Khambalia A.Z., Collins C.E., Roberts C.L., Morris J.M., Powell K.L., Tasevski V., Nassar N. Iron deficiency in early pregnancy using serum ferritin and soluble transferrin receptor concentrations are associated with pregnancy and birth outcomes. *Eur. J. Clin. Nutr.* 2015;70:358-363. doi: 10.1038/ejcn.2015.157.
- Kim, E. H., Kim, I. K., Kwon, J. Y., Kim, S. W., & Park, Y. W. (2006). The Effect of Fish Consumption on Blood Mercury Levels of Pregnant Women. *Yonsei Medical Journal*, 47(5), 626-633.
- Koh H, Ee TX, Malhotra R, Allen JC, Tan TC, Ostbye T. Predictors and adverse outcomes of inadequate or excessive gestational weight gain in an Asian population. *J Obstet Gynaecol Res.* 2013;39:905-13
- Koletzko B., Cetin I., Brenna J.T. Dietary fat intakes for pregnant and lactating women. *Br. J. Nutr.* 2007;98:873-877.
- Kramer M.S., Kakuma R. Energy and protein intake in pregnancy. *Cochrane Database Syst. Rev.* 2003 doi: 10.1002/14651858.CD000032
- Lauritzen L., Carlson S.E. Maternal fatty acid status during pregnancy and lactation and relation to newborn and infant status. *Matern. Child Nutr.* 2011;7:S41-S58. doi: 10.1111/j.1740-8709.2011.00303.x
- Leddy, M. A., Power, M. L., & Schulkin, J. (2008). The Impact of Maternal Obesity on Maternal and Fetal Health. *Reviews in Obstetrics and Gynecology*, 1(4), 170-178.
- LoMauro, A., & Aliverti, A. (2015). Respiratory

