Diplomarbeit

Nutritional Behavior and Gestational Weight Gain in Physically Active and Non-Active Pregnant Women

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Graz, am 20.11.2015 *Veronika Rad e.h.*

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"Every experience God gives us, every person He puts in our lives is the perfect preparation for the future that only He can see." (Corrie ten Boom)

Zusammenfassung

EINLEITUNG: Für eine gesunde Schwangerschaft muss auf ausreichende Nährstoffzufuhr geachtet werden. Körperliche Aktivität sollte ebenfalls zu einer gesunden Schwangerschaft dazugehöre, da sich diese positiv auf die Gesundheit der Schwangeren auswirken kann. Sowohl inadäquate als auch exzessive Gewichtszunahme in der Schwangerschaft können die Gesundheit von Mutter und Kind beeinflussen. Diese Diplomarbeit untersucht die Unterschiede zwischen körperlich aktiven und nicht aktiven Schwangeren im Hinblick auf Ernährung und Gewichtszunahme.

METHODEN: Diese prospektive Observationsstudie untersuchte 21 aktive und 23 körperlich nicht aktive Schwangere über die gesamte Schwangerschaft. Die Nährstoffzufuhr wurde jedes Trimester gemessen. Daraus wurden Gesamtenergiezufuhr, Makronährstoffzufuhr, Verteilung der Makronährstoffe und Zufuhr von 12 verschiedenen Lebensmittelgruppen berechnet. Die Gewichtszunahme während der Schwangerschaft wurde durch Gewicht vor der Schwangerschaft minus Gewicht bei Entbindung berechnet und laut den IOM 20098 Empfehlungen eingeteilt.

ERGEBNISSE: Die Gesamtenergiezufuhr und die Zufuhr von Makronährstoffen waren ähnlich in den zwei Aktivitätsgruppen. Beim Verzehr bestimmter Lebensmittelgruppen fand sich jedoch ein signifikanter Unterschied zwischen aktiven und nicht aktiven Schwangeren (Verzehr von Fisch, Fettzufuhr durch Verzehr von Fisch, Getreide und Kartoffel, Kohlehydratzufuhr durch Verzehr von Fleisch und Wurst). Die Energiezufuhr von aktiven Schwangeren unterschied sich während der gesamten Schwangerschaft signifikant von den D-A-CH Empfehlungen. Körperlich nicht aktive Schwangere hatten eine signifikant zu niedrige Energiezufuhr im dritten Trimester. Bei allen zwei Gruppen war über die gesamte Schwangerschaft die Kohlehydratzufuhr zu niedrig und die Zufuhr von Fett und gesättigten Fettsäuren zu hoch. Die mittlere Gewichtszunahme von aktiven Frauen war 15.16 ± 3.91 kg und von nicht aktiven Frauen 15.94 ± 5.52 kg. Mehr aktive (55%) als inaktive (42.86%) Frauen nahmen eine empfohlene Menge an Gewicht zu. Vor allem übergewichtige Frauen (80%) zeigten eine exzessive Gewichtszunahme.

DISKUSSION: Frauen, die zu Beginn der Schwangerschaft körperlich aktiv sind, scheinen eine geringere Energiezufuhr zu haben. Aktive Schwangere scheinen sich auch besser an Empfehlungen zur Gewichtszunahme in der Schwangerschaft zu halten. Es braucht noch mehr Studien um diese Unterschiede zwischen körperlich aktiven und nicht aktiven schwangeren Frauen in Österreich zu untersuchen.

Abstract

INTRODUCTION: Adequate nutrition plays an important role in achieving and maintaining a healthy pregnancy. Physical activity should also play a part in the life of pregnant women, as it can be beneficial to their health. Gestational weight gain (the inadequate as well as the excessive) can influence not only the health of mothers but, their offspring as well. This thesis aims to explore the difference of physically active and non-active pregnant women concerning nutrition and gestational weight gain.

METHODS: This prospective observational study followed 21 physically active and 23 non-active women throughout pregnancy. Nutritional intake was measured each trimester. Total energy intake, macronutrient intake, macronutrient distribution and intake of 12 food groups were calculated. Gestational weight gain was calculated by subtracting weight at delivery from prepregnancy weight and classified according to the IOM 2009 recommendations.

RESULTS: Total energy and macronutrient intake did not differ between the two activity groups. Certain food groups however differed significantly between active and non-active women (fish consumption, total fat through fish, cereal and potato consumption, carbohydrate intake through meat and sausage consumption). Energy intake of active women differed significantly from D-A-CH recommendations throughout the whole pregnancy. Physically non-active women also had a significantly low energy intake in the third trimester. Carbohydrate intake was too low and fat intake, as well as intake of saturated fatty acids, were too high in both groups for all trimesters. Mean weight gain was 15.16 ± 3.91 kg for active and 15.94 ± 5.52 kg for non-active women. A higher percentage of active women (55%) than non-active women (42.86%) gained within recommendations. Especially women who were overweight before pregnancy (80%) gained more than recommended.

DISCUSSION: There seems to be a trend that women, who are physically active at the beginning of pregnancy, have a lower energy intake than physically not active women. They also tend to adhere better to weight gain recommendations during pregnancy. Further studies are needed to explore the differences of physically active and non-active Austrian pregnant women.

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Abbreviations

25(OH)D	25-hydroxyvitamin D
ACOG	American College of Obstetricians and Gynecologists
BLS	"Bundeslebensmittelschlüssel" (German Federal Food Product Key)
BMI	Body Mass Index
BMR	Basal Metabolic Rate
bpm	beats per minute (heart rate)
CSEP	Canadian Society for Exercise Physiology
D-A-CH recommendations	Recommendations by the German, Austrian and Swiss Nutritional Societies
DHA	Docosahexaenoic Acid
EI	Energy Intake
IUGR	Intrauterine Growth Restriction
MUFAs	Monounsaturated Fatty Acids
ÖNWT	"Österreichische Nährwerttabelle" (Austrian Table of Nutritional Values)
PAL	Physical Activity Level
PUFAs	Polyunsaturated Fatty Acids
REE	Resting Energy Expenditure
SD	Standard Deviation
SOGC	Society of Obstetricians and Gynecologists of Canada
TEE	Total Energy Expenditure

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1 Introduction

Nutrition and exercise play an important role in a healthy pregnancy and also have a great influence on the developing child. (1, 2)

This thesis explores nutritional behavior, gestational weight gain and physical activity in a group of pregnant women from Graz. Furthermore, this thesis attempts to provide a compact guide and an overview of current guidelines about nutrition and exercise in pregnancy to both medical personnel and non-medically trained individuals.

1.1 Nutrition in Pregnancy

1.1.1 Energy

Our bodies need energy for various biological processes. Energy that is necessary for maintaining these processes is called Basal Metabolic Rate (BMR). When adding energy expenditure for physical activity and thermogenesis caused by food intake to BMR the sum results in total energy expenditure (TEE). Additional energy is required in pregnancy, for breastfeeding and in growing organisms. (3)

There are several possibilities to measure energy expenditure, namely the direct and indirect calorimetry, or the so-called doubly labeled water method. Measurements of different physiological parameters (heart rate, electromyography, thermal imaging and pulmonary ventilation volume) can be used to estimate energy expenditure. BMR should be measured 12 hours after the last food intake, directly after waking up from at least eight hours of sleep, at physical and mental rest and in a neutral thermal environment. If this is not possible, resting energy expenditure (REE) can instead be measured after waking up after a resting period of 60 minutes. Food can be consumed until six hours prior to the measurement of REE. REE is typically 10% higher than BMR. (3, 4) Five widely acknowledged equations can be used to calculate BMR in adults (Harris-Benedict equation, Schofield's equation, the Oxford equation by Henry, Mifflin-St Jeor equation and Müller's equation). (3, 5)

TEE per day equals all energy requirements and consequently describes the optimal energy intake per day. Energy intake is usually described in megajoules (MJ) or calories (kilocalories, kcal). To convert MJ in kcal or vice versa the following formulas are used:

1 MJ = 239 kcal

1 kcal = 4.184 kJ = 0.004184 MJ

Energy in food can be derived from protein, carbohydrates, fat and alcohol. Each gram protein and each gram carbohydrates contain 4 kcal (= 7 kJ), whereas one gram fat contains 9 kcal (=37 kJ) and one gram alcohol contains 7 kcal (= 29 kJ). Dietary fibers are normally not absorbed in the human intestine, but are still an important part of our nutrition. They can help to prevent diseases such as coronary heart disease, hypertonia, obesity, dyslipoproteinemia or colorectal cancer. Bacteria in the colon can ferment fibers to short chain fatty acids, which can be absorbed by the colon leading to an additional energy supply. Each gram dietary fiber then produces 2 kcal (= 8 kJ). (3)

1.1.2 Recommended Energy Intake in Pregnancy

The German, Austrian and Swiss Nutrition Societies (3) have calculated standard values for resting energy expenditure. For women between 19 and 25 years REE is 5.7 MJ/day (1370 kcal/day), for women from 25 to 51 years of age REE is 5.5 MJ/day (1310 kcal/day). Different physical activity levels (see Table 4) require different amounts of additional energy intake. The D-A-CH Recommendations for women in their reproductive age for different PAL values are summarized in Table 1. (3)

Table 1 Recommended Energy Intake Women for Different PAL Values (3, p.11)

Age	**PAL 1.4**		**PAL 1.6**		**PAL 1.8**		**PAL 2.0**	
	MJ/day	kcal/day	MJ/day	kcal/day	MJ/day	kcal/day	MJ/day	kcal/day
19 - <25	8.0	1900	9.2	2200	10.3	2500	11.5	2700
25 - <51	7.7	1800	8.8	2100	9.9	2400	11.0	2600

BMR (or REE) is elevated in pregnancy. The additional energy is required for the synthesis of new tissue, adaptions in the cardiovascular and pulmonary system and the energy requirements of fetus and uterus. These extra energy requirements vary for each trimester. In the first three months, energy requirements of pregnant women do not differ from non-pregnant women. Over the whole pregnancy 320.3 MJ (76 530 kcal) are additionally needed, separated for the specific requirements in each trimester (Table 2). As mentioned, not much additional energy is need in the first trimester, so the extra

0.3 MJ per day (or 70 kcal per day) can be omitted. These recommendations apply only to pregnant women with ideal weight gain (12 kg over the whole pregnancy), normal prepregnancy BMI and continued physical activity during pregnancy. Overweight, obese or inactive women need less energy in order to achieve ideal weight gain throughout pregnancy. (2, 3)

Table 2 Additional Energy Requirements in Pregnancy (3, p. 12)

	MJ/day	**kcal/day**
1st trimester	0.3	70
2nd trimester	1.1	250
3rd trimester	2.1	500

1.1.3 Recommended Intake of Macronutrients in Pregnancy

Macronutrients are nutrients that supply energy. They are the main components of human nutrition. Carbohydrates, fat and protein count as macronutrients.

In pregnancy, protein requirements are increased in the second and third trimester, as 20% of protein is deposited in the second and 80% in the third trimester. For women with 12 kg gestational weight gain, 597 g of protein are acquired throughout the whole pregnancy. Additional intake of 10 g of protein is recommended after the third month of pregnancy, resulting in 58 g of protein per day.

Women with 12 kg weight gain over the course of their pregnancy obtain 3.7 kg of fat, 11% in the first, 47% in the second and 42% in the third trimester. (3, 6) The German, Austrian and Swiss Nutrition Societies (3) recommend that 30 percent of total energy intake should be derived through fat intake, when living a sedentary or moderately active lifestyle. In pregnancy the proportion of fat intake can be increased up to 35 percent.

Saturated fatty acids should contribute to ten percent of total energy intake or a third of total fat intake (if total fat intake is 30% of total energy intake). The ratio of saturated to unsaturated fatty acids should be 1:2. Polyunsaturated Fatty Acids (PUFAs) should ideally contribute to seven percent of total energy intake. If the intake of saturated fatty intake is higher than 10 percent of total energy intake, then PUFAs can supply for up to 10 percent of energy intake. The remainder of fat intake (total fat intake minus saturated fatty acids

and PUFAs) should be made up of monounsaturated fatty acids (MUFAs). The consumption of MUFAs and PUFAs should increase if the amount of fat intake exceeds 30 percent of total energy intake. Two PUFAs are essential for the human organism: linoleic acid (n-6) and α-linolenic acid (n-3). To maintain the necessary level of these essential nutrients, 2.5 percent of total energy intake should come from linoleic acid and 0.5 percent from α-linolenic acid. These recommendations are the same for both non-pregnant and pregnant adult individuals. Pregnant women should, however, consume at least 200 mg of docosahexaenoic acid (DHA) per day. This helps to maintain a sufficient amount of this specific fatty acid during lactation and therefore an adequate supply of the newborn. To achieve the daily recommended amount of DHA, pregnant women should consume fish with high amounts of DHA (for example salmon, mackerel or herring) one to two times a week. (3)

The D-A-CH recommendation (3) for carbohydrate intake is similar to the one of the FAO/WHO consultation (7): over 50 (D-A-CH) or rather more than 55 (FAO/WHO) percent of total energy intake come from carbohydrates. (3, 7)

The Austrian Federal Ministry of Health summarized national recommendations for the nutrition in pregnancy through the "Austrian food pyramid for pregnant women" (Figure 1). It is a modification of the food pyramid addressed to the general population, focusing on the specific nutritional needs of pregnant women. They advise the daily consumption of at least two liters of water or other low-caloric drinks, four portions of vegetables or legumes, two portions of fruit per day and five portions of grain and cereal products and potatoes. As for protein intake, it is recommended to consume three portions of low-fat dairy product per day. After the fourth month of pregnancy, an additional portion of dairy products per day or one more portion of fish, low-fat meat or egg per week should be consumed. One or two portions of fish, three portions of lean meat or sausage and up to three eggs should be included into meals throughout the week. Furthermore, the consumption of one to two tablespoons of vegetable oil, seeds and nuts are recommended as well. Other fats and food high in sugar, fat or salt should, on the other hand, not be consumed very often. Generally, the food pyramid informs pregnant women that they do not need to eat "for two people". The Austrian food pyramid for pregnant women recommends an additional energy intake of 250 kcal per day. There are no specific recommendations for each trimester. (8)

Figure 1 Austrian Food Pyramid for Pregnant Women (8)

1.1.4 Recommended Intake of Micronutrients in Pregnancy

Micronutrients are needed in much smaller quantities than macronutrients but are still essential for maintaining our body's physiological functions.

