Dietary intake, capillary blood glucose, and activity level of activity-restricted, hospitalized, pregnant women in the third trimester: a pilot study

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Abstract: Activity restriction in hospital is commonly prescribed by care providers to decrease the incidence of maternal or fetal morbidity in high-risk pregnancies. The purpose of this pilot descriptive study was to collect preliminary data on dietary intake, capillary blood glucose concentrations, and activity level in high-risk, activity-restricted, pregnant women in the third trimester of pregnancy. Dietary food intake records, capillary blood glucose, and daily pedometer step totals were investigated in 20 activity-restricted women over 7 consecutive days in hospital. Subjects were asked to collect hospital meal tickets, as well as record any additional items not provided by the hospital in a dietary log each day. Capillary blood glucose was collected every morning (fasting) as well as 1 h after breakfast (post-prandial) using a glucometer. Subjects wore a pedometer 24 h/d, and recorded step totals 4 times daily in a pedometer log. In the analysis, average energy and macronutrient intakes met dietary reference intake (DRI) recommendations, as did average intakes of all micronutrients, including maternal supplementation. Without supplementation, vitamin E and iron intakes were lower (p < 0.05) than the DRI recommendations. Average fasting (4.6 ± 0.5 mmol/L) and post-prandial (7.1 ± 1.0 mmol/L) blood glucose concentrations in subjects without gestational diabetes (GDM) did not exceed Canadian Diabetes Association cut-off values for screening of GDM. The mean daily step total of 1579 ± 936 was lower than ambulatory third-trimester women (6495 ± 2282 steps; p < 0.001). Results from this pilot study suggest that with maternal supplementation, these activity-restricted, hospitalized, pregnant women were meeting dietary recommendations, and did not have elevated capillary blood glucose. However, given the severity of activity restriction, these women may be at risk for consequences of extreme inactivity.

Key words: activity restriction, pregnancy, dietary intake, activity level, pedometer, glucose, dietary reference intakes.

Résumé : Une restriction d’activité physique est souvent prescrite à l’hôpital par les professionnels de la santé afin de réduire le risque de complications pour la mère ou le fœtus lors de grossesses à risque élevé. L’objectif était d’assembler des données préliminaires concernant l’apport alimentaire, les glycémies capillaires et le niveau d’activité physique de femmes avec grossesse à haut risque et restriction d’activité durant leur troisième trimestre. Cette étude était descriptive et pilote. Des journaux d’apport alimentaire, les glycémies capillaires et les comptes totaux de pédomètres journaliers de vingt femmes avec activité restreinte ont été compilés lors de sept jours consécutifs d’hospitalisation. Nous avons demandé aux sujets d’amasser les billets qu’elles recevaient avec leurs repas d’hôpital, ainsi que de noter tout ajout d’items autres que ceux donnés par l’hôpital sur un journal alimentaire quotidien. Les glycémies capillaires étaient mesurées chaque matin à jeun et une heure après le déjeuner avec un glucomètre. Les sujets ont porté un pedomètre 24 heures par jour et ont noté leur nombre de pas totaux quatre fois par jour sur un journal de collecte de données de pédomètre. Les moyennes d’apport en énergie et en macronutriments correspondaient aux recommandations des apports nutritionnels de référence (ANR). Les apports moyens en micronutriments correspondaient aussi aux ANR, lorsque les suppléments maternels étaient inclus dans l’analyse. Sans supplémentation, les apports en vitamine E et fer étaient sous (p < 0,05) les recommandations des ANR. La moyenne des glycémies à jeun (4,6 ± 0,5 mmol/L) et postprandiales (7,1 ± 1,0 mmol/L) des sujets sans diabète gestational (DG) était sous les valeurs limites établies par l’Association canadienne du diabète pour le dépistage du DG. La moyenne de pas totaux de 1579 ± 936 était plus basse que celle de femmes enceintes sans restriction d’activité au troisième trimestre (6495 ± 2282 pas; p < 0,001). Les résultats de cette étude préliminaire suggèrent que ces femmes en-
centres hospitalisées avec restriction d’activité et prenant un supplément maternel avaient un apport alimentaire moyen correspondant aux recommandations et qu’elles n’avaient pas d’hyperglycémie. Par contre, due à la sévérité de leur restriction d’activité, ces femmes étaient possiblement à risque d’avoir des conséquences de leur inactivité extrême.