- physiology of pregnancy. *Breathe*, 11(4), 297–301. <https://doi.org/10.1183/20734735.008615>
- Marangoni, F., Cetin, I., Verduci, E., Canzone, G., Giovannini, M., Scollo, P., ... Poli, A. (2016). Maternal Diet and Nutrient Requirements in Pregnancy and Breastfeeding. An Italian Consensus Document. *Nutrients*, 8(10), 629. <http://doi.org/10.3390/nu8100629>
- Margerison Zilko CE, Rehkopf D, Abrams B. Association of maternal gestational weight gain with short- and long-term maternal and child health outcomes. *Am J Obstet Gynecol*. 2010;202:574. e1-8.
- Morrison, J. L., & Regnault, T. R. H. (2016). Nutrition in Pregnancy: Optimising Maternal Diet and Fetal Adaptations to Altered Nutrient Supply. *Nutrients*, 8(6), 342.
- National Institute of Medicine. Dietary reference intakes for Calcium and vitamin D. New York, National Academies Press, 2011.
- Nutrition during lactation. Institute of Medicine, National Academy Press; Washington, DC: 1991.
- O Connor, P. J., Poudevigne, M. S., Johnson, K. E., Brito de Araujo, J., & Ward-Ritacco, C. L. (2018). Effects of Resistance Training on Fatigue-Related Domains of Quality of Life and Mood During Pregnancy: A Randomized Trial in Pregnant Women With Increased Risk of Back Pain. *Psychosomatic Medicine*, 80(3), 327–332. <https://doi.org/10.1097/PSY.0000000000000559>
- Office of Disease Prevention and Health Promotion: physical activity for women during pregnancy and the postpartum period. <http://www.health.gov/paguidelines/guidelines/chapter7.aspx>. Accessed December 11, 2015.
- Padayachee, C., & Coombes, J. S. (2015). Exercise guidelines for gestational diabetes mellitus. *World Journal of Diabetes*, 6(8), 1033–1044. <https://doi.org/10.4239/wjd.v6.i8.1033>
- Pediatrics*. 2012;129(3):e827–841.\
- Pelvic Floor Muscles. (n.d.). Retrieved November 12, 2018, from <https://myhealth.alberta.ca:443/Health/Pages/conditions.aspx?hwid=zm6406>
- Petrov Fieril, K., Fagevik Olsén, M., Glantz, A., & Larsson, M. (2014). Experiences of exercise during pregnancy among women who perform regular resistance training: a qualitative study. *Physical Therapy*, 94(8), 1135–1143. <https://doi.org/10.2522/ptj.20120432>
- Rasmussen KM, Yaktine AL. Weight gain during pregnancy: re-examining the guidelines. Washington DC: National Academy Press; 2009
- Recommandations for the Use of Folic Acid to Reduce the Number of Cases of Spina Bifida and Other Neural Tube Defects, U.S. Department of Health and Human Services Public Health Service Centers for Disease Control Atlanta, Available at <https://www.cdc.gov/mmwr/preview/mmwrhtml/00019479.htm>
- Restall A, Taylor RS, Thompson JM, et al. Risk factors for excessive gestational weight gain in a healthy, nulliparous cohort. *J Obes*. 2014;2014:148391.
- Sallis H., Steer C., Paternoster L., Davey Smith G., Evans J. Perinatal depression and omega-3 fatty acids: A Mendelian randomisation study. *J. Affect. Disord*. 2014;166:124–131. doi: 10.1016/j.jad.2014.04.077
- Sanabria Martínez, G., Garcíab Hermoso, A., Poyatos León, R., Álvarez Bueno, C., Sánchez López, M., & Martínez Vizcaíno, V. (2015). Effectiveness of physical activity interventions on preventing gestational diabetes mellitus and excessive maternal weight gain: a meta-analysis. *BJOG: An International Journal of Obstetrics & Gynaecology*, 122(9), 1167–1174. <https://doi.org/10.1111/1471-0528.13429>
- Scan sports, cardiovascular, and wellness nutrition nutritionists, 2012, fueling the pregnant athlete, academy of nutrition and dietetics; Available at <https://www.scandpg.org/store/products/10319/>
- Section on Breastfeeding. Breastfeeding and the use of human milk. *Pediatrics* 2012;129:2011-3552