There is a higher demand for some of these nutrients in pregnancy (vitamin A, vitamin E, vitamin B1, vitamin B2, vitamin B6, niacin, folate, magnesium, phosphorus, iron, zinc and iodine). For others, the same requirements remain for pregnant as for non-pregnant women (vitamin D, vitamin K, pantothenic acid, biotin, potassium, calcium, selenium, copper, manganese, chromium, molybdenum and fluoride). Table 3 presents the recommended intake of different micronutrients during pregnancy. Sodium requirements are elevated in pregnancy (additional 3 mmol/d = 69 mg/d) due to fluid retention in the interstitial space. There, however, is no need to particularly watch sodium intake during pregnancy, as our normal nutrition contains enough sodium chloride for the increased requirements. Chloride intake is proportional to sodium intake (multiplication factor = 1.5). Further, as the fetal serum concentration of 25(OH)D is influenced by the mother's, it is important for pregnant women to achieve an adequate serum concentration of Vitamin D (at least 50 nmol/l of 25(OH)D). Vitamin D supply mainly comes from synthetization in the skin and to a smaller extent through food intake. Adequate Vitamin D supply can be reached only through a combination of these two means (endogenous production and nutritional intake). For women who cannot reach an adequate level through endogenous synthetization (by sun exposition of the skin) the intake of Vitamin D supplements (20 µg/d) is recommended. (1, 3)

Table 3 Nutrient Intake Recommended by the German, Austrian and Swiss Nutrition Societies (3)

Vitamins:		
Vitamin A	1.1 mg RE/d [a]	from 4th month on
Vitamin D	20 µg/d	without endogenous Vitamin D production
Vitamin E	13 mg TE/d [b]	
Vitamin K	60 µg/d	
Vitamin B_1	1.2 mg/d	from 4th month on
Vitamin B_2	1.5 mg/d	from 4th month on
Vitamin B_6	1.9 mg/d	from 4th month on
Vitamin B_{12}	3.5 µg/d	
Vitamin C	110 mg/d	from 4th month on
Niacin	15 mg NE/d [c]	from 4th month on

Folate	550 µg FE/d [d]	additional 400 µg/d[e]
Pantothenic acid	6 mg/d	
Biotin	30-60 µg/d	
Quantity elements:		
Sodium	550 mg/d	minimal supply
Chloride	830 mg/d	minimal supply
Potassium	2000 mg/d	minimal supply
Magnesium	310 mg/d	350 mg/d for pregnant women < 19 years
Calcium	1000 mg/d	1200 mg/d for pregnant women < 19 years
Phosphorus	800 mg/d	1250 mg/d for pregnant women < 19 years
Trace elements:		
Iron	30 mg/d	20 mg/d after birth to compensate for iron loss during pregnancy
Zinc	10 mg/d	from 4th month on
Iodine	230 µg/d (D, A); 200 µg/d (WHO, CH)	
Selenium	30-70 µg/d	
Copper	1- 1.5 mg/d	No specific recommendations for pregnancy
Manganese	2-5 mg/d	No specific recommendations for pregnancy
Chromium	30-100 µg/d	No specific recommendations for pregnancy
Molybdenum	50-100 µg/d	No specific recommendations for pregnancy
Fluoride	3.1 mg/d	

[a] RE = retinol equivalent: 1 mg retinol = 6 mg β-carotene = 12 mg other provitamin-A-carotenoids
[b] TE = tocopherol equivalent: 1 mg RRR-α-tocopherol-equivalent = 1 mg RRR-α-tocopherol = 1.49 IU
[c] NE = niacin equivalent: 1 mg niacin = 60 mg tryptophan
[d] FE = folate equivalent: 1 µg folate equivalent = 1 µg food folate = 0.5 µg synthetic folic acid (consumed on an empty stomach)
[e] To prevent neural tube defects, all women who want to or could get pregnant should consume 400 µg of folate through supplements per day before conception and during the first trimester.

1.1.5 Beverages During Pregnancy

Pregnant women should have a fluid intake of 1.47 liters through drinks and 0.89 liters through solid food per day. This adds up to 35 ml of fluid per kg body weight per day. (3) Alcohol, however, should be avoided during pregnancy. The effects of caffeine on the fetus are not completely clear. Therefore, a reduced consumption of 200 mg of caffeine per day is recommended. (1)

1.2 Physical Activity in Pregnancy

Physical activity level (PAL) is calculated with the following equation:

TEE:BMR = PAL

For different lifestyles specific standard PAL values have been calculated (Table 4). (3)

Table 4 PAL-Values for Different Work and Leisure Activities of Adults (3, p. 5)

work and leisure time activities/lifestyle	PAL	Examples
Only sitting or lying	1.2	Elderly, fragile or bedridden people
Solely sitting work activity, no or little exhausting leisure time activities	1.4 – 1.5	Office workers, precision engineers
Mostly seated work, intermittent walking or standing activities	1.6 – 1.7	Lab technicians, students, drivers, assembly line workers
Mostly standing or walking activities	1.8 – 1.9	Sales assistants, mechanics, waiters, housework
Physically exhausting vocational activities	2.0 – 2.4	Farmers, construction workers, miners, lumberjacks, professional athletes

Additional 0.3 PAL-units can be added for sports or other strenuous leisure time activities (30-60 minutes four to five times a week)

Most pregnant women perform some kind of physical activity during pregnancy. However a decrease in physical activity level throughout pregnancy can be observed. (9) Care giving, household tasks and recreational exercises are the most common sources of physical activity. (10) All pregnant women (except those with contraindications) can and should exercise during pregnancy. Health care professionals should recommend physical activity to pregnant women, address their concerns and inform them about benefits and possible risks. The goal of exercise in pregnancy should not be to train for competitions, but to maintain a healthy level of fitness. (9)

There are many physiological changes during pregnancy. Especially adjustments in the respiratory and cardiovascular system are important when discussing exercise during pregnancy. Pregnant women have a higher heart rate and stroke volume than non-pregnant women. Systemic vascular resistance decreases in pregnancy, which creates a higher venous system capacity and a decreased afterload. The cardiac output

therefore increases. At the beginning of pregnancy arterial pressure decreases a little (around 10 mmHg). This is partly caused by fluid retention mediated by an elevated secretion of antidiuretic hormone. Pregnant women have higher tidal volume and increased minute ventilation. Oxygen consumption increases during pregnancy, as well as arterial oxygen tension. Arterial carbon dioxide tension decreases as well in pregnant individuals. The diaphragm lies at a higher position during pregnancy due to the enlarged uterus. Breathlessness is a common complaint in pregnant women, especially at the end of pregnancy. The musculoskeletal system is also affected by pregnancy. Through hormonal changes connective tissue such as ligaments loosen during pregnancy. Many pregnant women have poor lower back posture and consequently develop back pain. This may also affect balance in pregnant women. Increased body weight during pregnancy puts higher pressure on joints. As basal metabolic rate is elevated in pregnancy, thermogenesis is also higher in pregnant women. Although there are no studies that report negative effects for the fetus caused by maternal hyperthermia, pregnant women should be advised to exercise in either a thermoneutral or air conditioned environment and should stay adequately hydrated. Besides hydration, sufficient energy intake should be noted when engaging in physical activity during pregnancy. (11–14)

Pregnant women who want to exercise should consider the aforementioned changes together with their health care providers. Concerns and minor health problems should be addressed at an individual level. However, there are some conditions and symptoms which are considered contraindications to exercise during pregnancy. The American College of Obstetricians and Gynecologists (ACOG) (15), the Society of Obstetricians and Gynecologists of Canada (SOGC) together with the Canadian Society for Exercise Physiology (CSEP) (9) and Bung and Hartmann in the German journal “Frauenarzt”(16) have compiled lists of absolute and relative contraindications to physical activity during pregnancy. These are summed up in Table 5 and Table 6.

Table 5 Absolute Contraindications to Exercise in Pregnancy (9, 15, 16)

Gynecological/obstetrical:
Incompetent cervix or cerclage
Multiple gestation (with a risk for preterm labor)
Placenta previa after 26th week of gestation (SOCG/CSEP: 28th week)

Rupture of membrane
Preterm labor
Persistent bleeding in the 2nd or 3rd trimester (Bung & Hartmann: uterine bleeding)
Hypertensive disorders of pregnancy/preeclampsia (Bung & Hartmann: hypertonia in general)
Growth restricted fetus /fetal hypotrophy
Fetal distress (Bung & Hartmann)
Placental insufficiency (Bung & Hartmann)
Cardiovascular and other:
hemodynamically significant heart disease (ACOG)
Cardiovascular diseases (Bung & Hartmann)
Restrictive lung disease (ACOG, Bung & Hartmann)
Serious cardiovascular, respiratory or other systemic disorder (SOGC/CSEP)
Uncontrolled diabetes mellitus type I (SOGC/CSEP)
Uncontrolled thyroid disease (SOGC/CSEP)
Renal disease (Bung & Hartmann)
Seizure tendency (Bung & Hartmann)

Table 6 Relative Contraindications to Exercise in Pregnancy (9, 15, 16)

Anemia (SOGC/CSEP: Hemoglobin < 10 g/dl)
Malnutrition/eating disorders (BMI < 12, anorexia, bulimia)
Obesity
(chronic) bronchitis (SOGC/CSEP: mild/moderate respiratory disorder)
(unevaluated) cardiac arrhythmia (SOGC/CSEP: mild/moderate cardiovascular disorder)
Poorly controlled diabetes mellitus type I (ACOG, Bung & Hartmann)
Intrauterine growth restriction (ACOG, Bung & Hartmann)
Orthopedic restriction, skeletal or joint diseases (ACOG, Bung & Hartmann)
(poorly controlled) hyperthyroidism (ACOG, Bung & Hartmann)
(heavy) smoking (ACOG, Bung & Hartmann)
Twin pregnancy after 28th week (SOGC/CSEP)
Extremely sedentary lifestyle before pregnancy (ACOG)
Poorly controlled hypertonia (ACOG)
Other significant medical conditions (SOGC/CSEP)

Recommended activities are walking, swimming, water aerobics or stationary cycling. Hiking or other physical activity should be restricted to lower altitudes (around 2000 m). Activities and exercises with a risk of falling down or abdominal trauma such as horseback riding, gymnastics, skiing, ice hockey, soccer, basketball or combat sports should be avoided. Adventure sports like bungee jumping or skydiving can also cause severe trauma to mother and fetus and could also induce preterm labor due to catecholamine release. Weight lifting and other exercises in a supine position should be avoided after the first trimester as this can lead to compression of the vena cava and consequential reduced cardiac output. Scuba diving is not recommended either because of risk for decompression sickness in the fetus, whereas snorkeling should not cause any problems. (9, 15, 16) In general, continuous light to moderate aerobic activities are recommended. Rhythmic activities that use big muscle groups should be preferred. (11, 16) When the symptoms presented in Table 7 occur, pregnant women should immediately stop exercising.

Table 7 Warning Signs for Pregnant Women to Stop Exercising (9, 11, 15, 16)

Vaginal bleeding
Preterm labor
Painful uterine contractions
Leakage of amniotic fluid
Decrease of fetal movement
Dyspnea (before exercising or excessive dyspnea during exercise)
Dizziness
Headache
Chest pain
Muscle weakness
Calf pain or swelling (thrombophlebitis has to be ruled out)
Presyncope

It is recommended for pregnant women to exercise 30 minutes every day at moderate intensity. (1, 15) Women who did not engage in physical activity before pregnancy should start exercising three times a week for 15 minutes and moderately increase exercising up to four times a week for 30 minutes. A warm-up and cool-down period of

10 to 15 minutes at the beginning and end of each exercise session is encouraged. (9, 17) When exercising for more than 45 minutes, pregnant women should carefully watch body temperature to avoid excessive rise of core body temperature. It is therefore recommended to exercise in temperature controlled environment. Pregnant women should also evaluate their energy intake when they are exercising. As mentioned before, exercising demands increased nutritional intake, which should be kept in mind. (11)

In a review of the exercise recommendations for pregnant women by the ACOG, Artal and O'Toole (11) recommend that previously inactive women exercise at 60-70% of maximal heart rate or 50-60% of maximal oxygen uptake. Pregnant women who engaged in physical activity before their pregnancy can have an exercise intensity of up to 90% of maximal heart rate and up to 85% of maximal oxygen uptake. They do not recommend the adherence to heart rate zones, because heart rate is very variable during pregnancy. Rather pregnant women should use rating of perceived exertion to observe the intensity of their activity. (11) The Canadian Guidelines by the SOGC and CSEP (9) on the other hand, have published modified target heart rate zones for pregnant women. Pregnant women younger than 20 years should exercise with a heart rate between 140 and 155 beats per minute (bpm). The target heart rate zones for pregnant women between 20 and 29 years of age are 135 to 150 bpm, for women between 30 and 39 year they are 130 to 145 bpm and for pregnant women aged 40 years or more they are 125 to 140 bpm. (9) For overweight and obese pregnant women separate target heart rate zones have been developed (110 to 131 bpm and 108 to 127 bpm for overweight and obese pregnant women between the ages of 20 to 29 year and 30 to 39 years, respectively). Another suggested target heart rate zone for pregnant women, who did not exercise before is 128 to 144 bpm (for women between the ages of 20 and 39 years). (17) All these guidelines propose using Borg's rating of perceived exertion (Table 8) as an appropriate tool for monitoring exercise intensity during pregnancy. A rating of 12 to 14 (meaning "somewhat hard") is recommended during pregnancy. (9, 11, 17) Additionally, the so-called "talk test" can be used to rate exercise intensity. The "talk test" means, that when one can hold a conversation while exercising, one exercises at proper intensity. (9, 17)

Table 8 Borg's rating of perceived exertion (9, 18)

6	(no exertion at all)
7	very, very light (extremely light)
8	
9	somewhat light (very light)
10	
11	fairly light (light)
12	
13	somewhat hard
14	
15	hard (heavy)
16	
17	very hard
18	
19	very, very hard (extremely hard)
20	(maximal exertion)

The Canadian Society for Exercise Physiology has summed up many recommendations for exercise in pregnancy and has developed a medical checkup questionnaire and guideline for pregnant women who want to exercise. The questionnaire is called PARmed-X for pregnancy and it is included in the Appendix. (19)

There have been no reports that physical activity during healthy pregnancy can be harmful to the fetus. There is, however, controversial evidence that links intrauterine growth restriction (IUGR) with hard physical labor and inadequate nutritional intake. Women with a healthy diet do not appear to have small babies. Some reports have been made of premature labor induced by physical activity. However, this seems to be confined to women who were at risk for premature labor. (11)

Physical activity in pregnancy can have beneficial effects. Studies have shown that exercise in pregnancy can be helpful in the treatment of gestational diabetes, also reducing the risk of developing gestational diabetes. Study results further suggest that physical activity in pregnancy might prevent the development of preeclampsia. In addition, exercise in pregnancy can help to reduce excessive gestational weight gain (see also chapter 4.1.1). Physical activity in pregnancy might also have a positive effect on birth weight and body composition of the child. The chance of preterm delivery also seems to be reduced in active mothers. (20) Exercise during pregnancy has not yet been

linked to the length of the pregnancy or the duration of contractions. There might be a higher number of vaginal births among active pregnant women because of their strengthened abdominal and pelvis muscles, however, this has yet to be confirmed. (16)

1.3 Gestational Weight Gain

The Institute of Medicine (IOM) together with the National Research Council (in the USA) has issued new recommendations for gestational weight gain in 2009. These guidelines suggest an optimal weight gain for pregnant women according to their prepregnancy BMI (Figure 2). (14)

TABLE S-1 New Recommendations for Total and Rate of Weight Gain During Pregnancy, by Prepregnancy BMI

	Total Weight Gain		Rates of Weight Gain* 2nd and 3rd Trimester	
Prepregnancy BMI	Range in kg	Range in lbs	Mean (range) in kg/week	Mean (range) in lbs/week
Underweight (< 18.5 kg/m^2)	12.5-18	28-40	0.51 (0.44-0.58)	1 (1-1.3)
Normal weight (18.5-24.9 kg/m^2)	11.5-16	25-35	0.42 (0.35-0.50)	1 (0.8-1)
Overweight (25.0-29.9 kg/m^2)	7-11.5	15-25	0.28 (0.23-0.33)	0.6 (0.5-0.7)
Obese (≥ 30.0 kg/m^2)	5-9	11-20	0.22 (0.17-0.27)	0.5 (0.4-0.6)

* Calculations assume a 0.5-2 kg (1.1-4.4 lbs) weight gain in the first trimester (based on Siega-Riz et al., 1994; Abrams et al., 1995; Carmichael et al., 1997).

