University of Alberta

Assessment of Pre-Pregnancy Dietary Intake and Physical Activity of Alberta Women

by

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Abstract

Pre-pregnancy dietary intake and physical activity may be important in fetal development. The objective of this study was to examine the use of a food frequency questionnaire (FFQ) and the Baecke physical activity questionnaire (Baecke) in a retrospective assessment of pre-pregnancy dietary intake and activity in pregnant women. A comparison *between groups* was completed with both pregnant and non-pregnant women completing the FFQ and Baecke. A comparison *between tools* was completed in non-pregnant women as dietary intake measured by the FFQ was compared to a 24 hour recall (24HR); and physical activity measured by the Baecke was compared to the Past Year Total Physical Activity Questionnaire (PYTPAQ). The FFQ was found to be comparable between groups, but was not comparable between tools. The Baecke was not comparable between groups, but was comparable between tools. Pre-pregnancy data from the FFQ and Baecke should be utilized with caution.

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List of Abbreviations

24HR – 24 Hour Recall

25(OH)D - 25-hydroxyvitamin D

ALSPAC – Avon Longitudinal Study of Pregnancy and Childhood

AMDR – Acceptable Macronutrient Distribution Range

APrON – Alberta Pregnancy Outcomes and Nutrition

BMI – Body Mass Index

CePAWHS – Central Pennsylvania Women's Health Study

DHQ – Diet History Questionnaire

DHA - Docosahexaenoic Acid

EPA - Eicosapentaenoic Acid

EAR - Estimated Average Requirement

FFQ – Food Frequency Questionnaire

K-S Test – Kolmogorov-Smirnov Test

METS – Metabolic Equivalents

PRAMS – Pregnancy Risk Assessment Monitoring Sytem

PYTPAQ – Past Year Total Physical Activity Questionnaire

RBC – Red Blood Cell

RDA - Recommended Dietary Allowance

SHARE – Study of Health Assessment and Risk in Ethnic groups

SIQ – Supplement Intake Questionnaire

USDA – United States Department of Agriculture

WCHRI – Women and Children's Health Research Institute (Edmonton, Alberta)

Chapter 1: Introduction

1. Rationale

It is well recognized that maternal lifestyle during pregnancy has a significant impact on fetal growth and development as well as maternal health. Lifestyle factors, specifically food intake and physical activity, also appear to play an important role *prior* to pregnancy in affecting maternal health and fetal development (Kind, Moore, & Davies, 2006; Donahue, Zimmerman, Starr, & Holt, 2010). These lifestyle factors contribute to maternal pre-pregnancy weight and body composition which impact nutrient utilization and a woman's metabolic response to pregnancy (Kind, et al., 2006). Maternal obesity prior to pregnancy, which results from an imbalance in energy input and output, has been associated with a number of negative maternal and fetal health outcomes (Gluckman PD, Hanson MA, & Beedle AS, 2007; Guelinckx, Devlieger, Beckers, & Vansant; 2008).

A classic example of how maternal nutrient intake prior to pregnancy may affect fetal development is the evidence of decreasing incidence of neural tube defects with increasing folate intake (Institute of Medicine, 1998; De Wals, et al., 2007). As a result, Health Canada (2009) recommends that all women capable of becoming pregnant take a multivitamin containing folate daily. However, the issue goes beyond folate, as relationships between fetal development and nutrient deficiency prior to and around conception have been shown to alter fetal

development, placental development, and increase the risk of preterm delivery (Kind, et al., 2006). For example, low maternal intake of vegetable protein, fibre, beta-carotene, vitamin C, vitamin E, iron, and magnesium has been linked with increased risk of orofacial cleft in the infant (Gardiner, et al., 2008).

Pre-pregnancy physical activity also appears to have a significant impact on maternal health and infant development. Ning, et al. (2003) reported that physical activity in the year prior to pregnancy was the strongest predictor of physical activity during pregnancy. This is important as physical activity during pregnancy leads to improved health and may decrease the risk of adverse maternal outcomes such as preeclampsia and excess weight retention postpartum (Donahue, et al., 2010). In addition, women with the highest level of physical activity prior to and during pregnancy have been found to have the lowest risk of developing gestational diabetes mellitus (Mattola MF, 2007). As a result, it is important that an assessment of pre-pregnancy dietary intake and physical activity be included as part of a comprehensive assessment of maternal and fetal health during pregnancy.

a. Background Information

This study was completed in conjunction with a larger ongoing study: Alberta Pregnancy Outcomes and Nutrition (APrON) Study. The APrON study, which began in 2009, is exploring the relationship of maternal dietary intake and nutrient status during pregnancy with maternal mental health, birth outcomes and infant/child neurodevelopment up to three years of age. In order to do this, the

APrON team is assessing dietary intake (food frequency questionnaire and 24 hour recall), vitamin and mineral supplement intake (Supplement Intake Questionnaire (SIQ)), nutrient status (blood analyses), maternal body size and shape changes (anthropometric measurements), thyroid function (urine sample), and maternal mental health (mental health questionnaires.) Women are recruited into the APrON study after they become pregnant. However, due to increasing evidence linking pre-pregnancy dietary intake and physical activity to maternal and infant outcomes, it was important to include measures of dietary intake and physical activity prior to pregnancy.

b. Dietary Intake

A Food Frequency Questionnaire (FFQ) was the diet assessment method chosen to assess dietary intake for the 12 months prior to pregnancy. However, it was necessary to adapt an existing FFQ to best assess pre-pregnancy dietary intake. The primary FFQ that was adapted for use in the APrON study was the Canadian version of the Diet History Questionnaire (DHQ) (Csizmadi, et al., 2007). The original American version of the DHQ was created with a specific focus on nutrients that were of interest in chronic disease development and/or prevention including dietary fat intake, especially the use of low-fat food choices and the addition of fat to foods during preparation and at the table, as well as energy, fiber, carotenoids, vitamin E, vitamin C, and vitamin A (Subar, et al., 2001). It was then adapted for a Canadian population by updating the nutrient database to reflect Canadian food products (Csizmadi, et al., 2007). Other FFQ's reviewed

during this initial process were those used by Fawzi, Rifas-Shiman, Rich-Edwards, Willet, & Gillman (2004), Rogers et al. (1998) and Kelemen et al. (2003) for *Project Viva*, the *Avon Longitudinal Study of Pregnancy and Childhood* (ALSPAC) and the *Study of Health Assessment and Risk in Ethnic groups* (SHARE), respectively.

The adaptation of the FFQ was necessary as this type of assessment of pre-pregnancy is novel. The pre-pregnancy time period, as described above, may be a key period in affecting both maternal health and fetal development. Other cohort studies investigating nutrition and pregnancy have not assessed the pre-pregnancy period likely because of complexity in gaining a relatively valid assessment of this time period.

There were specific nutrients of interest during this period including: dietary fat, including long chain omega-3 fatty acids, folate, vitamin B6, vitamin B12, calcium, vitamin D and iron. The focus on these additional nutrients required that some additional questions be added to the FFQ as well as rearranging of questions in order to improve questionnaire utility. These changes to the time frame and food items required that an assessment of relative validity be completed.

Long chain omega-3 fatty acids were a nutrient of interest because of their role in the development of the central nervous system specifically the brain and retinas (Gardiner, et al., 2008). Folate was of interest because of its well defined role during periconception in the prevention of neural tube defects (De Wals, et

al., 2007). In addition a poor periconception dietary pattern coupled with low red blood cell folate, increased plasma total homocysteine, low whole blood vitamin B_6 and low serum vitamin B_{12} were associated with increased risk of cleft lip. (Vujkovic, et al., 2007). Calcium and vitamin D were important for their role in bone development (Gardiner, et al., 2008). Additionally, the prevalence of vitamin D deficiency in some segments of this population may be a concern (Schwalfenberg, Genuis, & Hiltz, 2010). Iron was a nutrient of concern as low iron status in the pre-conception period, measured by plasma haemoglobin, has been associated with increased risk of low birthweight and fetal growth restriction (Gardiner, et al., 2008).

c. Physical Activity

In order to evaluate pre-pregnancy physical activity, the Baecke physical activity questionnaire (Pols, et al., 1995) was modified to assess physical activity in the 12 months before the participants knew they were pregnant instead of "current" activity for which it was originally designed. The Baecke physical activity questionnaire was originally designed for the general population, assesses three different types of physical activity and assigns a score for: work, sport, and leisure time physical activity. It also combines the three indices to provide a total physical activity score. It was of interest to investigate multiple types of physical activity as opposed to just leisure time activity as it has been shown that occupational and household/caregiving activity contribute significantly to pregnant women's energy expenditure (Schmidt, Pekow, Freedson, Markenson, &

Chasen-Taber2006) and in certain groups contributes significantly to the energy expenditure in non-pregnant women (Sternfeld, Ainsworth, & Quesenberry,1999). Using the Baecke physical activity questionnaire allowed for a more comprehensive assessment of physical activity in non-pregnant women as opposed to only measuring leisure time activity. However, because of the modification made to the time-frame assessed by the Baecke physical activity questionnaire it was necessary to assess the relative validity of the adapted version.

2. Assessment of Comparison Tools

In order to use the adapted versions of the FFQ and Baecke physical activity questionnaire with confidence in the APrON study, it was necessary to test the relative validity of both tools in the target population. Relative validity is defined as the comparison of the results of the assessment method in question with a reference method of assessment that has its own limitations (Masson LF, et al., 2003). Both tools retrospectively measure the 12 months prior to pregnancy. As such it was necessary to determine not only how well the assessment tools compare to a reference method of assessment but also how well they represent the non-pregnant condition. Therefore two different comparisons were initiated for each of the FFQ and the Baecke physical activity questionnaire.

a. Dietary Intake

First, a group of pregnant women and a group of non-pregnant women completed the FFQ, and nutrient intake was compared between these two groups; the FFQ completed by pregnant women asked about intake in the year prior to pregnancy, while the FFQ completed by non-pregnant women asked about intake in the past year. Second, in non-pregnant women only, nutrient intakes estimated by the FFQ were compared to nutrient intakes estimated by the reference method: 24 hour recall. The non-pregnant group was necessary because a 24 hour recall completed with the pregnant group would not reflect non-pregnant intake.

b. Physical Activity

Similarly, the pregnant and non-pregnant women completed the Baecke physical activity questionnaire and activity levels were compared between the two groups. The non-pregnant women also completed the Past Year Total Physical Activity Questionnaire (PYTPAQ) (Friedenreich, et al., 2006) as the reference method against which Baecke physical activity scores were compared.

3. Purpose

The purpose of the thesis was to:

a) To determine the relative validity of a food frequency questionnaire adapted to assess pre-pregnancy dietary intake.

b) To determine the relative validity of a physical activity questionnaire adapted to assess pre-pregnancy physical activity.

4. Research Questions

a) The primary research questions for this study were:

i. Does the FFQ provide a similar estimate of nutrient intake of women in the 12 months prior to pregnancy compared to nutrient intake of non-pregnant women for the past 12 months using the same tool?

ii. Does the FFQ provide a similar estimate of nutrient intake of non-pregnant women for the past 12 months in comparison to a 24 hour recall?

iii. Does the Baecke physical activity questionnaire provide a similar estimate of physical activity in the 12 months prior to pregnancy compared to physical activity of non-pregnant women for the past 12 months using the same tool?

iv. Does the Baecke physical activity questionnaire provide a similar estimate of physical activity of non-pregnant women for the past 12 months in comparison to the PYTPAQ?

b) Secondary research questions for this study were:

i. Was the FFQ acceptable to participants?

ii. How much time was required for participants to complete the FFQ?

5. Objectives

The objectives of this study were:

a) To compare nutrient intake based on the FFQ completed by pregnant women (pre-pregnancy intake) and non-pregnant women (usual intake for the past 12 months). Specific nutrients compared are outlined in Tables 1.1 and 1.2.

b) To compare nutrient intakes based on the FFQ completed by non-pregnant women, with 24 hour recalls to determine the relative validity of the FFQ. Specific nutrients compared are listed in Tables 1.1 and 1.2.

c) To compare physical activity information from the Baecke physical activity questionnaire completed by pregnant women (pre-pregnancy activity) and non-pregnant women (usual activity for the past 12 months). The components of physical activity compared are listed in Table 1.3.

d) To compare physical activity information from the Baecke physical activity questionnaire completed by non-pregnant women with the PYTPAQ to determine the relative validity of the Baecke physical activity questionnaire. The components of physical activity compared are outlined in Table 1.3.

e) To determine the acceptability of the FFQ as indicated by a Yes/No question answered by participants.

f) To determine the length of time and number of sittings taken by participants to complete the FFQ.

Table 1.1: Macronutrients Compared to Assess Relative Validity

Macronutrients	
Energy (kcal)	Total Energy
Fats (g)	Total Fat
	Saturated Fat
	Trans Fat
	Monounsaturated Fatty Acids
	Polyunsaturated Fatty Acids
	Alpha-Linolenic Acid
	Eicosapentaenoic Acid and Docosahexaenoic Acid
Carbohydrates (g)	Total Carbohydrate
	Fibre
Protein (g)	Total Protein
Alcohol (g)	Total Alcohol

Table 1.2: Micronutrients Compared to Assess Relative Validity

Micronutrients
Folate
Vitamin B_6
Vitamin B_{12}
Calcium
Vitamin D
Iron

Table 1.3: Components of Physical Activity Compared to Assess Relative Validity

Baecke Physical Activity Questionnaire	**Past Year Total Physical Activity Questionnaire**
Work Physical Activity Score	Occupational MET hr/wk and Transportation MET hr/wk
Sport Physical Activity Score	Recreational MET hr/wk
Leisure Time Physical Activity Score	Household MET hr/wk

Chapter 2: Literature Review

1. Importance of Pre-pregnancy Dietary Intake and Physical Activity

When studying pregnancy there are two individuals to consider: the mother and the developing child. First, the mother, for whom pregnancy is a time that has been likened to a "physiological stress test" in that it may indicate risk of future disease (Rich-Edwards JW, McElrath TF, Karumanchi SA, & Seely EW, 2010). Outcomes such as gestational diabetes mellitus indicates future risk of type 2 diabetes in the mother while, maternal preeclampsia, low birth weight or preterm delivery may all indicate future maternal cardiovascular risk (Rich-Edwards, et al., 2010). Second, the developing fetus is greatly affected by maternal lifestyle, which includes dietary intake and physical activity (Newnham, Moss, Nitsos, Sloboda, & Challis, 2002; Hegaard, Pedersen, Nielsen, & Damm, 2007). Maternal lifestyle influences nutrient delivery, hormone levels, and growth patterns (Newnham, Moss, Nitsos, Sloboda, & Challis, 2002). Nutrient delivery is not simply a function of maternal diet, but is also affected by maternal energy expenditure, maternal metabolic and cardiovascular function, placental function, and fetal endocrine status (Gluckman et al, 2007). Problems with maternal energy balance in fetal development may negatively affect organ development and birth weight (either high or low) putting the fetus at increased risk of developing chronic diseases such as cardiovascular disease or type 2 diabetes (Gluckman et al, 2007; Newnham et al, 2002).

A lifecourse approach allows for the consideration of cumulative exposures to risk factors for chronic disease beginning *in utero* and accumulating across the lifespan, including consideration of critical periods of development (Darton-Hill et al., 2004; Ben-Schlomo Y & Kuh D, 2002). Risk of chronic disease may not only be affected by over the course of one lifespan but across generations (Ben-Schlomo & Kuh, 2002). The process of programming risk of chronic disease occurs before a woman becomes pregnant, and was affected by the fetal environment provided by her own mother which was affected by the generation before and so on (Newnham et al, 2002). Therefore, in terms of the present study, lifestyle factors *prior* to pregnancy have the potential to have a significant impact on fetal development and must be assessed.

a. Healthy Body Weight/Long-term Consequences

Promotion of healthy lifestyle behaviours and a healthy body weight in women prior to pregnancy have been recognized as strategies that could greatly improve the health of future generations (CDC, 2006; Moos, et al., 2008; Downs, et al., 2009). Development of overweight and obesity results from energy imbalance, high energy intake, low energy expenditure, or a combination of both (Guelinckx, et al., 2008). It is unknown whether high energy intake or low energy expenditure prior to pregnancy impacts the development of maternal overweight or obesity to a greater extent but both impact energy balance and therefore it is prudent to have a comprehensive assessment of both when examining preconception health and body weight.

While lifestyle factors such as dietary intake and physical activity play a role in preconception health, obesity is an independent risk factor for adverse pregnancy outcomes (Giroux I, Lander S, Charlesworth S, Mottola M, 2009). Overweight and obesity prior to pregnancy have been associated with poor maternal health outcomes including polycystic ovary syndrome, increased risk of miscarriage, gestational diabetes, pregnancy-induced hypertension, venous thrombo-embolism, induction of labour, and caesarean delivery (Guelinckx, et al., 2008; Mehta, 2008). Poor infant outcomes are also increased with maternal overweight or obesity, specifically fetal macrosomia, childhood obesity and increased risk of diabetes later in life (Guelinckx, et al., 2008). There are also links between maternal obesity and fetal birth defects including defects of the neural tube, abdominal wall and heart (Guelinckx, et al., 2008, Mehta, 2008). The increased risk of neural tube defects associated with increased maternal pre-pregnancy obesity has been hypothesized to be due to decreased folate delivery to the fetus as a result of either poor folate absorption or increased maternal metabolic requirement (Mehta, 2008).

Pre-pregnancy overweight and obesity have also been linked to excessive gestational weight gain (Weisman, Hillemeier, Downs, Chuang, & Dyer, 2010). Excessive gestational weight gain may lead to adverse outcomes in the mother as well as the infant. For the mother, excessive gestational weight gain has been associated with postpartum weight retention as well as long-term weight gain and obesity (Weisman, et al., 2010; Giroux, et al., 2009). Negative outcomes for the

infant include increased risk of high birth weight, macrosomia, and overweight during infancy (Weisman, et al., 2010). This is a concern as overweight early in life increases the risk of development of chronic disease later in life including cardiovascular disease and type 2 diabetes (Darnton-Hill, et al., 2004).

Weight retention from previous pregnancies may also be a contributor to higher BMI in subsequent pregnancies (Moos, et al, 2008). One study of Canadian pregnant women found that a great majority (88%) had retained weight from a previous pregnancy, with an average weight retention of 12.7 ± 9.4kg (Giroux et al., 2009). Those women who retained weight following one pregnancy are at increased risk of retaining more weight following another pregnancy (Giroux et al, 2009). Post-partum weight retention increases a woman's risk of long-term overweight and obesity (Giroux et al, 2009).

It may be possible to reverse some of the detrimental effects of pre-pregnancy overweight and obesity by initiating healthy behaviours prior to pregnancy. One study in rodents found that rats with diet induced obesity , when switched to a normal chow (healthy) diet for one month prior to mating, had offspring with similar metabolic profiles to controls at the time of weaning (Zambrano, Martinez-Samayoa, Rodriguez-Gonzalez, & Nathanielsz, 2010). However, rats with diet induced obesity who remained on the high fat diet from pre-pregnancy through gestation and lactation had offspring with increased subcutaneous adipose tissue, and had higher serum triglycerides, leptin and insulin concentrations compared to controls at the time of weaning (Zambrano, et

al., 2010). At 120 days after birth the offspring of dams who had undergone dietary intervention had insulin resistance indicators significantly lower than the offspring of dams who had remained on the high fat diet; however insulin resistance in offspring of dams who had undergone dietary intervention was significantly higher than control animals (Zambrano, et al., 2010).

Insulin resistance was calculated using a formula for an insulin resistance index = glucose (mmol 1^{-1}) x insulin (μUml^{-1})/22.5 (Zambrano, et al., 2010).

Additionally, at 150 days after birth the offspring of dams in the dietary intervention group had significantly less total body fat and smaller fat cells than offspring of dams who remained on the high fat diet; but total body fat and fat cell size in the dietary intervention offspring were significantly higher than control animals (Zambrano, et al., 2010). This indicates a potential blunting of the impact of maternal obesity but not complete reversal of negative outcomes by dietary intervention. Although there is currently a lack of evidence from human studies it may be possible to reverse the negative impact of pre-pregnancy obesity or reduce the impact of adverse metabolic changes by implementing healthy dietary changes prior to pregnancy.

b. Nutrition Prior to Pregnancy

The impact of pre-pregnancy dietary intake is not well known but it is possible that improved dietary intake prior to pregnancy may decrease the risk of poor maternal and fetal outcomes. Maternal nutrition status prior to conception and during the perimplantation phase is believed to affect embryonic and fetal

growth (Gardiner, et al., 2008). Nutrition prior to pregnancy has been linked to oocyte and embryo development mediating the ability for implantation of the embryo to occur and result in a pregnancy (Kind, et al., 2006). In a mouse model, maternal obesity induced by a high-fat diet prior to pregnancy showed significantly increased apoptotic ovarian follicles, smaller oocytes, and more immature oocytes (Jungheim, et al., 2010). Following mating, mice on the high fat diet showed decreased insulin like growth factor receptor (IGF-IR), smaller fetuses, increased insulin like growth factor 2 receptor (Igf2r) mRNA in the placenta, and smaller offspring which then underwent catch-up growth (Jungheim, et al., 2010). At 10 weeks following delivery, male pups from obese mice exhibited increased cholesterol concentrations, increased percent body fat, and at 13 weeks these males already exhibited glucose intolerance (Jungheim, et al., 2010). It was not clear why male offspring were more affected than female offspring in this experiment (Jungheim, et al., 2010). This potential for dietary intake to reprogram offspring development makes it imperative that nutrition assessment should be completed during the pre-pregnancy time period.

Overnutrition prior to pregnancy is not the only concern. Maternal nutrient deficiencies prior to pregnancy have also been linked with fetal developmental defects (Goh, Bollano, Einarson, & Koren, 2006). The most well known defect related to pre-pregnancy nutrition is the increased risk of neural tube defects with low levels of maternal folate (De Wals, 2007). This relationship has been thoroughly studied and has led to the public health recommendation that

every woman of child bearing age should take a folate-containing multivitamin daily (Wilson, et al., 2007). Since 1998, there has been mandatory folate fortification of white flour, cornmeal and enriched pasta in Canada which resulted in a significant decrease in the rate of neural tube defects (De Wals, 2007). Prior to fortification the Canadian prevalence of neural tube defects at birth was 1.58 per 1000 births; after full-fortification, that decreased to 0.86 per 1000 births (De Wals, 2007).

However, folate is not the only nutrient of concern in this population. In addition to folate, a multivitamin taken prior to pregnancy and during the first trimester has been shown to reduce the risk of fetal congenital anomalies in addition to neural tube defects including: cardiovascular defects, limb defects, cleft palate, oral cleft with or without cleft palate, urinary tract anomalies and congenital hydrocephalus (Goh et at, 2006). It is not only supplements that affect fetal development. One study in the Netherlands found that after adjusting for energy intake, low maternal dietary intake of vegetable protein, fibre, beta-carotene, vitamin C, vitamin E, iron, and magnesium were linked to an increased risk of orofacial clefts in newborns (Krapels, et al., 2004).