- Siega-Riz AM, Viswanathan M, Moos MK, et al. A systematic review of outcomes of maternal weight gain according to the Institute of Medicine recommendations: birth weight, fetal growth, and postpartum weight retention. *Am J Obstet Gynecol*. 2009;201(4):339. doi: 10.1016/j.ajog.2009.07.002.
- Skinner, J., Bryant, C., Merrill, S., Green, D. (2015). ACE medical exercise specialist manual. San Diego, California: American Council on Exercise
- Society of Obstetricians and Gynaecologists of Canada & Canadian Society for Exercise Physiology (2003). Joint SOGC/CSEP clinical practice guideline: Exercise in pregnancy and the postpartum period. *Journal of Obstetrics and Gynaecology Canada*, 25, 6, 516-522.
- Soma-Pillay, P., Catherine, N.-P., Tolppanen, H., Mebazaa, A., Tolppanen, H., & Mebazaa, A. (2016). Physiological changes in pregnancy. *Cardiovascular Journal of Africa*, 27(2), 89–94. <https://doi.org/10.5830/CVJA-2016-021>
- Soultanakis HN, Artal R, Wiswell RA. Prolonged exercise in pregnancy: glucose homeostasis, ventilatory and cardiovascular responses. *Semin Perinatol*1996;20:315–27
- Stuebe AM, Oken E, Gillman MW, et al. Associations of diet and physical activity during pregnancy with risk for excessive gestational weight gain. *Am J Obstet Gynecol*.2009;201:58e1–8
- Szostak-Wegierek D., (2000), Importance of proper nutrition before and during pregnancy, *Med Wieku Rozwoj*; 4(3 Suppl 1):77-88.
- Szymanski & Satin, A. (2012). Exercise during pregnancy: Fetal responses to current public health guidelines, *Obstetrics & Gynecology*, 119, 3, 603-610.
- Tomic, V. et al. (2013). The effect of maternal exercise during pregnancy on abnormal fetal growth. *Croatian Medical journal*, 54, 4, 362-368.
- Trumbo P, Yates AA, Poos M. Food and Nutrition Board, Institute of Medicine: Dietary Reference Intakes for Energy, Carbo-hydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. National Academies Press; Washington, DC: 2002. SS.
- Trumbo P., Schlicker S., Yates A. A., Poos M. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. *J. Am. Diet. Assoc*. 2002;102:1621–1630. doi: 10.1016/S0002-8223(02)90346-9
- US Food and Drug Administration Web site, authors. Eating Fish: What Pregnant Women and Parents Should Know (January 2017). <https://www.fda.gov/downloads/Food/FoodborneIllnessContaminants/ Metals/UCM537120.pdf>
- Villar J et al. Methodological and technical issues related to the diagnosis, screening, prevention and treatment of pre-eclampsia and eclampsia. *International Journal of Gynecology and Obstetrics*, 2004, 85(Suppl. 1):S28– S41.
- Weekly SJ. Diets and eating disorders: implications for the breastfeeding mother. *NAACOG's clinical issues in perinatal and women's health nursing*. 1992;3(4):695–700.
- Weissgerber T.L. et al. (2006). Exercise in the prevention and treatment of maternal-fetal disease.
- White, E., Pivarnik, J., & Pfeiffer, K. (2014). Resistance training during pregnancy and perinatal outcomes. *Journal of Physical Activity & Health*, 11(6), 1141–1148. <https://doi.org/10.1123/jpah.2012-0350>
- World Health Organization, Food and Agricultural Organization of the United Nations. Vitamin and mineral requirements in human nutrition, 2nd ed. Geneva, World Health Organization, 2004 (<http://www.who.int/nutrition/publications/micronutrients/9241546123/en/index.html>, accessed 13 June 2013).
- Wrotniak BH, Shults J, Butts S, Stettler N. Gestational weight gain and risk of overweight in the offspring at age 7 y in a multicenter, multiethnic cohort study. *Am J Clin Nutr*. 2008;87:1818–1824.
- Yang, H., Xun, P., and He, K. 2013. Fish and fish oil intake in relation to risk of asthma: a systematic review and meta-analysis. *PLoS ONE*, 8(11): e80048. doi: 10.1371/journal.pone.0080048.