Figure 2 IOM Weight Gain Recommendations (14, p. 2)

These recommendations were developed with consideration of five adverse outcomes concerning mothers and children. The values for weight gain in pregnancy were suggested, because of their beneficial influence on number of cesarean sections, preterm deliveries, weight retention after pregnancy, large or small for gestational age babies and obesity in the offspring. The IOM states, that their recommendations should be used at an individual level. Different factors contribute to gestational weight gain and should be taken into consideration if women gain excessively or inadequately during pregnancy. Gestational weight gain is determined by maternal and fetal factors. These are: fat mass and fat-free mass gained by the mother and the fetus, weight of the placenta, amniotic fluid and water deposition by the mother. Nutrition and physical activity further influence weight gain during pregnancy. (14)

Maternal weight gain in pregnancy can not only affect a mother's health, but also the health of her children, as the following paragraph tries to explore.

Weight gain above the recommended amount has been associated with higher odds of developing gestational hypertension and having cesarean section delivery in a Dutch study. (21) Meta-analyses show that both excessive and inadequate weight gain have an influence on maternal weight retention up to 20 years after delivery. (22, 23) Furthermore, excessive weight gain seems to be related to maternal abdominal obesity even eight years after delivery. (24)

Other study results suggest that especially the weight gained in early pregnancy has a great influence on offspring anthropometrics. (25, 26) In a German study, excessive gestational weight gain also had a negative effect on the newborns' APGAR[1] values and umbilical cord blood pH values. (27) Generally, there seems to be an association between excessive gestational weight gain and delivering large babies and excessive gestational weight gain and overweight or obesity in the offspring. (21, 27–31)

1.4 Obesity in Pregnancy

Overweight and obesity are a growing problem around the world, especially in developed countries, such as Austria. (32) In the years 2006 and 2007, 460 000 Austrian women were overweight or obese. A number of women amongst these were in their reproductive age (Table 9). (33)

Table 9 Distribution of BMI in Austrian women 2006/2007 (33)

age	underweight	normal weight	overweight	obese
	BMI <18.5 kg/m^2	BMI 18.5-24.9 kg/m^2	BMI 25-29.9 kg/m^2	BMI > 30 kg/m^2
20 to 29	7,6%	72,5%	14,1%	5,8%
30 to 44	3,1%	64,0%	23,4%	9,4%

[1] APGAR score: a score to assess a newborns' postnatal adaption. The five parameters appearance, pulse, grimace, activity and respiration are measured one, five and ten minutes after delivery. Each parameter is rated with 0 to 2 points (see below). The highest score is therefore 10 points, the lowest 0 points.

	0 points	1 point	2 points
appearance (skin color)	pale, blue	acrocyanosis	body and extremities pink
pulse (heart rate)	none	< 100 bpm	> 100 bmp
grimace (reflex irritability)	no reaction	grimacing	crying
activity (muscle tone)	limp	some flexion	active movement
respiration (respiratory effort)	absent	irregular, weak	strong effort, crying

High maternal BMI has been associated with higher chances for developing hypertension in pregnancy, preeclampsia, gestational diabetes and thromboembolism. Obstetrical complications such as shoulder dystocia, postpartum hemorrhage or wound infection after cesarean sections seem to be more common in overweight and obese women. Generally, the odds of having a cesarean section delivery are increased in these women. A higher prevalence of macrosomia in the offspring of mothers with a higher BMI than in mothers who are normal weight has been reported. Furthermore, maternal overweight and obesity are associated with the risk for stillbirth. (21, 34, 35) Children of overweight and obese mothers seem to be at higher risk of developing overweight and obesity themselves. (21)

1.5 Research Questions

As illustrated in the chapters above, adequate nutrition and gestational weight gain are important for the health of mothers and their offspring. This thesis aims to explore if physical activity has an influence on gestational weight gain and if the nutrition of women who exercise during pregnancy differs from those who do not exercise.

These goals have been expressed in the following research questions.

1. Does the daily intake of nutrients and food groups of physically active women differ from physically non-active women in each trimester of pregnancy?
2. Does gestational weight gain vary between physically active and non-active pregnant women?

This study will help to explore the health status of Austrian pregnant women and explore if physical activity is a factor that positively (or negatively) influences nutrition and weight gain during pregnancy.

2 Methods

2.1 Study Design

The pilot study with the title “Effect of physical activity in pregnancy on low grade inflammation” was approved by the ethics committee of the Medical University of Graz (EK No. 24-249 ex 11/12). This prospective observational study planned to follow 40 healthy pregnant women throughout their pregnancy. The women were assigned into two groups based on their physical activity level.

The participants were recruited at the University Hospital of the Medical University of Graz. After signing an informed consent, they were allocated to one of the groups. Physical activity behavior before and in early pregnancy was assessed by a questionnaire. When women reported over 150 minutes of moderate to rigorous exercise per week, they were classified as physically active. Women who reported less than 150 minutes of exercise per week were considered physically non-active. To objectify physical activity level, all participants wore an accelerometer for 7 consecutive days in each trimester.

The participants were examined three times during their pregnancy, once each trimester. Recruitment took place between 10^{th} and 14^{th} week of gestation. Follow-up visits were scheduled between 19^{th} and 24^{th} week and 32^{nd} and 36^{th} week of gestation. Each visit included an ultrasound scan to assess fetal growth, measurement of maternal subcutaneous fat tissue with a handheld lipometer, a short interview about the patient’s wellbeing, weighing of the patient and the taking of venous blood samples. To measure physical activity throughout the pregnancy, all participants were handed out an accelerometer at each appointment. During labor and after delivery more venous blood samples were collected from the mother. Additionally, arterial and venous blood sample from the umbilical cord and samples of placental material were retrieved and newborn fat tissue was measured using a lipometer. At each visit participants were given food record questionnaires and were asked to fill them out the following week. Prepregnancy weight and height were reported by the participants.

2.2 Recruitment

Study participants were recruited at the department of gynecology and obstetrics at the University Hospital Graz. The women were approached at the visit for their first-trimester ultrasound scan and combined test. Inclusion criteria for our study were an ongoing pregnancy between 10^{th} and 14^{th} week of gestation and giving informed consent.

The outpatient clinic of the department of gynecology and obstetrics performs around 600 first-trimester ultrasound scans and combined tests each year. As recruiting took place for 9 months, the number of potential study participants was 450. Due to other running studies at the department, only approximately 240 women were approached.

About one third out of those 240 women had to be excluded, which left a number of 160 potential study participants. Exclusion criteria were:

(a) Not wanting to give birth at the university hospital of Graz
(b) Multiple pregnancies
(c) Gestational age after 14^{th} week of gestation
(d) Three or more consecutive miscarriages
(e) Smoking
(f) Diagnosis of diabetes mellitus type 1 or 2
(g) Increased risk of chromosomal abnormalities after the combined test (≥ 1:300)
(h) Other fetal anomalies
(i) Maternal metabolic risk factors (autoimmune conditions, increased risk for thromboembolic events requiring anticoagulative therapy)
(j) Pre-pregnancy hypertension

53 of the 160 women approached decided to participate in the study. Women who did not want to participate stated the following reasons:

(a) Not wanting to have further pregnancy tests taken at University Hospital Graz
(b) Not wanting to deliver at University Hospital Graz
(c) Not wanting to be measured with the lipometer
(d) Not wanting to have the baby measured with the lipometer
(e) Not wanting to wear an accelerometer

The 53 participants signed an informed consent, after having been thoroughly informed about the study, its goal and all the procedures and measurements involved.

2.3 Physical Activity Assessment

Two different methods were used to assess physical activity in the participants. First, all women had to fill out a physical activity questionnaire about their activity behavior before pregnancy in general and in the last seven days specifically. Women who reported 150 or more minutes of physical activity per week were considered physically active. The questionnaire for physical activity was based on the Pregnancy Physical Activity Questionnaire (PPAQ) by Chasan-Taber et. al. This questionnaire has been found to be reliable in measuring physical activity during pregnancy. (36) To objectify the self-assessed physical activity level all participants were asked to wear an accelerometer for seven consecutive days in each trimester. The accelerometer used was the ActiGraph wGT3X-BT. It measures accelerations in three dimensions and permits measurement of quantity and intensity of the performed physical activity. The device was worn on a belt around the participants' abdomen either under or above their clothing, as it does not require direct skin contact. All women participating in the study were instructed to put on the accelerometer in the morning and only take it off during sleeping, showering or swimming, as the device is not waterproof. The devices were programmed to start the recording at the morning after the day they were handed out and record for seven consecutive days. Each device was checked for proper programming, function and battery life before giving it to a patient. Analysis of data from the ActiGraph was performed with ActiLife 6 Data Analysis Software.

When data of the accelerometer showed that a participant exercised for 150 or more minutes per week, they were classified as physically active and vice versa. As there were some discrepancies between physical activity level reported in the questionnaire and assessment of the accelerometer data, only the more objective measurement of the ActiGraph was used to assign the participant to the corresponding group. Only the data of the first accelerometer measurement during the 10^{th} and 14^{th} week of gestation was available for physical activity level classification.

2.4 Dietary Assessment

For dietary assessment a seven day estimated food record each trimester was used (refer to Appendix for an example). Study participants were asked to write down all foods and beverages they consumed throughout one week. Each day was divided into six meals

(breakfast, morning snack, lunch, afternoon snack, dinner and late night snack). Instructions at the beginning of the questionnaire explained shortly how the food record should be filled out (write down the exact type of food and state the amount as precisely as possible). If participants could not remember the exact amount of what they consumed, they were asked to use estimates (small, medium or big portion, a little amount, a lot). They were also asked to fill out time and place of the meal and if they had eaten alone or in company.

2.4.1 Software nut.s

Analysis of nutritional intake was performed with nut.s nutritional software (37). Food data of the „Deutscher Bundeslebensmittelschlüssel“ (BLS, German federal food product key) (38) and the „Österreichische Nährwerttabelle“ (ÖNWT, Austrian table of nutritional values) (39) have been used. If there was no data available for a certain meal or if the record was very unspecific, the food that resembled the one reported the most, was used.

2.4.2 Underreporting

In nutritional assessment it is common to compare reported energy intake with basal metabolic rate (BMR) to detect underreporting. The consequences of underreporting on published data are not fully understood, but it should be considered when interpreting the results (5). By classifying the study participants into physically active and non-active it was possible to compare the measured and the calculated PAL to detect underreporting, as it is suggested for small studies (40).

PAL can be calculated using the following equation:

$$EI:BMR = PAL$$

In this equation EI stands for reported energy intake, BMR for basal metabolic rate and PAL for physical activity level. (40) Calculated PAL was compared to the physical activity level based on measurements by the accelerometer. Women who exercised for 150 minutes or more per week were assigned to the active group and to a physical activity level of 1.8. Women who exercised less than 150 minutes per week were classified as non-active women with a PAL of 1.4. To calculate BMR, Schofield’s Equation was used (5). Underreporting was more common in physically active women and increased with the duration of pregnancy (Table 10).

Table 10 Percentage of Underreporting

Physical activity	1st trimester	2nd trimester	3rd trimester
active	86%	100%	100%
not active	62%	88%	100%

2.5 Statistics

Statistical analysis was performed with the software SPSS (Version 22) (41). All metric data was tested for normal distribution using Kolmogorow-Smirnow and Shapiro-Wilk tests. Both of these tests have the null hypothesis that the data used follows a normal distribution. So a significant result ($p < 0.05$) means that the data is not normally distributed. (42) When variables did not have any significant results in both tests it was assumed that those parameters followed a normal distribution. This was affirmed by looking at histograms for all metric data. For these variables t-tests were used to test for statistical significance. Other variables had significant results in the Kolmogorow-Smirnow and Shapiro-Wilk tests. These were tested with a Mann-Whitney U test, which does not require normally distributed data. (42)

Body weight was measured in kg, height in cm, BMI was calculated as kg per m^2 body surface. Energy intake was calculated in MJ and kcal, nutrient intake in mg and g. Mean energy and macronutrient intake were calculated over one week, and are listed as mean intake per day.

3 Results

Out of the 53 study participants, two had to be excluded at the second visit. One of them withdrew her consent and the other had to be excluded due to medical reasons. For seven of the 51 women there was no physical activity data measured by the ActiGraph available. Thus 21 women were allocated to the physically active and 23 to the physically non-active group (Figure 3).

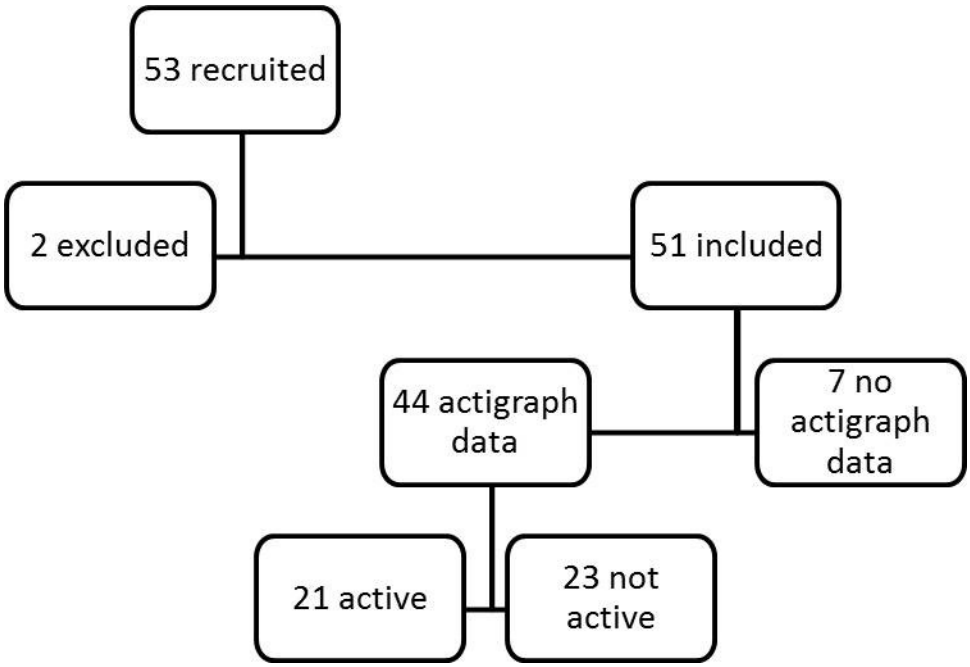

Figure 3 Data Collection

Out of the 44 participants five did not return any food record. Six women returned only one of the questionnaires, 18 returned two and 15 returned all three food questionnaires. (Table 11)

Table 11 Number of Returned Food Records

Number of returned food records	active	not active
none	2	3
one	3	3
two	8	10
three	8	7

3.1 Population Characteristics

The study population consisted of 51 women between the ages of 22 and 44 years (mean age 34 years). The average height was 167.80 cm (ranging from 156 to 182 cm). Pre-pregnancy weight ranged from 49 to 91 kg, with the mean weight being 63.13 kg. Consequently, mean pre-pregnancy BMI was 22.38 kg/m^2; ranging from 18 to 2 8.7 kg/m^2. For 44 of those 51 women, data on physical activity was available. Therefore, when not otherwise specified, the following analyses include only these 44 participants.