Mots-clés : restriction d’activité, grossesse, apport alimentaire, niveau d’activité, pédomètre, glucose, apports nutritionnels de référence.

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Introduction

A high-risk pregnancy is defined as a condition (i.e., multiple fetuses, preterm labour, placenta previa, etc.) in which the mother or fetus has significantly increased probability of death or disability (Maloni 1996). Activity restriction in hospital is commonly prescribed by care providers to decrease the incidence of maternal or fetal morbidity in high-risk pregnancies (Goldenberg et al. 1994; Maloni 1996). Approximately 18% of all pregnant women are activity restricted in hospital each year (Goldenberg et al. 1994). No research to date has assessed actual dietary intake or capillary blood glucose concentrations in this population, nor has the activity level of activity-restricted pregnant women been compared with ambulatory pregnant women using pedometers.

The aim of the present pilot study was to collect preliminary data on dietary intake, capillary blood glucose concentrations, and activity level in activity-restricted women in hospital owing to high-risk pregnancies during the third trimester of pregnancy.

Adequate nutrition during pregnancy is essential for the maintenance of maternal health, as well as fetal growth and development. Currently, numerous nutritional guidelines and recommendations exist for healthy pregnant women, including dietary reference intake (DRI) recommendations (Food and Nutrition Board of the Institute of Medicine 2005; Health Canada 1999; Institute of Medicine 1997, 1998, 2000, 2003a, 2003b). However, the dietary intake of high-risk pregnant women on activity restriction has never been assessed as part of a research protocol.

The recommended intakes for energy and many nutrients are increased during pregnancy (particularly during the second and third trimesters); these nutrients include protein, carbohydrate, iron, zinc, magnesium, essential fatty acids, fibre, folate, and vitamins A, B6, B12, and C (Food and Nutrition Board of the Institute of Medicine 2005; Health Canada 1999; Institute of Medicine 1997, 1998, 2000, 2003a, 2003b). In addition, protein, calcium, iron, folate, vitamin D, zinc, and essential fatty acids are known to be of special concern during pregnancy, as there is a potential for inadequate intake in some women (Food and Nutrition Board of the Institute of Medicine 2005; Health Canada 1999; Institute of Medicine 1997, 1998, 2000, 2003a, 2003b). A review of dietary intake studies indicates that pregnant women are unlikely to meet recommendations for iron, zinc, calcium, folate, and vitamins B12, C, D, and E (Menard 1997). However, iron and folate are the only micronutrients for which routine supplementation is prescribed during pregnancy (Gunderson 2003; Menard 1997; Picciano 2003). In addition, current evidence suggests that women with multi-fetal pregnancies have increased needs for weight gain, energy, essential fatty acids, iron, calcium, vitamin D and some other nutrients, compared with women with singleton pregnancies (Bo et al. 2001). The Institute of Medicine recommends the following supplementation (per day) in the second and third trimesters for multiple pregnancies: 30 mg iron, 15 mg zinc, 2 mg copper, 250 mg calcium, 2 mg vitamin B6, 300 μg folate, 50 mg vitamin C, and 5 μg vitamin D (Brown and Carlson 2000; Food and Nutrition Board of the Institute of Medicine 1990; National Academy of Sciences 1990; Rosello-Soberon et al. 2005). Brown and Carlson (2000) have calculated that women pregnant with twins might require an extra 150 kcal/d (627 kJ/d) above the recommendation for singleton pregnancy to gain enough weight. However, due to the lack of research, there are no specific estimated energy requirement (EER), recommended dietary allowance (RDA), and adequate intake (AI) recommendations for multi-fetal pregnancies, nor have glycemic targets been established for this population. It has been suggested that use of the current Institute of Medicine recommendations, along with pregnancy monitoring, is the prudent course of action for managing nutrition in multi-fetal pregnancies (Brown and Carlson 2000; Rosello-Soberon et al. 2005).