A number of key nutrients have been identified as potentially inadequate during pregnancy including: long-chain omega-3 fatty acids, folate, vitamin B_6, vitamin B_{12}, calcium, vitamin D and iron (Giddens, et al., 2000; Denomme, Stark, & Holub 2005; Bodnar, et al., 2007; Turner, Langkamp-Henken, Littell, Lukowski, & Suarez, 2003; Mouratidou, Ford, Prountzou & Fraser 2006). The

status and intake of these nutrients will be measured prospectively during the APrON study. However, intake prior to pregnancy is also of concern.

i. Long-Chain Omega-3 Fatty Acids

Long-chain omega-3 fatty acids especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are required for optimal development of the fetal central nervous system as well as vision (Bourre, 2007; Gardiner, et al., 2008). A sufficient intake of EPA and DHA prior to pregnancy may ensure a sufficient reserve in the mother's adipose tissue (Bourre, 2007). This reserve can then help supply these essential omega-3 fatty acids to during gestation and lactation where they are important in development (Bourre, 2007).

ii. Folate, Vitamin B_6, Vitamin B_{12}

As discussed, folate is of concern as it is involved in the proper formation of the neural tube early in fetal development and adequate maternal intake has been shown to be involved in the prevention of neural tube defects (De Wals, et al., 2007). In addition a poor maternal periconception dietary pattern coupled with low maternal red blood cell folate, increased plasma total homocysteine, low whole blood vitamin B_6 and low serum vitamin B_{12} were associated with increased risk of cleft lip in newborns (Vujkovic. et al., 2007). Maternal deficiency in folate, vitamin B_6 and/or vitamin B_{12} have been linked with mild hyperhomocysteinemia (Leeda M, et al., 1998). Elevated maternal plasma homocysteine has been linked with increased incidence of neural tube defects, as well as other negative outcomes such as spontaneous abortion, preeclampsia,

premature birth and low birth weight (Leeda, et al., 1998; Obeid & Herrmann, 2005). Maintaining adequate levels of these B vitamins appears to be of importance for women planning pregnancy as periconceptional levels are important in maintaining low levels of homocysteine and avoiding negative outcomes as well as avoiding deficiency during pregnancy (Obeid & Herrmann , 2005).

iii. Calcium and Vitamin D

Calcium and vitamin D are important for the development of healthy bones in the fetus (Gardiner, et al., 2008). During pregnancy, fetal calcium requirement is met by maternal sources, a balance between dietary intake and maternal bone stores (Gardiner et al., 2008). If dietary intake of calcium is low and maternal bones stores do not have enough calcium for both maternal and fetal needs, maternal bone will be weakened to provide for the fetus (Gardiner, et al., 2008). Population dietary intake data suggests that women in Canada are not consuming enough calcium from food and/or supplements to meet recommendations (Vatanparast, Dolega-Cieszkowski, & Whiting, 2009).

Vitamin D aids in calcium absorption (Gardiner et al., 2008). The recent report on the Dietary Reference Intakes for Calcium and Vitamin D indicated that population-level vitamin D deficiency may have been overestimated recently due to a lack of agreement on the level of serum 25-hydroxyvitamin D (25(OH)D) that indicates deficiency (Institute of Medicine, 2010). However, even when the cut-off of 50nmol/L serum 25(OH)D is applied (a level at which almost all people

would have sufficient vitamin D) (Institute of Medicine, 2010), a number of studies still found low serum 25(OH)D levels in Canadian subgroups (Schwalfenberg, et al., 2010). One study in healthy Canadian women 18-35 years of age found low serum 25(OH)D (defined in this study as serum levels <40nmol/L) in 25.6% of non-Caucasian, non-black women and 14.8% of Caucasian women (Vieth, Cole, Hawker, Trang, & Rubin, 2001). In addition, vitamin D deficiency in animal models has been shown to negatively impact fertility (Lewis, Lucas, Halliday, & Ponsonby, 2010). These negative impacts were reversed when animals were fed a high calcium diet indicating that the problem may be due to low calcium status as a result of low vitamin D instead of low vitamin D itself (Lewis, et al., 2010). Although it has not been widely studied in humans, after adjusting for maternal age, body mass index (BMI), ethnicity, and number of embryos transferred, increased maternal serum vitamin D was predictive of success with *in vitro* fertilization (Lewis, et al., 2010).

iv. Iron

Iron is a nutrient of concern as low maternal iron status in the pre-conception period, measured by plasma haemoglobin, has been associated with increased risk of maternal anemia during pregnancy, low birthweight and fetal growth restriction (Krapels, et al., 2004; Gardiner, et al., 2008). In addition maternal anemia diagnosed prior to conception has been associated with preterm delivery, indicating a potential role for iron supplementation during the pre-pregnancy period (Scholl, 2005).

c. Physical Activity prior to pregnancy

Physical activity prior to pregnancy has been associated with appropriate gestational weight gain which is linked with better pregnancy outcomes (Lof, Hilakivi-Clarke, Sandin & Weiderpass, 2008; Weisman, et al., 2010). Physical activity before pregnancy appears to decrease the risk of negative outcomes including gestational diabetes (Mattola, 2007), preeclampsia and it has been found to have neither a positive or neutral effect on risk of low birth weight or preterm delivery (Hegaard, et al., 2007, Hegaard, et al., 2008). Tyldum, Romunstad, & Slordahl (2010) did not find a relationship between pre-pregnancy physical activity and risk of preeclampsia. The potential benefits of pre-pregnancy physical activity on fetal outcomes are not yet well-defined but it does not appear to be related to negative fetal outcomes.

In addition, Ning, et al. (2003) reported that physical activity in the year prior to pregnancy was the strongest predictor of physical activity during pregnancy. Physical activity during pregnancy has been shown to decrease the risk of adverse maternal outcomes such as gestational diabetes, preeclampsia and excessive gestational weight gain and post-partum weight retention (Donahue, et al., 2010, Weisman, et al., 2010). For the infant, excessive maternal gestational weight gain increases the risk of macrosomia and infant overweight (Weisman, et al., 2010).

There are many potential sources of physical activity in daily life. Therefore it is important to assess all components of physical activity including

occupational activity, sports and exercise, and activities performed during leisure time (Lof, et al., 2008). Schmidt, et al. (2006) found that occupational and household/caregiving activities contribute significantly to pregnant women's energy expenditure. Additionally, some groups of non-pregnant women were found to have significant contributions to energy expenditure from occupational and household/caregiving activities (Sternfeld, et al., 1999).

2. Pre-pregnancy Diet Assessment Methodology

Diet assessment is typically completed by one of three widely-used methods: Food Frequency Questionnaire (FFQ), 24 Hour Recall, or Food Records. There is currently no single method of diet assessment that can capture dietary intake completely without error, and each method has its strengths and limitations (Cade, Thompson, Burley, & Warm, 2001; Henriquez-Sanchez P, et al., 2009). It is important to be aware of the strengths and limitations in order to choose the most appropriate diet assessment method for use in a specific study (Serra-Majem, Andersen, et al., 2009).

a. Food Frequency Questionnaire

A FFQ is a questionnaire that contains lists of foods and choices for frequency of consumption. Participants put a check mark beside the foods they consume and how frequently they consume them (i.e. 1-6 times per year, 7-12 times per year, 1 time per month, 1 time per week, 1 time per day, as examples). The questionnaire may be self-administered or interviewer-administered. It may also be semi-quantitative if participants have the option to check the portion sizes

of foods consumed. For example, if a participant indicated that they consume apples, the corresponding portion size question would ask them to indicate if they typically eat less than 1 apple, 1 apple, or more than 1 apple. Nutrient intake is adjusted according to the portion size selected. A review of FFQ validation studies by Molag, et al., found that increasing the number of food items in a FFQ improved the ability to rank individuals in terms of nutrient intake (2007). However, having participants choose the typical portion sizes consumed compared to using standard portion sizes did not appear to affect validity (Molag, et al., 2007).

Food Frequency Questionnaires are generally used in epidemiological studies to measure usual dietary intake (Masson, et al., 2003). They are not as effective in measuring absolute nutrient intake but are appropriate to rank individuals into groups of low, medium, and high nutrient intakes (Masson, et al., 2003; Molag, et al., 2007).

Some of the strength of FFQs are that they are relatively inexpensive, easily self-administered, and they can measure dietary intake over an extended period of time or "usual" dietary intake (Molag, et al., 2007). Weaknesses include that they are cognitively complex, affected by recall bias, contain a fixed number of foods, and they are lengthy which may decrease completion (Molag, et al., 2007; Henriquez-Sanchez P, et al., 2009). FFQs must continually be updated to reflect changes in demographics and changes in the food supply both of which may change the "usual" diet of the population in question (George, Milani, Hanss-

Nuss, Kim, & Freeland-Graves, 2004). Furthermore FFQs are less able to detect weak associations between diet and disease as they are a less precise method of dietary assessment (Molag, et al., 2007).

b. 24 Hour Recalls

A 24 hour recall is a diet assessment protocol where an interviewer prompts an individual to describe all foods and beverages consumed in the past 24 hours. The multiple pass method allows for the interviewer and participant to list all foods and beverages first, then in a "second pass" the participant describes in more detail food brands and cooking methods. In a third pass, they describe portion sizes. The recall is reviewed one final time to ensure no errors are present.

Strengths of 24 hour recalls are that they provide very detailed information about one day, are obtained with low participant burden, and participants are not able to change their eating behaviours as the behavior happened in the past (Subar, et al., 2007). Some limitations of 24 hour recalls are that they rely on trained interviewers, which makes them more costly, they do not represent "typical dietary intake", and they may be affected by recall bias (Subar, et al., 2007).

c. Food Records

Food records are a diet assessment tool that requires a participant to record all food and beverages consumed over a period of time (typically 3 to 7 days). Weighing of food consumed may or may not be required. Food records provide

detailed information on foods and beverages consumed including brand names and cooking methods (Cade, et al., 2001). However, participants must be literate and highly motivated as food records involve a higher participant burden and the process of recording foods and beverages consumed may change intake (Cade, et al., 2001).

3. Pre-pregnancy Physical Activity Assessment Methodology

Assessment of physical activity is also complex. The most commonly used forms of assessment are either objective (i.e. direct measurement including direct or indirect calorimetry, doubly labelled water, heart rate monitors, accelerometers, or pedometers) or subjective (i.e. self-reported measurement through questionnaires or activity diaries) (Prince, et al., 2008). Currently, as with diet assessment, there is no gold standard for assessment of physical activity (Prince, et al., 2008). Methods of assessment from each category have their strengths and limitations and the choice of assessment included in research depends on the study design and budget (Tudor-Locke & Myers, 2001).

a. Objective Measures

Direct calorimetry assesses total energy expenditure by measuring heat production within a contained environment (Vanhees, et al., 2005). Indirect calorimetry measures oxygen consumption and/or carbon dioxide production and uses those values to estimate energy expenditure (Vanhees, et al., 2005). Doubly labelled water uses stable isotopes ^{2}H and ^{18}O in water which is consumed and distributed throughout the body and the rate of elimination of the isotopes as

water and carbon dioxide provides a measure of carbon dioxide production as well as energy expenditure (Vanhees, et al., 2005). The positive aspects of these direct methods are that participants are able to be free living thus avoiding changes to physical activity behaviour, except in the case of direct calorimetry. However, they are intensive, expensive measures and as a result are not useful for large scale studies (Vanhees, et al., 2005). Furthermore, these methods only measure energy expenditure and while this is useful, there are times when it is important to divide energy expenditure into its three components: resting metabolic rate, thermic effect of food, and physical activity (Vanhees, et al., 2005).

Other direct assessment tools of physical activity include pedometers and accelerometers which are both easy to use and provide measurement of physical activity as opposed to energy expenditure. A pedometer is an inexpensive device worn by a subject which counts the number of steps taken determined by the number of mechanical impacts within the device (Vanhees, et al., 2005). As a result, it is only able to measure activities with a vertical movement component such as walking or running. Other activities such as swimming, bicycling, or activities focused on the upper body will not be recorded (Vanhees, et al., 2005; Tudor-Locke & Myers, 2001). Similarly an accelerometer is a device worn by the subject and it is capable of measuring either biaxial or triaxial movement, depending on the device (Vanhees, et al., 2005; Tudor-Locke & Myers, 2001). It measures "counts" of activity by the movement of piezoelectric transducers and

microprocessors inside the device which provide a measure of both magnitude and direction of acceleration (Vanhees, et al., 2005; Tudor-Locke & Myers, 2001). Thus it can recognize activity better than the pedometer but it is still unable to measure certain types of activities such as swimming or upper body activities (Vanhees, et al., 2005).

Additionally, heart rate monitors provide a direct measure of changes in heart rate or cardiovascular stress as a proxy measure of physical activity (Vanhees, et al, 2005). The linear relationship between heart rate and oxygen consumption during moderate to vigorous activity is used to estimate energy expenditure (Vanhees, et al., 2005). The positive aspects of this tool include that it is directly related to a physiological response, is relatively inexpensive, and easy to use (Vanhees, et al., 2005). However, there is large variability in heart rate data as the relationship between heart rate and oxygen consumption is not linear during low-intensity activity and may be confounded by other factors such as psychological stress, caffeine intake, and body position which all may increase heart rate (Vanhees, et al., 2005).

b. Subjective Measures

Subjective physical activity assessments rely on the individual to report their activity levels. There are many different questionnaires available as well as physical activity records or diaries, with the 7 day activity record being most widely used (Tudor-Locke & Myers, 2001). However, these subjective measures are not as accurate as objective measures and as such, data from questionnaires

are best utilized to rank participants into levels of activity (i.e. low, medium, high) rather than to estimate actual energy expenditure (Vanhees, et al., 2005). Subjective measures are affected by recall bias, they typically do not capture spontaneous or incidental activity and often do not address routine light activity such as household chores and family care (Tudor-Locke & Myers, 2001). As a result these measures suffer from "floor effects" meaning that they are unable to capture low intensity activity or activity of short duration which may be significant for sedentary individuals (Tudor-Locke & Myers, 2001). Therefore, as subjective measures tend to be less expensive but also less specific, they are considered to be most appropriate for epidemiological studies (Vanhees, et al., 2005).

4. Validation of Diet Assessment and Physical Activity Assessment

In order to be confident in the method used to assess nutrition or physical activity it is important that the method is validated. Validation is the process of comparing the approach in question against the "gold standard" which has been determined to give the closest estimation of the true value (Cade, et al., 2001). The higher the level of agreement between the two tools, the more valid. Currently, there is no consensus on the gold standard for pre-pregnancy dietary intake or physical activity assessment thus we are limited to describing relative validity - comparing one assessment methodology against another with its own set of limitations, and describing the differences observed (Cade, et al., 2001; Masson, et al., 2003; Prince, et al., 2008).

5. Validation of Pre-Pregnancy Diet Assessment

With increasing awareness of the importance of pre-pregnancy nutrition there is also increased interest in assessing dietary intake during that period, however, this information is difficult to capture. Assessing dietary intake prospectively is more reliable; however, a prospective sample would only include those women who are actively planning a pregnancy. With the estimation that currently fifty percent of all pregnancies in Canada are unplanned, a large segment of the pre-pregnant population would be missed (Wilson, et al., 2007). It is likely that those women planning a pregnancy may have different dietary intake patterns than those not planning a pregnancy.

This leaves researchers with the option of assessing pre-pregnancy dietary intake retrospectively. Retrospective diet assessment is not ideal as it relies on participant memory in reporting and may be affected by recall bias. However, for the purposes of this population group it appears to be the only way to include women with both planned and unplanned pregnancies. As the assessments in this study were retrospective, a FFQ was chosen as it is the only tool which assesses habitual or "usual" dietary intake retrospectively. As such FFQs will be the focus of this section.

Relative validation of a FFQ should focus on the comparability of the nutrient intake as assessed by the FFQ with the comparison method of choice, typically 24 hour recall or diet records (Cade, et al., 2001; Henriquez-Sanchez P, et al., 2009; Molag, et al., 2007). The correlation between a FFQ and the

reference method may appear high if the sources of error are similar between methods but the agreement will not be high (Verkleij-Hagoort, et al., 2007, Bland & Altman, 1986). The sources of error found with weighed food records have been found to have the lowest correlations with the sources of error for FFQs (Cade, et al., 2001). Although measurement error between the 24 hour recall and the FFQ tend to be more correlated, because both methods rely on self-report of past intake, 24 hour recall may be a more appropriate reference method if participants have limited time to invest in the study, have a lower literacy level or are less motivated to complete food records (Cade, et al., 2001).

The number of days the reference method assesses diet varies among studies. Most studies complete 2-5 days of dietary intake assessment with the reference method to compare with a FFQ because the more days captured by the reference method the more likely it is to estimate "usual" dietary intake (Cade, et al., 2001).

A number of characteristics have been identified with which to evaluate the quality of FFQ validation studies including: sample and sample size, statistical analysis completed, method of data collection, seasonality and supplements (Serra-Majem, Andersen, et al., 2009). A sample of more than 100 participants from both sexes with varied levels of socioeconomic status, smoking and obesity is considered optimal (Serra-Majem, Andersen, et al., 2009). Statistical analysis must be used to assess validity including a comparison of method means, medians or differences, correlations and statistics to assess agreement or similarity in

classification (Serra-Majem, Andersen, et al., 2009). The Bland-Altman method, for example, is often used as it assesses the agreement between two methods across a range of intakes, instead of agreement of the means (Cade, et al., 2001). For this method a sample of at least 50 but preferably 100 subjects is desirable (Cade, et al., 2001). Quality is also improved if data are collected in person, if seasonality of food intake is considered in the study design, and if supplement intake is included and validated as part of the study (Serra-Majem, Andersen , et al., 2009).

There have been at least five studies published with FFQ's validated for use in pregnancy (Erkkola, et al., 2001; Wei, et al., 1999; Fawzi, et al., 2004; Brantsaeter, Haugen, Alexander, & Meltzer, 2008; Mouratidou, Ford, & Fraser, 2005), however the pre-pregnancy time period has not received as much attention as of yet. One study in women of reproductive age in the Netherlands used a FFQ to assess maternal folate and vitamin B_{12} intake for the past month in an effort to determine risk factors for fetal congenital heart defects (Verkleij-Hagoort, et al., 2007). Validity was assessed by comparing the results of the FFQ with three 24 hour recalls completed over 3 weeks as well as a blood sample for the biomarkers: serum folate, serum vitamin B_{12} and red blood cell (RBC) folate (Verkleij-Hagoort, et al., 2007). This use of a second reference measure is known as the method of triads, a triangular approach which uses the correlations between the three methods to estimate a validity coefficient (Verkleij-Hagoort, et al., 2007). The validity coefficient attempts to estimate the coefficient between the diet

assessment method in question, a FFQ in this case, and the "true" dietary intake, instead of the relationship with an alternate method that is known to have its own limitation (Verkleij-Hagoort, et al., 2007). The authors reported acceptable correlations between the 3 methods with validity coefficients of 0.94 for serum folate, 0.75 for RBC folate and 1.00 for serum vitamin B_{12} (Verkleij-Hagoort, et al., 2007). The correlation coefficients between the two diet assessment methods, once adjusted for energy intake and deattenuated to account for day-to-day variation of intake, were 0.98 for folate and 0.66 for vitamin B_{12} (Verkleij-Hagoort, et al., 2007).

A study in Portugal assessed food intake for the year prior to pregnancy by administering a FFQ early in gestation (Pinto, Barros, dos Santos Silva, 2008). These researchers also administered a FFQ soon after delivery to assess food intake during pregnancy (Pinto, et al., 2008). In order to validate the FFQ, a subsample of women completed 3-day food records in each trimester (Pinto, et al., 2008). Nutrient intake, as assessed by the FFQ and 3-day food records, was compared to assess accuracy of the FFQ during pregnancy (Pinto, et al., 2008). There was no prospective diet assessment completed for the pre-pregnancy time period as women were recruited into the study once pregnant (Pinto, et al., 200). Pinto, et al., found that the micronutrients with the highest proportion of inadequate intake, compared to the estimated average requirement (EAR), during the preconception period were vitamin E (83%), folate (58%) and magnesium (19%) (2008). Portugal does not currently employ folate fortification of staple

foods which may provide some explanation to the high level of folate inadequacy observed (Pinto, et al., 2008).

Another study examining the preconception period was the Central Pennsylvania Women's Health Study (CePAWHS) *Strong Healthy Women* Study which contained 2 phases (Hillemeier, et al., 2008). The first phase was a telephone health interview conducted with a representative sample of non-pregnant women in central Pennsylvania to determine the prevalence of risk factors for poor gestational outcomes at baseline and two years later (Hillemeier, et al., 2008). Data were collected from self-report and birth records of all live births that occurred during that two year time period (Weisman, et al., 2009). They found that self-reported pre-pregnancy vegetable intake of at least 1 serving per day was associated with increased birth weight (within the normal range) (Weisman, et al., 2009). This indicated a potential impact of nutritious food intake on fetal growth and development and prevention of low birth weight which must be explored further (Weisman, et al., 2009).

The second phase was a prospective community based randomized controlled intervention examining pre- or interconceptional lifestyle factors including physical activity, food intake, tobacco use, alcohol use, stress exposure and infection (Downs, et al., 2009). The intervention included 6 bi-weekly sessions led by a trained instructor (Hillemeier, et al., 2008). The nutrition education included ideas on increasing healthy food intake and consumer food knowledge (Downs, et al., 2009). The study focused on a social cognitive

approach to behaviour change and therefore measured attitudes and perceptions related to healthy eating as opposed to completing a nutritional assessment on participants (Hillemeier, et al., 2008). Upon completion, women in the intervention group, compared with controls, reported increased self-efficacy for eating healthy food, increased behavioural intent to eat healthier foods, and self-reported behaviour change positive for reading food labels and daily use of a multivitamin containing folic acid (Hillemeier, et al., 2008). This study illustrated the potential to have an impact on maternal health prior to pregnancy, leading to improved pregnancy outcomes. In future research of this type, it would be helpful to complete a pre and post-intervention diet assessment on participants to obtain an estimate of real changes to dietary intake.

6. Validation of Pre-Pregnancy Physical Activity Assessment

As the assessments in the current study were retrospective the only choice for physical activity assessment was a self-report questionnaire therefore physical activity questionnaires will be the focus of this section. While direct benefits of physical activity prior to pregnancy have not been completely elucidated, physical activity prior to pregnancy may improve weight status and therefore improve overall health status (Moos, et al., 2008). The Centres for Disease Control and Prevention maintains the Pregnancy Risk Assessment Monitoring System (PRAMS) which assesses self-reported physical activity in women in the United States in addition to many other risk factors (Donahue, et al., 2010). According to PRAMS, pre-pregnancy obesity (BMI $\geq$ 30), underweight (BMI < 18.5), maternal

education of 12 years (high school), and a higher number of previous live births (≥3) have all been associated with self-reported pre-pregnancy physical inactivity (active less than 1 day per week) (Donahue, et al., 2010). In a logistic regression model maternal education was the most predictive factor in terms of pre-pregnancy physical inactivity (Donahue, et al., 2010). That is, the higher the education the greater likelihood of pre-pregnancy physical activity.