3.2 Weight and Weight Gain

Mean BMI of physically active women was slightly lower than that of non-active women throughout the whole pregnancy (Table 12). The difference between those two groups was tested with a t-test for independent samples at each testing point. These results are also listed in Table 12.

Table 12 BMI of Physically Active and Non-Active Women over the Course of Pregnancy

physical activity		prepregnancy_BMI	t1_BMI	t2_BMI	t3_BMI	delivery_BMI
not active	Mean	22.70	23.14	24.95	27.16	28.58
	Std. Deviation	2.83	2.84	2.83	2.39	3.45
	Median	22.80	22.69	24.76	26.99	28.36
	Minimum	18.30	18.93	20.70	24.24	21.31
	Maximum	28.70	29.98	31.88	31.63	35.35
active	Mean	21.83	22.38	23.56	26.77	27.12
	Std. Deviation	2.36	2.22	2.12	2.37	2.48
	Median	22.05	22.41	23.51	26.61	27.54
	Minimum	18.00	19.00	19.72	23.78	22.66
	Maximum	28.10	28.09	28.09	32.24	32.88
p-value (2-tailed significance)		0.275	0.331	0.088	0.663	0.130

Mean weight gain (defined as delivery minus prepregnancy weight) was similar for both groups (15.94 ± 5.52 kg for non-active and 15.16 ± 3.91 kg for active women) with a greater variance in non-active women. Weight gain ranged from a minimum of 3 kg to maximum 25.5 kg in physically non-active and from 7 to 24.5 kg in physically active women. Figure 4 illustrates these results.

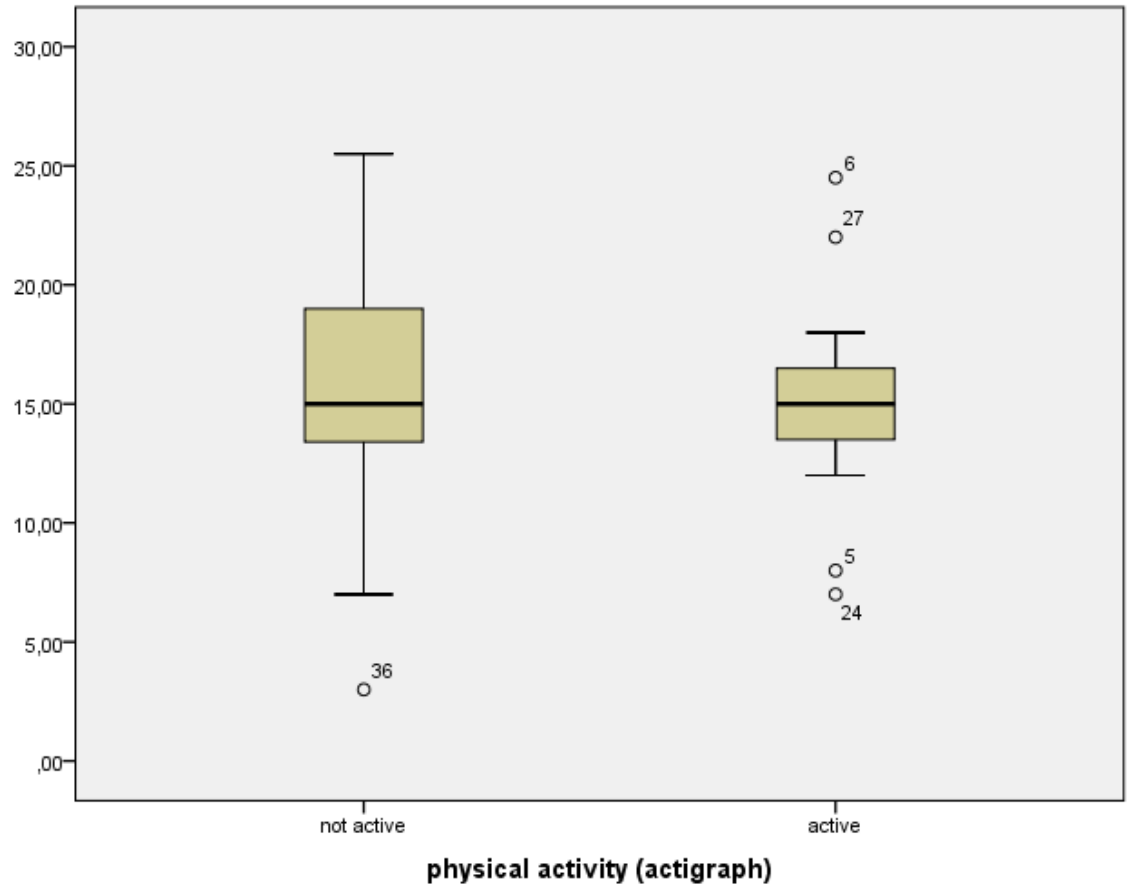

Figure 4 Gestational Weight Gain in Physically Active and Non-Active Women

To evaluate gestational weight gain the participants were divided into categories according to their prepregnancy BMI as recommended by the IOM (14) (see also chapter 1.3). For four women (two non-active women, one active and one woman without activity data) there was no delivery weight available. One of them was underweight, two were normal weight and one was overweight before pregnancy. As gestational weight gain for those four women could not be calculated, their data was not included in the following calculations.

None of the women had a BMI greater than 30 kg/m^2. About two thirds of the participants were normal weight before pregnancy, 4% were underweight and 21% were classified as overweight (Table 13).

Table 13 Prepregnancy BMI Categories

	BMI <18.5 kg/m^2	BMI 18.5-24.9 kg/m^2	BMI 25-29.9 kg/m^2	Total
Not active	0	15	6	21
Active	1	17	2	20
No activity data	1	3	2	6
Total	2	35	10	47

A comparison of measured weight gain with recommended weight gain for each BMI category showed the results listed in Table 14. A little over fifty percent of physically active women and nearly half of physically not active women gained within IOM's weight gain recommendations. Almost half of non-active women and over one third of active women exceeded the recommended weight gain, according to their prepregnancy BMI. Of the six pregnant women for whom no activity data was available, half gained too little and half too much weight throughout pregnancy.

As Table 15 shows, none of the women who were underweight before pregnancy gained more than recommended. Half of normal weight women gained within recommendations and over a third gained too much. Most women with a prepregnancy BMI greater than 25 kg/m^2 gained more weight than recommended by the IOM (14). All in all, seven out of the 47 women gained inadequately, 20 gained within recommendations and 20 gained excessively.

Table 14 Comparison with IOM Weight Gain Recommendations (14)

	< recommended weight gain	within recommended weight gain	> recommended weight gain
Not active	9.52%	42.86%	47.62%
Active	10.00%	55.00%	35.00%
No activity data	50.00%	0.00%	50.00%

Table 15 Weight Gain in Different BMI Categories [Recommendations by IOM (14)]

BMI	<18.5 kg/m^2	18.5-24,9 kg/m^2	25-29.9 kg/m^2
< recommended weight gain	50%	14%	10%
within recommended weight gain	50%	51%	10%
> recommended weight gain	0%	34%	80%

3.3 Energy Intake

Mean daily energy intake was somewhat higher in physically active pregnant women in all trimesters (Table 16). Non-physically active women had a slightly higher daily energy intake at the end of their pregnancy (7.84 ± 1.84 MJ in the third compared to 7.78 ± 1.08 MJ in the first trimester). Active women consumed 8.30 ± 1.55 MJ at the beginning of pregnancy. Their energy intake was lowest in the last trimester with a daily intake of 8.04 ± 1.53 MJ. The highest daily energy intake occurred during the second trimester in both groups (8.22 ± 1.67 MJ for non-active and 8.31 ± 1.29 MJ for active women) (Figure 5). A t-test, exploring the difference of energy intake between non-active and active women, showed no significant results (Table 16).

Table 16 Energy Intake [kcal] of Physically Active and Non-Active Women Throughout Pregnancy

physical activity		t1_kcal	t2_kcal	t3_kcal
not active	N	13	17	14
	Mean	1859.44	1964.95	1872.06
	Std. Deviation	258.25	398.63	439.81
	Median	1861.66	2003.61	1955.06
	Minimum	1514.33	1177.10	1057.08
	Maximum	2340.72	3026.78	2596.30
active	N	14	15	14
	Mean	1981.81	1985.52	1919.63
	Std. Deviation	369.18	308.09	365.01
	Median	2016.04	1978.74	1963.10
	Minimum	1447.77	1394.50	1399.00
	Maximum	2625.10	2651.32	2457.89
p-value (2-tailed significance)		0.331	0.873	0.758

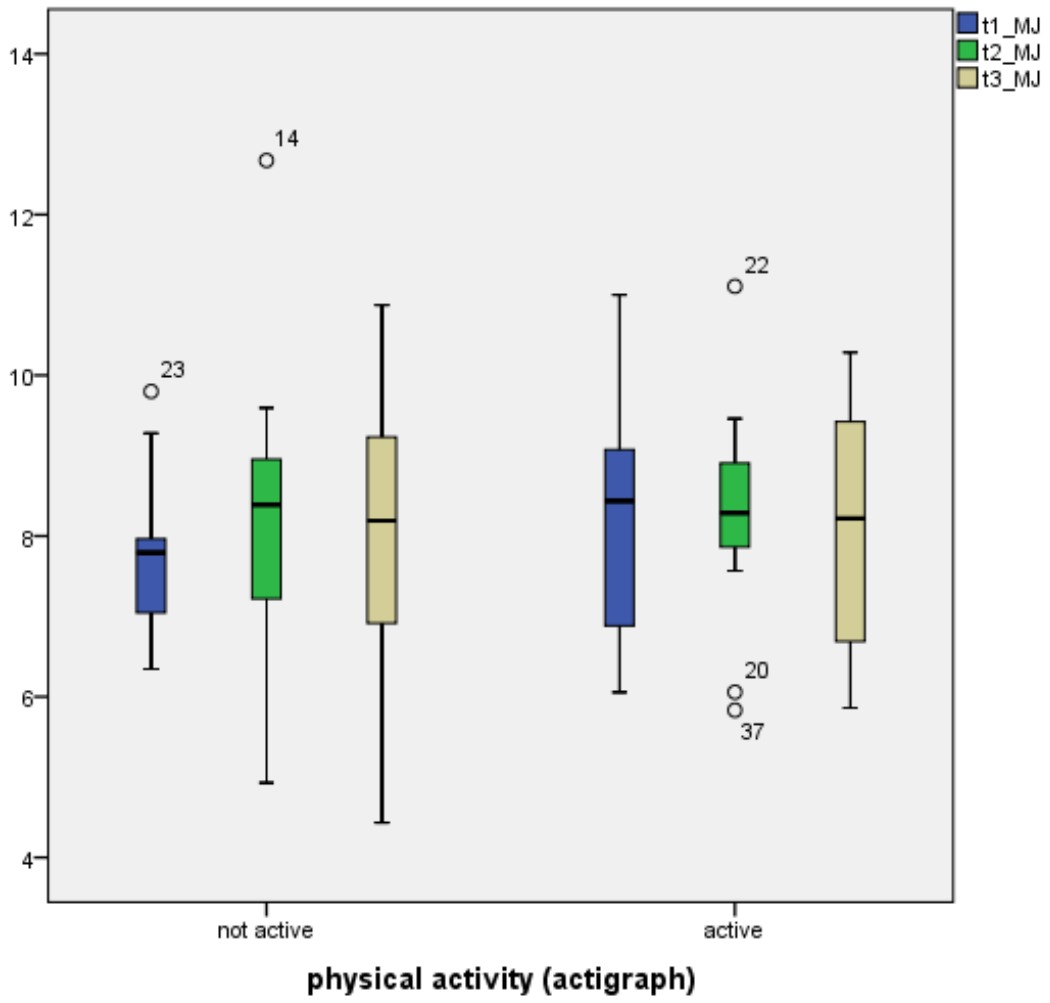

Figure 5 Energy Intake [MJ] of Non-Active and Active Women During Pregnancy

Mean daily energy intake measured in this study was compared to the recommendations made by the German, Austrian and Swiss Nutrition Societies (3) for each trimester. As mentioned above it was assumed that the physical activity level of active women corresponded to a PAL value of 1.8 and the PAL of non-active women corresponded to a PAL value of 1.4. Energy intake measurements of physically active women differed significantly from the recommended daily energy intake for active women in all trimesters. The energy intake of non-active women was not significantly different from D-A-CH recommendations in the first and second trimester, but was significantly lower than the recommended energy intake in the third trimester (Table 17).

Figure 6 further illustrates these differences of measured and recommended daily energy intake (in MJ).