In addition to the lack of literature regarding dietary intake of high-risk, activity-restricted, pregnant women, very little research has been conducted to examine the physiological effects of activity restriction in pregnancy. Activity restriction for as little as three days may induce peripheral insulin resistance, glucose intolerance, and hyperglycaemia in trained men (Arciero et al. 1998). In late pregnancy, women develop peripheral insulin resistance and higher post-prandial blood glucose concentrations to accommodate the energy needs of the growing fetus (Catalano et al. 1993; Catalano et al. 1999). This physiological adaptation puts some women at risk of developing gestational diabetes mellitus (GDM), which is glucose intolerance with onset or recognition during gestation (Meltzer et al. 2000; Ur et al. 2000). Inactivity during pregnancy has also been shown to induce physiological de-conditioning, and an increased risk of hyperglycaemia, similar to that encountered during activity restriction (MacPhail et al. 2000). Thus, a combination of activity restriction and pregnancy could potentially augment the risk of GDM in some women, especially those on complete activity restriction for an extended period of time during late pregnancy. It is therefore useful to assess capillary glucose concentrations, as well as the degree of inactivity, during activity restriction in pregnant women while hospitalized.

Materials and methods

Ethics approval for involvement of human subjects was obtained through the University of Western Ontario and St.
Joseph’s Health Care, London, Ontario. Women who were hospitalized and activity-restricted in the antenatal ward of St. Joseph’s Hospital, London, due to high-risk pregnancies were recruited to participate in this study. Subjects had been hospitalized for a minimum of 3 d prior to beginning the study, and were in the third trimester of pregnancy. Women who were on total parenteral nutrition were excluded. Each subject was approached in an interview setting, and provided with an information sheet and consent form. Subjects were given detailed instruction on how to complete daily dietary, capillary blood glucose, and pedometer logs. Dietary intake, capillary blood glucose, and pedometer data collection occurred over the same 7 d for each subject.

Food intake records
Subjects were asked to collect their hospital meal tray tickets following each meal for 7 consecutive days. They were shown how to record on each of their meal tray tickets the actual amount of each food item they consumed, using estimations in household measures. Subjects also recorded intake of any additional items not provided by the hospital meal service. Dietary intake included all food, liquids, snacks, and supplements taken.

Dietary intake was analyzed using The Food Processor® SQL version 9.2 (ESHA Research 2002–2003) including the Canadian Nutrient File. Daily food intake was divided into food group servings, according to Canada’s food guide to healthy eating (Health Canada 1997; Health Canada 1999). The intake of energy and nutrients were compared with the current DRI recommendations (Food and Nutrition Board of the Institute of Medicine 2005; Institute of Medicine 1997, 1998, 2000, 2003a, 2003b).

Calculated nutrient intake
Dietary intake assessments provided estimates of actual daily intake of energy, macronutrients, and micronutrients for each subject. Recommended daily energy intake for each subject was calculated based on the following formulas (Food and Nutrition Board of the Institute of Medicine 2005):

\[ \text{Adult woman EER} = 354.1 - (6.91 \times \text{age}) + (\text{PA level} \times (9.36 \times \text{body mass})) + (726 \times \text{height}) \]

\[ \text{Pregnancy EER} = \text{Adult EER} + 180 + (8 \times \text{No. of weeks pregnant}) \]

where EER is the estimated energy requirement in kilocalories per day (1 kcal = 4.184 kJ), PA is physical activity, age is measured in years, body mass is measured in kilograms, and height is measured in metres. The coefficient for PA level is 1 for sedentary individuals.

Recommended daily protein intake was calculated for each subject as follows: \(1.1 \text{ g·kg}^{-1}·\text{d}^{-1} \times \text{kg body mass} \) (Food and Nutrition Board of the Institute of Medicine 2005). Recommended daily fat and saturated fat for each subject were calculated as 28% and 9%, respectively, of total daily energy intake.

Capillary blood glucose concentration measurements
Subjects were instructed on how to use a glucometer with glucose electrodes (Precision Xtra™, Medisense®, Abbott Laboratories). All glucometers used in this study were routinely calibrated and validated against control solutions provided by the manufacturer, to ensure accuracy of results to within the accepted 15% measurement error for capillary blood glucose monitoring devices (American Diabetes Association 1990). Glucometers were used to measure fasting capillary blood glucose concentration every morning, as well as 1 h after breakfast, for the same 7 consecutive days.