The CePAWHS Strong Healthy Women Study, as discussed previously, also examined physical activity behaviours (Downs, et al., 2009). The intervention phase attempted to improve the number of women meeting the physical activity recommendation of ≥30 minutes of moderate or vigorous physical activity on ≥4 days per week, increase achievement of personal physical activity goals and to improve the psychosocial determinants and reduce the barriers to activity (Downs, et al., 2009). During the intervention phase women reported increased behavioural intent to be more physically active and the number of women who reported meeting recommended physical activity levels of ≥30 minutes of moderate or vigorous physical activity on ≥4 days per week increased compared to the pre-intervention period (Hillemeier, et al., 2008). However, the use of a validated assessment of physical activity would be important in future research to quantify any changes to physical activities that occur.

7. Timeframe for Diet Assessment

Maternal nutritional status at the time of conception is very important (Gardiner, et al., 2008). Pre-implantation and the period of rapid placental growth

that follows implantation are the two periods most influenced by maternal nutrition status (Gardiner, et al., 2008). Inadequate availability of nutrients during that time may negatively affect fetal development and lead to "re-programming" of development that may predispose the infant to negative health outcomes later in life (Gardiner, et al., 2008).

Including the 12 months prior to pregnancy as the frame of reference for a FFQ would allow researchers to capture some of the differences that occur in dietary intake according to seasonality (Serra-Majem, Pfrimer, et al., 2009). In addition, FFQs have typically been designed to assess the previous 12 months (Serra-Majem, Pfrimer, et al., 2009).

8. Timeframe for Physical Activity Assessment

Accuracy of physical activity measurement decreases with increasing time period of assessment (Shephard, 2003). It is easier to recall activity in the previous day versus the previous month. However, it is also important to measure the past 12 months to get a measure of seasonal variability in activity (Shephard, 2003). Thus if assessment is retrospective and it only occurs once, a time period of 12 months is most appropriate to account for seasonal variability.

As described above, nutrition and physical activity assessment are complex issues and the population of study, as well as the type of information required, dictates how the assessment should be completed. For the pre-pregnancy population standard tools to assess nutrition and physical activity are not readily available. As a result it was necessary to adapt tools to assess the pre-

pregnancy time period for both of these lifestyle variables. As with any adaptation it was necessary to test the relative validity of the novel tools to ensure their appropriateness for use in the APrON study (Cade, et al., 2001).

Chapter 3: Methods

1. Recruitment

a. Recruitment Strategies and Questionnaire Dissemination

Pregnant and non-pregnant women were recruited from the Edmonton area with the goal of recruiting 100 women in each group. Different recruitment strategies were employed for the pregnant and non-pregnant groups.

For the pregnant group, recruitment was also a pilot test for one of the APrON recruitment strategies. This recruitment strategy was set up in conjunction with the Women and Children's Health Research Institute (WCHRI) at the University of Alberta along with two other studies in Edmonton also recruiting pregnant women. Upon having pregnancy confirmed at a medical clinic, potential participants were asked if they would be interested in participating in pregnancy research. If the individual indicated that she was interested, her name and telephone number was forwarded to the central WCHRI office. Names were randomly assigned between the three studies recruiting pregnant women at that time. Inclusion criteria, which differed slightly between studies, were taken into consideration when assigning participants. Once names and telephone numbers were received by APrON staff members, potential participants were called to solicit participation in the APrON FFQ comparison study. It was made clear that participants would only be taking part in a "pre-

study" to test questionnaires for a larger study. The time commitment for the pregnant women was one to two hours to complete two questionnaires which would be mailed to them (See Figure 3.1). A stamped, addressed envelope was also provided to participants to return the questionnaires to researchers at the University of Alberta. Other recruitment strategies employed in the current study included "word of mouth", maternity events and a booth set up at a local mall.

Non-pregnant participants were recruited through a variety of other methods as there was no affiliation with medical clinics to recruit these women. These methods included recruitment tables, posters, advertisements in newsletters and word-of-mouth at a variety of locations including the University of Alberta community and City of Edmonton recreation facilities. In most cases the 24 hour recall was completed at the point of recruitment once the study had been explained and the participant had provided informed consent. If it was not possible to complete the 24 hour recall at the point of recruitment (i.e. recruitment via poster or participant did not have enough time) an appointment was made to complete this aspect of the study at a later date. A questionnaire package containing the FFQ, Baecke physical activity questionnaire and Past Year Total Physical Activity Questionnaire (PYTPAQ) was given to non-pregnant participants either at the time of recruitment or at the subsequent appointment (See Figure 3.1). A stamped, addressed envelope was provided to facilitate the return of the questionnaires to the researchers. If the participant was not able to attend an appointment on the university campus, the 24 hour recall was completed

over the telephone and the questionnaires were mailed to the participant's home. All participants had the option to request an assessment of their 24 hour recall based on guidelines from Canada's Food Guide.

b. Ethics Approval

This research was approved by the Health Research Ethics Board – Panel B at the University of Alberta (Appendix A). All participants provided informed consent prior to participation (Appendix B and C).

2. Study Design

a. Inclusion Criteria

For the pregnant group, any woman who was currently pregnant was able to participate. There were no restrictions on number of weeks of gestation. For the non-pregnant group, women were recruited who were 17-45 years of age.

b. Exclusion Criteria

Women in either group were excluded from the study if they were unable to speak, read or write in English. In the non-pregnant group, women were excluded if they had been pregnant in the past 12 months, as the dietary intake reported in the FFQ would not be entirely represent "non-pregnant" intake.

c. Sample Size

A sample size of 100 participants in each of the pregnant and non-pregnant groups was chosen based on the norm in the field of validation as recommended by Willett (1990). In addition, a minimum of 100 participants is

preferable to complete the Bland-Altman analysis, a statistical analysis recommended for validation studies (Cade, et al., 2001).

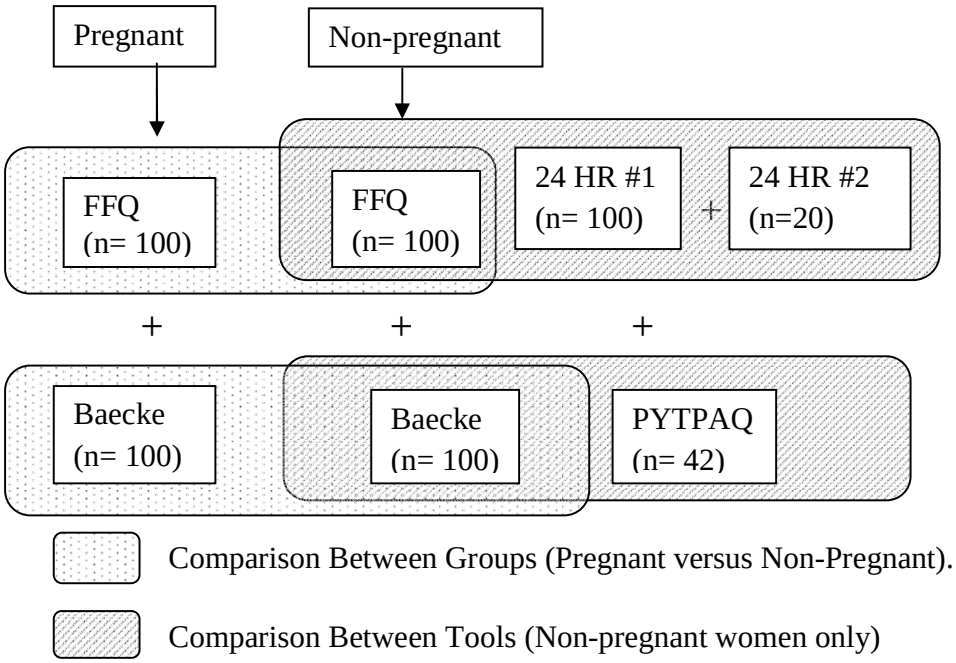
3. Assessment Tools

a. Demographic Assessment

Pregnant participants were asked to report their age, height, weight immediately prior to pregnancy, and number of week's gestation. Non-pregnant participants were asked to report their age, height, and current weight. Both groups were also asked to respond to a number of categorical demographic questions about marital status, parity, ethnicity, chronic illness, education level, employment status, and annual household income.

Two approaches were taken to assess the relative validity of the FFQ and Baecke Physical Activity Questionnaire for measuring pre-pregnancy dietary intake and physical activity respectively. It was not possible to assess validity as that would require comparison against a gold standard which does not exist for either of these measures (Cade, et al., 2001). Thus, assessment of relative validity, or comparison of one tool against a similar tool with its own strengths and limitations (Cade, et al., 2001; Masson, et al., 2003; Prince, et al., 2008) was performed. The approaches are illustrated in Figure 3.1.

Figure 3.1: Study Design



Abbreviations: FFQ (Food Frequency Questionnaire), 24 HR (24 hour recall), Baecke (Baecke Physical Activity Questionnaire), PYTPAQ (Past Year Total Physical Activity Questionnaire)

b. Dietary Assessment Tools

The FFQ was the primary method of dietary assessment of "pre-pregnancy" food intake. It allowed for a retrospective assessment of food intake over an extended period of time (Molag, et al., 2007). In this study, the assessment was for the previous 12 months.

The second method of diet assessment was a 24 hour recall. Both 24 hour recalls and dietary records have been used as comparison methods for the relative validation of FFQs (Molag, et al., 2007; Cade, et al., 2001). For this study, 24 hour recalls were chosen in order to minimize subject time commitment and resources required for analysis. In addition, using a 24 hour recall kept the methodology consistent with the larger APrON study.

Both pregnant and non-pregnant women completed the FFQ. Pregnant women were asked about dietary intake in the year prior to pregnancy, while non-pregnant women were asked about intake in the past year. The non-pregnant women also completed a 24 hour recall where they reported all food and beverages consumed in the past day. The 24 hour recall was completed either face-to-face or over the telephone and utilized the multiple pass method. Food models and common kitchen measurement tools were utilized to aid in portion size recall. Nutrient intake between the FFQ and 24 hour recall was assessed only in non-pregnant women because the goal of the FFQ was to describe dietary intake in the non-pregnant state. The validity of a comparison between a FFQ and 24 hour recall improves as the number of 24 hour recalls completed increases

(Cade, et al., 2001). As a result, a sub-sample of 20 non-pregnant women in this study completed two 24 hour recalls (Figure 3.1).

The FFQ was adapted from the Canadian version of the Diet History Questionnaire (Csizmadi, et al., 2007) which was originally developed by the National Cancer Institute in the United States (Subar, et al., 2001). The original Diet History Questionnaire utilized the USDA Nutrient Database for Standard Reference (SR11) and the software program Diet*Calc to interface with the dietary input (Subar, et al., 2001). Csizmadi et al., (2007) adapted the FFQ for use in Canada by utilizing the Canadian Nutrient File 2001b nutrient database. Orange and grapefruit juices fortified with calcium and vitamin D as well as the artificial sweetener Splenda® were added to the questionnaire (Csizmadi, et al., 2007). In addition, highly fortified cereals and potato chips made with fat substitutes were removed from the questionnaire as they were not available in Canada. These changes required adaptations to be made to the Diet*Calc software. Both the American and Canadian versions of the DHQ were developed by researchers specifically interested in cancer. As a result the food items were more focused on vegetable and fruit as well as fat consumption.

In order to focus the FFQ on nutrients of concern prior to pregnancy, it was further adapted for the APrON study. Changes included the addition of foods fortified with omega-3 fatty acids (eggs, juice, margarine, milk, soymilk, and yogurt), an expanded fish section, and more options for multigrain/flax grain products such as bread and pasta. As well, the order of some questions were

changed from the original DHQ. Some foods were combined into a single question in order to keep the time required to complete the FFQ to one to two hours. The nutrient profiles of additional foods were added to the nutrient database using the Canadian Nutrient File 2007b (Health Canada, 2007). The changes also required substantial modifications to the Diet *Calc software. As a result, the Diet*Calc software was re-created with technical support in Microsoft Excel (Excel version 2007). Responses to all FFQ's were double-entered to ensure accuracy and errors were corrected as necessary.

The 24 hour recalls were analyzed using ESHA Food Processor SQL version 10.5.0. (ESHA Research 1987-2010). This database was supplemented with detailed omega-3 data using the United States Department of Agriculture nutrient database (USDA, 2010). Omega-3 values were inserted food-by-food into the 24 hour recall database by trained research assistants. All 24 hour dietary recall entries were double checked by a trained research assistant. In addition, omega-3 fatty acid values chosen for use in this study and calculations on omega-3 fatty acid values for each food item were double checked by a trained research assistant.

c. Physical Activity Assessment Tools

The Baecke physical activity questionnaire was chosen as the primary method for assessing pre-pregnancy physical activity because it is a short, easily administered questionnaire that has been validated in a number of populations

including healthy as well as obese men and women (Pols, et al., 1995, Tehard, et al., 2005). It takes approximately 10-15 minutes to complete.

The Baecke questionnaire was originally designed to measure "current" physical activity, not activity over the past 12 months. Although it does not appear to have been validated for the pre-pregnancy time period, it has previously been used to retrospectively assess physical activity during the year prior to pregnancy in a group of Canadian pregnant women (Retnakaran, et al., 2009). In order to assess how well this questionnaire measures physical activity retrospectively it was compared to the Past Year Total Physical Activity Questionnaire (PYTPAQ) in a sub-sample of non-pregnant women. The PYTPAQ was specifically designed to measure physical activity retrospectively over the past 12 months in Alberta, Canada making it a good comparison tool for the Baecke questionnaire as this was the time frame of interest (Friedenreich, et al., 2006). The PYTPAQ takes approximately 15-20 minutes to complete.

Both pregnant and non-pregnant women completed the Baecke questionnaire which included questions about activity related to work, sports, and leisure time (Pols, et al., 1995). Work and leisure time questions utilized a Likert scale, while questions about sports required participants to list the sport type, frequency and duration (Pols, et al., 1995). In coding the Baecke questionnaire intensity of sport activity was estimated using the Compendium of Physical Activity with an activity of less than 3 metabolic equivalents (METS) equal to light intensity, 3-6 METS equal to moderate intensity, and greater than 6 METS

equal to vigorous intensity (Ainsworth, et al., 2000). Questionnaire coding provided an index score for each sub-section of activity as well as a total score (Pols, et al., 1995). In the pregnant group, the Baecke questionnaire asked about activity for the year prior to pregnancy, while in the non-pregnant group it asked about activity for the past year. A sub-sample of the non-pregnant group also completed the PYTPAQ as a secondary physical activity assessment. The PYTPAQ required participants to list their activities in four areas: (1) employment and volunteer activities ("Occupational Activity"), (2) transportation to and from employment and volunteer activities (added to "Occupational Activity"), (3) household, childcare and do-it-yourself activities ("Household Activity"), and (4) recreation and leisure activities ("Recreational Activity") (Friedenreich, et al., 2006). For each area, participants listed the type of activity, frequency, duration and an estimate of intensity (1 = sedentary, 2 = light activity, 3 = moderate activity, and 4 = vigorous activity) (Friedenreich, et al., 2006). Examples were provided for each area. The Occupational activity section was the only section that allowed sedentary activity to be listed (Friedenreich, et al., 2006). The coded PYTPAQ provided a measure of the hours of activity per week and MET hours of activity per week for each of the four sections. These sections were summed to determine the total hours of activity per week and total MET hours of activity per week (Friedenreich, et al., 2006).

All Baecke questionnaires were double-entered to ensure accuracy and data were corrected as necessary. All PYTPAQ's were coded by a trained

research assistant and all coding and data entry was double checked to ensure accuracy.

d. FFQ Feedback Tools

Participants were asked whether or not they agreed that the FFQ was acceptable, a simple yes/no question was used. In addition, participants were asked to estimate the length of time it took to complete the FFQ and in how many sittings they completed the FFQ.

4. Methods for Comparison of Tools

a. Comparison of Diet Assessment Tools

Nutrient intakes estimated by the FFQ in pregnant women were compared to nutrient intakes estimated by the FFQ in non-pregnant women. In order to compare dietary intake between groups, key nutrients were chosen. The comparison of nutrient intakes indicated how closely matched food intake in the previous year was *between groups* (pre-pregnant or non-pregnant food intake). The key nutrients chosen were long-chain omega-3 fatty acids, folate, vitamin B_6, vitamin B_{12}, calcium, vitamin D and iron. In addition, total energy and macronutrient intake (carbohydrate, protein and fat) were compared *between groups*.

Nutrient intakes estimated by the FFQ in non-pregnant women were also compared to nutrient intakes estimated by the 24 hour dietary recall. The same

key micronutrients, macronutrients and energy were used to compare nutrient intake *between tools*.

It is well known that nutrient intake can vary day-to-day and that a single 24 hour recall is not an appropriate measure of usual dietary intake as it will be impacted by intra-individual variation (Barr, 2006). A method developed by Nusser, Carriquiry, Dodd, & Fuller (1996) takes into account intra-individual variation in dietary intake and provides an adjusted usual intake distribution but it requires that a sub-sample of the individuals under assessment have repeated measurements. The Software for Intake Distribution Estimation (PC-SIDE) is a software program that uses this method (Nusser, et al., 1996). In order to assess intra-individual variation in dietary intake in the non-pregnant group, a sub-sample of participants (n=20), approximately 20%, were recruited to complete a second 24 hour recall, in addition to all other measures collected.

b. Comparison of Physical Activity Tools

The key components of physical activity were also compared *between groups* (pregnant vs. non-pregnant) and *between tools* (Baecke vs. PYTPAQ in the non-pregnant group). Scores on the four indexes of the Baecke questionnaire were compared between the pregnant and non-pregnant groups. The key areas compared between the Baecke and the PYTPAQ are illustrated in Table 3.1. Although the key areas were not identical between questionnaires they measured similar types of activities.

Table 3.1: Variables of the Baecke Physical Activity Questionnaire Compared to the Past Year Total Physical Activity Questionnaire.

Baecke	**PYTPAQ**
Total Score	Total MET hr/week
Occupational Score	Occupational MET hr/week and Transportation MET hr/week
Sport Score	Recreational MET hr/week
Leisure Time Score	Household MET hr/week

Abbreviations: Baecke (Baecke Physical Activity Questionnaire), PYTPAQ (Past Year Total Physical Activity Questionnaire), MET (Metabolic Equivalents)

5. Statistical Analysis

Assessment for outliers for dietary intake data was completed using unrealistic reported energy expenditure as a basis for exclusion as recommended by Csizmadi et al. (2007). Box plots were also used to examine for outliers for dietary intake data, Baecke physical activity questionnaire data and PYTPAQ data.

a. t-tests

Independent samples t-tests were used to compare group means for continuous demographic variables: age, height, weight, and body mass index (BMI). Independent samples t-tests were used to compare group means for the key nutrients measured by the FFQ *between groups*. Independent samples t-tests were also used to compare the key physical activity variables measured by the Baecke questionnaire *between groups*. Finally, this test was used to determine if there were differences in mean time to complete the FFQ between groups.

Dependent samples (paired) t-tests were used to compare group means within the non-pregnant group *between tools* for the key nutrients measured by the FFQ versus the 24 hour dietary recall, as well as the key physical activity variables measured by the Baecke questionnaire versus the PYTPAQ.

b. Chi square analysis and Fisher's exact test

Chi square analysis and Fisher's exact test were used to examine the differences in categorical demographics between groups including: marital status, parity, ethnicity, chronic illness, education level, employment status, annual

household income and BMI classification. Chi square analysis was also used to determine if there were differences between groups in the number of sittings taken to complete the questionnaire.

c. Correlational Analysis

Correlation coefficients are widely used to assess validity and they are of value when used in conjunction with other methods of assessment (Cade, et al., 2001). Correlations were completed examining the relationship *between tools*: for key nutrients as measured by the FFQ and the 24 hour recall in non-pregnant women and key physical activity variables as measured by the Baecke questionnaire and PYTPAQ in non-pregnant women.

A Pearson product moment correlation coefficient was utilized when data was normally distributed while the Spearman correlation coefficient was used for non-normally distributed data (a more conservative estimate of correlation). In this sample, the intake of some nutrients appeared normal while others were clearly skewed. To test for normality the Kolmogorov-Smirnov (K-S) Test was performed. This test determines whether or not the data set has a distribution significantly different from a normal distribution. For those nutrients where the K-S Test was significant, data was not normally distributed and therefore a Spearman correlation coefficient was utilized. If the K-S Test was not significant, data was normally distributed and a Pearson Correlation coefficient was used (Appendix E).

d. Bland Altman Plots

In addition to correlation coefficients which measure the strength of the relationship between two tools it was also important to assess agreement between the two tools in question (Bland & Altman, 1986). Bland Altman plots are a preferred method for testing relative validity (Cade, et al,, 2001). Firstly, for each comparison, the key values for the primary tool were plotted against the key values as measured by the reference tool. Using this information, pair-wise correlation coefficients were calculated to test the null hypothesis of no linear relationship between the two tools. Secondly, the differences in the key values between the tools were plotted against the mean value for the two tools to demonstrate the relationship between the methods. Limits of agreement (95% confidence interval) were also determined by calculating 1.96 ± the standard deviation of the mean difference.

Bland-Altman plots were constructed for those nutrient comparisons where correlations met the minimum acceptable level ($r \geq 0.3$) as per Cade, et al. (2001).

e. Agreement of Ranking

For the comparison of non-pregnant dietary intake assessed by FFQ and by 24 hour recall, nutrient intake levels were divided into tertiles. Physical activity levels of non-pregnant participants were also divided into tertiles based on physical activity level as assessed by the Baecke and by the PYTPAQ. Results were reported by classification in the same tertile and misclassification

classification in ± 2 tertiles. The kappa statistic was used to assess agreement between diet assessment methods and physical activity assessment methods.

All analyses were performed using SPSS (version 18.0, SPSS Inc, Chicago IL) except for the demographic variables: parity, education level, annual household income and BMI classification. For these variables the Fisher's exact test was used to detect differences between groups using the statistical software program STATA (version 10, StataCorp LP, College Station TX).

Chapter 4: Results

1. Recruitment

Overall, 98 pregnant women (67% of total recruited) and 103 non-pregnant women (65% of total recruited) completed participation in the study. The majority of pregnant women were recruited through a trial of the APrON recruitment strategy as described in the methods. In addition two participants were recruited by word of mouth and two participants were recruited through additional APrON recruitment efforts: one participant at a Welcome Wagon maternity event and one through an APrON recruitment booth at a local mall. Recruitment strategies for non-pregnant women, the number of women recruited and the number of women who completed the study are listed in Table 4.1. In total, 10 locations were visited with 5 different recruitment strategies utilized.