SPECIAL CONSIDERATIONS

Maternal Exercise & Fetal Response

Theoretical Concerns Surrounding Maternal Exercise:

//The selective redistribution of blood flow away from the fetus during regular or prolonged exercise in pregnancy.

//Transient Hypoxia resulting in fetal tachycardia and increase in fetal blood pressure. No reports to link such adverse event.

//Intrauterine growth restriction due to strenuous physical activity. Studies are inconclusive. It has been reported that participating in moderate to high intensity P.A. have a higher risk than light to moderate intensity P.A.

Special Considerations

The health concerns affecting both the pregnant women and the fetus/child get worse as the BMI values of the future mother to be rises

Even though physical activity is proven to be effective during and after pregnancy, there are some cases that require special considerations since they may cause negative health consequences on the pregnant women and the unborn child. For this reason, any of the following special considerations: **gestational diabetes mellitus, preeclampsia and/or maternal obesity**, can impose changes on the course of a pre and postnatal exercise program.

Gestational Diabetes Mellitus (GDM)

The increase in blood glucose levels (hyperglycemia) or glucose intolerance that affects the pregnant women during their pregnancies.

Gestational diabetes mellitus is becoming one of the most common medical complications of pregnancy (Hopkins, S., & Artal, R. 2013). Although it usually resolves after delivery, if not treated, it can prevail as type 2 diabetes mellitus affecting the mother later in her life,

.....jaundice (yellow discoloration of the newborn's skin and eyes due to excessive bilirubin pigmentation)

it can also increase the risk of hypertension, preeclampsia and cesarean section delivery. Regarding the baby's future health, untreated GDM can lead to macrosomia (figure 1), acute breathing difficulty, jaundice along with hypoglycemia. Gestational diabetes mellitus (GDM) can be due to either a family history of GDM or Diabetes mellitus type 2, maternal obesity, increased maternal age of equal or more than 35, hypertension, sedentary lifestyle and poor nutrition (Padayachee, C., & Coombes, J. S. 2015). Due to its detrimental effects on the health of both the pregnant women/mother to be and the fetus/newborn baby, in addition to the fact that some of the most important risk factors leading to GDM are maternal obesity and sedentary lifestyle; medically cleared prenatal exercise plays a crucial role in both preventing and treating GDM (American College of Sports Medicine, 2014).

Preeclampsia

A serious disorder that can affect several body systems, preeclampsia is referred as a medical disorder usually diagnosed after 20 weeks of pregnancy and characterized by the combination of maternal persistent hypertension of >140/90 mmHg and proteinuria of >300mg protein present in maternal urine over a period of 24 hours.

Risk factors of preeclampsia include **maternal obesity, increased maternal age, renal problems, pre-existing hypertension, previous preeclampsia, family history of preeclampsia, first pregnancy and multiple pregnancies** (English, F. A., Kenny, L. C., & McCarthy, F. P. 2015). Beside being directly responsible of several maternal deaths annually, preeclampsia can lead to several complications

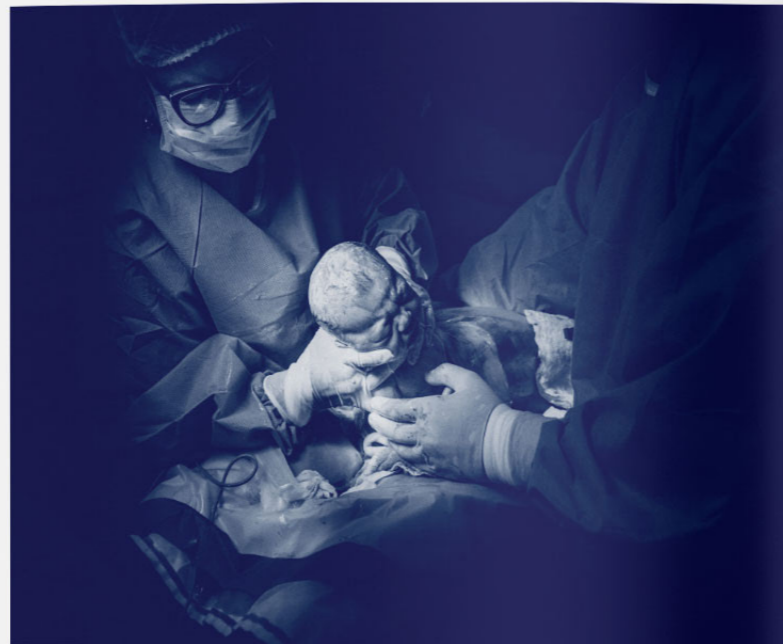
including fetal death, fetal growth retardation, premature delivery, along with maternal cardiac, cerebrovascular and renal disorders (Skinner, J., Bryant, C., Merrill, S., Green, D. 2015). While the one and only cure being premature delivery after stabilizing the condition, preeclampsia can be prevented and managed by several ways including physical activity that must be closely monitored by the mother's physician (Bezerra Maia e Holanda Moura, S., Marques Lopes, L., Murthi, P., & da Silva Costa, F. 2012); a study conducted in 2006 had successfully proven that exercise can prevent and help in the management of preeclampsia by enhancing placental vascularization improving fetal growth along with antioxidant defense mechanisms and reducing inflammation

Maternal Obesity

Alarmingly, and due to the emergence of cheaper high caloric non healthy food combined with an overall decrease in the amount of physical activity, overweight and obesity is increasing worldwide and affecting pregnant women either prior or after conception. Maternal obesity imposes several concerns on the health of the pregnant mother, in addition to the health and development of her fetus/child.