Pedometer and activity log
Subjects wore a pedometer (Accusplit®, Eagle™ 120 Activity Pedometer) 24 h/d for 7 consecutive days while in hospital. Subjects were asked to remove the pedometer only to bathe or shower. Step totals were recorded by subjects in the pedometer log four times daily: 08:00, 12:00, 17:00, and before sleep at night.

Statistical analysis
Mean daily intake of energy and protein were compared with individually calculated EER and RDA recommendations using Wilcoxon two-sample tests (Conover and Iman 1981). Mean daily group intake values were compared with RDA or AI recommendations for pregnant women using one-sample \( t \) tests (Food and Nutrition Board of the Institute of Medicine 2005). Mean daily group micronutrient intakes were compared with RDA or AI recommendations for pregnant women (Food and Nutrition Board of the Institute of Medicine 2005; Institute of Medicine 1997, 1998, 2000, 2003a, 2003b) using one-sample \( t \) tests; first using values calculated without maternal micronutrient supplementation, and secondly using values including micronutrient supplementations. All subjects were compared with recommendations for singleton pregnancies, given that there are no current EER, RDA, or AI recommendations for multiple pregnancies.

Mean daily fasting and post-prandial glucose concentrations in non-GDM subjects were compared with the cut-off values used as criteria in GDM glucose-screening tests: <5.3 mmol/L (fasting) and <7.8 mmol/L (1 h after 50 g standard glucose load). These comparisons were made using one-sample \( t \) tests. The aforementioned cut-off values for GDM screening tests are also recommended by the Canadian Diabetes Association (CDA) for best neonatal and maternal outcomes (Clark et al. 2003; de Veciana et al. 1995; Drexl et al. 1988; Evans and Patry 2004; Harris and Lank 2004; Jovanovic and Pettiti 2001; Meltzer et al. 2000; Mensing et al. 2004; Ur et al. 2000).

The mean for daily step total for the hospitalized pregnant women was compared with unpublished data collected in a group of ambulatory, sedentary, pregnant women \((n = 19)\), using Wilcoxon two-sample tests. An \( \alpha \) level of \( p < 0.05 \) was used to judge significance in all statistical tests.

Results
Subject characteristics
Twenty subjects \((31 \pm 5 \text{ years of age})\) participated in the study. All subjects were in the third trimester of pregnancy, and had been activity restricted in hospital for a minimum of 3 d, to a maximum of 69 d, with an average activity-restriction
time of 22 ± 19 d. The reasons for activity restriction included multiple pregnancies (7 subjects: 4 twins, 2 quadruplets, 1 triplets), preterm labour (4 subjects), placenta previa (4 subjects), ruptured membranes (2 subjects), incompetent cervix (1 subject), and hypertension (2 subjects). Of the 20 subjects, 2 also had gestational diabetes in addition to the conditions for which they were activity restricted (placenta previa and hypertension). Fourteen women (70%) completed dietary records, 7 (non-GDM) women (35%) volunteered to provide capillary blood glucose concentrations, and 16 (80%) participated in the pedometer log component of the study.

Dietary records

Energy, macronutrient, and fibre intake

Dietary intake analyzed using The Food Processor® SQL version 9.2 (ESHA Research 2002–2003) provided estimates of actual daily intake of energy, macronutrients, and micronutrients for each subject. Mean daily intake of energy and macronutrients over the 7 d, and corresponding DRI recommendations for pregnant women with singleton pregnancies, are presented in Table 1 (n = 14). On average, energy, dietary fat, protein, and carbohydrate recommendations were met. There was no significant difference between individually calculated EER and average daily energy intake. On average, subjects consumed approximately 211 kcal (882 kJ) over the EER for a singleton pregnancy, and none had a mean daily energy intake below 1530 kcal (6595 kJ). Of the 14 subjects, 4 (29%) had actual energy intake lower than their individually calculated EER. One of these subjects was carrying twins. This subject’s actual mean daily intake was 2186 ± 403 kcal/d (9137 ± 1685 kJ/d), compared with the recommended value of 2660 kcal/d (11119 kJ/d).