Table 17 Comparison of Measured and Recommended (3) Energy Intake [kcal]

D-A-CH recommendations	1st trimester	2nd trimester	3rd trimester
PAL 1.4	1870	2050	2300
PAL 1.8	2470	2650	2900
mean measured intake	1st trimester	2nd trimester	3rd trimester
not active	1859.44	1964.95	1872.06†
active	1981.81*	1985.52*	1919.63*

† significant difference to D-A-CH recommendations (paired samples t-test, p = 0.003)

* significant difference to D-A-CH recommendations (paired samples t-test, p < 0.001)

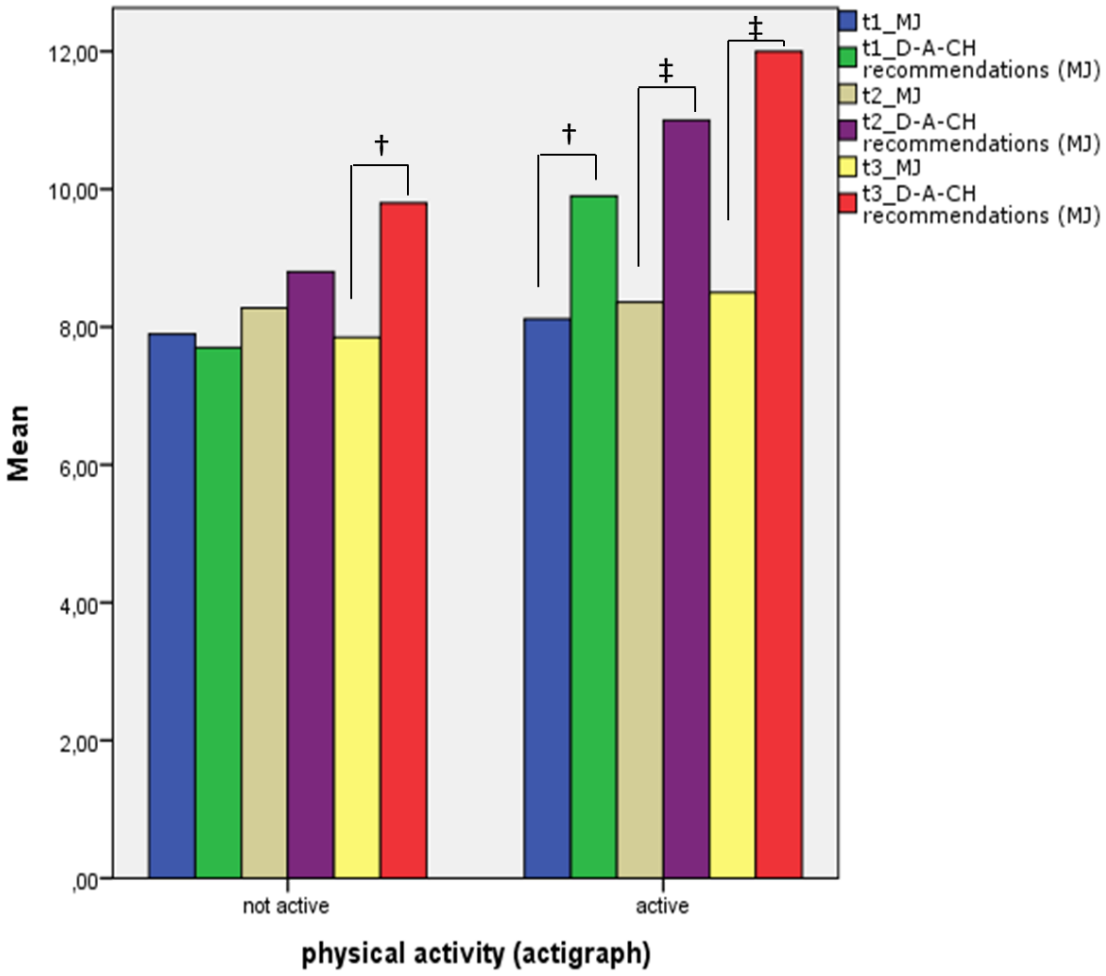

Figure 6 Measured and Recommended (3) Energy Intake [MJ]

†significant difference to D-A-CH recommendations (paired samples t-test, p = 0.002)
‡significant difference to D-A-CH recommendations (paired samples t-test, p < 0.001)

3.4 Nutrient Intake

Mean daily protein intake of physically active and non-active women did not differ much during all trimesters. Physically non-active women had the lowest protein intake in the third trimester. Active women consumed the least amount of protein during their second trimester of pregnancy (Table 18). Daily protein intake in the first trimester ranged from 45.58 to 88.16 g for non-active and from 51.09 to 122.48 g for active women. Non-physically active women consumed a minimum of 37.74 g protein and a maximum of 116.71 g in the second trimester. Active women had a slightly smaller range of daily protein intake in the second trimester (52.24–88.05 g). At the end of pregnancy, daily protein intake ranged from 38.58 to 100.36 g for non-active and from 57.55 to 91.93 g for active women. A t-test showed no significant difference of protein intake between active and non-active women (independent samples t-test, $p = 0.812$, $p = 0.797$ and $p = 0.929$ for the first, second and third trimester, respectively).

As presented in Table 18, physically active women tended to have a slightly higher daily fat intake than non-active women (independent samples t-test $p = 0.356$, $p = 0.717$ and $p = 0.714$ for the first, second and third trimester, respectively). The mean fat consumption was highest in the second trimester in non-active and highest in the first trimester in active women. Physically non-active women consumed a minimum of 43.67 g and a maximum of 130.95 g fat over the course of pregnancy. Fat intake in active women ranged from 43.17 g to 135.32 g in all trimesters.

Both groups of pregnant women consumed a similar amount of carbohydrates during pregnancy (independent samples t-test, $p = 0.357$, $p = 0.997$ and $p = 0.766$ for the first, second and third trimester, respectively). Carbohydrate intake during the whole pregnancy ranged from 121.52 to 339.30 g in non-active and from 150.18 to 325.28 g in active women. Mean daily carbohydrate intake was lowest in the first trimester for non-active and in the last trimester for active women.

Comparison of sugar intake between the two activity groups showed no statistically significant difference (independent samples t-test, $p = 0.091$, $p = 0.116$ and $p = 0.806$ for the first, second and third trimester, respectively). The parameter “sugar” includes all mono- and disaccharides. Mean daily sugar intake of non-physically active women was 91.63 g in the first, 101.32 g in the second and 106.31 g in the third trimester. Active

women consumed a daily mean of 110.66 g of sugar in the first, 116.62 g in the second and 109.80 g in the third trimester.

Figure 7 shows, that active women had a greater variance of macronutrient intake in the first trimester, whereas in the second and third trimester non-active women showed a greater variance in nutrient intake.

Table 18 Macronutrient Intake of Active and Non-Active Women

		1st trimester Mean ± SD	2nd trimester Mean ± SD	3rd trimester Mean ± SD
Protein intake [g]	not active	(N = 13) 73.07 ± 11.77	(N = 17) 73.77 ± 17.77	(N = 14) 72.35 ± 20.76
	active	(N = 14) 74.64 ± 20.62	(N = 15) 72.48 ± 9.57	(N = 14) 72.91 ± 9.98
Fat intake [g]	not active	(N = 13) 77.14 ± 11.77	(N = 17) 78.75 ± 21.75	(N = 14) 74.79 ± 20.95
	active	(N = 14) 82.87 ± 19.14	(N = 15) 81.50 ± 20.51	(N = 14) 77.45 ± 16.98
Carbohydrate intake [g]	not active	(N = 13) 211.94 ± 41.43	(N = 17) 233.80 ± 42.22	(N = 14) 220.18 ± 53.77
	active	(N = 14) 227.40 ± 43.97	(N = 15) 233.85 ± 39.64	(N = 14) 226.25 ± 53.27

Carbohydrates contributed to almost 50 percent of total energy intake in our study population. Over a third of energy came from fat intake and fifteen percent from protein intake. Fat intake decreased while carbohydrate intake increased over the course of pregnancy (Figure 9). There was no difference in the distribution of macronutrients between physically active and non-active pregnant women.

Analysis of total fat intake showed that over 40 percent of fat intake was derived from saturated fatty acids. Polyunsaturated (PUFAs) and monounsaturated (MUFAs) fatty acids together contributed to nearly half of total fat intake. Active women had a higher intake of saturated fatty acids than non-active women in the first and third trimester. They also consumed more MUFAs than non-active women in the first two trimesters. Physically non-active women had a greater intake of PUFAs than active women in the first and last trimester (Figure 8). Table 19 shows how fatty acids contributed to total energy intake.

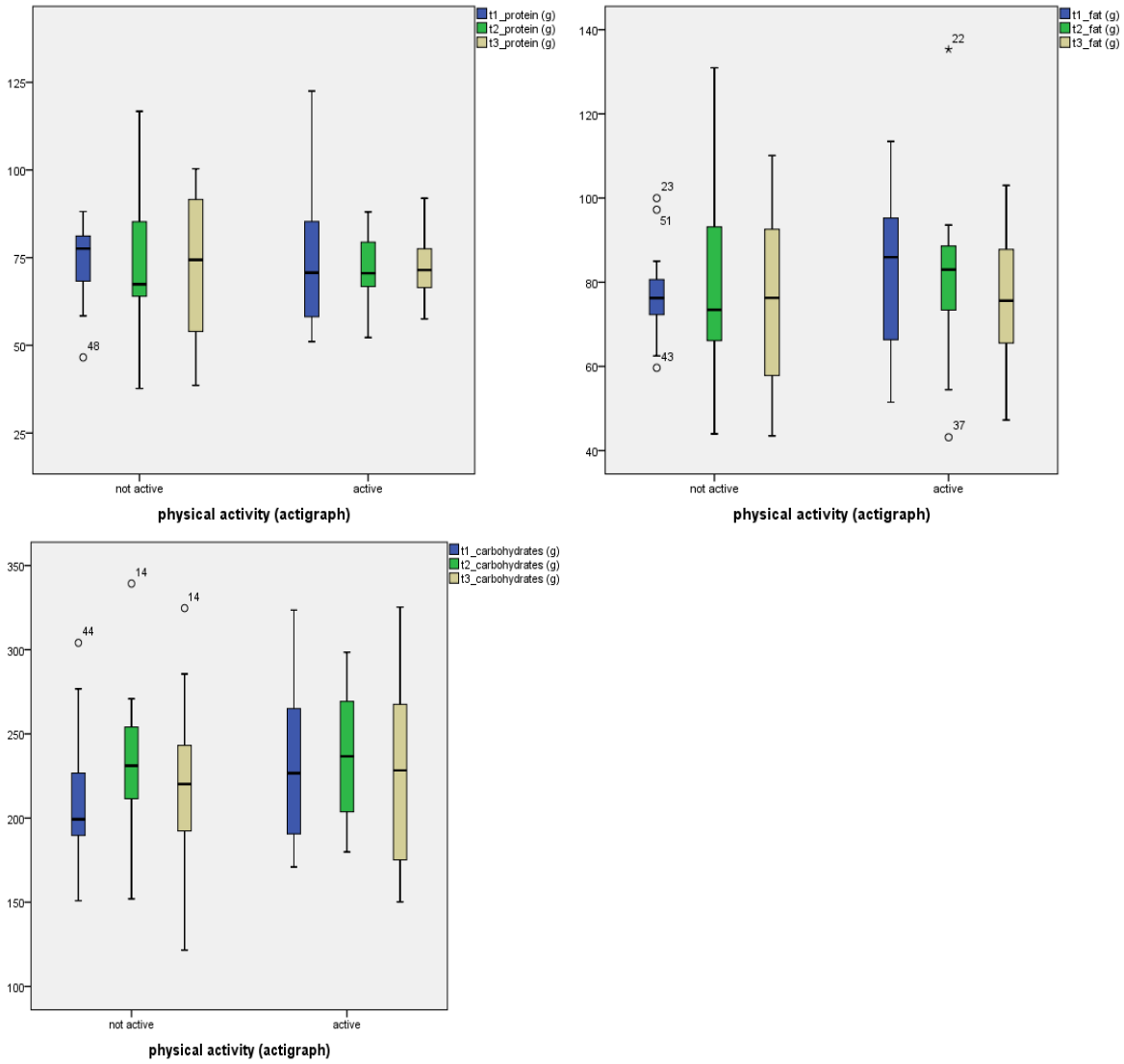

Figure 7 Macronutrient Intake of Non-Active and Active Women During Pregnancy

Table 19 Intake of Fatty Acids [in % of Total Energy Intake]

		1st trimester	2nd trimester	3rd trimester
not active	saturated fatty acids	16.34%	16.65%	16.2%
	MUFAs	12.16%	12.21%	11.52%
	PUFAs	6.84%	5.92%	5.76%
active	saturated fatty acids	16.72%	15.91%	16.56%
	MUFAs	12.54%	12.58%	11.52%
	PUFAs	6.08%	5.92%	5.4%