2. Demographic Information

Participant demographic information is described in Tables 4.2 and 4.3. Height and weight values were self-reported. The women in the pregnant group were asked to report their weight immediately prior to pregnancy and the women in the non-pregnant group were asked to report current weight. BMI was calculated by dividing weight (in kilograms) by height (in meters) squared.

Significant differences were found between groups for mean body weight and mean BMI. In both cases, weight and BMI were higher in the pregnant group.

A secondary analysis was completed to determine if age, parity, or presence of a chronic disease were significantly associated with BMI using Pearson's chi square analysis for categorical variables and independent t-test for the continuous variable (age). Participants were divided into two groups: normal BMI range (BMI $\leq$ 24.9) and above normal BMI range (BMI $\geq$ 25.0). There were no significant differences found between BMI groups in terms of age, parity, or chronic illness.

The women in the pregnant group were more likely to be married ($p<0.01$), have more children ($p<0.05$), be employed($p<0.05$), have a higher household income ($p<0.01$), and have a body weight that placed them in the obese category in terms of BMI ($p<0.05$). There were no significant differences found between groups for ethnicity, chronic illness, or level of education. Data on ethnicity was collapsed into two groups, Caucasian and Other. Pregnant participant self-reported "Other" ethnicities included: Chinese (n=5), Aboriginal (n=2), Arab (n=2), Japanese (n=2), Latin American (n=2), Southeast Asian (i.e. Cambodian, Indonesian, Laotian, Vietnamese) (n=2), Aboriginal/Caucasian (n=2), Portuguese (n=1), Filipino (n=1), Korean (n=1), and Black (n=1). Non-pregnant participant self-reported ethnicities included: Latin American (n=4), Korean (n=2), Chinese (n=2), South Asian (i.e. East Indian, Pakistani, Sri Lankan) (n=2), Arab (n=2), Japanese/Caucasian (n=2), Chinese/Caucasian (n=1), East Indian/Caucasian (n=1), West Asian (i.e. Afghan, Iranian) (n=1). Data on chronic illness was also collapsed into two groups, Yes or No, due to a wide variety of

chronic illness reported. Chronic illnesses reported by women in the pregnant group included: Irritable bowel syndrome (n=5), hypothyroidism (n=4), gestational diabetes (n=3), type 1 diabetes, breast cancer (in remission), fibromyalgia, gallstones, myasthenia gravis, asthma, chronic headaches, ventricular tachycardia, Crohn`s disease, and inactive sarcoidoisis. Chronic illnesses reported by the non-pregnant group included: Asthma (n=7), irritable bowel syndrome (n=5), allergy (environment, food, drug) (n= 2), celiac disease (n=2), polycystic ovary syndrome, multiple sclerosis, chronic gastritis, gastroesophageal reflux disease, and ventricular tachycardia. Chronic illnesses were reported by just 1 participant unless otherwise indicated.

Table 4.1: Recruitment Strategies for Non-Pregnant Participants

Recruitment Location	Approach	Women Recruited	Women Completed
University of Alberta Community			
Graduate Student's Association	Weekly E-newsletter	31	31
Students Union Building	Recruitment Table	48	25
Gymnastics Centre	Recruitment Table	15	11
Bulletin boards around campus	Posters	7	3
Michener Park Spouse's Coffee Time	Described face-to-face	2	2
Nutrition 100 Class	In-class Announcement	2	2
Recreation Facilities			
Millennium Place, Sherwood Park, AB	Recruitment Table	30	14
All City of Edmonton Recreation Centres	Posters	2	1
Other			
Word of Mouth	Described face-to-face	15	12
Edmonton Pakistani Community Centre	Recruitment Table	6	2
Edmonton Pregnancy Fair	Recruitment Table	1	0
Total		159	103

Table 4.2: Participant Demographic Characteristics (Continuous)

	Pregnant (n=98) (mean ± SD)	Non-Pregnant (n=103) (mean ± SD)	p value
Age (years)	30.2 ± 5.3	28.9 ± 7.6	0.169
Weeks Gestation	30.6 ± 8.2	N/A	N/A
Weight (kg)	68.9 ± 19.0	62.9 ± 9.0	0.004**
Height (cm)	166.3 ± 6.4	166.3 ± 7.3	0.997
Body Mass Index (BMI) (kg/m^2)	24.9 ±6.5	22.8 ±3.1	0.003**

*Independent t-test significant at $p<0.05$ level; ** Independent t-test significant at $p<0.01$ level.

Abbreviations: SD (standard deviation), kg (kilograms), cm (centimeters), m (meters)

Table 4.3: Participant Demographic Characteristics (Categorical)

	Pregnant (n=98)[a]	Non-Pregnant (n=103)[a]	p value
Marital Status			<0.001**[b]
Married/Common Law	96%	51%	
Single/Divorced/Other	4%	49%	
Parity			0.011*[c]
0	53%	68%	
1	31%	14%	
2 or more	15%	18%	
Ethnicity			0.377[b]
Caucasian	78%	83%	
Other[d]	22%	17%	
Chronic Illness			0.869[b]
No	82%	83%	
Yes[e]	18%	17%	
Education Level			0.662[c]
High school graduate or less	7%	5%	
Some college or university	16%	20%	
College or university degree or above	77%	73%	
Employment Status			0.024*[b]
Income[f]	70%	54%	
No Income[g]	30%	45%	
Annual Household Income			<0.001**[c]
<$30,000	6%	34%	
$30-59,000	19%	21%	
> $60,000	73%	40%	
BMI Classification (kg/m^2)			0.037*[c]
Underweight (BMI<18.5 kg/m^2)	3%	3%	
Normal (BMI = 18.5-24.9 kg/m^2)	66%	79%	
Overweight (BMI = 25.0-29.9)	14%	13%	
Obese (BMI ≥ 30.0)	15%	4%	

*p value significant at p<0.05 level; **p value significant at p<0.01 level.

[a]May not equal 100% due to no response on some questions by some participants

[b]p value indicated Chi square analysis.

[c]p value indicated by Fisher's Exact Test

[d]Pregnant participant self-reported ethnicities included: Chinese (n=5), Aboriginal (n=2), Arab (n=2), Japanese (n=2), Latin American (n=2), Southeast Asian (i.e. Cambodian, Indonesian, Laotian, Vietnamese) (n=2), Aboriginal/Caucasian (n=2), Portuguese (n=1), Filipino(n=1), Korean(n=1), and

Black(n=1). Non-pregnant participant self-reported ethnicities included: Latin American (n=4), Korean (n=2), Chinese (n=2), South Asian (i.e. East Indian, Pakistani, Sri Lankan) (n=2), Arab (n=2), Japanese/Caucasian (n=2), Chinese/Caucasian (n=1), East Indian/Caucasian (n=1), West Asian (i.e. Afghan, Iranian) (n=1).

[e]Pregnant participant self-reported chronic illnesses included: Irritable bowel syndrome (n=5), hypothyroidism (n=4), gestational diabetes (n=3), type 1 diabetes , breast cancer (in remission), fibromyalgia, gallstones, myasthenia gravis, asthma, chronic headaches, ventricular tachycardia, Crohn`s disease, inactive sarcoidoisis. Non-pregnant participant self-reported chronic illnesses included: Asthma (n=7), irritable bowel syndrome (n=5), allergy (environment, food, drug) (n= 2), celiac disease (n=2), polycystic ovary syndrome, multiple sclerosis, chronic gastritis, gastroesophageal reflux disease, and ventricular tachycardia. Chronic illnesses were reported by 1 participant unless otherwise indicated.

[f]Denotes individuals that stated they were employed or self-employed.

[g]Denotes individuals that stated they were students, homemakers, unemployed or other.

Abbreviations: BMI (body mass index), kg (kilograms), m (meters)

3. Nutrient Intake

Nine participants (7 pregnant and 2 non-pregnant) were excluded from all nutrient intake analysis on the basis of unrealistic reported energy intake on the FFQ as recommended by Csizmadi et al. (2007) and after examining for outliers.

a. Nutrient Intake Comparison Between Groups (Pregnant versus Non-Pregnant)

Energy and macronutrient intakes are shown in Table 4.4. The women in the pregnant group had significantly higher mean intakes of saturated fat ($p < 0.05$) and trans fat ($p<0.01$) compared to the non-pregnant group. The non-pregnant group had a significantly higher mean intake of alcohol ($p<0.05$).

Macronutrient intakes were compared to the Acceptable Macronutrient Distribution Range (AMDR) described by the Institute of Medicine as part of the Dietary Reference Intakes (2005). In order to do this, the mean macronutrient intake percentage was calculated using the mean total energy for each group. Both groups of women had macronutrient distributions within the recommended ranges (Table 4.5).

Table 4.4: Energy and Macronutrient Intake Measured by FFQ (Pregnant vs. Non-Pregnant)

Nutrient	Pregnant [a] (n=91) (mean ± SD)	Non-Pregnant[b] (n=101) (mean ± SD)	p-value
Energy (kcal)	1927 ± 537	1869 ± 529	0.456
Carbohydrate (g)	261.8 ± 82.2	246.9 ± 78.9	0.204
Fibre (g)	22.2 ± 9.2	24.1 ± 10.2	0.169
Protein (g)	77.6 ± 25.6	77.3 ± 26.2	0.958
Fat (g)	67.6 ± 22.1	66.1 ± 25.2	0.660
Saturated Fat (g)	22.1 ± 8.6	19.6 ± 8.1	0.039*
Monounsaturated Fat (g)	26.6 ± 9.8	27.1 ± 12.0	0.733
Polyunsaturated Fat (g)	13.1 ± 4.7	13.5 ± 5.8	0.527
ALA (g)	1.8 ± 0.8	1.7 ± 0.7	0.265
EPA/DHA (g)	0.14 ± 0.13	0.17 ± 0.21	0.246
Trans Fat (g)	3.5 ± 1.4	2.9 ± 1.4	0.007**
Cholesterol (mg)	200.6 ± 75.6	182.7 ± 82.7	0.120
Alcohol (g)	3.7 ± 4.9	5.6 ± 7.3	0.043*

*Independent samples t-test significant at $p<0.05$ level; **Independent samples t-test significant at $p<0.01$ level.

[a]Energy and macronutrient intake for the year prior to becoming pregnant

[b]Energy and macronutrient intake for the past year

Abbreviations: FFQ (food frequency questionnaire), kcal (kilocalories), g (grams), mg (milligrams), SD (standard deviation), ALA (alpha-linolenic acid), EPA/DHA (Eicosapentaenoic acid/Docosahexaenoic acid)

Table 4.5: Macronutrient Intake as a Percent of Total Energy Measured by FFQ in Pregnant and Non-Pregnant Women

	AMDR[a]	Pregnant (n=91)	Non-Pregnant (n=101)
Carbohydrate	45-65%	54%	53%
Protein	10-35%	16%	17%
Fat	20-35%	32%	32%

[a]Institute of Medicine, 2005.

Abbreviations: AMDR (Acceptable Macronutrient Distribution Range), FFQ (food frequency questionnaire)

Micronutrient intakes are reported in Table 4.6. The EAR is presented for comparison. The EAR was utilized instead of recommended dietary allowance (RDA) because intake was examined on the group level. Calcium intake was significantly higher among the pregnant group compared to the non-pregnant group ($p<0.05$). Intakes of all other key micronutrients were similar between groups.

Table 4.6: Micronutrient Intake Measured by FFQ of Pregnant and Non-Pregnant Women

	EAR[a]	Pregnant[b] (n=91) (mean ± SD)	Non-Pregnant[c] (n=101) (mean ± SD)	p value
Folate (µg)	320	369 ± 124	392 ± 148	0.250
Vitamin B_6 (mg)	1.1	2.1 ± 0.8	2.1 ± 0.8	0.856
Vitamin B_{12} (µg)	2.0	5.1 ± 2.3	5.0 ± 2.3	0.802
Calcium (mg)	800	1146 ± 556	988 ± 408	0.026*
Vitamin D (µg)	10	5.8 ± 3.5	5.2 ± 3.2	0.204
Iron (mg)	8.1	15.3 ± 5.0	16.4 ± 6.0	0.193

*Independent samples t-test significant at $p<0.05$ level; **Independent samples t-test significant at $p<0.01$ level.

[a]Institute of Medicine, 2010, 2001, 1998.

[b]Micronutrient intake for the year prior to becoming pregnant

[c]Micronutrient intake for the past year

Abbreviations: FFQ (food frequency questionnaire), mg (milligrams), µg (micrograms), SD (standard deviation), EAR (Estimated Average Requirement)

b. Nutrient Intake Comparison Between Tools in Non-Pregnant Women (FFQ versus 24 Hour Recall)

i. Paired Samples t-test

The comparison of energy and macronutrient intake *between tools* (Table 4.7), demonstrated that intake of monounsaturated fat ($p<0.01$), polyunsaturated fat ($p<0.01$), alpha-linolenic acid ($p<0.01$), and trans fat ($p<0.01$) were significantly higher when assessed by the FFQ in comparison to the 24 hour recall. Although day of the week on which the 24 hour recall was completed was not controlled for statistically, 83 (82%) of the 24 hour recalls reflected a weekday (Monday-Friday) and 18 (18%) reflected a weekend day (Saturday or Sunday).

Macronutrient intake as assessed by each tool was converted into a percent of total mean energy intake and compared against the AMDR (IOM, 2005). Percent intake from each of the macronutrients fell within the recommended ranges for both tools (Table 4.8).

Table 4.7: Energy and Macronutrient Intake as Measured by FFQ and 24 Hour Recall in Non-Pregnant Participants (n=101)

	FFQ[a] (mean ± SD)	24 Hour Recall[b] (mean ± SD)	p value
Energy (kcal)	1869.8 ± 629.4	1937.9 ± 565.2	0.341
Carbohydrate (g)	246.9 ± 78.9	264.8 ± 88.5	0.074
Fibre (g)	24.1 ± 10.3	22.6 ± 10.7	0.170
Protein (g)	77.4 ± 26.2	77.2 ± 26.7	0.949
Fat (g)	66.1 ± 25.3	63.7 ± 29.8	0.511
Saturated Fat (g)	19.6 ± 8.1	21.2 ± 11.8	0.242
Monounsaturated Fat (g)	27.1 ± 12.0	19.2 ± 11.9	0.000**
Polyunsaturated Fat (g)	13.6 ± 5.8	10.3 ± 6.9	0.000**
ALA (g)	1.7 ± 0.7	1.1 ± 0.9	0.000**
EPA/DHA (g)	0.17 ± 0.21	0.19 ± 0.55	0.676
Trans Fat (g)	2.9 ± 1.4	0.6 ± 0.8	0.000**
Cholesterol (mg)	182.7 ± 82.7	209.8 ± 157.0	0.099
Alcohol (g)	5.6 ± 7.3	5.7 ± 15.3	0.916

*Paired samples t-test significant at $p<0.05$ level; **Paired samples t-test significant at $p<0.01$ level.

[a]Energy and macronutrient intake for the past year

[b]Energy and macronutrient intake for the past 24 hours

Abbreviations: FFQ (food frequency questionnaire), kcal (kilocalories), g (grams), mg (milligrams), SD (standard deviation), ALA (alpha-linolenic acid), EPA/DHA (Eicosapentaenoic acid/Docosahexaenoic acid)

Table 4.8: Macronutrient Intake: Percent of Total Energy Measured by FFQ and 24 Hour Recall in Non-Pregnant Women (n=101)

	AMDR[a]	FFQ[b]	24 Hour Recall[c]
Carbohydrate	45-65%	53%	55%
Protein	10-35%	17%	16%
Fat	20-35%	32%	30%

[a]Institute of Medicine, 2005.

[b]Energy and macronutrient intake for the past year

[c]Energy and macronutrient intake for the past 24 hours

Abbreviations: AMDR (Acceptable Macronutrient Distribution Range), FFQ (food frequency questionnaire)

Mean micronutrient intake measured by the FFQ was significantly higher for all key micronutrients except calcium, compared to the 24 hour recall (Table 4.9).

Table 4.9: Micronutrient Intake as Measured by FFQ and 24 Hour Recall in Non-Pregnant Participants (n=101)

	EAR[a]	FFQ[b] (mean ± SD)	24 Hour Recall[c] (mean ± SD)	p value
Folate (µg)	320	392± 148	304± 203	<0.001**
Vitamin B_6 (mg)	1.1	2.1 ± 0.8	1.5 ± 0.7	<0.001**
Vitamin B_{12} (µg)	2.0	5.0 ± 2.4	3.6 ± 2.8	<0.001**
Calcium (mg)	800	988 ± 408	943 ± 404	0.345
Vitamin D (µg)	10	5.2 ± 3.3	4.0 ± 3.2	0.002**
Iron (mg)	8.1	16.4 ± 6.0	14.6 ± 7.2	0.031*

*Paired samples t-test significant at $p<0.05$ level; **Paired samples t-test significant at $p<0.01$ level.

[a]Institute of Medicine, 2010, 2001, 1998.

[b]Micronutrient intake for the past year

[c]Micronutrient intake for the past 24 hours

Abbreviations: FFQ (food frequency questionnaire), mg (milligrams), µg (micrograms), SD (standard deviation), EAR (Estimated Average Requirement)

ii. Correlation Analysis

Correlation coefficients for nutrient intake measured by FFQ and 24 hour recall were calculated to assess the strength of the relationship between tools. The K-S Test indicated that ALA, EPA/DHA, trans fat, alcohol, vitamin B_{12}, and vitamin D were not normally distributed. All other macronutrients and micronutrients were normally distributed.

The correlation coefficients between intakes measured by the FFQ and 24 hour recall were significant for the macronutrients: carbohydrate ($p<0.01$), fibre ($p<0.01$), protein ($p<0.05$), monounsaturated fat ($p<0.05$), polyunsaturated fat ($p<0.01$), trans fat ($p<0.05$) and alcohol ($p<0.01$) (Table 4.10). Correlation coefficients between intakes determined by the two assessment methods were also significant for intakes of the micronutrients: vitamin B_6 ($p<0.01$,), vitamin B_{12} ($p<0.01$), calcium ($p<0.01$), vitamin D ($p<0.01$) and iron ($p< 0.01$) (Table 4.11) as determined by the two assessment methods.

Table 4.10: Pearson and Spearman Correlation Coefficients of Macronutrient Intake Measured by FFQ and 24 Hour Recall in Non-Pregnant Participants (n=101)

	Correlation	p value
Energy (kcal)[a]	0.147	0.142
Carbohydrate (g)[a]	0.300	0.002**
Fibre (g)[a]	0.455	<0.001**
Protein (g)[a]	0.207	0.038*
Fat (g)[a]	0.178	0.075
Saturated Fat (g)[a]	0.125	0.213
Monounsaturated Fat (g)[a]	0.235	0.018*
Polyunsaturated Fat (g)[a]	0.341	<0.001**
ALA (g)[b]	-0.107	0.286
EPA/DHA (g)[b]	0.189	0.059
Trans Fat (g)[b]	0.204	0.042*
Cholesterol (mg)[a]	0.177	0.077
Alcohol (g)[b]	0.400	<0.001**

*Correlation is significant at p<0.05 level; **Correlation is significant at p<0.01 level.

[a]Pearson correlation coefficient

[b]Spearman correlation coefficient

Abbreviations: FFQ (food frequency questionnaire), kcal (kilocalories), g (grams), mg (milligrams), ALA (alpha-linolenic acid), EPA/DHA (Eicosapentaenoic acid/Docosahexaenoic acid)

Table 4.11: Pearson and Spearman Correlation Coefficients of Micronutrient Intake Measured by FFQ and 24 Hour Recall in Non-Pregnant Participants (n=101)

	Correlation	p value
Folate (µg)[a]	0.181	0.070
Vitamin B_6 (mg)[a]	0.406	<0.001**
Vitamin B_{12} (µg)[b]	0.312	0.002**
Calcium (mg)[a]	0.308	0.002**
Vitamin D (µg)[b]	0.393	<0.001**
Iron (mg)[a]	0.275	0.005**

*Correlation is significant at p<0.05 level; **Correlation is significant at p<0.01 level.

[a]Pearson correlation coefficient

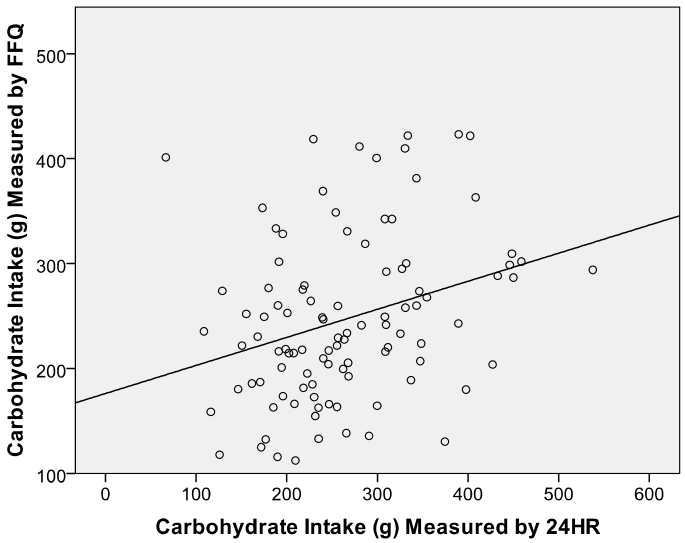
[b]Spearman correlation coefficient

Abbreviations: FFQ (food frequency questionnaire), mg (milligrams), µg (micrograms)

iii. Bland-Altman Plots

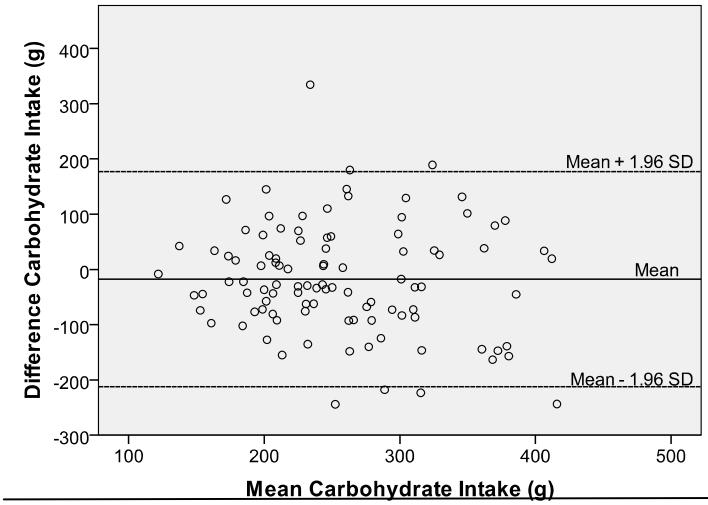
Two plots were created to examine agreement for each nutrient between the two dietary assessment methods using the Bland-Altman approach. The first plot in the pair for each nutrient represents the correlation between intake of the nutrient as determined by the two methods. The second plot in the pair represents the difference between intakes measured by each tool plotted against the mean intake of both tools. The solid line represents the mean difference between tools and the dotted lines represent the 95% limits of agreement, which is ±1.96 standard deviations from the mean difference (Bland & Altman, 2003). As a result of using 1.96 standard deviations from the mean to determine placement of the limits of agreement, approximately 95% of the points should be within 1.96 standard deviations from the mean difference (Bland & Altman, 2003) (Figures 4.1-4.8).