Mean daily protein intake was not significantly different from the individually calculated protein recommendations. Five subjects (36%) did not meet their individually calculated RDA protein recommendations, based on average daily protein intake (Table 1). Of these 5 subjects, none were carrying multiple fetuses. Mean daily carbohydrate intake of all subjects was above the RDA (p < 0.05). Mean daily fibre intake was 28 g below the AI for pregnancy; however, not significantly so (Table 1). Mean intake of linoleic acid (11 ± 3 g) and α-linolenic acid (2 ± 1 g) were not found to be significantly different from recommendations (Table 1). Ten subjects (71%) had a mean daily linoleic acid intake below AI. Three of these subjects were carrying multiple fetuses. Six subjects (43%) had a mean α-linolenic acid intake below AI recommendation. Two of these subjects were carrying multiple fetuses.

The average macronutrient intake of all subjects was within the average macronutrient distribution range (AMDR) recommendations (Food and Nutrition Board of the Institute of Medicine 2005). All subjects had an average food intake within the recommended ranges for pregnancy for all food groups (Health Canada 1999) (Table 2). On average, subjects met the recommendations for intake of energy and macronutrients, with the exception of dietary fibre and linoleic acid, which were lower than recommended, but not significantly so.

Micronutrient intake

Of the 14 subjects who completed the dietary record, 12 were taking some form of maternal micronutrient supplement, including all subjects with multi-fetal pregnancies.

<table>
<thead>
<tr>
<th>Food group</th>
<th>Average no. of servings</th>
<th>Recommended no. of servings according to Canada’s food guide to healthy eating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains products</td>
<td>6.1±1.7</td>
<td>5–12</td>
</tr>
<tr>
<td>Milk products</td>
<td>6.5±2.4</td>
<td>3–4</td>
</tr>
<tr>
<td>Meat and alternatives</td>
<td>2.4±1.8</td>
<td>2–3</td>
</tr>
<tr>
<td>Vegetables and fruit</td>
<td>6.4±2.7</td>
<td>5–10</td>
</tr>
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Therefore, dietary intake was analyzed before including maternal supplementation \((n = 14)\) and after supplements had been added to daily intake \((n = 12)\) (Table 3). On average, with the exception of iron and vitamin E, subjects were meeting recommendations for intake of micronutrients before maternal supplementation was added to the analysis. Including maternal supplementation in the analysis, intake of all micronutrients was found to be greater than recommended (Table 3).

**Vitamins: with and without maternal supplementation**

Mean daily vitamin intake was compared with vitamin RDA and AI recommendations \((n = 14)\) (Table 3). On average, all subjects consumed less vitamin E than the RDA. Fifty-seven percent of subjects had an average vitamin C intake below RDA, 43% were below the vitamin \(B_6\) RDA, 14% were below the vitamin D AL, and 7% were below the vitamin \(B_{12}\) RDA. Of those subjects below the vitamin D AL, none were carrying multiple fetuses. Only intake of vitamin E was significantly below the recommended value (RDA) \((p < 0.05)\). Ten women (71%) had at least 1 vitamin, and 6 (43%) had at least 2 vitamin intakes below the recommended RDA or AI before maternal supplementation was added to the analysis.

Including supplementation in the mean daily totals, 100% of supplemented subjects were above the RDAs for vitamins E, \(B_{12}\), C, D, and folate, and 92% were above the RDA for vitamin \(B_6\). Mean intake of vitamins D, E, \(B_{12}\), folate, \(B_6\), and C was significantly greater than RDA recommendations \((p < 0.05)\).

**Minerals: with and without maternal supplementation**

When mean daily mineral intake values were compared with AIs and RDAs (Table 3) not including maternal supplementation, 100% of subjects were over the AI recommended daily for calcium and the RDA for phosphorus, whereas 50% were under the RDA for magnesium, 57% were under the RDA for zinc, and 100% were under the RDA for iron. Calcium and phosphorous intakes were significantly greater than the AI and RDA, respectively \((p < 0.001)\). The mean intakes for both magnesium and zinc were not significantly different from the RDAs. Iron intake was significantly lower than the RDA value \((p < 0.0001)\). Fourteen women (100%) had at least 1 mineral, 4 (29%) had at least 2, and 5 (36%) had at least 3 mineral intakes below the recommended RDA or AI before maternal supplementation was added to the analysis.