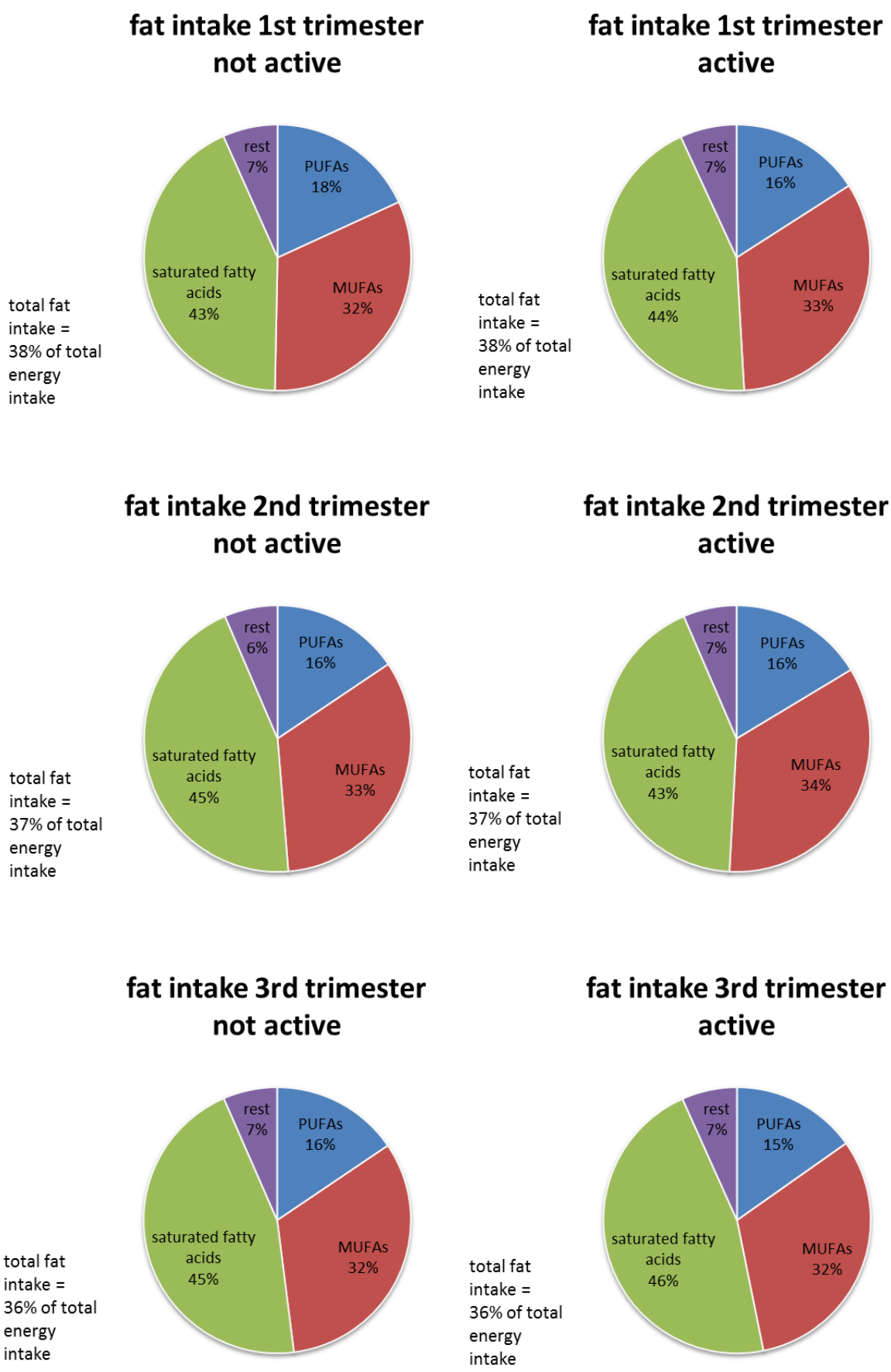

Figure 8 Fat Intake During Pregnancy in Active and Non-Active Women

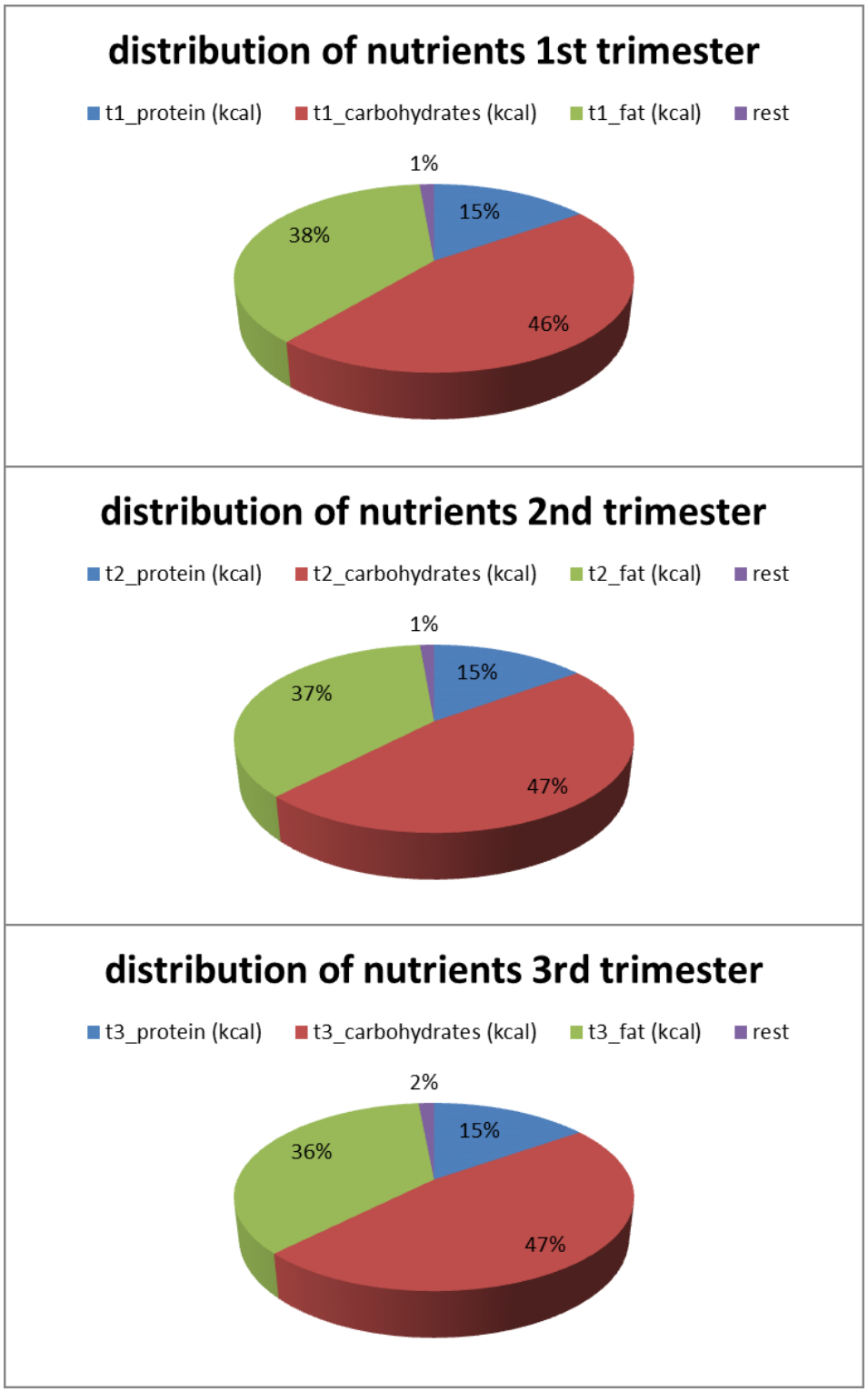

Figure 9 Distribution of Macronutrients Throughout Pregnancy

3.5 Diversity and Food Groups

"Diversity" was calculated by nut.s nutritional software (37). "Diversity" describes the number of different food groups that were consumed by each participant. Mean daily "diversity" values were similar in non-active and active pregnant women (Mann-Whitney U-Test, $p = 0.313$, $p = 0.552$ and $p = 0.925$ for the first, second and third trimester, respectively). Active women had a smaller range than non-physically active women (Table 20).

Table 20 "Diversity" in Active and Non-Active Women Throughout Pregnancy

	1st trimester	2nd trimester	3rd trimester
	Mean ± SD	Mean ± SD	Mean ± SD
not active	(N = 13) 14.77 ± 1.30	(N = 17) 14.35 ± 2.23	(N = 14) 14.29 ± 2.13
active	(N = 14) 14.43± 1.34	(N = 15) 14.93 ± 1.16	(N = 14) 14.14 ± 1.46
	Range (min–max)	Range (min–max)	Range (min–max)
not active	(N = 13) 13–18	(N = 17) 10–18	(N = 14) 12–19
active	(N = 14) 13–17	(N = 15) 13–17	(N = 14) 11–16

The following food groups were analyzed for differences between non-active and active women and their contribution to total energy intake and macronutrient intake was calculated.

- Bread
- Backed goods
- Cereal
- Dairy
- Drinks
- Fish
- Fruit
- Meat
- Potatoes
- Sausage
- Sweets
- Vegetables

Out of these twelve food groups, bread contributed most to total energy intake in the first trimester (non-active women 17%, active women 14%), followed by dairy and backed goods (10% and 9%) in non-active or drinks (12%), dairy and backed goods (10% each) in active women. Thirty percent of energy derived from other than the analyzed food groups in the first trimester.

In the second trimester bread accounted for 16% (non-active) or 14% (active) of total energy intake, backed goods accounted for 11% (non-active) or 13% (active) and drinks for 9% (non-active) or 12% (active). In the second trimester, non-physically active women acquired 30%, physically active women 23% of total energy intake from other food groups than those we analyzed.

In the third trimester bread and dairy (14% each, non-active women) or bread and drinks (13% each, active women) contributed most to total energy intake. Second highest contributors were drinks (12%, non-active women) or dairy (12%, active women). In the last trimester 26% (non-active women) or 25% (active women) of total energy intake derived from other than the analyzed food groups.

When comparing the two activity groups with a Manny-Whitney U test, a significant difference of fish intake between active and non-active women in the first trimester ($p = 0.026$) was observed. Non-active women consumed a mean of 41.32 kcal through fish compared to a mean 17.88 kcal fish intake in active women. Fish contributed to two percent of total energy intake in non-active and one percent in active women.

Further analysis explored how much each food group contributed to total intake of protein, fat and carbohydrates and compared the two groups of pregnant women (non-active versus active). Table 21 to Table 23 show the results of these calculations.

The biggest sources of protein intake were bread and dairy in non-active and active women. About a third of total protein intake was caused by other than the analyzed food groups in both activity groups.

Nearly half of total fat intake came from other food groups than those we analyzed. Among these groups dairy, backed goods and sausage contributed the most to fat intake. In the first trimester there was a significant difference of fat intake due to fish consumption (Mann-Whitney U test, $p = 0.015$) between the two activity groups. Non-active women consumed a mean of 1830.10 mg of fat through fish, whereas active

women got 580.71 mg of fat from fish consumption. In the third trimester fat intake caused by cereal (Mann-Whitney U test, $p = 0.012$) and potatoes (Mann-Whitney U test, $p = 0.046$) was significantly different in non-active and active women. Mean fat consumption through cereal was 1763.29 mg in non-active and 582.93 mg in active women. Mean amount of fat consumed through potatoes was 535.28 mg in non-active and 59.52 mg in active pregnant women.

Total carbohydrate intake mostly originated from consumption of bread, drinks, fruit and backed goods. Bread contributed up to a fourth of carbohydrate intake in non-active women and to over a fifth of total carbohydrate intake in active women. In the second trimester a significant difference of carbohydrate intake due to meat (Mann-Whitney U test, $p = 0.046$) and sausage (Mann-Whitney U test, $p = 0.049$) consumption could be found. Non-active women consumed a mean 8.26 mg of carbohydrates through meat and 194.15 mg through sausage intake. Active women's mean carbohydrate intake through meat was 190.15 mg and 258.79 mg was through sausage.

Table 21 Food Groups Contributing to Total Protein Intake

	non-active 1st trimester	active 1st trimester	Mann-Whitney U test Asymp. Sig. (2-tailed)
Backed goods	5%	6%	0.662
Bread	16%	13%	0.891
Cereal	2%	1%	0.164
Dairy	15%	15%	0.560
Drinks	5%	8%	0.528
Fish	7%	4%	0.100
Fruit	2%	3%	0.145
Meat	4%	2%	0.550
Potatoes	1%	1%	0.558
Sausage	7%	9%	0.139
Sweets	1%	1%	0.438
Vegetables	3%	1%	0.225
Other	32%	36%	
	non-active 2nd trimester	active 2nd trimester	Mann-Whitney U test Asymp. Sig. (2-tailed)
Backed goods	6%	7%	0.206
Bread	15%	14%	0.462
Cereal	2%	2%	0.405
Dairy	17%	13%	0.317
Drinks	7%	7%	0.865
Fish	3%	8%	0.168
Fruit	2%	3%	0.193
Meat	3%	5%	0.664
Potatoes	1%	1%	0.199
Sausage	6%	9%	0.062
Sweets	1%	1%	0.610
Vegetables	3%	2%	0.748
Other	34%	28%	
	non-active 3rd trimester	active 3rd trimester	Mann-Whitney U test Asymp. Sig. (2-tailed)
Backed goods	4%	5%	0.491
Bread	12%	12%	0.890
Cereal	3%	2%	0.103
Dairy	19%	17%	0.748
Drinks	8%	9%	0.383
Fish	4%	3%	1.000
Fruit	3%	3%	0.646
Meat	3%	5%	0.297
Potatoes	1%	1%	0.297
Sausage	7%	9%	0.141
Sweets	1%	1%	0.434
Vegetables	3%	2%	0.270
Other	32%	31%	

Table 22 Food Groups Contributing to Total Fat Intake

	non-active 1st trimester	active 1st trimester	Mann-Whitney U test Asymp. Sig. (2-tailed)
Backed goods	10%	11%	0.382
Bread	4%	3%	0.326
Cereal	1%	1%	0.317
Dairy	15%	13%	0.846
Drinks	4%	4%	0.467
Fish	2%	1%	**0.015**
Fruit	1%	1%	0.560
Meat	2%	1%	0.593
Potatoes	1%	2%	0.380
Sausage	6%	11%	0.094
Sweets	4%	3%	0.680
Vegetables	1%	0%	0.308
Other	49%	49%	
	non-active 2nd trimester	active 2nd trimester	Mann-Whitney U test Asymp. Sig. (2-tailed)
Backed goods	12%	14%	0.720
Bread	4%	4%	0.806
Cereal	2%	1%	0.623
Dairy	15%	12%	0.249
Drinks	4%	4%	0.925
Fish	1%	3%	0.116
Fruit	1%	1%	0.558
Meat	1%	2%	0.602
Potatoes	0%	1%	0.954
Sausage	6%	11%	0.093
Sweets	5%	6%	0.533
Vegetables	1%	1%	0.720
Other	48%	40%	
	non-active 3rd trimester	active 3rd trimester	Mann-Whitney U test Asymp. Sig. (2-tailed)
Backed goods	8%	11%	0.251
Bread	3%	3%	0.679
Cereal	2%	1%	**0.012**
Dairy	18%	17%	0.963
Drinks	4%	7%	0.054
Fish	1%	1%	0.923
Fruit	1%	1%	1.000
Meat	2%	2%	0.322
Potatoes	1%	0%	**0.046**
Sausage	6%	9%	0.073
Sweets	5%	5%	0.890
Vegetables	1%	1%	0.927
Other	48%	42%	

Table 23 Food Groups Contributing to Total Carbohydrate Intake

	non-active 1st trimester	active 1st trimester	Mann-Whitney U test Asymp. Sig. (2-tailed)
Backed goods	11%	11%	0.846
Bread	27%	22%	0.499
Cereal	5%	4%	0.317
Dairy	5%	5%	0.286
Drinks	12%	18%	0.073
Fish	0%	0%	0.286
Fruit	14%	15%	0.467
Meat	0%	0%	0.307
Potatoes	3%	3%	0.884
Sausage	0%	0%	0.395
Sweets	7%	7%	0.207
Vegetables	2%	1%	0.382
Other	14%	14%	
	non-active 2nd trimester	active 2nd trimester	Mann-Whitney U test Asymp. Sig. (2-tailed)
Backed goods	12%	14%	0.396
Bread	25%	22%	0.439
Cereal	5%	5%	0.650
Dairy	7%	5%	0.345
Drinks	12%	19%	0.067
Fish	0%	0%	0.053
Fruit	12%	16%	0.100
Meat	0%	0%	**0.046**
Potatoes	2%	1%	0.088
Sausage	0%	0%	**0.049**
Sweets	7%	8%	0.355
Vegetables	2%	2%	0.558
Other	16%	8%	
	non-active 3rd trimester	active 3rd trimester	Mann-Whitney U test Asymp. Sig. (2-tailed)
Backed goods	7%	9%	0.646
Bread	22%	21%	0.854
Cereal	6%	5%	0.346
Dairy	8%	8%	0.435
Drinks	19%	18%	0.854
Fish	0%	0%	0.345
Fruit	18%	17%	0.713
Meat	0%	0%	0.345
Potatoes	2%	1%	0.477
Sausage	0%	0%	0.270
Sweets	6%	9%	0.383
Vegetables	2%	1%	0.435
Other	10%	11%	

4 Discussion

4.1 Weight and Weight Gain

In this study 4% of the participants were underweight, 75% were normal weight and 21% were overweight before pregnancy (Table 13). Mean prepregnancy BMI was 22.38 kg/m^2 (22.70 kg/m^2 for non-active and 21.83 kg/m^2 for active women). Mean BMI of active women was slightly lower throughout the whole pregnancy, although the difference was not statistically different.

A study (43) conducted in 2001 assessed the influence of socioeconomic status of Austrian pregnant women on weight, nutritional intake and physical activity. They measured a mean prepregnancy BMI of 22.7 kg/m^2. In their study population of 261 women, 8.7% of women were underweight, 71% were normal weight, 14.3% were overweight and 6.1% were obese. (43)

The Austrian health survey of 2006/2007 (33) shows a similar distribution of BMI categories of women in their reproductive age (Table 9, page 24).