Maternal obesity is defined as having a high body mass index BMI (BMI 25-30 kg/m², Overweight, BMI > 30 kg/m², Obese, and BMI > 40 kg/m², Severely obese)

The health concerns affecting both the pregnant women and the fetus/child get worse as the BMI values of the future mother to be rises. **These adverse health outcomes include: congenital anomalies (neural tube defect: birth defect of the brain and spinal column;**



Absolute Contraindications

- // Hemodynamically significant heart disease
- // Restrictive lung disease
- // Incompetent cervix/cerclage
- // Multiple gestation at risk for premature labor
- // Premature labor during the current women with persistent second or third trimester bleeding or placenta preiva after 26 weeks of gestation (ACOG, 2002)

Relative Contraindications

- // Morbid obesity (100 pounds (45 kg) over ideal weight, a BMI of > 40 kg/m² or BMI > 35 kg/m² and experiencing obesity related health conditions such as high blood pressure or diabetes
- // Extreme underweight (BMI <12 kg/m²)
- // Severe anemia
- // Unevaluated maternal cardiac arrhythmia
- // Chronic bronchitis
- // Orthopedic limitations
- // History of extreme sedentary lifestyle
- // Intrauterine growth in the current pregnancy
- // Heavy smoking habit
- // Poorly controlled hypertension
- // Seizure disorder
- // Hyperthyroidism

Signs to Terminate Exercise

In case of the following signs and symptoms immediately terminate exercise and follow up with a physician:

- // Vaginal bleeding
- // Dyspnea prior to exertion
- // Dizziness
- // Headache
- // Chest Pain
- // Muscle weakness
- // Calf pain or swelling
- // Preterm labor
- // Decreased fetal movement
- // Amniotic fluid leakage (ACOG, 2002)

Lastly, the American Council of Obstetricians and Gynecologists had also tested and published the types of activities that are recommended to pregnant ladies due to their various exercise benefits (discussed in the “health benefits” section of this chapter), and the types of activities that are contraindicated due to the high risk they pose on the health of the pregnant mother and her fetus/child (ACOG, 2015, reaffirmed 2017).

PHYSIOLOGICAL CHANGES DURING PREGNANCY

Several physiological changes occur to the pregnant woman's body during the 38 weeks of pregnancy in order to accommodate and nurture the developing fetus for a healthy gestation and an uncomplicated delivery. These changes are caused by the pregnant woman's endocrine system through hormones affecting her musculoskeletal, cardiovascular, respiratory and many other systems; changes that must be acknowledged to maintain safe and effective physical activity throughout pregnancy.

Note that each and every one of these changes is completely normal and should resolve after delivery in all uncomplicated pregnancies.

Musculoskeletal System

One of the most noticeable changes that occur to the pregnant woman's body affects her musculoskeletal system. First, every pregnancy is accompanied by weight gain causing the build-up of extra pressure and mechanical stress on the joints leading to a discomfort at the level of previously normal joints, and an increased damage and injury risk on previously healthy joints. Second, the fact that the fetus develops in the female uterus at the level of the abdominal area shifts the pregnant lady's center of gravity upward and out putting an additional stress on the joints of the spine, pelvis, hip, knees and ankles; this posture change also leads to a decrease in balance and an increased risk of recurrent falls. Third, the increased production of relaxin and progesterone (Skinner, J., Bryant, M., & Granger, J. P. 2017) to enlarge the uterine cavity and to loosen the sacroiliac and pubic symphysis ligaments will also lead to the softening of other ligaments especially at the lumbar area predisposing the pregnant mother to a higher risk of both sprain and strain injuries along with lordotic posture and lower back pain (Aemil, S., Green, D. 2015).

Note that cardiac output increases gradually during the 1st and 2nd trimesters and plateaus after the 20th week till delivery.