When mean daily mineral intakes including maternal supplementation were compared with RDA and AI values, 100% of subjects were above the recommendations for calcium, phosphorous, and iron, whereas 83% were above for magnesium, and 92% were above for zinc. When intakes were compared with RDA and AI, the average intakes of calcium \((p < 0.0001)\), phosphorous \((p < 0.0001)\), magnesium \((p < 0.05)\), zinc \((p < 0.0001)\), and iron \((p < 0.05)\) were all significantly greater than the corresponding recommendations.

**Capillary blood glucose concentrations**

The mean fasting capillary glucose concentration for non-GDM subjects \((n = 7)\) \((4.6 ± 0.5 \text{ mmol/L})\) was lower \((p <
0.05) than the GDM screening cut-off value recommended by the CDA (5.3 mmol/L) (Evans and Patry 2004; Meltzer et al. 2000; Mensing et al. 2004; Ur et al. 2000). Mean post-prandial glucose concentration for non-GDM subjects (7.1 ± 1.0 mmol/L) was not significantly different from the recommended GDM screening cut-off value of 7.8 mmol/L (de Veciana et al. 1995; Drexel et al. 1988; Jovanovic and Pettitt 2001). Of the capillary glucose concentrations found to exceed the GDM screening cut-off values, 77% were 1 h post-prandial (Table 4).

Of the 7 (non-GDM) subjects who provided capillary blood glucose concentrations, 2 were carrying twins and 1 was carrying triplets. Of these subjects with multiple pregnancies, only one (carrying twins) exhibited a capillary glucose concentration that was higher than the cut-off values (subject 2, Table 4). This subject exhibited higher than recommended fasting capillary glucose on 1 of 7 days.

Activity level

The average daily step total for 16 subjects was 1579 ± 936 (mean ± SD) steps. Daily step totals ranged from a minimum of 271 ± 248 steps/d to a maximum of 3725 ± 1141. Compared with the group of ambulatory, sedentary pregnant women (n = 19) with a mean daily step total of 6495 ± 2282, the activity-restricted group took significantly fewer steps (p < 0.05).

Discussion

Macronutrient intake

Currently no specific nutritional guidelines exist for high-risk pregnant women who are activity-restricted, or for those with multi-fetal pregnancies (especially for women bearing more than two fetuses). No research has been conducted to examine the actual dietary intake of high-risk pregnant women during prolonged activity restriction. As such, in the present preliminary study, dietary intake of all subjects, including those with multi-fetal pregnancies, were compared with the current DRIs for low-risk, sedentary, singleton pregnant women (Food and Nutrition Board of the Institute of Medicine 2005; Health Canada 1999; Institute of Medicine 1997, 1998, 2000, 2003a, 2003b).

Energy intake

Results of the present pilot study suggest that these activity-restricted pregnant women were not at risk for inadequate energy intake while in hospital. This is important, given that adequate energy intake is essential during pregnancy to support the growth and development of maternal and fetal tissues. Because increased energy intake is of special importance during multi-fetal pregnancies, the one subject who was below her calculated EER by more than 150 kcal/d could have benefited from a greater intake of high-energy foods and (or) more frequent meals and snacks.

The EER calculation for pregnancy accounts for change in total energy expenditure and energy deposition during pregnancy. However, no research has been conducted to determine if the specific energy requirements for activity-restricted pregnant women are in fact different from those of low-risk sedentary pregnant women. Research is therefore warranted in this area before determining adequate energy intake for activity-restricted pregnant women, especially those with multi-fetal pregnancies.

Fibre

Results suggest that the majority of subjects in the present study would have benefited from increased intake of foods high in fibre (i.e., bran, whole grain products, fruit, vegetables, legumes, seeds and nuts). A diet rich in fibres, especially insoluble fibres, with adequate hydration may help prevent constipation. In addition, a diet rich in soluble fibres aids in normalizing blood cholesterol, hyperinsulinemia and post-prandial blood glucose concentrations (American Dietetic Association 2002a; Anderson et al. 1999; Ludwig 2002; Food and Nutrition Board of the Institute of Medicine 2005). Thus increased fibre intake may have been beneficial for our subjects with elevated blood glucose concentrations.