During the 2014 evaluation of the Austrian project "Richtig essen von Anfang an", 1667 pregnant women who participated in a workshop about nutrition in pregnancy were asked about their height and prepregnancy weight. From these values body mass index was calculated (mean BMI 23.06 kg/m^2). After dividing them into BMI categories, 5.8% of the women were underweight, 65.8% normal weight, 15.7% overweight and 6% obese. For 6.7% of the participants, no values were available. (44)

Hence the study population presented in this thesis, albeit small, seems to be a good representation of the Austrian female population in their reproductive age. A slightly higher percentage of normal weight women than in the above mentioned studies could be observed. The absence of obese women in the study sample might be because the study was advertised with a combination of the words "physical activity" and "pregnancy". This might have caused obese women to not want to participate or to think that they were not qualified, even though it was explained that physically active as well as sedentary women could participate in the study.

Mean gestational weight gain in this study was 15.44 kg (15.94 kg in non-active and 15.16 kg in active women). Considering that most women were either normal weight or

overweight, 15.44 kg almost exceeds (normal weight women) or actually exceeds (overweight women) recommendations for gestational weigh gain (refer to Figure 2). Out of all women 14.9% gained too little, and 42.6% each gained within or over the recommended amount. Eighty percent of overweight women exceeded weight gain recommendations, compared to 34% of normal weight and none of underweight women. Half of women with a prepregnancy BMI < 18.5 kg/m^2 gained inadequately and the other half gained within the recommended amount (Table 15). Though no statistically significant difference in weight gain between physically active and non-active women was found, more active women gained within the IOM recommendations (Table 14).

In the Austrian Nutrition Report 2008 a mean weight gain of 12 kg was observed (45).

A German study by Ferrari and Mallann (27) collected data of 11 771 pregnant women from the years 2000 to 2012. Mean weight gain in this study population was 13.3 kg. Mean weight gain in the year 2012 was over a kilogram higher than in the year 2000 (13.7 kg in 2012 and 12.3 kg in 2000). They also compared mean weight gain with recommendations by the IOM (14). Most women gained within (36.5%) or above the recommendations (36.0%), and 27.4% of women gained inadequately. Out of the populations of underweight women, 42.3% gained less than and 44.6% gained within the recommended amount. Of the women who were normal weight before pregnancy, 31.9% gained less than recommended, 29.3% gained too much and 39.8% gained within recommendations. Most overweight (54.5%) and obese (57.7%) women gained excessively. (27)

Another German study (46) reported on an intervention consisting of counseling on nutrition and physical activity during pregnancy and advice on adequate weight gain. Mean weight gain was 15.6 kg in their control group and 14.1 kg in their intervention group. In the control group 59% of women gained more than recommended by the IOM and 19% gained too little. In the intervention group 38% of women gained more and 21% gained less than recommended. (46)

When regarding the above listed figures, it seems to be a general trend that overweight and obese women are more likely to gain excessively. Mean weight gain in Austrian and German pregnant women tends to be within recommendations for normal weight women (12 to 15.6 kg in the studies mentioned above). The problem of inadequate weight gain seems to be not as common as that of excessive gestational weight gain.

4.1.1 Prevention of Excessive Gestational Weight Gain

There are a number of studies that try to explore how physical activity or nutritional behavior can help women to have an adequate weight gain during pregnancy. Not all of them can be described in this thesis, but some examples will be explored in the next paragraph.

Two Canadian studies were able to prevent excessive weight gain in normal weight and in overweight and obese women through a structured walking program and a diet plan. (47, 48) In an American study a behavioral lifestyle intervention including regular contact, counseling on diet, physical activity and weight gain and self-monitoring of weight gain reduced excessive weight gain in normal weight but not overweight or obese women. (49) A German study used counseling on nutrition and physical activity and weight gain monitoring to prevent excessive weight gain in normal weight, overweight and obese women. (46)

A review by Ruchat and Mottola (50) concludes that especially the combination of supervised physical activity and dietary counseling can be successful in preventing excessive weight gain. (50) A literature research by Mudd et. al. (20) presents successful, partially successful und unsuccessful interventions using physical activity to prevent excessive weight gain in overweight and obese women. Partially successful and successful studies included exercise classes, programs, counseling, feedback on weight gain, lifestyle modification or a free gym membership. Unsuccessful interventions included education materials, media campaigning and counseling. (20) It seems that structured and supervised programs are more effective in preventing excessive gain than interventions based on information.

Although the aforementioned study results seem promising, a Cochrane review reports inconsistent evidence for recommending a certain type of intervention to successfully prevent excessive weight gain. Therefore, big randomized controlled trials are needed for further research on this topic. (51)

4.2 Nutrition

4.2.1 Energy Intake

The study population of this thesis consumed a daily mean of 1923.55 kcal (8.05 MJ) during all trimesters.

An Austrian study conducted in 2001 measured energy and nutrient intake once during pregnancy. Mean energy intake was 2042 kcal (8.5 MJ). (43) In the Austrian nutritional report of 2008, food records of 426 pregnant women in the second and third trimester of pregnancy were analyzed. Mean energy intake was 7.8 MJ. (45)

The recommended energy intake for sedentary (PAL = 1.4) pregnant women is 7.7 MJ in the first, 8.8 MJ in the second and 9.8 MJ in the third trimester. (3)

It seems that Austrian pregnant women consume less energy than recommended, as the above mentioned figures show. There might be a few reasons for these results in the aforementioned studies. Underreporting might play a big role in the measurement of low energy intake. Unfortunately no data on percentage of underreporting are available in the study of Freisling and Elmadfa (43) or the Austrian nutritional report of 2008 (45). Both of these reports mention low physical activity as a possible reason for the observed low energy intake. (43, 45) This might also be the case in this study, as discussed in the paragraph below.

The significant difference between measured and recommended energy intake (Table 17, Figure 6) could be a result of different factors. High prevalence of underreporting might be one of these. In this study, percentage of underreporting was especially high in active women and at the end of pregnancy (Table 10). Most of the study participants had adequate or excessive weight gain, which speaks for underreporting as one of the main factors for the low measured energy intake. Another contributing factor might be that only the physical activity level measured at 10 to 14 weeks of gestation was used for allocating the study participants into the according group. Women who were active at the beginning of pregnancy and became sedentary during the second and third trimester were still considered as active. Therefore, energy requirements for women in the physically active group might have been overestimated. However, there was also a significant difference between the energy intake we measured and the

D-A-CH recommendations (3) in physically not active women in the third trimester. In spite of high rates of underreporting and probable overestimation of physical activity level it should be taken into consideration that the women in this study ate too little or consumed the wrong kind of foods in order to achieve an adequate energy supply for themselves and their offspring. If this is the case, measures to prevent low energy intake and to ensure adequate nutrition in pregnancy should be taken.

The Austrian Federal Ministry of Health, the "Hauptverband der österreichischen Sozialversicherungsträger" (association of Austrian social security agencies) and the Austrian Agency for Health and Food Safety (AGES) have launched a project called "Richtig essen von Anfang an" (correct nutrition from the beginning). Since 2013 workshops about nutrition in pregnancy are offered in all Austrian provinces. (52) These measures, if continued and expanded could help to ensure an adequate energy intake and a favorable distribution of macronutrients in Austrian pregnant women. However, the effect of workshops with the topic of healthy nutrition in pregnancy on energy and nutrient intake has to be evaluated. Nutritional intake should be measured before and after the participation in such a workshop to see if pregnant women will implement the received information. This could happen as an independent study or within the framework of the project "Richtig essen von Anfang an".

4.2.2 Nutrient Intake

Mean protein intake in this study population was 73 g, mean carbohydrate intake 225 g and mean fat intake 78 g throughout the whole pregnancy. Fat intake contributed to 36 to 38 percent of total energy intake. Carbohydrates contributed to 46 to 47 percent and protein contributed to 15 percent of total energy intake. (Figure 9) In an Austrian study with data from 2001, the participants consumed a daily mean of 71 g of protein (15 % of total energy intake), 252 g of carbohydrates (51% of total energy intake) and 80 g of fat (35% of total energy intake). (43) In the Austrian nutritional report of 2008, 36 percent of total energy intake came from fat consumption, 47 percent came from carbohydrate and 16 percent came from protein intake. (45)

Recommendations suggest that fat intake should not exceed 35 percent of total energy intake. Recommended protein intake for pregnant women in the second and third trimester is 58 g per day or 15 percent of total energy intake. Carbohydrates should constitute for more than 50 percent of energy intake. (3) Data from this study and the

Austrian nutritional report 2008 (45) show, that fat intake was too high at the cost of low carbohydrate intake. Low carbohydrate and high fat intake seem to be not only a problem amongst pregnant women but also among the general public in Austria. (45, 53)

In the Austrian nutritional report, saturated fatty acids accounted for 15 percent, MUFAs for 13 percent and PUFAs for 6 percent of total energy intake of pregnant women. (45) Women in this study had a similar intake of fatty acids (16% saturated fatty acids, 12% MUFAs and 6% PUFAs, refer to Table 19 for exact values). Recommendations state that saturated fatty acids should not make up more than 10 percent of total energy intake. PUFAs should contribute between 7 and 10 percent to total energy intake. Generally, MUFAs and PUFAs should be preferred to saturated fatty acids and should make up two thirds of total fat intake. (3) The trend of wrong distribution of fatty acids can be observed among all adults in Austria. (53) As the intake of MUFAs and PUFAs can reduce LDL-cholesterol the correct distribution of fatty acids is an important factor in the protection of coronary heart disease. (3, 53) Dietary advice for pregnant as well as non-pregnant individuals should consider these trends in fat intake and should aim to promote healthy intake of fat and fatty acids.

4.2.3 Food Groups and Nutrient Intake

Consumption of fish differed significantly between active and non-active women, although fish only mad up one (active women) to two (non-active) percent of total energy intake. In the first trimester, fish contributed significantly different to total fat intake in the two activity groups.

In the third trimester cereal and potatoes contributed differently to fat intake in active and not active women, although they did only marginally contribute to total fat intake (Table 22). Carbohydrate intake through meat and sausage was also different between physically non-active and active women. These two food groups also did only contribute in a very small part to total carbohydrate intake (Table 23).

These differences could result from variabilities in the completion of the food record questionnaires. They could however also indicate that physically non-active and active women chose different food groups. In bigger studies these differences in food choice could also result in differences of macronutrient and energy intake.

4.3 Limitations of the Study

A major limitation of this study is the high rate of underreporting (Table 10). It might have a big influence on the measured low energy intake. It cannot be reconstructed if underreporting included all nutrients and food groups or was selective. If selective underreporting of certain food groups (e.g. sweets) occurred, all analyses concerning macronutrient intake and food groups could be biased. However, the distribution of macronutrients we measured is in accordance with other studies (see 4.2.2).

The problem of underreporting might be partly caused by the method of nutrient assessment used. Food questionnaires are an easy and cheap method of nutritional assessment. However other methods might be less prone to bias. (5)

Some of the food record questionnaires were not filled out very accurately, which might have led to under- or overestimation of certain food groups. Although input into nut.s nutritional software (37) was performed by the same person for all questionnaires, a certain variability and bias cannot be ruled out. Out of all food questionnaires only 65% have been returned fully filled out. This, together with the rather small sample size, is another limitation of the study.

A further problem of this study has been discussed before (chapter 4.2.1). Physical activity was measured three times during pregnancy but only the first measurement was used to allocate the women into the respective activity group. Changes in physical activity level throughout pregnancy have not been taken into account.

The influence of nutrients and food groups on gestational weight gain was not explored in this study, as high rates of underreporting, and low energy intake but normal to excessive weight gain in the study population would have led to biased results.

4.4 Suggestions for Further Studies

The difference in weight gain between physically active and non-active women was not statistically significant. This could partly be a result of the small sample size and the above describes limitations of this study. The trend observed in this study seems to be that active women tend to have a lower prepregnancy BMI and that a higher percentage of active women gains adequately throughout pregnancy. Bigger studies could try to verify this trend and figure out how physical activity and gestational weight gain in Austrian pregnant women are linked.

Further studies might also use accelerometer data from the second and third trimester to see, if previously active women became sedentary over the course of pregnancy. These results, together with the nutritional data from this thesis, could provide further information about the nutritional status of Austrian pregnant women.

Another idea would be to measure energy and nutrient intake before and after dietary counseling to see if adequate energy intake and adequate fat and fatty acid intake can be achieved.

Furthermore, studies can also investigate the influence of nutrition on gestational weight gain. Differences in energy or macronutrient intake could influence the amount of weight gained throughout pregnancy. By especially assessing excessive weight gain in Austrian women, these findings could be helpful for developing prevention strategies.

This study did not measure the intake of micronutrients. As an adequate supply of micronutrients is especially important in pregnancy, the nutritional status of Austrian pregnant women concerning those nutrients is important to know. Up to now, the Austrian nutritional report of 2008 was the last published nationwide study that assessed micronutrient intake in pregnant women.

4.5 Conclusion

Our research questions can be answered as followed through the results obtained in this study: Total energy intake of pregnant women, active in the first trimester, did not differ from energy intake of physically non-active women. However, active women had a significantly lower energy intake than recommended for their PAL. There was no difference in daily intake of macronutrients between active and non-active women. There were, however, some differences in the intake of certain food groups (fish, cereal, potatoes, meat and sausage). The mean gestational weight gain was not statistically different in active and non-active pregnant women. A greater percentage of physically active women gained within weight gain recommendations.

There seems to be a trend that women, who are physically active at the beginning of pregnancy, have a lower energy intake and tend to gain more adequately during pregnancy. The observed better adherence to the IOM guidelines by physically active women could either be the result of exercise or of their lower energy intake. This warrants further study to explore the health of Austrian pregnant women who exercise.

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6 Appendix

6.1 Food Record Questionnaire

TAG 1 Assoz.-Prof. Dr. SJ Wallner-L., Medizinische Universität Graz

Mahlzeit	**Was haben Sie zur jeweiligen Mahlzeit gegessen und getrunken?**	**ungefähre Menge**
Frühstück Uhrzeit: Ort: o alleine gegessen o in Gesellschaft gegessen	Bitte die Getränke nicht vergessen!!!	
Vormittagsjause Uhrzeit: Ort: o alleine gegessen o in Gesellschaft gegessen	Bitte die Getränke nicht vergessen!!!	
Mittagessen Uhrzeit: Ort: o alleine gegessen o in Gesellschaft gegessen	Bitte die Getränke nicht vergessen!!!	

Nachmittagsjause Uhrzeit: Ort: o alleine gegessen o in Gesellschaft gegessen	Bitte die Getränke nicht vergessen!!!	
Abendessen Uhrzeit: Ort: o alleine gegessen o in Gesellschaft gegessen	Bitte die Getränke nicht vergessen!!!	
Spätmahlzeit Uhrzeit: Ort: o alleine gegessen o in Gesellschaft gegessen	Bitte die Getränke nicht vergessen!!!	