Figure 4.1A: Correlation of Carbohydrate Intake Measured by FFQ and 24HR



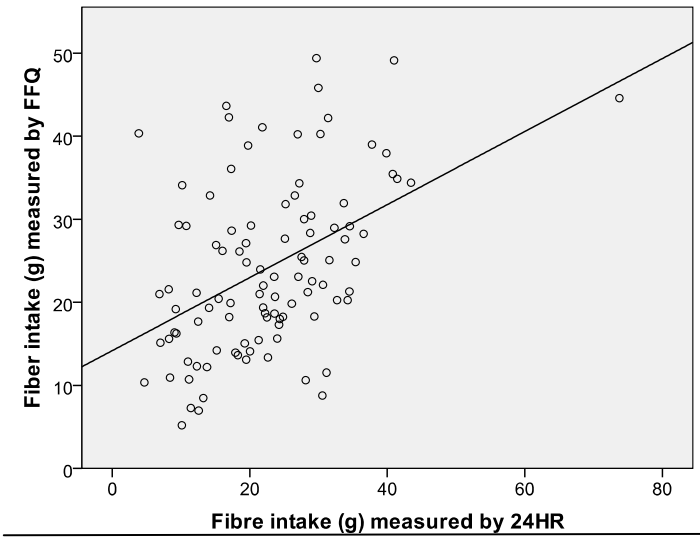
Pearson r = 0.300, p = 0.002
Abbreviations: FFQ (Food Frequency Questionnaire), 24HR (24 hour recall), g (grams)

Figure 4.1B: Bland Altman Plot of Difference Versus Mean Carbohydrate Intake



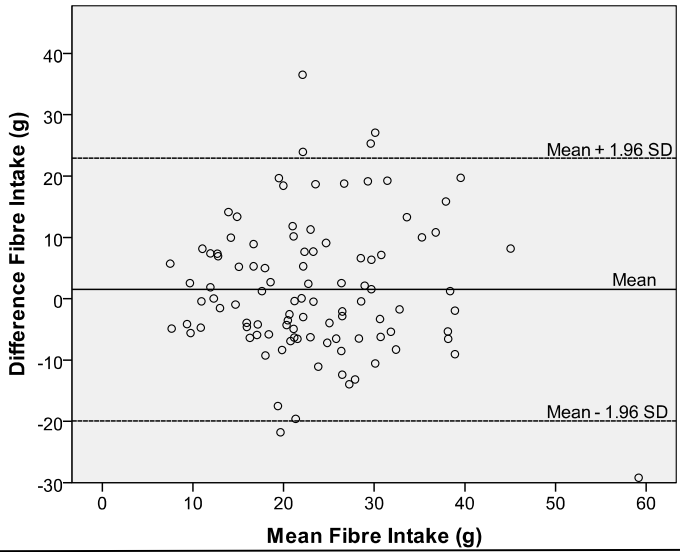
Mean Difference= -17.84, Standard Deviation (SD) = 99.31g
Limits of Agreement: 176.8g, -212.5g
Abbreviations: g (grams), SD (standard deviation)

Figure 4.2A: Correlation of Fibre Intake Measured by FFQ and 24HR



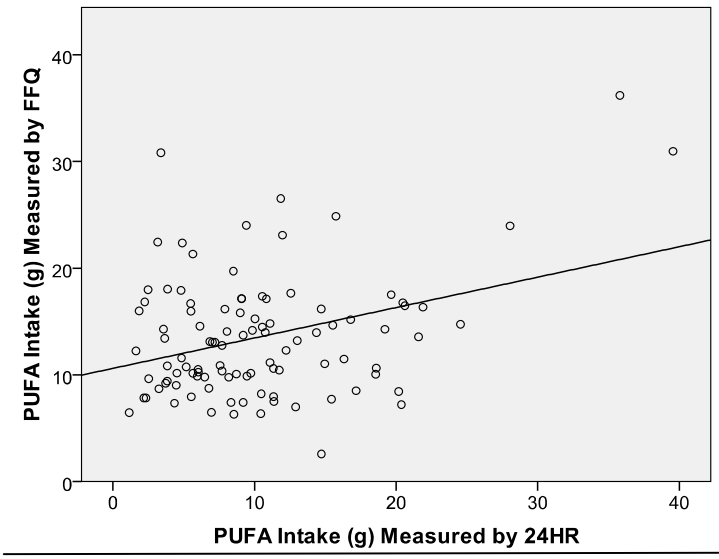
Pearson r = 0.455, p = 0.000Abbreviations: FFQ (Food Frequency Questionnaire), 24HR (24 hour recall), g (grams)

Figure 4.2B: Bland Altman Plot of Difference Versus Mean Fibre Intake



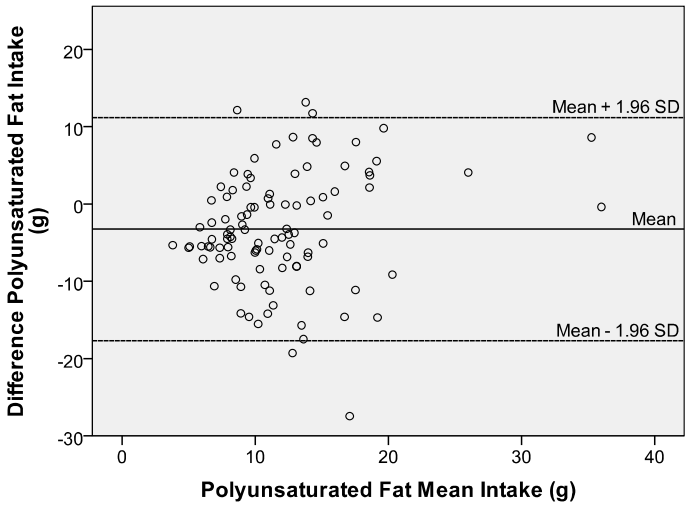
Mean Difference = 1.50g, Standard Deviation (SD) = 10.93g
Limits of Agreement: 22.9g, -19.9g
Abbreviations: g (grams), SD (standard deviation)

Figure 4.3A: Correlation of PUFA Intake Measured by FFQ and 24HR



Pearson r = 0.341, p = 0.000
Abbreviations: FFQ (Food Frequency Questionnaire), PUFA (Polyunsaturated Fat), 24HR (24 hour recall), g (grams)

Figure 4.3B: Bland Altman Plot of Difference Versus Mean PUFA Intake

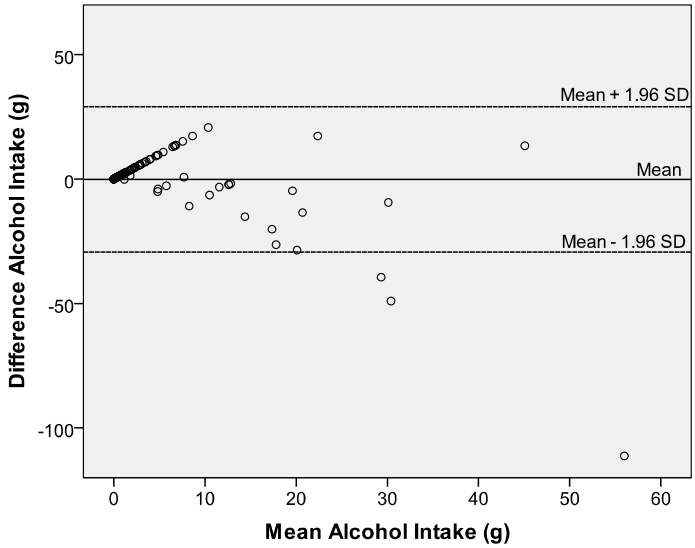


Mean Difference = -3.25g, Standard Deviation (SD) = 7.36g
Limits of Agreement: 11.2g, -17.7g
Abbreviations: g (grams), SD (standard deviation)

Figure 4.4A: Correlation of Alcohol Intake Measured by FFQ and 24HR

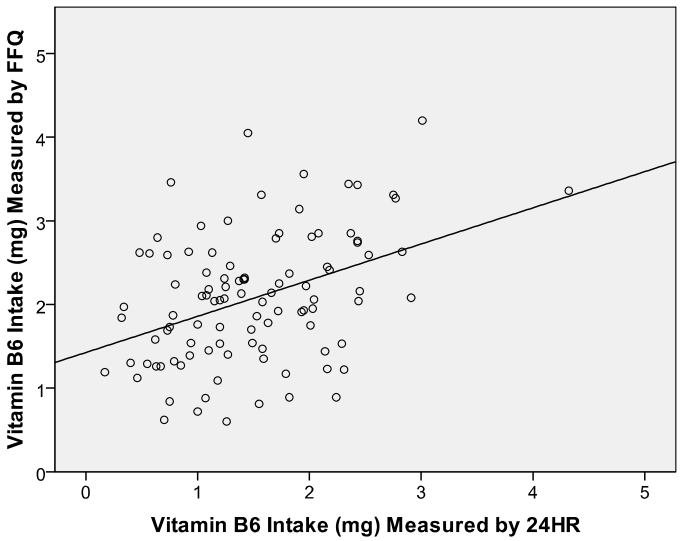
Spearman r = 0.400, p = 0.000
Abbreviations: FFQ (Food Frequency Questionnaire), 24HR (24 hour recall), g (grams)

Figure 4.4B: Bland Altman Plot of Difference Versus Mean Alcohol Intake



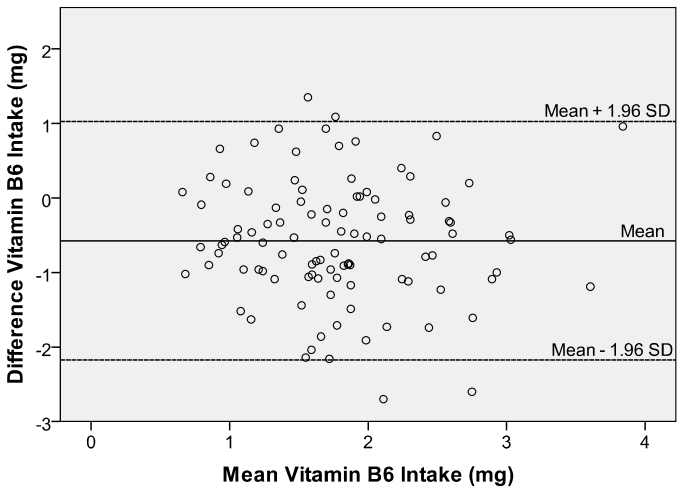
Mean Difference = -0.16g, Standard Deviation (SD) = 14.92g
Limits of Agreement: 29.1g, -29.4g
Abbreviations: g (grams), SD (standard deviation)

Figure 4.5A: Correlation of Vitamin B_6 Intake Measured by FFQ and 24HR



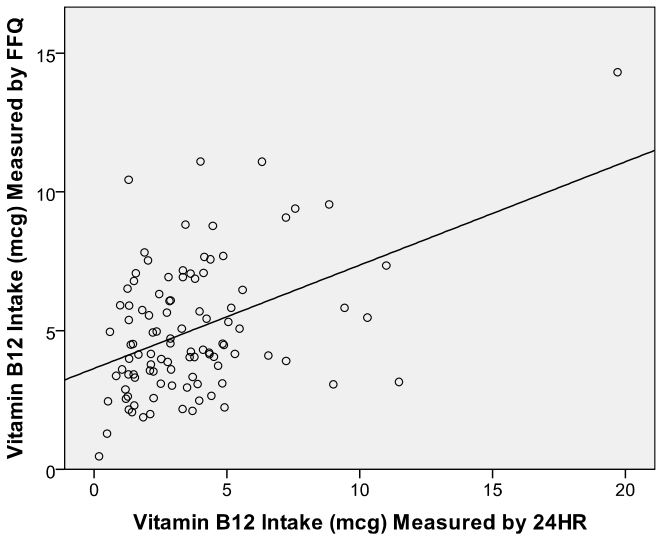
Pearson r = 0.406, p = 0.000
Abbreviations: FFQ (Food Frequency Questionnaire), 24HR (24 hour recall), mg (milligrams)

Figure 4.5B: Bland Altman Plot of Difference Versus Mean Vitamin B_6 Intake



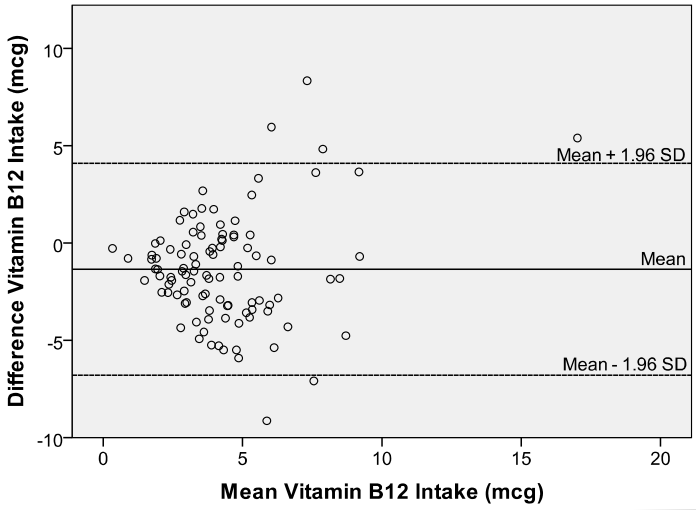
Mean Difference = -0.57mg, Standard Deviation: 0.82mg
Limits of Agreement: 1.0mg, -2.2mg
Abbreviations: mg (milligrams), SD (standard deviation)

Figure 4.6A: Correlation of Vitamin B_{12} Intake Measured by FFQ and 24HR



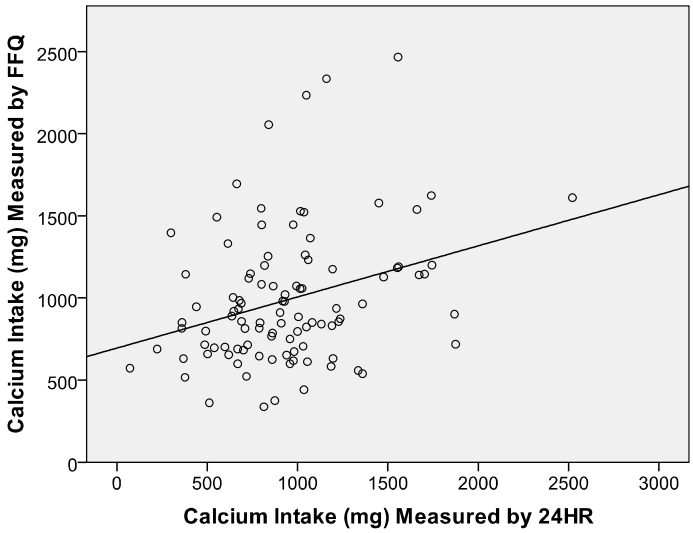
Spearman r = 0.312, p = 0.002
Abbreviations: FFQ (Food Frequency Questionnaire), 24HR (24 hour recall), mcg (micrograms)

Figure 4.6B: Bland Altman Plot of Difference Versus Mean Vitamin B_{12} Intake



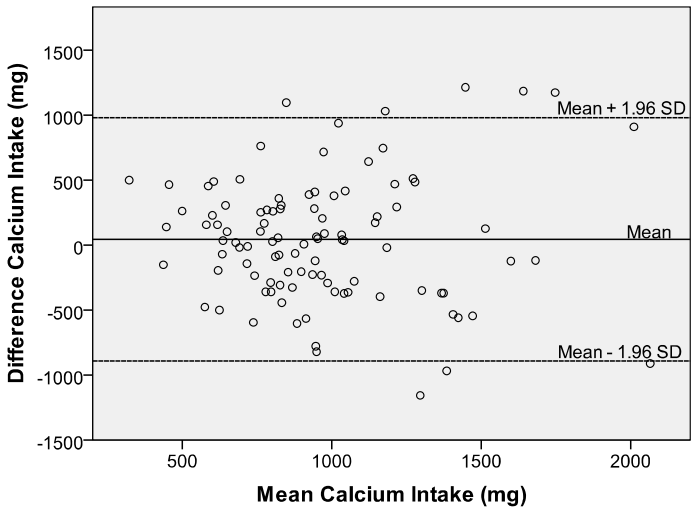
Mean Difference = -1.36µg, Standard Deviation: 2.78µg
Limits of Agreement: 4.1µg, -6.8µg
Abbreviations: mcg or µg (micrograms), SD (standard deviation)

Figure 4.7A: Correlation of Calcium Intake Measured by FFQ and 24HR



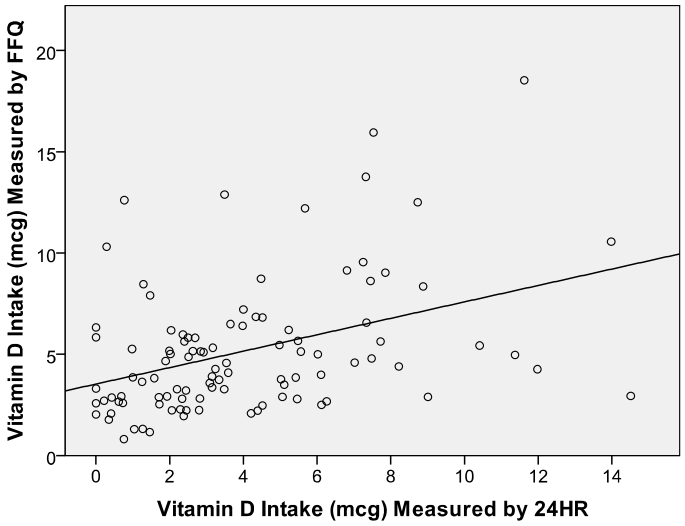
Pearson r = 0.308, p = 0.002
Abbreviations: FFQ (Food Frequency Questionnaire), 24HR (24 hour recall), mg (milligrams)

Figure 4.7B: Bland Altman Plot of Difference Versus Mean Calcium Intake



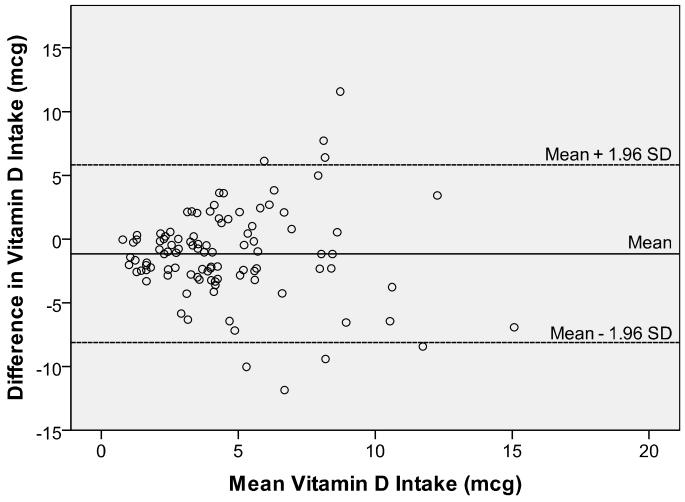
Mean Difference: 45.07mg, Standard Deviation: 477.72mg
Limits of Agreement: 981.4mg, -891.3mg
Abbreviations: mg (milligrams), SD (standard deviation)

Figure 4.8A: Correlation of Vitamin D Intake Measured by FFQ and 24HR



Spearman r = 0.393, p = 0.000
Abbreviations: FFQ (Food Frequency Questionnaire), 24HR (24 hour recall), g (grams)

Figure 4.8B: Bland Altman Plot of Difference Versus Mean Vitamin D Intake



Mean Difference = -1.15µg, Standard Deviation = 3.56µg
Limits of Agreement: 5.8 µg, -8.1 µg
Abbreviations: mcg or µg (micrograms), SD (standard deviation)

While the mean differences were relatively close to zero for most nutrients assessed, the limits of agreement were large. The limits of agreement (95% confidence interval) for carbohydrate were 176.8g and -212.5g indicating an intake for one tool would be expected to be within 389g of the other tool. By calculating this difference between the limits of agreement for each of the nutrients assessed, a range was determined within which one tool would be expected to predict intake compared to the other. For fibre this range was 42.8g, for polyunsaturated fat the range was 28.9g, for alcohol the range was 58.5g, vitamin B_6 had a range of 3.2mg, vitamin B_{12} had a range of 10.9µg, the range for calcium was 1872.7mg and for vitamin D the range was 13.9µg.

For all plots, there did not appear to be a bias for one tool to overestimate or underestimate consistently. This was illustrated by points falling equally on either side of the mean difference.

From visual inspection, it appears that variability in measurement increases as intake increases among alcohol, vitamin B_{12}, calcium and vitamin D. However, there does not appear to be differences in variability across intake for carbohydrate, fibre, polyunsaturated fat and vitamin B_6.

iv. Tertile Classification

An alternate analysis in assessment of agreement is to examine the ability of a FFQ to rank nutrient intake into tertiles of low, medium, and high intake in comparison to a reference method (Masson, et al., 2003; Molag, et al., 2007). The ability of the FFQ to rank energy, macronutrient intake and micronutrient intake

in comparison to the reference method, 24 hour recall is described in Table 4.12 and Table 4.13.

It was not possible to quantify alcohol intake measured by the 24 hour recall into tertiles as more than 1 tertile had 0g of alcohol intake per day. For energy and macronutrients, the proportion of participants classified into the same tertile by both tools ranged from 31-47% while the proportion of participants misclassified by ± 2 tertiles ranged from 12%-26%.

For micronutrients (Table 4.13), the proportion of participants classified into the same tertile by both tools ranged from 36-52% while the proportion of participants misclassified by ± 2 tertiles ranged from 13%-19%.

A kappa statistic, which is a measure of agreement for categorical variables, was also calculated (Cade et al, 2001). For energy and macronutrients the kappa statistic ranged from -0.04 to 0.198. For micronutrients the kappa statistic ranged from 0.035 to 0.272.