Fat and saturated fat

Mean intake of fat and saturated fat by subjects in the present study was 31% and 12%, respectively. Excessive fat intake (specifically saturated fat) may be of concern, given potential health implications of increased blood cholesterol concentration, increased total cholesterol to high-density lipoprotein cholesterol ratio, and macromnesia, as well as the long-term risks of obesity, hypertension, and type 2 diabetes.
in mothers and offspring (Kjos and Buchanan 1999). It has also been suggested that high intakes of saturated fat may contribute to hyperglycaemia and glucose intolerance in women who have been diagnosed with GDM (Bo et al. 2001). Thus, the results of the present preliminary study imply that the activity-restricted pregnant subjects may have benefited from decreasing saturated fat intake and increasing unsaturated fat intake from plant sources, which may also have favoured a higher overall micronutrient and fibre intake.

**Micronutrient intake**

**Vitamins and minerals**

On average, before maternal supplementation was added to the analysis, subjects were meeting DRI recommendations for micronutrient intake, with the exceptions of vitamin E and iron. However, individual results of the present pilot study suggest the need for micronutrient supplementation in this population, given that before supplementation, varying percentages of subjects were below DRI recommendations for vitamins E, C, B<sub>6</sub>, B<sub>12</sub>, and D, as well as magnesium, zinc, and iron. The finding that 100% of subjects were significantly below the RDA for iron (before supplementation) is consistent with the literature, and of clinical importance given that iron deficiency during pregnancy has been associated with anemia, low birth weight, prematurity, infant mortality, and impaired post-natal development (Gunderson 2003; Kwik-Uribe et al. 1999; Menard 1997; Picciano 2003).

It has been suggested that pregnant women should attempt to meet the RDAs and AIs for micronutrients through a well-balanced, nutritious diet (Gunderson 2003; Menard 1997; Picciano 2003). Even though our subjects met the recommendations for the number of daily servings from each food group of Canada’s food guide to healthy eating (Health Canada 1997), their food choices were likely high in fat and saturated fat and too low in nutrient density to meet some of their increased micronutrient needs during pregnancy. According to the American Dietetic Association (2002b), pregnant women with a low-quality diet may require an appropriate multivitamin and mineral supplement to help them meet their micronutrient needs. The results of the present study suggest that these activity-restricted pregnant women would have benefited from a more micronutrient-dense diet and that micronutrient supplementation helped them to meet their micronutrient needs.

**Multi-fetal pregnancies**

Seven of the 20 subjects in the current study had multi-fetal pregnancies. Current evidence suggests that women with multi-fetal pregnancies have additional increased need for weight gain, energy, essential fatty acids, iron, calcium, vitamin D, and other nutrients (Brown and Carlson 2000; Luke 2005; Rosello-Soberon et al. 2005). The Food and Nutrition Board of the Institute of Medicine (1990) recommends micronutrient supplementation in the second and third trimesters for multiple pregnancies and an extra 150 kcal/d (627 kJ/d) above the recommendation for singleton pregnancy to gain enough weight. However, based on lack of research, there are no specific dietary recommenda-

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ple placentas have the potential to increase insulin resistance, thereby increasing the possibility of hyperglycemia in women with multi-fetal pregnancies (Bühling et al. 2001; Dornhorst and Chan 1998; Simmons and Yapa 2002; Spellacy and Goetz 1978). However, only 1 of the 3 subjects with a multi-fetal pregnancy (twins) exhibited higher than recommended capillary blood glucose concentration (5.6 mmol/L, fasting) on 1 of 7 days, suggesting that hyperglycemia may not have been a concern in this small sample of women with multi-fetal pregnancies. In addition, although multi-fetal pregnancies have the potential to increase insulin resistance, it is possible that higher glycemic targets may be appropriate in women with multi-fetal pregnancies, given the potential for more rapid depletion of glycogen stores and increased risk of low-birth-weight neonates (Brown and Carlson 2000; Casele et al. 1996). However, there is limited evidence to support glycemic targets in this population, and more research is warranted in this area.