This increase in cardiac output is related to an increase in both heart rate and stroke volume. Blood pressure decreases in the 1st and 2nd trimesters to increase again gradually midway through the 3rd trimester reaching pregnancy values (Hill, M. E., George, E. M., & Granger, J. P. 2017). All of these hemodynamic changes aim to improve the delivery of oxygen and nutrients to the baby and the mother especially during physical activity of the pregnant woman. Every certified medical exercise specialist must be aware of these changes and act accordingly; due to the fluctuations in the heart rate response, the intensity of the exercises should be assessed via the RPE method (ratings of perceived exertion). Supine positions and motions standing both decrease cardiac output especially during the 2nd and 3rd trimesters and must be avoided during workout.

Cardiovascular System

Several changes in the cardiovascular system take place during pregnancy. Relaxin, along with other hormones released throughout pregnancy causes the relaxation of the vascular smooth muscles or vasodilation decreasing both systolic and diastolic blood pressure (which leads to several symptoms including fatigue, lightheadedness, and nausea...) in addition to a decrease in the venous return. In addition, the pregnant female's endocrine system releases hormones preventing salt and water excretion by the kidneys increasing salt and water output in order to increase blood flow towards the tissues to meet their higher need during pregnancy. The decreased urination also leads to an accumulation of extracellular fluid and possible lower limb edema.

Thermoregulatory System

An improvement in the ability of the pregnant woman to dissipate heat and regulates its body temperature is noticeable. During pregnancy, the increased amounts of blood reaching the skin (elevated cardiac output as mentioned in this chapter) allows for direct heat exchange with the atmospheric air or heat loss. Similarly, additional heat loss is detected with the increase in gas exchange with each breathe (elevated tidal volume as mentioned in the respiratory system changes earlier in this chapter) through expiration.

Note that fetal body temperature is 1 degree Celsius higher than the maternal body temperature.

This indicates that the exercising pregnant women must stay hydrated (in order to keep the blood volume and blood flow high) and avoid training in hot and/or humid environment otherwise she will face higher risks of hyperthermia which is scientifically proven to increase the risk of fetal neural tube defects (defects affecting the spine, spinal tube defects or brain of the fetus during the 1st month of pregnancy) (Skinner, J., Bryant, M., Merrill, S., Green, D. 2015).

Respiratory System

During pregnancy, the respiratory system undergoes changes as well. There are both biochemical and mechanical variations affecting the lungs function improving oxygen delivery to the fetus. On the biochemical level, the elevated estrogen and progesterone has a bronchodilator effect in addition to the fact that it increases the brain's respiratory center sensitivity for carbon dioxide stimulating hyperventilation and improving oxygen uptake along with carbon dioxide elimination. Mechanically, the enlarged uterus displaces the diaphragm upward (around 5cm) lengthening its muscular fibers allowing it to produce more tension creating extra space for the lungs to get filled with air. These changes increase the amount of gas exchange at the level of the alveoli with each breath (tidal volume) enabling more oxygen to reach both maternal and fetal tissues.

Hyperventilation is a condition in which you start to breathe very fast.





NUTRITIONAL CONSIDERATIONS

Introduction

During pregnancy and breastfeeding lifestyle and dietary habits are critical determinants of health of both mother and fetus. Starting from the preconceptional period, maternal nutrition is crucial to ensure the maternal well-being and pregnancy outcomes, as well as ensuring long term health of the offspring. In fact, current scientific literature highlights that the first 1000 days of life starting from conception plays an important role in the prevention of non-communicable diseases (NCDs) in adulthood (1). Moreover, certain maternal conditions such as obesity prior to pregnancy and excessive weight gain during pregnancy are associated with adverse pregnancy outcomes and influences negatively child's health in its early life (2). Breastfeeding, "the gold standard" of infant feeding has also a critical role in infant health outcome. It is well known that it saves and improves the quality of life (3).

Optimizing nutrition prior and during pregnancy and promoting breastfeeding are critical interventions to reduce chronic disease risk later in life.