Table 4.12: Proportion of Non-Pregnant Participants Categorized into the Same Tertile or Misclassified into ± 2 Tertiles of Energy and Macronutrient Intake using the FFQ and 24 Hour Recall (n=101)

Nutrient	Proportion categorized into the same tertile (%)	Proportion of misclassification ± 2 tertile (%)	Kappa Statistic
Energy (kcal)	33	18	-0.010
Carbohydrate (g)	43	14	0.139
Fibre (g)	47	12	0.198
Protein (g)	43	16	0.139
Fat (g)	39	21	0.079
Saturated Fat (g)	37	22	0.049
Monounsaturated Fat (g)	42	23	0.124
Polyunsaturated Fat (g)	39	20	0.079
ALA (g)	31	26	-0.040
EPA/DHA (g)	38	16	0.064
Trans Fat (g)	41	18	0.109
Cholesterol (mg)	40	19	0.094
Alcohol (g)	N/A	N/A	N/A

Abbreviations: FFQ (food frequency questionnaire), kcal (kilocalories), g (grams), mg (milligrams), ALA (alpha-linolenic acid), EPA/DHA (Eicosapentaenoic acid/Docosahexaenoic acid), N/A (not applicable)

Table 4.13: Proportion of Non-Pregnant Participants Categorized into the Same Tertile or Grossly Misclassified into ± 2 Tertiles of Micronutrient Intake using the FFQ and 24 Hour Recall (n=101)

Nutrient	Proportion categorized into the same tertile (%)	Proportion of gross misclassification ± 2 tertile (%)	Kappa Statistic
Folate (µg)	40	19	0.094
Vitamin B_6 (mg)	52	15	0.272
Vitamin B_{12} (µg)	45	14	0.168
Calcium (mg)	45	14	0.168
Vitamin D (µg)	46	13	0.183
Iron (mg)	36	17	0.035

Abbreviations: FFQ (food frequency questionnaire), mg (milligrams), µg (micrograms)

v. Intra-individual Variation

In order to determine the intra-individual variation in dietary intake a sub-sample of non-pregnant participants (n=20) completed two 24 hour recalls. A comparison of mean intakes of energy and macronutrients and the correlation between intakes for day 1 and 2 are described in Table 4.14. A comparison of mean key micronutrient intakes and the correlation between intakes for day 1 and 2 are described in Table 4.15. The K-S Test was again utilized to determine whether nutrient intake in the sub-sample of 20 non-pregnant participants was normally distributed (Appendix E). It was found that energy and all nutrients were normally distributed except alcohol and EPA/DHA. As a result Pearson correlation coefficients were calculated for all nutrients except alcohol and EPA/DHA where Spearman correlation coefficients were used.

Although approximately 20% of the non-pregnant sample had repeated 24 hour recall, there were not enough repeated measures for adjustment for the whole sample using PC-SIDE, thus usual nutrient intake was not determined. In this sub-group there were no significant differences between mean intakes of energy, macro or micronutrients between the first and second 24 hour recalls. In addition there were fair correlations ($r > 0.3$) between recall 1 and 2 for fibre, fat, saturated fat, monounsaturated fat, alcohol, and vitamin B_6 as well as good correlations ($r > 0.5$) for energy, carbohydrate, and polyunsaturated fat intake.

Table 4.14: Comparison of variability of nutrient intake assessed by 24 hour recall in a subset of non-pregnant participants (n=20)

Nutrient	24 HR #1 (Mean ± SD)	24 HR #2 (Mean ± SD)	Paired t-test (p value)	r
Energy (kcal)[a]	2144 ± 586	2204 ± 866	0.703	0.601**
Carbohydrate (g) [a]	294.7 ± 103.9	286.9 ± 107.2	0.733	0.542 *
Fibre (g) [a]	25.7 ± 14.4	28.3 ± 11.6	0.400	0.440
Protein (g) [a]	82.4 ±25.0	90.5 ± 36.3	0.365	0.228
Fat (g) [a]	72.4 ± 31.8	78.0 ± 45.0	0.578	0.387
SFA (g) [a]	23.8 ± 12.8	21.9 ± 16.7	0.621	0.351
MUFA (g) [a]	22.3 ± 12.6	23.5 ± 16.4	0.756	0.308
PUFA (g) [a]	13.3 ± 8.6	14.5 ± 10.5	0.536	0.628**
ALA (g) [a]	1.06 ± 0.59	1.43 ± 1.49	0.338	-0.091
EPA/DHA (g) [b]	0.29 ± 0.81	0.18 ± 0.50	0.567	0.039
Trans Fat (g) [a]	0.5 ± 0.7	0.3 ± 0.5	0.215	0.143
Cholesterol (mg) [a]	245.7 ± 206.8	198.1 ± 146.1	0.369	0.174
Alcohol (g) [b]	6.5 ± 10.9	7.3 ± 12.8	0.771	0.414

*Significant at p<0.05 level; **Significant at p<0.01 level.

[a]Pearson correlation coefficient

[b]Spearman correlation coefficient

Abbreviations: 24HR (24 hour recall), r (correlation coefficient), kcal (kilocalories), g (grams), mg (milligrams), SD (standard deviation), SFA (saturated fat), MUFA (monounsaturated fat), PUFA (polyunsaturated fat), ALA (alpha-linolenic acid), EPA/DHA (Eicosapentaenoic acid/Docosahexaenoic acid)

Table 4.15: Comparison of variability of nutrient intake assessed by 24 hour recall in a subset of non-pregnant participants (n=20)

Nutrient	24 HR #1 (Mean ± SD)	24 HR #2 (Mean ± SD)	Paired t-test (p value)	Pearson r
Folate (µg)	354 ± 202	267 ±155	0.128	0.084
Vitamin B_6 (mg)	1.8 ± 0.9	1.9 ± 0.7	0.692	0.475*
Vitamin B_{12} (µg)	4.6 ± 4.3	3.2 ± 2.0	0.227	-0.114
Calcium (mg)	977 ± 419	1095 ± 589	0.463	0.060
Vitamin D (µg)	5.0 ± 3.6	4.4 ± 4.6	0.592	0.147
Iron (mg)	15.7 ± 5.2	15.3 ± 5.8	0.854	0.075

*Significant at $p<0.05$ level; **Significant at $p<0.01$ level.

Abbreviations: mg (milligrams), µg (micrograms), SD (standard deviation), r (correlation coefficient)

4. Physical Activity

a. Physical Activity Comparison Between Groups (Pregnant versus Non-Pregnant)

i. Independent t-test

In a similar manner to the dietary intake data, the mean physical activity levels measured by the Baecke physical activity questionnaire were compared between the pregnant and non-pregnant groups using independent t-tests. Significant differences between groups were found for the sport score ($p<0.01$), leisure time score ($p<0.05$), and total activity score ($p< 0.05$), with the pregnant group having lower values than the non-pregnant group for these three variables (Table 4.16).

Table 4.16: Physical Activity Level Measured by the Baecke Physical Activity Questionnaire (Pregnant vs. Non-Pregnant)

Physical Activity Component	Pregnant (n=98) (mean ± SD)	Non-Pregnant (n=103) (mean ± SD)	p value
Work Score	2.6 ± 0.80	2.4 ± 0.65	0.061
Sport Score	2.6 ± 0.87	3.1 ± 0.78	<0.001**
Leisure Time Score	2.7 ± 0.59	2.9 ± 0.51	0.010*
Total Score	7.8 ± 1.65	8.3 ±1.24	0.016*

*Independent samples t-test significant at $p<0.05$ level; **Independent samples t-test significant at $p<0.01$ level.

Abbreviations: SD (standard deviation)

b. Physical Activity Comparison Between Tools in Non-Pregnant Women (Baecke Physical Activity Questionnaire versus Past Year Total Physical Activity Questionnaire)

i. Paired Samples t-test

It was not appropriate to use paired samples t-tests to compare the mean scores for the Baecke Physical Activity Questionnaire and the PYTPAQ because the two questionnaires report activity level using different scales. As such, mean scores would be significantly different but this would not be an informative comparison.

ii. Correlation Analysis

The strength of the relationship between the Baecke Physical Activity Questionnaire and the PYTPAQ was determined by calculating Pearson correlation coefficients, presented in Table 4.17. Pearson correlation coefficients were used because K-S tests confirmed that data were normally distributed (Appendix E). Correlations were significant for work/occupation score ($p<0.01$), sport/exercise score ($p<0.01$), and total score ($p<0.01$).

iii. Bland Altman Plots

It was not appropriate to use a Bland-Altman plot to assess the agreement between the Baecke physical activity questionnaire and the PYTPAQ because the two tools provided an output in different units. This in an issue because one of the measures used in the Bland-Altman analysis is the difference between the two scores. This would not provide a meaningful number with different scales.

Table 4.17: Pearson Correlation Coefficients of Physical Activity Measured by the Baecke Physical Activity Questionnaire and the PYTPAQ in Non-Pregnant Participants (n=42)

Variables (Baecke versus PYTPAQ)	Baecke Score (mean ± SD)	PYTPAQ (MET hr/week) (mean ± SD)	Pearson r
Work Score versus Occupational MET hr/week	2.4 ± 0.7	86.6 ± 47.7	0.572**
Sport Score versus Exercise MET hr/week	3.1 ± 0.8	37.7 ± 35.3	0.581**
Leisure Time Score versus Household MET hr/week	2.8 ± 0.6	36.1± 22.8	0.130
Total Activity	8.3± 1.4	160.3 ± 65.8	0.662**

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

Abbreviations: SD (standard deviation), MET (Metabolic Equivalents), PYTPAQ (Past Year Total Physical Activity Questionnaire), hr (hour)

iv. Tertile Classification

The ability of the Baecke physical activity questionnaire and PYTPAQ to categorize non-pregnant women into the same tertile of activity level was examined in Table 4.18. The proportion of participants classified into the same tertile by both tools ranged from 38-74% while the proportion of participants misclassified by ± 2 tertiles ranged from 2-19%. The kappa statistic was also calculated for each of the physical activity variables and ranged from 0.071 to 0.607.

Table 4.18: Proportion of Non-Pregnant Participants Categorized into the Same Tertile or Grossly Misclassified into ± 2 Tertiles of Physical Activity using the Baecke Physical Activity Questionnaire and PYTPAQ (n=42)

Physical Activity	Proportion categorized into the same tertile (%)	Proportion of misclassification ± 2 tertiles (%)	Kappa Statistic
Work Score versus Occupational MET hr/week	45	7	0.179
Sport Score versus Exercise MET hr/week	74	2	0.607**
Leisure Time Score versus Household MET hr/week	38	19	0.071
Total Activity	55	2	0.321**

*Kappa statistic is significant at the 0.05 level; **Kappa statistic is significant at the 0.01 level

Abbreviations: MET (Metabolic Equivalents), PYTPAQ (Past Year Total Physical Activity Questionnaire), hr (hour)

5. FFQ Feedback

a. Acceptability of the FFQ

Nearly all participants in the pregnant group (97%) and non-pregnant group (99%) indicated that the FFQ was acceptable (Table 4.19). Acceptability was assessed by a simple Yes or No question.

b. Time to Complete the FFQ

Self-reported time taken to complete the FFQ is presented in Table 4.20 and number of sittings required for participants to complete the FFQ is presented in Table 4.21.

There was no significant difference between the pregnant and non-pregnant groups in the reported time to complete the FFQ when mean time to complete was compared using independent t-test. There was also no significant difference in the number of sittings in which the FFQ was completed between groups when compared using a Chi square analysis.

Table 4.19: Acceptability of the FFQ to Pregnant and Non-Pregnant Participants

Acceptable	Pregnant (%) (n=91)[a]	Non-Pregnant (%) (n=101)[a]
Yes	97	99
No	1	0

[a]Percentage may not add up to 100% as some participants did not complete the question. (Pregnant n=2, Non-pregnant n=1)
Abbreviations: FFQ (food frequency questionnaire)

Table 4.20: Self-reported time to complete FFQ by Pregnant and Non-Pregnant Participants

	Pregnant (n=91) (Mean ± SD)	Non-Pregnant (n=101) (Mean ± SD)	p value
Time to complete (min)	77 ± 34	80 ± 35	0.522

*Independent samples t-test significant at $p<0.05$ level; **Independent samples t-test significant at $p<0.01$ level.
Abbreviations: FFQ (food frequency questionnaire), SD (standard devation), min (minutes)

Table 4.21: Number of sittings to complete FFQ by Pregnant and Non-Pregnant Participants

	Pregnant (n=89)	Non-Pregnant (n=100)	p value[a]
Number of sittings			0.816
1	30%	37%	
2	36%	33%	
3	24%	21%	
4 or more[b]	10%	9%	

[a]p value indicated Chi square analysis
[b]A maximum of 8 sittings were reported
Abbreviations: FFQ (food frequency questionnaire)

Chapter 5: Discussion

1. Research Questions and Findings

Assessment of the relative validity of dietary intake and physical activity is difficult. Many studies have examined the relationship between a FFQ and alternative method of diet assessment (Molag, et al., 2007). However, differences in the FFQ used, sample size, time period covered by FFQ, reference method, and demographic characteristics make it difficult to compare across studies. The novel aspect of this study is the comparison between pregnant and non-pregnant women to determine if there were differences in the way pregnant women recalled their food intake and physical activity in the year prior to pregnancy versus non-pregnant women for the past year. It appeared that there were differences between groups in terms of physical activity but not dietary intake. However, it is not known whether these differences were due to actual differences in food intake and physical activity between groups or differences in the way women answered the questionnaires between groups.

a. Nutrient Intake

Two comparisons (*between groups* and *between tools*) were used in this study to determine the ability of a FFQ to measure food intake prior to pregnancy.

i. Nutrient Intake Comparison Between Pregnant and Non-Pregnant Women

Pregnant and non-pregnant women completed the FFQ to determine its ability to measure food intake for the year prior to pregnancy versus the past year of non-pregnant intake in order to answer the first research question:

Does the FFQ provide a similar estimate of nutrient intake of women in the 12 months prior to pregnancy compared to nutrient intake of non-pregnant women for the past 12 months using the same tool?

In order to answer this question energy, macronutrient and micronutrient intakes measured by the FFQ were compared between groups. Saturated fat, trans fat, and calcium intakes were significantly higher, and alcohol intake was significantly lower in the pregnant group recalling the year prior to pregnancy compared to the non-pregnant group recalling the past year. The differences in intake may have been due to a number of possibilities, a few examples are: 1) some women may have made dietary changes in the year prior to becoming pregnant if they were planning their pregnancy, 2) there may have been real differences between groups in usual intake irrespective of whether the pregnancy was planned or not, and finally 3) there may have been increased reporting bias among the pregnant women such that they perceived that their diet was healthier in the year prior to pregnancy than it actually was. For example, a woman planning a pregnancy may decrease or eliminate intake of alcoholic beverages and increase consumption of other beverages, such as milk. The mean difference in calcium intake between groups was 158mg which is approximately the amount of

calcium in half a cup of milk (Health Canada, 2007). Saturated and trans fats may be present in milk although in varying amounts depending on the type of milk. Thus even if some of the pregnant women changed their beverage consumption as a result of planning pregnancy, intake of these nutrients would be higher in this group. However, data on whether the pregnancy was planned was not collected so a definitive statement on this issue cannot be made.

Although this is a novel comparison, one study in Portugal also asked pregnant women to recall their dietary intake for the year prior to pregnancy using a FFQ (Pinto, et al., 2008). The FFQ was validated for pregnancy but not the pre-pregnancy time period (Pinto, et al., 2008). Dietary intakes reported in this study were very similar to those reported by pregnant women in the present study. Mean intake of macronutrients (% of energy) as well as key micronutrients from the pregnant women in the present study were close to median intakes from the Portuguese study and within the interquartile range for all except energy, vitamin D and vitamin B_{12} (Pinto, et al., 2008). Energy intake in women in the present study (mean: 1927kcal) was lower than the Portugese women (median: 2393) and below the interquartile range (1973-2796kcal) (Pinto, et al., 2008). Vitamin D intake in women in the present study was higher (mean: 5.8 µg) and vitamin B_{12} (mean: 5.1 µg) intake was lower compared to the Portuguese women (median vitamin D: 3.9 µg and vitamin B_{12}: 9.1 µg). However, in both instances mean intakes from Alberta women exceeded the EAR. Vitamin D intake from dietary sources is not a concern for Portuguese women due to higher amounts of UV sun

exposure throughout the year (Pinto, et al., 2008). Although mean folate for women in the present study (369µg) fell within the interquartile range of folate intakes (239.4-380.1 µg) of the Portugese women, their median intake was only 293.5 µg (Pinto, et al., 2008). This difference in intake is likely due to folic acid fortification that is present in Canada but not in Portugal (Pinto, et al., 2008; De Wals, et al., 2007).

In the adaptation of the DHQ for Canadian use, Csizmadi, et al. also reported mean energy and nutrient intake of women aged 35-60 years (2007). Reported intakes of energy, all macronutrients, folate, vitamin B_{12}, calcium, vitamin D and iron reported were all slightly lower than intakes in pregnant and non-pregnant women in the present study (Csizmadi, et al., 2007). This systematic difference is likely due to the difference in age of study participants. Women from the study by Csizmadi, et al., were 35-60 years (2007) compared to present study where women were 18-45 years of age. It is recognized that dietary intake tends to decrease with age (Wakimoto & Block, 2001).

In addition two studies from the Netherlands used FFQ's to assess preconception dietary intake, one that examined maternal nutrient intake in relation to risk of orofacial cleft in infants using a FFQ with a time frame of 1 month prior to conception until 2 months after conception (Krapels, et al., 2004) and another that examined food intake for the past month using a FFQ in women planning pregnancy and in controls (non-pregnant, women) (de Weerd, et al., 2003). Nutrient intakes from the women in the present study were similar to those

found in both studies with two exceptions. Women in the study examining risk of infant orofacial cleft consumed a mean of 81g of fat /day (case) and 88g fat/day (control) (Krapels, et al., 2004) whereas women in the present study consumed approximately 68g (pregnant) and 66g (non-pregnant) of fat per day. However, fat intake in the present study was still within the 5^{th} and 95^{th} percentile presented by Krapels, et al. (2004). Secondly, energy in the study by de Weerd, et al., was also higher than observed in women in the present study by approximately 400 kcal per day (2003). However, different FFQ's were used in these studies and while FFQ's are typically believed to overestimate nutrient intake it may be that some overestimate intake more than others or even underestimate intake (de Weerd, et al., 2003; Krapels, et al., 2004; Subar, et al., 2003).

Overall, the FFQ provided a similar estimate of energy, macronutrient intake and key micronutrients: folate, vitamin B_6, vitamin B_{12}, vitamin D and iron of women in the 12 months prior to pregnancy compared to nutrient intake of non-pregnant women for the previous 12 months. However, the measurement of some of the components of fat (saturated and trans fat) as well as calcium were not comparable between groups.

ii. Nutrient Intake Comparison Between Tools in Non-Pregnant Women (FFQ versus 24 Hour Recall)

The second comparison examined nutrient intake measured by FFQ with a reference method, 24 hour recall. This allowed for the second research question to be examined:

Does the FFQ provide a similar estimate of nutrient intake of non-pregnant women for the past 12 months in comparison to a 24 hour recall?

At the group level, the tools had similar estimates of energy and macronutrient intake. However, the different components of fat intake or micronutrient intake were not comparable between tools. It is relatively common for a FFQ to provide a validated estimate of macronutrient intake but not micronutrient intake (Serra-Majem, Andersen, et al., 2009) and this FFQ appears to perform similarly. Intake of monounsaturated fat, polyunsaturated fat, ALA, trans fat, folate, vitamin B_6, vitamin B_{12}, vitamin D and iron were consistently higher when measured by FFQ compared to the 24 hour recall. The overestimation observed for this FFQ is in agreement with a strong body of literature on overestimation of intake with assessment by FFQ and underestimation of intake by 24 hour recall (Erkkola, et al., 2001; George, et al., 2004; Mouratidou, et al., 2006; Ortiz-Andrelluchi, Doreste-Alonso, Henriquez-Sanchez, Cetin, & Serra-Majem, 2009; Overby, Serra-Majem, & Andersen, 2009).

However, the Observing Protein and Energy Nutrition (OPEN) Study, compared the original American version of this FFQ with 24 hour recall as well as biomarkers of energy (doubly labeled water) and protein (urinary nitrogen) (Subar, et al., 2003). The FFQ as well as the 24 hour recall were found to underestimate intake of energy and protein compared with their respective biomarkers (Subar, et al., 2003). On the FFQ, women were found to

underestimate energy by 34-38% and protein by 27-32% (Subar, et al., 2003). On the 24 hour recall, women were found to underestimate energy by 16-20% and protein by 11-15% (Subar, et al., 2003). This was one of the first times a FFQ was compared against objective measures of dietary intake instead of a subjective measure of dietary intake (i.e. 24 hour recall or dietary record) with a large number of participants (n=484) (Subar, et al., 2003). It brought into question the commonly accepted idea of FFQs over-reporting dietary intake. There are a couple of reasons for this. First, FFQs previous to this were being compared against other tools which are also known to underreport intake. Therefore it is possible for the FFQ to appear to over-report intakes in comparison with the reference tool while in reality both tools were reporting intakes below the actual intake level. Secondly, in the OPEN study, energy was underreported more than protein (Subar, et al., 2003). This indicates that some foods may be underreported than others, i.e. energy-dense, high fat foods may be selectively underreported while nutrient-dense, low energy foods may be reported accurately or even over-reported. This may help explain why some of the micronutrients appeared to be overreported in the current study.

Correlations were calculated to determine the strength of the relationship between tools in measuring nutrient intake. In terms of validation studies assessing nutrient intake with FFQ's, a correlation <0.3 is considered poor, 0.3-0.49 is considered fair, and >0.5 is considered good (Brantsaeter, et al., 2008). Fair correlations were found for carbohydrate, fibre, polyunsaturated fat, alcohol,

vitamin B_6, vitamin B_{12}, calcium, and vitamin D. Correlations for energy and all other nutrients were poor.

It is difficult to compare between studies because of the differences in types of FFQ, time period covered by FFQ, and population group. However, three other studies were found that compared an FFQ with 24 hour recalls that examined most of the nutrients of interest in the present study. One validation study of a FFQ for use in pregnancy found mostly poor correlations ($r < 0.3$) between FFQ-estimated nutrient intake over the past 4 weeks and the mean of two 24 hour recalls (Mouratidou, et al., 2005). Only fibre and iron were found to have fair correlations ($r = 0.3$-0.49) (Mouratidou, et al., 2005). A study in Canadian women by Boucher, et al. (2006) found correlations between FFQ and the mean of two 24 hour recalls that were higher than those found in the present study for all macro and micronutrients except polyunsaturated fat and alcohol. Correlations in this study ranged from 0.24-0.63 (Boucher, et al., 2006). A study by Wei, et al. (1999) in pregnant women also found for all nutrients of interest that correlations between FFQ and the mean of one, two, or three 24 hour recalls were higher than correlations found in the present study (range of 0.3-0.61). The reasons for the higher correlations found in this study likely were due to the fact that the reference method, 24 hour recall, was repeated twice for the most part. Also, Boucher, et al. (2006) utilized the Block FFQ while Wei, et al. (1999) used the Harvard Service FFQ adapted for use in low income pregnant women which only

inquires about food intake for the past 4 weeks. Different FFQ's are likely to have different levels of validity.

Validation studies often report correlations (Cade, et al., 2001), however, the issue with this type of analysis is that biased relationships may still be strongly correlated (Bland & Altman, 1986). For example, a FFQ may be found to overestimate calcium intake compared to a 24 hour recall. However, if the overestimation is consistent across participants, the relationship would be strong (as measured by correlation) but agreement between tools would be weak.