War das typisch für Ihre Ernährungsgewohnheiten?

o ja o nein

Wenn nein, was war der Grund?

o Es war Wochenende und da sieht meine Ernährung ein wenig anders aus

o Anderer Grund: ✍.....

6.2 PARmed-X for Pregnancy (19)

CSEP | SCPE
THE GOLD STANDARD IN EXERCISE SCIENCE AND PERSONAL TRAINING

PARmed-X FOR PREGNANCY

Physical Activity Readiness Medical Examination

PARmed-X for PREGNANCY is a guideline for health screening prior to participation in a prenatal fitness class or other exercise.

Healthy women with uncomplicated pregnancies can integrate physical activity into their daily living and can participate without significant risks either to themselves or to their unborn child. Postulated benefits of such programs include improved aerobic and muscular fitness, promotion of appropriate weight gain, and facilitation of labour. Regular exercise may also help to prevent gestational glucose intolerance and pregnancy-induced hypertension.

The safety of prenatal exercise programs depends on an adequate level of maternal-fetal physiological reserve. PARmed-X for PREGNANCY is a convenient checklist and prescription for use by health care providers to evaluate pregnant patients who want to enter a prenatal fitness program and for ongoing medical surveillance of exercising pregnant patients.

Instructions for use of the 4-page PARmed-X for PREGNANCY are the following:

1 The patient should fill out the section on PATIENT INFORMATION and the PRE-EXERCISE HEALTH CHECKLIST (PART 1, 2, 3, and 4 on p. 1) and give the form to the health care provider monitoring her pregnancy.
2 The health care provider should check the information provided by the patient for accuracy and fill out SECTION C on CONTRAINDICATIONS (p. 2) based on current medical information.
3 If no exercise contraindications exist, the HEALTH EVALUATION FORM (p. 3) should be completed, signed by the health care provider, and given by the patient to her prenatal fitness professional.

In addition to prudent medical care, participation in appropriate types, intensities and amounts of exercise is recommended to increase the likelihood of a beneficial pregnancy outcome. PARmed-X for PREGNANCY provides recommendations for individualized exercise prescription (p. 3) and program safety (p. 4).

*Note: **Sections A and B** should be completed by the patient before the appointment with the health care provider.*

A PATIENT INFORMATION

NAME _____ ADDRESS _____

PHONE _____ BIRTHDATE MM / DD / YEAR HEALTH INSURANCE No. _____

NAME OF PRENATAL FITNESS PROFESSIONAL _____ PHONE NUMBER OF PRENATAL FITNESS PROFESSIONAL _____

B PRE-EXERCISE HEALTH CHECKLIST

PART 1: GENERAL HEALTH STATUS

In the past, have you experienced:	Y	N
1 Miscarriage in an earlier pregnacy?	☐	☐
2 Other pregnancy complications?	☐	☐
3 I have completed a PAR-Q within the last 30 days.	☐	☐

If you answered YES to question 1 or 2, please explain:

Number of previous pregnancies: _____

PART 2: STATUS OF CURRENT PREGNANCY

Due Date: MM / DD / YEAR

During this prenancy, have you experienced:	Y	N
1 Marked fatigue?	☐	☐
2 Bleeding from the vagina ("spotting")?	☐	☐
3 Unexplained faintness or dizziness?	☐	☐
4 Unexplained abdominal pain?	☐	☐
5 Sudden swelling of ankles, hands or face?	☐	☐
6 Persistent headaches or problems with headaches?	☐	☐
7 Swelling, pain or redness in the calf of one leg?	☐	☐
8 Absence of fetal movement after 6th month?	☐	☐
9 Failure to gain weight after 5th month?	☐	☐

If you answered YES to any of the above questions, please explain:

PART 3: ACTIVITY HABITS DURING THE PAST MONTH

1 List only regular fitness/recreational activities:

INTENSITY	FREQUENCY (times/week) 1-2	2-4	4+	TIME (minutes/day) <20	20-40	40+
Heavy						
Medium						
Light						

2 Does your regular occupation (job/home) activity involve:	Y	N
Heavy lifting?	☐	☐
Frequent walking/stair climbing?	☐	☐
Occasional walking (> once/hr)?	☐	☐
Prolonged standing?	☐	☐
Mainly sitting?	☐	☐
Normal daily activity?	☐	☐
3 Do you currently smoke tobacco?*	☐	☐
4 Do you consume alcohol?*	☐	☐

PART 4: PHYSICAL ACTIVITY INTENTIONS

What physical activity do you intend to do?

Is this a change from what you currently do? ☐ YES ☐ NO

**Note: Pregnant women are strongly advised not to smoke or consume alcohol during pregnancy and during lactation.*

CONTRAINDICATIONS TO EXERCISE *To be completed by your health care provider*

ABSOLUTE CONTRAINDICATIONS

Does the patient have:	Y	N
1 Ruptured membranes, premature labour?	☐	☐
2 Persistent second or third trimester bleeding/ placenta previa?	☐	☐
3 Pregnancy-induced hypertension or pre-eclampsia?	☐	☐
4 Incompetent cervix?	☐	☐
5 Evidence of intrauterine growth restriction?	☐	☐
6 High-order pregnancy (e.g., triplets)?	☐	☐
7 Uncontrolled Type I diabetes, hypertension or thyroid disease, other serious cardiovascular, respiratory or systemic disorder?	☐	☐

RELATIVE CONTRAINDICATIONS

Does the patient have:	Y	N
1 History of spontaneous abortion or premature labour in previous pregnancies	☐	☐
2 Mild/moderate cardiovascular or respiratory disease (e.g., chronic hypertension, asthma)?	☐	☐
3 Anemia or iron deficiency? (Hb < 100 g/L)?	☐	☐
4 Malnutrition or eating disorder (anorexia, bulimia)?	☐	☐
5 Twin pregnancy after 28th week?	☐	☐
6 Other significant medical condition? Please specify:	☐	☐

Note: Risk may exceed benefits of regular physical activity. The decision to be physically active or not should be made with qualified medical advice.

PHYSICAL ACTIVITY RECOMMENDATION ☐ Recommended/Approved ☐ Contraindicated

PRESCRIPTION FOR AEROBIC ACTIVITY

RATE OF PROGRESSION: The best time to progress is during the second trimester since risks and discomforts of pregnancy are lowest at that time. Aerobic exercise should be increased gradually during the second trimester from a minimum of 15 minutes per session, 3 times per week (at the appropriate target heart rate or RPE to a maximum of approximately 30 minutes per session, 4 times per week (at the appropriate target heart rate or RPE).

WARM-UP/COOL-DOWN: Aerobic activity should be preceded by a brief (10-15 min.) warm-up and followed by a short (10-15 min.) cool-down. Low intensity calesthenics, stretching and relaxation exercises should be included in the warm-up/cool-down.

F **FREQUENCY**
Begin at 3 times per week and progress to four times per week

I **INTENSITY**
Exercise within an appropriate RPE range and/or target heart rate zone

T **TIME**
Attempt 15 minutes, even if it means reducing the intensity. Rest intervals may be helpful

T **TYPE**
Non weight-bearing or low-impact endurance exercise using large muscle groups (e.g., walking, stationary cycling, swimming, aquatic exercises, low impact aerobics)

"TALK TEST": A final check to avoid overexertion is to use the "talk test". The exercise intensity is excessive if you cannot carry on a verbal conversation while exercising.

PRESCRIPTION/MONITORING OF INTENSITY: The best way to prescribe and monitor exercise is by combining the heart rate and rating of perceived exertion (RPE) methods.

HEART RATE RANGES FOR PREGNANT WOMEN

MATERNAL AGE	FITNESS LEVEL OR BMI	HEART RATE RANGE (beats/minute)
Less than 20	–	140-155
20-29	Low	129-144
	Active	135-150
	Fit	145-160
	BMI > 25kg m^{-2}	102-124
30-39	Low	128-144
	Active	130-145
	Fit	140-156
	BMI > 25kg m^{-2}	101-120

Target HR ranges were derived from peak exercise tests in medically prescreened low-risk women who were pregnant. (Mottola et al., 2006; Davenport et al., 2008).

RATING OF PERCIEVED EXERTION (RPE)

Check the accuracy of your heart rate target zone by comparing it to the scale below. A range of about 12-14 (somewhat hard) is appropriate for most pregnant women.

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Very, very light		Somewhat light		Fairly light		Somewhat hard		Hard		Very hard		Very, very hard	

The original PARmed-X for PREGNANCY was developed by L.A. Wolfe, Ph.D., Queen's University and updated by Dr. M.F. Mottola, Ph.D., University of Western Ontario.

Disponible en français sous le titre «Examination medicale sur l'aptitude à l'activité physique pour les femmes enceintes (X-AAP pour les femmes enceintes)»

Additional copies of the PARmed-X for PREGNANCY, can be downloaded from Canadian Society for Exercise Physiology ***www.csep.ca/forms***

PRESCRIPTION FOR MUSCULAR CONDITIONING

It is important to condition all major muscle groups during both prenatal and postnatal periods.

WARM-UPS & COOL DOWN:

Range of Motion: neck, shoulder girdle, back, arms, hips, knees, ankles, etc.

Static Stretching: all major muscle groups

(Do not over stretch!)

EXAMPLES OF MUSCULAR STRENGTHENING EXERCISES

CATEGORY	PURPOSE	EXAMPLE
Upper back	Promotion of good posture	Shoulder shrugs, shoulder blade pinch
Lower back	Promotion of good posture	Modified standing opposite leg & arm lifts
Abdomen	Promotion of good posture, prevent low-back pain, prevent diastasis recti, strengthen muscles of labour	Abdominal tightening, abdominal curl-ups, head raises lying on side or standing position
Pelvic floor ("Kegels")	Promotion of good bladder control, prevention of urinary incontinence	"Wave", "elevator"
Upper body	Improve muscular support for breasts	Shoulder rotations, modified push-ups against a wall
Buttocks, lower limbs	Facilitation of weight-bearing, prevention of varicose veins	Buttocks squeeze, standing leg lifts, heel raises

PRECAUTIONS FOR MUSCULAR CONDITIONING DURING PREGNANCY

VARIABLE	EFFECTS OF PREGNANCY	EXERCISE MODIFICATIONS
Body position	• in the supine position (lying on the back), the enlarged uterus may either decrease the flow of blood returning from the lower half of the body as it presses on a major vein (inferior vena cava) or it may decrease flow to a major artery (abdominal aorta)	• past 4 months of gestation, exercises normally done in the supine position should be altered • such exercises should be done side lying or standing
Joint laxity	• ligaments become relaxed due to increasing hormone levels • joints may be prone to injury	• avoid rapid changes in direction and bouncing during exercises • stretching should be performed with controlled movements
Abdominal muscles	• presence of a rippling (bulging) of connective tissue along the midline of the pregnant abdomen (diastasis recti) may be seen during abdominal exercise	• abdominal exercises are not recommended if diastasis recti develops
Posture	• increasing weight of enlarged breasts and uterus may cause a forward shift in the centre of gravity and may increase the arch in the lower back • this may also cause shoulders to slump forward	• emphasis on correct posture and neutral pelvic alignment. Neutral pelvic alignment is found by bending the knees, feet shoulder width apart, and aligning the pelvis between accentuated lordosis and the posterior pelvic tilt position.
Precautions for resistance exercise	• emphasis must be placed on continuous breathing throughout exercise • exhale on exertion, inhale on relaxation using high repetitions and low weights • Valsalva Manoevre (holding breath while working against a resistance) causes a change in blood pressure and therefore should be avoided • avoid exercise in supine position past 4 months gestation	

PARMED-X FOR PREGNANCY – HEALTH EVALUATION FORM

(to be completed and given to the prenatal fitness professional after obtaining medical clearance to exercise)

I, _____ (please print patient's name), have discussed my plans to participate in physical activity during my current pregnancy with my health care provider and I have obtained his/her approval to begin participation.

PATIENTS SIGNATURE _____ DATE _____

NAME OF HEALTH CARE PROVIDER _____

ADDRESS _____

PHONE _____

HEALTH CARE PROVIDER'S COMMENTS:

HEALTH CARE PROVIDER'S SIGNATURE _____

ADVICE FOR ACTIVE LIVING DURING PREGNANCY

Pregnancy is a time when women can make beneficial changes in their health habits to protect and promote the healthy development of their unborn babies. These changes include adopting improved eating habits, abstinence from smoking and alcohol intake, and participating in regular moderate physical activity. Since all of these changes can be carried over into the postnatal period and beyond, pregnancy is a very good time to adopt healthy lifestyle habits that are permanent by integrating physical activity with enjoyable healthy eating and a positive self and body image.

ACTIVE LIVING

- see your doctor before increasing your activity level during pregnancy
- exercise regularly but don't overexert
- exercise with a pregnant friend or join a prenatal exercise program
- follow FITT principles modified for pregnant women
- know safety considerations for exercise in pregnancy

HEALTHY EATING

- the need for calories is higher (about 300 more per day) than before pregnancy
- follow Canada's Food Guide to Healthy Eating and choose healthy foods from the following groups: whole grain or enriched bread or cereal, fruits and vegetables, milk and milk products, meat, fish, poultry and alternatives
- drink 6-8 glasses of fluid, including water, each day
- salt intake should not be restricted
- limit caffeine intake i.e., coffee, tea, chocolate, and cola drinks
- dieting to lose weight is not recommended during pregnancy

POSITIVE SELF AND BODY IMAGE

- remember that it is normal to gain weight during pregnancy
- accept that your body shape will change during pregnancy
- enjoy your pregnancy as a unique and meaningful experience

For more detailed information and advice about pre- and postnatal exercise, you may wish to obtain a copy of a booklet entitled Active Living During Pregnancy: Physical Activity Guidelines for Mother and Baby © 1999. Available from the Canadian Society for Exercise Physiology, ***www.csep.ca****. Cost: $11.95*

Public Health Agency of Canada. The sensible guide to a healthy pregnancy. Minister of Health, 2012. Ottawa, Ontario K1A 0K9. http://www.phac-aspc.gc.ca/hp-gs/guide/assets/pdf/hpguide-eng.pdf. HC Pub.: 5830 Cat.: HP5-33/2012E. 1 800 O-Canada (1-800-622-6232) TTY: 1-800-926-9105.

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SAFETY CONSIDERATIONS

- Avoid exercise in warm/humid environments, especially during the 1st trimester
- Avoid isometric exercise or straining while holding your breath
- Maintain adequate nutrition and hydration – drink liquids before and after exercise
- Avoid exercise while lying on your back past the 4th month of pregnancy
- Avoid activities which involve physical contact or danger of falling
- Know your limits – pregnancy is not a good time to train for athletic competition
- Know the reasons to stop exercise and consult a qualified health care provider immediately if they occur

REASONS TO STOP EXERCISE AND CONSULT YOUR HEALTH CARE PROVIDER

- Excessive shortness of breath
- Chest pain
- Painful uterine contractions (more than 6-8 per hour)
- Vaginal bleeding
- Any "gush" of fluid from vagina (suggesting premature rupture of the membranes)
- Dizziness or faintness