Appropriate weight gain and consumption of an adequate healthy diet are two key components of a health-promoting lifestyle during pregnancy. The optimal supply of nutrients and oxygen from the mother to the developing fetus is required to achieve appropriate fetal growth and development. During pregnancy, the total energy needs are increased because of the increased maternal metabolism, blood volume and red cell mass expansion by 50%, and the delivery of nutrients to the fetus (4).

Energy Expenditure during Pregnancy

A total of 80,000 kcal is needed to support a full-term pregnancy to account for increased maternal metabolism and fetal growth. Thus, caloric intake should increase by about 300

kcal/day during pregnancy (the mean pregnancy duration is 250 days) (5). The Institute of Medicine 2002, advise no additional calories for the first trimester, addition of 340 Kcal/day for the second trimester and 452 kcal/day in the third trimester. However, there are factors that affect caloric requirements such as woman's age, preconception BMI, and activity level. **Therefore, caloric intake must be individualized.**

Macronutrient needs

Protein

To ensure the full-term delivery of a healthy newborn, adequate dietary protein is crucial during pregnancy. Protein needs increases progressively throughout pregnancy to maintain maternal tissues and fetal growth, particularly during the third trimester. Thus, guidelines agree on increasing protein requirements during pregnancy, especially during the second and third trimester to ensure the extra 21 grams needed for maternal tissues and fetal growth (6). Protein recommendation for non-pregnant women is 0.8g of protein/kg/day. However, according to the 2002 DRI for pregnant women, **the amount of protein recommended is 1.1g of protein/kg/day, or an extra 25 g/day to meet the requirements of pregnancy.** Insufficient energy and protein intake during pregnancy may be associated with preterm birth and have several adverse effects on both mother and fetus (7).

Carbohydrates

Glucose is the main energy substrate for fetal rapid growth and development and is transmitted in a regular from mother to fetus (8). It should be available to the fetus at all times to ensure his normal growth. **The recommended daily allowance (RDA) for pregnant women is 175 g/day** whereas the RDA for non-pregnant women is 130 g/day. Moreover, adequate fiber supply is important during pregnancy; it helps in reducing constipation which is a common side effect of pregnancy. The DRI for fiber during pregnancy is 28 g/day. Fiber rich foods include whole-grain

breads and cereals, fresh fruits and vegetables and legumes.

Furthermore, during pregnancy adequate carbohydrate intake is crucial for an active pregnant woman. Indeed, pregnant women use carbohydrates at a higher rate during exercise than do non-pregnant women (9). Studies have shown that there is preferential use of carbohydrates during anaerobic exercises such as non-weight bearing exercise during pregnancy (10).

Fats

During pregnancy, the quality of fats is more important than their total quantity. In fact, PUFA are of utmost importance; they play a critical role in fetal development and infant growth. Eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA), and docosahexaenoic acid (DHA) are typically referred to as n-3 long-chain PUFA. Many systematic reviews revealed a positive impact of maternal intake and status of n-3 long-chain PUFA during pregnancy and lactation on maternal, infant, and child health.

Of these n-3 long-chain PUFA, DHA is of greatest importance. Indeed, it is the main PUFA in the human brain and retinal rods and, thus, is critical for optimal fetal neurodevelopment. Several literatures supported the benefits of DHA for the fetus and overall infant health and maternal health (14) (15).

DHA and EPA can only be obtained from dietary sources. The richest sources of these fatty acids are seafood and fish oil supplements. Vegetable oils and flax seed oil do not contain directly EPA and DHA, they contain ALA that needs to be converted to EPA and DHA to become biologically active. According to US Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) **pregnant woman should consume 2 to 3 serving of seafood per week to optimize pregnancy outcomes (16).** The 2015–2020 Dietary Guidelines for Americans states that pregnant or lactating women should consume 8–12 ounces of low mercury fish every week, such as salmon, sardines, and trout.



Polyunsaturated fatty acid