In order to measure agreement between tools, Bland-Altman plots were utilized. Bias appeared relatively low as the mean differences in nutrient intake were close to zero and were not consistently positive or negative. Variability increased as intake increased for alcohol, vitamin B_{12}, calcium, and vitamin D. For alcohol, variability increased once intake was greater than approximately one alcoholic drink/day (approximately 14g of alcohol per 341mL bottle of beer or 150mL glass of wine) (Health Canada, 2007b). For vitamin B_{12}, calcium, and vitamin D, variability was increased at intake levels beyond the EAR (IOM, 2010; IOM 1998).

The limits of agreement for all nutrients assessed by these plots were very wide. For example, from this analysis it would be expected for one tool to vary by 389g of carbohydrate compared to another tool. This would be the dietary equivalent of approximately 26 slices of bread (approximately 15g of carbohydrate per slice) (Health Canada, 2007b). As a result there was found to be

an unacceptable level of agreement between tools for all nutrients assessed. In their study of pregnant women, Mouratidou, et al. (2006) utilized Bland-Altman plots and also found increased variability in agreement between diet assessment tools as nutrient intake increased as well as wide limits of agreement. The similarity in assessment of agreement between the present study and that of Mouratidou, et al. (2006) appears to be due to the problem of comparing two different diet assessment tools that were designed for two different purposes. While one tool provides a more general a measure of usual intake over time the other provides a specific description of foods eaten within a 24 hour time period. It is expected that the two would not agree well, and this is demonstrated in the present study as well as that of Mouratidou, et al. (2006).

Another way to assess comparability between tools is to determine the similarity between tools in ranking individuals into tertiles of low, medium, and high intake. As mentioned above, a FFQ assesses usual dietary intake in a broad way. It is not expected that an FFQ would deliver precise determinations of energy and nutrient intake however, it should be able to rank an individual's intake into a category of low, medium or high intake (Cade, et al., 2001; Masson, et al., 2003; Molag, et al., 2007; Willet, 1990). Therefore, the ability of a tool to classify intake into tertiles has also been used widely in the validation literature. Masson, et al. (2003), state that for a tool to be shown to reliably rank nutrient intake compared to another, greater than 50% of participants should be correctly classified in the same tertile and less than 10% of participants misclassified by ± 2

tertiles. In addition, a kappa statistic of greater than 0.4 is desirable (Masson, et al., 2003). Vitamin B_6 was the only nutrient where more than 50% of participants were classified into the same tertile in the present study. Energy as well as all nutrients had more than 10% of participants misclassified by ± 2 tertiles. The kappa statistic did not reach 0.4 for energy or any of the nutrients. It was determined that good agreement between tools was not present in terms of ranking nutrient intake.

In comparison, Mouratidou, et al., ranked people into quintiles of nutrient intake and observed more than 50% of participants classified in the same quintile except alcohol (48% classified in same quintile) in terms of macronutrients and key micronutrients (that were examined the present study) (2006). The correct classification may be high in this case because the FFQ inquired about food intake over the past 4 weeks as opposed to the past year. In addition George, et al. used a FFQ in two groups of women (college students and low-income women) to measure intake over the past 6 months (2004). A combination of food records and 24 hour recalls were used as reference methods (George, et al., 2004). Intake measured by FFQ and reference methods ranked into quartiles performed similarly to the present study. In the group of college women no nutrients had more than 50% of participants ranked in the same quartile while protein and iron had more than 10% of participants grossly misclassified (George, et al., 2004). Similar results were found in the low-income group, with alcohol being the only nutrient of interest with more than 50% of participants classified in the same

quartile; however all nutrients had less than 10% of participants grossly misclassified (George, et al., 2004).

It is well known that nutrient intake can vary widely day-to-day. Thus, a single 24 hour recall is not an appropriate measure of usual dietary intake as it will be affected not only by inter-individual variation but also intra-individual variation (Barr, 2006). In the sub-group that completed two 24 hour recalls, there were no significant differences between mean intakes of energy, macro or micronutrients between the first and second 24 hour recalls. In addition there were fair correlations (> 0.3) between recall 1 and 2 for fibre, fat , saturated fat, monounsaturated fat , alcohol , and vitamin B_6 as well as good correlations (>0.5) for energy, carbohydrate, and polyunsaturated fat intake. It appears as though dietary intake was very similar between the first and second 24 hour recall. However, because adjustment with the PC-SIDE program was not an option, nutrient intake determined from 24 hour recall does not represent usual dietary intake in this group.

Overall, there were few significant differences in terms of mean dietary intake between groups. However, correlation analysis illustrated a poor to moderate relationship between tools, assessment of Bland-Altman plots showed relatively poor agreement between tools, and ability of tools to similarly classify intake into tertiles was also poor. Therefore in response to the second research question, based on the restrictions of the sample and the tools available, the FFQ

does not provide a similar estimate of nutrient intake in comparison to 24 hour recall.

b. Physical Activity

Two comparisons (*between groups* and *between tools*) were used in this study to determine the efficacy of the Baecke physical activity questionnaire to measure physical activity for the year prior to pregnancy.

i. Physical Activity Comparison Between Groups (Pregnant versus Non-Pregnant)

First, pregnant and non-pregnant women completed the Baecke physical activity questionnaire in order to answer the third research question:

> **Does the Baecke physical activity questionnaire provide a similar estimate of physical activity in the 12 months prior to pregnancy compared to physical activity of non-pregnant women for the past 12 months using the same tool?**

The non-pregnant group had significantly higher mean activity levels for the sport score, leisure time score, and the total activity score. Two potential reasons for the significant differences are: 1) there were real differences in usual activity level between groups or 2) there may have been increased reporting bias among the pregnant women such that they perceived a higher level of activity in the year prior to pregnancy than there actually was. It is possible that real differences in usual activity level existed between the pregnant and the non-pregnant groups as

self-reported pre-pregnancy body weight was significantly higher than self-reported current weight in non-pregnant women. This in turn lead to a significantly higher pre-pregnancy BMI in the pregnant group.

Another study of Canadian pregnant women used the Baecke physical activity questionnaire to assess activity in the year prior to pregnancy (Retnakaran, et al., 2009). The physical activity scores were divided into quartiles and were comparable to the activity scores found in pregnant women in the present study as seen in Table 5.1 (Retnakaran, et al., 2009). Mean scores from non-pregnant women in the present study also fit within these quartiles except for the Sport score, which was higher among non-pregnant women. This demonstrates that the non-pregnant sample in the present study may have been more physically active than the general population, thus explaining the differences between groups. It is not likely that pregnant women changed their activity level in preparation for pregnancy as activity levels were lower in this group compared to the non-pregnant group. If women were making a change prior to conception it would be expected that activity would increase in an effort to improve health (Donahue, et al., 2010).

In comparison to the non-pregnant group, three studies have reported Baecke physical activity questionnaire values for non-pregnant women. Although the three studies reported scores similar to the non-pregnant group in the present study for work activity, the other two activity variables as well as the total activity score were lower in each study (Ono, et al., 2007; Pols, et al., 1995; Tehard, et al.,

2005). However, Tehard, et al. (2005) examined obese women while Ono, et al. (2007) studied women with hip disorders; both are likely to be relatively sedentary populations. Pols, et al. (1995) studied healthy active women aged 20-70 years. The mean age was 48.8 years, approximately 20 years older than the mean age of the present non-pregnant group, which may have accounted for the difference in activity level (Pols, et al., 2005). Activity scores in these three studies were similar to those in the pregnant group. It is possible that the non-pregnant group was highly active, more so than the general population.

Overall, a definitive statement cannot be made on the reason for the difference between groups. However, the pregnant group reported similar levels of physical activity prior to pregnancy as other Canadian pregnant women. In addition, significant differences in BMI between groups suggest that the groups may have had real differences in activity and the Baecke physical activity questionnaire accurately assessed these differences. Thus in response to the third research question, based on the participants recruited for this study, the Baecke physical activity questionnaire does not provide a similar estimate of activity for the year prior to pregnancy as opposed to the past year in non-pregnant women.

Table 5.1: Comparison of the Baecke Physical Activity Questionnaire Scores from the Present Study (Pregnant Women) to Those Reported by Retnakaran, et al.

	Pregnant women in Present Study (Mean ± SD)	First Quartile (Retnakaran, et al., 2009). (Mean ± SD)	Fourth Quartile (Retnakaran, et al., 2009). (Mean ± SD)
Work Score	2.6 ± 0.80	2.0 ± 0.4	2.9 ± 0.6
Sport Score	2.6 ± 0.87	1.6± 0.4	3.0 ± 0.7
Leisure Time Score	2.7 ± 0.59	2.5 ± 0.4	3.5 ± 0.5
Total Score	7.8 ± 1.65	6.2 ± 0.6	9.4 ± 0.7

Abbreviations: SD (standard deviation)

ii. Physical Activity Comparison Between Tools in Non-Pregnant Women (Baecke physical activity questionnaire versus PYTPAQ)

The second comparison of physical activity assessment between tools allowed for the fourth research question to be examined:

> **Does the Baecke physical activity questionnaire provide a similar estimate of physical activity of non-pregnant women for the past 12 months in comparison to the Past Year Total Physical Activity Questionnaire?**.

Correlations were greater than 0.5 for the comparisons of work/occupation activity, sport/recreational activity, and total activity. This indicates that there was a strong relationship between activities assessed between tools. The poor correlation between tools that was found for leisure time/household activity may be due to more subjectivity in this category than the others and potentially more variability over time. Pols, et al. (1995) found that the leisure time activity score had the lowest level of repeatability compared to the other scores.

The correlations in this study were greater than those found by Pols, et al. (1995) in validation of the Baecke physical activity questionnaire against four 3-day activity diaries where correlation of total activity ranged from 0.42-0.44. In the present study both assessments of physical activity were by questionnaire. Therefore, it is possible that if participants provided a biased answer on the first questionnaire they would also do so on the second. There was a strong relationship found between the Baecke physical activity questionnaire and the

PYTPAQ. However, as it was not possible to create Bland-Altman plots for these variables thus the agreement between tools is unknown. Future studies should include an alternate type of physical activity assessment (such as an activity diary) or an objective assessment tool like a pedometer or accelerometer in order to better assess relative validity.

As the PYTPAQ is relatively new, only a few studies that have utilized it and none have involved pregnant women. However, non-pregnant participants in the present study had higher reported levels of activity with this questionnaire than were found in the validation of the PYTPAQ (participants age 35-64 years) (Friedenriech, et al., 2006) and one study of postmenopausal, sedentary women (age 50-74 years) in Alberta Canada (Friedenriech, et al., 2010). The non-pregnant participants were younger than participants in these reference studies which may have been why activity was higher in this group. Nevertheless, this adds to the evidence that non-pregnant participants in the present study were a highly active group.

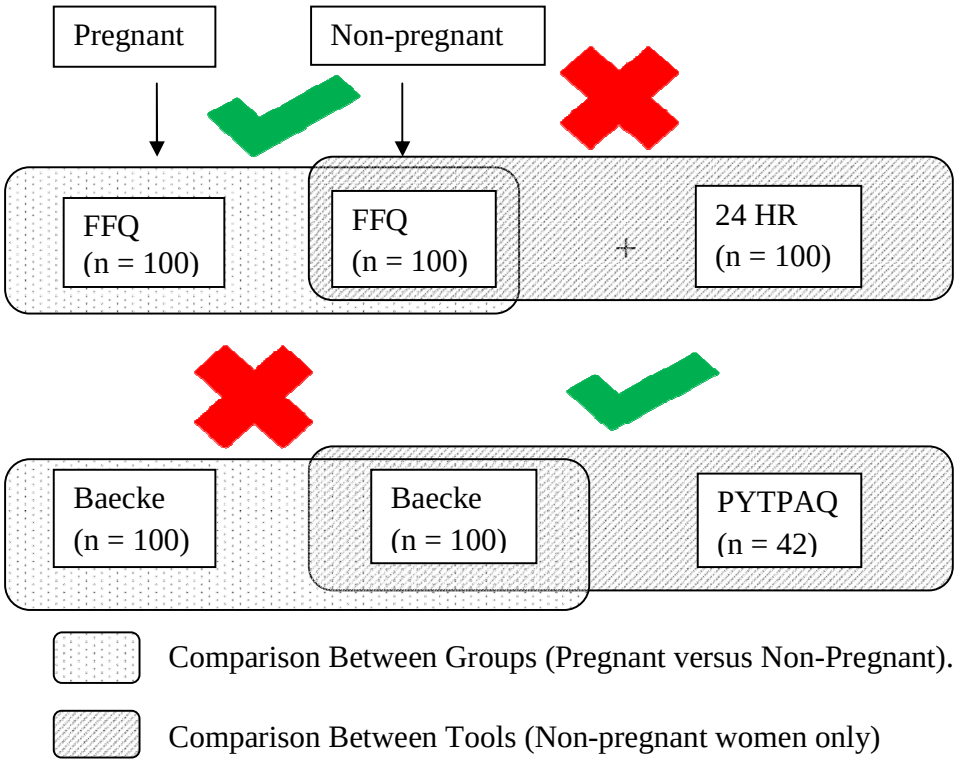
The ability of these two questionnaires to rank individual's physical activity levels into tertiles was also assessed. The Baecke physical activity questionnaire and the PYTPAQ were comparable in terms of classification of participant activity levels into tertiles. Sport/recreation activity and total activity had more than 50% of participants categorized into the same tertile and less than 10% misclassified by ± 2 categories which is desired (Masson, et al., 2003). Work/occupation activity was found to have close to desired level of correct

classification at 45% and was below the recommended 10% misclassification by ±2 tertiles. Leisure time/household activity did not respond as well as the other physical activity variables. Although the leisure time/household activity variable appears to be slightly less comparable than the other variables, the overall total activity score performed very well which is an important result for the fourth research question. In validation of the Baecke physical activity questionnaire against four 3-day activity diaries percent agreement was 40-44% while gross misclassification was 11% (Pols, et al., 1995). It is possible that the higher percent agreement seen in the present study is a result of correlated errors with the questionnaires. A more objective measure of physical activity in comparison to the Baecke appears to have lower agreement.

Overall, in response to the fourth research question it appeared that the Baecke physical activity questionnaire and the PYTPAQ provide similar estimates of physical activity in non-pregnant women over the past year.

A summary of the findings to the four primary research questions is presented in Figure 5.1.

Figure 5.1: Summary of Findings



Abbreviations: FFQ (Food Frequency Questionnaire), 24 HR (24 hour recall), Baecke (Baecke Physical Activity Questionnaire), PYTPAQ (Past Year Total Physical Activity Questionnaire)

c. Secondary Research Questions

In addition to the four key research questions, two secondary research questions were asked in this study. They were:

i. Was the FFQ acceptable to participants?

ii. How much time was required for participants to complete the FFQ?

In total, 97% of pregnant participants and 99% of non-pregnant participants responded "yes" that the FFQ was acceptable when asked a yes/no question. Thus it was determined that the FFQ was acceptable to participants. In terms of time required to complete the FFQ, it took pregnant participants approximately 77 minutes to complete the FFQ and non-pregnant participants approximately 80 minutes to complete the FFQ and these times were not significantly different. In addition, participants most commonly used 1, 2 or 3 sittings to complete the FFQ and number of sittings also was not significantly different between groups. This may indicate that one group did not struggle with answering the questionnaires more than the other. If one group found the questionnaire more difficult, longer times and more sittings would be likely.

2. Strengths and Limitations

One strength of this study was that recruitment was conducted over the period of about 18 months. At the group level, this would have dampened the seasonal effect on 24 hour recall versus the FFQ which covers the year.

Anecdotally, it was noted that 24 hour recalls were affected by season. Seasonal vegetables and fruit and foods associated with holidays are two examples of differences in foods reported in 24 hour recalls throughout the year. Although we did not control statistically for day of the week that the 24 hour recall took place, the distribution was fairly representative of a typical work week. Friday was the most common day with 25 recalls (25%) occurring on that day. This occurred because recruitment was most successful on Saturdays at community locations.

In terms of the FFQ, every effort was made to update the food list to include new fortified foods that have been added to the food supply as well as a variety of ethnic foods. However, one of the weaknesses of FFQs in general is that they continually need updating to reflect changes in the food supply as well as changes in demographics of the population of interest.

Another strength of this study was that the PYTPAQ was specifically designed for people living in Alberta and allows for measurement of changes in activity across seasons. Additionally, it was validated for activity recall for the past 12 months which was the time frame of interest for the Baecke physical activity questionnaire.

Additionally, all data entry was completed in a systematic and thorough way. All entries were either double entered (FFQ and Baecke physical activity questionnaire) or double checked (24 hour recall and PYTPAQ) by a second researcher depending on the type of data. This allowed for great confidence in the data presented.

Finally, in assessing the comparability between tools, more than one statistical analysis was applied. As more assessments were completed, a clearer picture of the comparability of tools resulted. Whereas, simply relying on one statistical analysis may have led to a misleading conclusion. As a result, there is high confidence that the proposed research questions were thoroughly considered.

There are also some limitations to this study. The first is that neither of the diet assessment tools is considered a gold standard. There are known limitations to each tool, and their purposes in assessing dietary intake are quite different. Therefore comparing one against the other is inherently problematic. A FFQ was chosen for the APrON study because it was the best tool to assess the research question of nutrient intake prior to pregnancy. One of the limitations of the APrON study is that women are recruited only after pregnancy is confirmed. This only allows for retrospective assessment of dietary intake for the year prior to pregnancy and the FFQ is the only commonly used diet assessment tool that assesses usual intake retrospectively. Typically, FFQs are used at the epidemiological level with thousands of participants. This study included only 100 participants in each group. It is likely that some of the disagreement between tools was a result of the small sample size. However, 100 participants is a recommended number for validations studies (Willet, 1990). The 24 hour recall was chosen as the reference method in order to lower participant burden and because it was the other diet assessment method being employed in the APrON study therefore it was a way of keeping methodology consistent. In the space of

more time and more resources, repeated 24 hour recalls may have improved the comparability between tools as the more 24 hour recalls that are completed, the closer the estimate of nutrient intake gets to usual intake (Cade, et al., 2001). Additionally, with a larger sample of repeated 24 hour recalls it would have been possible to assess intra-individual variation in nutrient intake in order to estimate usual intake.

Similarly, neither of the physical activity assessment measures is recognized as a gold standard. Each of these tools was developed separately to assess physical activity in different ways. As such, comparing these tools in the assessment of relative validity has its limitations. It is interesting that they appear to measure physical activity in the past year similarly in non-pregnant women. However, this similarity does not necessarily mean that they are interchangeable.

In addition, there were significant differences in the demographic characteristics of the two groups. This may have augmented the differences observed when comparing the same tool between groups. For example, the significantly lower weight status of non-pregnant women compared to pregnant women may indicate differences in food intake and physical activity patterns between groups. There were also significant differences in marital status, parity, employment status, household income and BMI classification. The difference found in marital status was not surprising as it is likely that pregnant women would be in a married or common-law relationship while many of the non-pregnant participants were single. This may also have contributed to the

differences in parity seen between groups. One reason for the differences in employment status and household income was that many of the non-pregnant women were students recruited from the University of Alberta community. Also, more pregnant women had a partner who was likely also contributing to household income. If a diet assessment or physical activity assessment tool is consistent and valid, when it is applied to two different groups it should measure the actual difference between groups.

These differences in demographics were likely a result of recruitment strategies and the apparent ease with which pregnant women participated and the difficulty in recruiting non-pregnant participants. It is likely that motivation to participate also differed between groups. Pregnant women may have been motivated by their pregnancy, a desire to make healthy choices for their growing child and to contribute to knowledge of healthy fetal development. Non-pregnant women would not have the same motivating factors. As a result it is possible that the non-pregnant participants reflected more of the typical characteristics of self-selected research participants and were more physically active, and regularly ate what they considered to be nutritious foods than the general population.

Finally, supplement intake was not measured using the 24 hour recall methodology. As a result, nutrient intake was assessed only from food, not food and supplements.

3. Conclusion

Over the course of this study, we have confirmed the difference between the two diet assessment tools more than we have assessed their comparability. The FFQ provides a general look at usual dietary intake from a finite list of foods which is then calculated to one day's intake. The 24 hour recall is a rigorous look at specific foods consumed on one specific day. It is expected that there would be differences between tools, and these differences have been confirmed.

There are times when FFQs are the appropriate choice for diet assessment. For example, a FFQ may more accurately measure nutrients with sporadic intake as opposed to daily intake. In this case a 24 hour recall may miss intake of these nutrients. For example, long-chain omega-3 fatty acid intake may be best measured by FFQ as foods containing high levels of long-chain omega-3 fatty acids (i.e. fatty fish) are typically not eaten on a daily basis (Innis & Elias, 2003).

This is the first time to the researcher's knowledge, that the relative validity of pre-pregnancy dietary assessment has been completed. That comparison showed similar dietary intake between pre-pregnancy and non-pregnancy. In future research, it would be helpful to know whether the pregnancy was planned or not as there may have been differences in dietary intake between those women who were planning their pregnancy and those who were not.

With the data collected in the current study, it is not possible to state that the FFQ is relatively valid. However, there is also insufficient evidence to state the the FFQ is invalid. At the group mean level, estimates of micronutrients were

significantly different. Therefore, with the data collected, considering the limitations of the tools and the populations recruited, the FFQ can only be recommended for assessment of group mean macronutrient intake at this time. At the individual level, estimates of macro and micronutrient intake were not acceptable. Future research should include multiple days of dietary intake using the reference tool for comparison against the FFQ in order to generate stronger conclusions regarding the relative validity of the FFQ.

The FFQ is currently being used in the Alberta Pregnancy Outcomes and Nutrition (APrON) cohort study and has been completed by approximately 1600 pregnant women up to this point. Although the relationship between the FFQ and 24 hour recall was not strong in this assessment of relative validity it still has a role in the larger study. The sample size in the APrON study will be very large and it is expected that some of the variability in intake measured by the FFQ will normalize due to sample size. However, it is essential that data from this questionnaire be interpreted and utilized with caution especially in terms of group micronutrient intake and individual intake of macronutrients as well as micronutrients.

Alternatively, we have confirmed similarities between physical activity assessment tools. At the individual level the Baecke physical activity questionnaire appears to estimate activity similarly to the PYTPAQ. We are unsure whether the differences between groups were due to real differences in activity level or differences in perception of the questions based on state of

pregnancy or non-pregnancy. However, we have confidence in the data due to the fact that pregnant women in our study reported activity levels similarly to another Canadian study looking at pre-pregnancy activity using the same tool. In future research it would be helpful to match the pregnant and non-pregnant women for demographic variables including age and BMI in order to avoid problems in interpretation of data when groups are different.