**Activity level**

In addition to taking fewer steps, on average, than ambulatory sedentary pregnant women, the activity-restricted subjects in the present study also took fewer steps than sedentary non-pregnant women (7220 ± 2406 steps/d) (Wilde et al. 2001), as well as fewer than the value expected for those living with disabilities and chronic disease (3500–5500 steps/d) (Tudor-Locke 2001). According to the preliminary pedometer indices introduced by Tudor-Locke and Bassett (2004), people taking fewer than 5000 steps/d can be considered sedentary, at risk for numerous adverse health outcomes, and have the greatest potential to benefit from physical activity intervention. A number of potential adverse health outcomes of activity restriction have been demonstrated in pregnant women, including decreased exercise capacity due to muscular and cardiovascular de-conditioning, muscle atrophy, decreased bone mass, joint pain, sleep changes, fatigue, indigestion, decreased appetite, less than recommended pregnancy weight gain, stress, depression, and prolonged recovery (Maloni et al. 1993; Maloni et al. 1998; Maloni et al. 2006; Sprague 2004). As previously stated, additional adverse effects of activity restriction demonstrated in non-pregnant populations include insulin resistance and glucose intolerance (Arici 1998; Catalano et al. 1991; Catalano et al. 1999; Cousins 1991; Kuhl 1991; Spellacy and Goetz 1963). Many of these potential adverse outcomes of activity restriction may have important implications for mothers in terms of prolonged post-partum recovery and care for the infant, given that women who were activity restricted for high-risk pregnancies have reported difficulty resuming ambulation and activities of daily living in the post-partum period (Maloni et al. 1993). In addition, it is possible that given the severity of activity restriction in this population, deep vein thrombosis prophylaxis could be considered, depending on the etiology of the disorder that resulted in activity restriction (Kehl-Pruett 2006).

**Limitations**

The nutritional analysis component of the present study was limited in a number of ways. Some subjects may not have recorded their dietary intake accurately. The Canadian Nutrient File database used had limited information about the food content of some micronutrients, including vitamin A, folate, and chromium. The intake of these micronutrients in pregnant activity-restricted women should be evaluated in future studies, especially given that chromium may play a role in the regulation of carbohydrate metabolism during pregnancy, and in the prevention of GDM (Bo et al. 2001; Catalano et al. 1993), whereas folate is implicated in the prevention of neural tube defects (George et al. 2002; Scholl and Johnson 2000). It may also be of value to collect dietary intake data over a number of weeks, including a larger sample size, to confirm that the data obtained are representative of the average intake for these women while in hospital. This would be especially helpful to more accurately estimate micronutrient intake. In addition, the number of subjects who consented to providing capillary blood glucose concentrations was small. It would be valuable to repeat the capillary blood glucose portion of this study with a larger number of subjects, to make more valid and representative conclusions regarding risk levels for hyperglycaemia in this population.

**Conclusions**

The results of the present pilot study suggest that, on average, hospitalized, activity-restricted, pregnant women were meeting DRI energy and macronutrient recommendations. Including maternal supplementation, these women were also meeting recommended micronutrient intakes. However, without maternal supplementation this population may be at risk for low intake of vitamin E and iron. In addition, activity-restricted pregnant women could benefit from a high-fibre and nutrient-dense diet to help control their glycaemia and meet the increased micronutrient needs of a singleton or multi-fetal pregnancy. Results of our preliminary work also suggest that activity-restricted pregnant women are not exceeding the capillary blood glucose screening criteria for GDM as described by the Canadian Diabetes Association (Clark et al. 2003; de Veciana et al. 1995; Drexel et al. 1988; Evans and Patry 2004; Harris and Lank 2004; Jovanovic and Pettitt 2001; Meltzer et al. 2000; Mensing et al. 2004; Ur et al. 2000). However, given the extreme activity restriction observed, these women may be at risk for health consequences because of extreme inactivity. Further research is warranted to more comprehensively examine the nutrient intake, nutrient status, and capillary blood glucose of activity-restricted pregnant women, including those with multi-fetal pregnancies.

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