It is likely that using the Baecke physical activity questionnaire to retrospectively assess physical activity in the year prior to pregnancy is a worthwhile tool which may provide interesting data to continue to inform that base of knowledge surrounding the importance of pre-pregnancy physical activity. The Baecke physical activity questionnaire is also currently being used in the APrON cohort study and has been completed by approximately 1600 pregnant women up to this point. However, as with results of the FFQ, data on pre-pregnancy activity assessed by the Baecke physical activity questionnaire should be interpreted carefully and used with caution.

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Appendices

Appendix A: Ethics Approval

September 30, 2008

Dr. Rhonda Bell

Alberta Institute Human Nutrition File# B-140908

4126 HRIF – East

Re: Validation of a Food Frequency Physical Activity Questionnaire

Dear Dr. Bell:

Thank you for your email correspondence dated September 17th, 2008, which addressed the requested revisions to the above-mentioned study. These changes have been reviewed and approved on behalf of the Research Ethics Board. Your approval letter is enclosed.

In order to comply with the Health Information Act, a copy of the approval form is being sent to the Office of the Information and Privacy Commissioner.

Next year, a few weeks prior to the expiration of your approval, a Progress Report will be sent to you for completion. If there have been no major changes in the protocol, your approval will be renewed for another year. All protocols may be subject to re-evaluation after three years.
For studies where investigators must obtain informed consent, signed copies of the consent form must be retained, and be available on request. They should be kept for the duration of the project and for a minimum of seven years following its completion.

Approval by the Health Research Ethics Board does not encompass authorization to access the patients, staff or resources of Capital Health or other local health care institutions for the purposes of research. Enquiries regarding Capital Health administrative approval, and operational approval for areas impacted by research, should be directed to the Capital Health Regional Research Administration office, #1800 College Plaza, phone 407-6041.

Sincerely,

Charmaine N. Kabatoff

Senior Administrator

Health Research Ethics Board (Panel B)

Appendix B: Information Letter for Participants

1. Original Information Letter

Information Sheet

Title of Project

Validation of a Food Frequency and Physical Activity Questionnaire
(Part of the *Alberta Pregnancy Outcomes and Nutrition* (APRON) study)

Principle Investigators

Dr. Rhonda Bell	**780-492-7742**	**rhonda.bell@ualberta.ca**
Dr. Linda McCargar	**780-492-9287**	**linda.mccargar@ualberta.ca**
Dr. Donna Manca	**780-492-8592**	**dmanca@ualberta.ca**
Dr. Catherine Field	**780-492-2597**	**catherine.field@ualberta.ca**

Purpose

This purpose of this study is to determine what you eat and drink. We also want to find out how physically active you are.

We are testing some new questionnaires that will measure what you eat and drink and how active you are. We want to use them in a larger study called: *Alberta Pregnancy Outcomes and Nutrition* (APRON) study. This larger study is about what pregnant women eat and drink, their mental health during pregnancy, and the mental and physical development of their children. The questions have been asked in studies with non-pregnant women, and comparing the responses of pregnant and non-pregnant women will help us in planning our research.

Background

What women eat and drink may affect their health and even the health of their children. We need to find questionnaires that will help us measure what women are eating and how active they are while they are pregnant.

Procedure

If you agree to participate, you will be asked to answer a Food Frequency Questionnaire (FFQ), and a questionnaire about how physically active you are. If you are not currently pregnant, you will also be asked to tell us what you ate during the last 24 hours. The FFQ will take approximately one hour to complete and the physical activity questionnaire will take about ten minutes to complete. There are also some questions about your age, ethnicity, how many children you currently have and other general information.

You will be asked questions about what you eat and drink during the year and how often you eat these foods and drinks. You will also be asked about how much of the food or drink you usually eat (or drink). We will then ask you how long you took to finish the questionnaire and whether you had any trouble understanding the questions.

The physical activity questionnaire asks about sports you do and what physical work you do in a paid job and at home.

You can take these questionnaires home to fill out and return them to us in the mail, or you can fill them out and return them to us in person at our study site.

If you are not currently pregnant one of our staff will ask you to remember everything that you ate and drank yesterday. This is called a 24 hour dietary recall. You can either do this now or we can make an appointment for you to do this either on the telephone or in person at a later date and time that is convenient for you. The 24 hour dietary recall may take up to 45 minutes.

Confidentiality

If you are part of this study you will be assigned a study number and we will use that number on all your questionnaires. Your name will not appear on any of the questionnaires. Data from this study will be summarized, meaning we are interested in studying groups versus specific individuals. We will keep a list of the study numbers and names in locked filing cabinets along with the raw data. Only the study team will have access to your name. The results from this study may be used for scientific publications and presentations.

Benefits

If you like, after the study is finished, we will send you an assessment of your diet, according to Canada's Food Guide. You will help us make sure that the questionnaires we use in the larger study are right for women living in Alberta. This may benefit child and women's health in our community, and help with health planning.

Risks

There are no known risks or inconveniences to participating in this research other than the time you need to take to complete the questionnaires.

Voluntary Participation

Whether you decide to participate in this study is entirely voluntary. If you don't want to participate your health care, nor your child's health care, will not be jeopardized in any way. You have the right to quit participating in this study at any time. Your decision to complete and return the questionnaires will be interpreted as you consent to participate.

If you want more information, or have any questions about this study, please contact any of the principal investigators on the list above. If you have any concerns about the way this study is being run or about your rights as a research participant, please call the Health Research Ethics Office at the University of Alberta, at 780-492-0302.

2. Information Letter with Addition of Past Year Total Physical Activity Questionnaire

Information Sheet

Title of Project

Validation of a Food Frequency and Physical Activity Questionnaire
(Part of the *Alberta Pregnancy Outcomes and Nutrition* (APRON) study)

Principle Investigators

Dr. Rhonda Bell	**780-492-7742**	**rhonda.bell@ualberta.ca**
Dr. Linda McCargar	**780-492-9287**	**linda.mccargar@ualberta.ca**
Dr. Donna Manca	**780-492-8592**	**dmanca@ualberta.ca**
Dr. Catherine Field	**780-492-2597**	**catherine.field@ualberta.ca**

Purpose

This purpose of this study is to determine what you eat and drink. We also want to find out how physically active you are.

We are testing some new questionnaires that will measure what you eat and drink and how active you are. We want to use them in a larger study called: *Alberta Pregnancy Outcomes and Nutrition* (APRON) study. This larger study is about what pregnant women eat and drink, their mental health during pregnancy, and the mental and physical development of their children. The questions have been asked in studies with non-pregnant women, and comparing the responses of pregnant and non-pregnant women will help us in planning our research.

Background

What women eat and drink may affect their health and even the health of their children. We need to find questionnaires that will help us measure what women are eating and how active they are while they are pregnant.

Procedure

If you agree to participate, you will be asked to answer a Food Frequency Questionnaire (FFQ), and two questionnaires about how physically active you are. If you are not currently pregnant, you will also be asked to tell us what you ate during the last 24 hours. The FFQ will take approximately one to two hours to complete and the physical activity questionnaires may take one hour to complete. There are also some questions about your age, ethnicity, how many children you currently have and other general information.

You will be asked questions about what you eat and drink during the year and how often you eat these foods and drinks. You will also be asked about how much of the food or drink you usually eat (or drink). We will then ask you how long you took to finish the questionnaire and whether you had any trouble understanding the questions.

There are two physical activity questionnaires that ask about sports you do and what physical work you do in a paid job and at home. There are two because we plan to compare the results of both questionnaires.

You can take these questionnaires home to fill out and return them to us in the mail, or you can fill them out and return them to us in person at our study site.

If you are not currently pregnant one of our staff will ask you to remember everything that you ate and drank yesterday. This is called a 24 hour dietary recall. You can either do this now or we can make an appointment for you to do this either on the telephone or in person at a later date and time that is convenient for you. The 24 hour dietary recall may take up to 45 minutes.

Confidentiality

If you are part of this study you will be assigned a study number and we will use that number on all your questionnaires. Your name will not appear on any of the questionnaires. Data from this study will be summarized, meaning we are interested in studying groups versus specific individuals. We will keep a list of the study numbers and names in locked filing cabinets along with the raw data. Only the study team will have access to your name. The results from this study may be used for scientific publications and presentations.

Benefits

If you like, after the study is finished, we will send you an assessment of your diet, according to Canada's Food Guide. You will help us make sure that the questionnaires we use in the larger study are right for women living in Alberta. This may benefit child and women's health in our community, and help with health planning.

Risks

There are no known risks or inconveniences to participating in this research other than the time you need to take to complete the questionnaires.

Voluntary Participation

Whether you decide to participate in this study is entirely voluntary. If you don't want to participate your health care, nor your child's health care, will not be jeopardized in any way. You have the right to quit participating in this study at any time. Your decision to complete and return the questionnaires will be interpreted as you consent to participate.

If you want more information, or have any questions about this study, please contact any of the principal investigators on the list above. If you have any concerns about the way this study is being run or about your rights as a research participant, please call the Health Research Ethics Office at the University of Alberta, at 780-492-0302.

3. Information Letter with Addition of Second 24 Hour Recall

Information Sheet

Title of Project

Validation of a Food Frequency and Physical Activity Questionnaire
(Part of the *Alberta Pregnancy Outcomes and Nutrition* (APRON) study)

Principle Investigators

Dr. Rhonda Bell	**780-492-7742**	**rhonda.bell@ualberta.ca**
Dr. Linda McCargar	**780-492-9287**	**linda.mccargar@ualberta.ca**
Dr. Donna Manca	**780-492-8592**	**dmanca@ualberta.ca**
Dr. Catherine Field	**780-492-2597**	**catherine.field@ualberta.ca**

Purpose

This purpose of this study is to determine what you eat and drink. We also want to find out how physically active you are.

We are testing some new questionnaires that will measure what you eat and drink and how active you are. We want to use them in a larger study called: *Alberta Pregnancy Outcomes and Nutrition* (APRON) study. This larger study is about what pregnant women eat and drink, their mental health during pregnancy, and the mental and physical development of their children. The questions have been asked in studies with non-pregnant women, and comparing the responses of pregnant and non-pregnant women will help us in planning our research.

Background

What women eat and drink may affect their health and even the health of their children. We need to find questionnaires that will help us measure what women are eating and how active they are while they are pregnant.

Procedure

If you agree to participate, you will be asked to answer a Food Frequency Questionnaire (FFQ), and two questionnaires about how physically active you are. If you are not currently pregnant, you will also be asked to tell us, on two different days, what you ate during the last 24 hours. The FFQ will take approximately one to two hours to complete and the physical activity questionnaires may take one hour to complete. There are also some questions about your age, ethnicity, how many children you currently have and other general information.

You will be asked questions about what you eat and drink during the year and how often you eat these foods and drinks. You will also be asked about how much of the food or drink you usually eat (or drink). We will then ask you how long you took to finish the questionnaire and whether you had any trouble understanding the questions.
There are two physical activity questionnaires that ask about sports you do and what physical work you do in a paid job and at home. There are two because we plan to compare the results of both questionnaires.

You can take these questionnaires home to fill out and return them to us in the mail, or you can fill them out and return them to us in person at our study site.

If you are not currently pregnant one of our staff will ask you to remember everything that you ate and drank yesterday. This is called a 24 hour dietary recall. You can either do this now or we can make an appointment for you to do this either on the telephone or in person at a later date and time that is convenient for you. The 24 hour dietary recall may take up to 45 minutes. A second 24 hour dietary recall will be completed in 2-3 weeks. Again, we can make an appointment to do this on the telephone or in person.

Confidentiality

If you are part of this study you will be assigned a study number and we will use that number on all your questionnaires. Your name will not appear on any of the questionnaires. Data from this study will be summarized, meaning we are interested in studying groups versus specific individuals. We will keep a list of the study numbers and names in locked filing cabinets along with the raw data. Only the study team will have access to your name. The results from this study may be used for scientific publications and presentations.

Benefits

If you like, after the study is finished, we will send you an assessment of your diet, according to Canada's Food Guide. You will help us make sure that the questionnaires we use in the larger study are right for women living in Alberta. This may benefit child and women's health in our community, and help with health planning.

Risks

There are no known risks or inconveniences to participating in this research other than the time you need to take to complete the questionnaires.

Voluntary Participation

Whether you decide to participate in this study is entirely voluntary. If you don't want to participate your health care, nor your child's health care, will not be jeopardized in any way. You have the right to quit participating in this study at any time. Your decision to complete and return the questionnaires will be interpreted as you consent to participate.

If you want more information, or have any questions about this study, please contact any of the principal investigators on the list above. If you have any concerns about the way this study is being run or about your rights as a research participant, please call the Health Research Ethics Office at the University of Alberta, at 780-492-0302.

Appendix C: Consent Form

UNIVERSITY OF ALBERTA
Department of Agricultural, Food and Nutritional Science
Faculty of Agricultural, Life and Environmental Sciences
410 Agriculture/Forestry Centre
Edmonton, Alberta, Canada T6G 2P5
www.afns.ualberta.ca
afns-chair@ualberta.ca
Tel: 780.492.3239
Fax: 780.492.4265

Consent Form

Part 1 (to be completed by the Principal Investigator):

Title of Project: Validation of a Food Frequency Questionnaire and Physical Activity Questionnaire
(Part of the Alberta Pregnancy Outcomes and Nutrition (APRON) Study)

Principal Investigator(s): Rhonda Bell — Phone Number(s):780-492-7742
Co-Investigator(s): — Phone Number(s):
Linda McCargar — 780-492-9287
Donna Manca — 780-492-8592
Catherine Field — 780-492-2597

Part 2 (to be completed by the research subject):

	Yes	No
Do you understand that you have been asked to be in a research study?	☐	☐
Have you read and received a copy of the attached Information Sheet?	☐	☐
Do you understand the benefits and risks involved in taking part in this research study?	☐	☐
Have you had an opportunity to ask questions and discuss this study?	☐	☐
Do you understand that you are free to withdraw from the study at any time, without having to give a reason and without affecting your future medical care?	☐	☐
Has the issue of confidentiality been explained to you?	☐	☐
Do you understand who will have access to your records?	☐	☐
Do you want the investigator(s) to inform your family doctor that you are participating in this research study? If so, give his/her name _____	☐	☐

Who explained this study to you?
_____

I agree to take part in this study: YES ☐ NO ☐

Signature of Research Subject _____

(Printed Name) _____

Date:_____ Signature of Witness _____

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

Signature of Investigator or Designee_____ Date _____

THE INFORMATION SHEET MUST BE ATTACHED TO THIS CONSENT FORM AND A COPY GIVEN TO THE RESEARCH SUBJECT

Appendix D – Adapted Version of Baecke Physical Activity Questionnaire

We would like you to recall the **12 MONTHS before you knew you were pregnant.** Please answer the following questions according to what you **usually** did during this time. Some of the questions ask about your occupation. For some people this will be your job, for others this could be attending school and studying or household activities. Consider your main daily activities to be your occupation.

1. **BEFORE you knew you were pregnant,** what was your main occupation?
   _____

2. Based on the definitions below, how would you rate your occupation in terms of physical activity.

_____1 _____3 _____5

Almost all occupations will contain all three ratings of physical activity once in a while. However, please choose the rating that fits your occupation most of the time.

1 (light)	desk work, driving, teaching, studying, housework, all other occupations with a university education
3 (moderate)	Occupations requiring moderate effort and considerable use of arms, legs or occasional total body movements including cleaning services, waiting tables or institutional dishwashing, carpentry, plumbing, electrical work, dry wall, farming, assembly line work (tasks requiring movement of the entire body, arms or legs with moderate effort), mail carriers, patient care (bathing, dressing, moving patients, physical therapy).
5 (vigorous)	Occupations requiring strenuous effort and extensive total body movement including sports, teaching an aerobics or physical activity class requiring active and strenuous participation, fire fighting, masonry, heavy construction work, manually shoveling or digging ditches, most forestry work, moving items professionally.

BEFORE I knew I was pregnant…

3. At work I sat…
_____ Never _____Seldom _____Sometimes _____Often _____Always

4. At work I stood…
_____ Never _____Seldom _____Sometimes _____Often _____Always

5. At work I walked…
_____ Never _____Seldom _____Sometimes _____Often _____Always

6. At work I lifted heavy loads…

_____ Never _____Seldom _____Sometimes _____Often _____Very Often

7. After work I was tired…

_____ Never _____Seldom _____Sometimes _____Often _____Very Often

8. At work I would sweat…

_____ Never _____Seldom _____Sometimes _____Often _____Very Often

9. In comparison with others my own age I think my work was physically…

_____Much lighter _____Lighter _____as heavy

_____Heavier _____Much heavier

10. Did you play sport? _____Yes _____No

If yes: -which sport did you play most frequently?

_____

-how many hours a week?

_____<1 _____1-2 _____2-3 _____3-4 _____>4

-how many months a year?

_____<1 _____1-3 _____4-6 _____7-9 _____>9

If you played a second sport: -which sport is it? _____

-how many hours a week?

_____<1 _____1-2 _____2-3 _____3-4 _____>4

-how many months a year?

_____<1 _____1-3 _____4-6 _____7-9 _____>9

11. In comparison with others my own age I think my physical activity during leisure time was…

_____Much less _____Less _____The same

_____More _____Much more

12. During leisure time I would sweat…

_____ Never _____Seldom _____Sometimes _____Often _____Very often

13. During leisure time I played sport…

_____ Never _____Seldom _____Sometimes _____Often _____Very often

14. During leisure time I watched television…

_____ Never _____Seldom _____Sometimes _____Often _____Very often

15. During leisure time I walked…

_____ Never _____Seldom _____Sometimes _____Often _____Very often

16. During leisure time I cycled…

_____ Never _____Seldom _____Sometimes _____Often _____Very often

17. How many minutes per day did you walk and/or cycle to and from work, school and shopping?

_____<5 _____5-15 _____15-30 _____30-45 _____>45

18. During leisure time I did do-it-yourself activities…

_____ Never _____Seldom _____Sometimes _____Often _____Very often

19. During leisure time I worked in the garden…

_____ Never _____Seldom _____Sometimes _____Often _____Very often

20. How many hours per day did you sleep on average?

_____<5 _____6 _____7 _____8 _____>9

Appendix E – Kolmogorov-Smironov Tests for Normality

Table E.1: Kolmogorov-Smirnov Test for Normality in Nutrient Data from Comparison of FFQ versus 24 Hour Recall in Non-Pregnant Participants (n=101)

Nutrient	FFQ		24HR	
	K-S Z score	p value	K-S Z score	p value
Energy (kcal)	0.574	0.897	0.793	0.556
Carbohydrate (g)	0.778	0.580	0.993	0.277
Fibre (g)	0.948	0.331	0.497	0.966
Protein (g)	0.758	0.614	1.033	0.236
Fat (g)	1.273	0.078	0.837	0.486
Saturated Fat (g)	1.225	0.099	1.023	0.246
MUFA (g)	1.256	0.085	1.168	0.131
PUFA (g)	1.063	0.208	1.327	0.059
ALA (g)	1.258	0.084	1.443	0.031*
EPA/DHA (g)	2.190	<0.001**	3.930	<0.001**
Trans Fat (g)	1.103	0.175	2.528	0.000**
Cholesterol (mg)	1.145	0.145	1.179	0.124
Alcohol (g)	2.240	<0.001**	4.090	<0.001**
Folate (µg)	0.647	0.797	1.192	0.117
Vitamin B_6 (mg)	0.526	0.944	0.803	0.539
Vitamin B_{12} (µg)	1.197	0.114	1.570	0.014*
Calcium (mg)	1.180	0.123	1.205	0.110
Vitamin D (µg)	1.501	0.022*	1.284	0.074
Iron (mg)	0.820	0.512	1.046	0.224

*Significant at p<0.05 level; **Significant at p<0.01 level.

Abbreviations: K-S (Kolmogorov-Smirnov Test), FFQ (Food Frequency Questionnaire), 24HR (24 hour recall), kcal (kilocalories), g (grams), mg (milligrams), µg (micrograms), MUFA (monounsaturated fat), PUFA (polyunsaturated fat), ALA (alpha-linolenic acid), EPA/DHA (Eicosapentaenoic acid/Docosahexaenoic acid)

Table E.2: Kolmogorov-Smirnov Test for Normality in Nutrient Data from Comparison of 24 Hour Recall 1 versus 24 Hour Recall 2 in Non-Pregnant Participants (n=20)

Nutrient	24HR 1		24HR 2	
	K-S Z score	p value	K-S Z score	p value
Energy (kcal)	0.561	0.911	0.699	0.712
Carbohydrate (g)	0.593	0.874	0.513	0.955
Fibre (g)	0.779	0.579	0.784	0.570
Protein (g)	0.666	0.767	0.554	0.919
Fat (g)	0.841	0.479	0.709	0.696
Saturated Fat (g)	0.741	0.642	0.923	0.362
MUFA (g)	0.678	0.747	0.603	0.861
PUFA (g)	0.953	0.324	0.815	0.520
ALA (g)	0.680	0.744	0.952	0.325
EPA/DHA (g)	2.059	<0.001**	1.973	0.001**
Trans Fat (g)	0.971	0.302	1.316	0.063
Cholesterol (mg)	0.884	0.415	0.626	0.829
Alcohol (g)	1.517	0.020*	1.720	0.005**
Folate (µg)	0.738	0.648	0.670	0.760
Vitamin B_6 (mg)	0.660	0.776	0.547	0.925
Vitamin B_{12} (µg)	0.943	0.337	0.686	0.734
Calcium (mg)	0.723	0.672	0.721	0.675
Vitamin D (µg)	0.672	0.756	0.934	0.348
Iron (mg)	0.695	0.720	0.412	0.996

*Significant at $p<0.05$ level; **Significant at $p<0.01$ level.

Abbreviations: K-S (Kolmogorov-Smirnov Test), 24HR (24 hour recall), kcal (kilocalories), g (grams), mg (milligrams), µg (micrograms), MUFA (monounsaturated fat), PUFA (polyunsaturated fat), ALA (alpha-linolenic acid), EPA/DHA (Eicosapentaenoic acid/Docosahexaenoic acid)

Table E.3: Kolmogorov-Smirnov Test for Normality in Physical Activity Data from Comparison of Baecke versus PYTPAQ in Non-Pregnant Participants (n=42)

Physical Activity Variable	Tool	K-S Z score	p value
Work Score	Baecke	1.061	0.210
Sport Score	Baecke	0.705	0.702
Leisure Time Score	Baecke	0.630	0.822
Total Activity Score	Baecke	0.674	0.755
Occupation MET hr/week	PYTPAQ	1.189	0.118
Exercise MET hr/week	PYTPAQ	1.230	0.097
Household MET hr/week	PYTPAQ	0.900	0.392
Total Activity MET hr/week	PYTPAQ	1.025	0.245

*Significant at $p<0.05$ level; **Significant at $p<0.01$ level.

Abbreviations: K-S (Kolmogorov-Smirnov Test), Baecke (Baecke Physical Activity Questionnaire), PYTPAQ (Past Year Total Physical Activity Questionnaire), MET (Metabolic Equivalents)