Assessing diet concordance among cohabitating middle-aged/older adult couples

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Abstract

Background: Research that examines couple-based interventions for improving dietary behaviours is mixed. Investigating diet concordance among couples could guide the development for more effective couple-based lifestyle behaviour interventions by increasing our understanding of how couples share dietary behaviours. The main objective of this thesis was to assess concordance for diet quality and adherence to Canada's Food Guide (CFG) 2019 among middle-aged/older adult couples. Given that there are no plate-based dietary assessment tools, this thesis also explored the agreement in nutrition information between the three-day food diary and the plate-based tool to explore the use of the plate-based tool in assessing adherence to the CFG 2019.

Methods: This thesis includes three studies; a systematic review on concordance in diet, body mass index and type 2 diabetes among couples to investigate if cohabitating couples share health and health behaviours (Manuscript 1), a cross-sectional secondary analysis of diet data obtained from 42 participants to assess the agreement in food group portions and adherence to the CFG 2019 between the three-day food diary and the plate-based tool (Manuscript 2) and a cross sectional analysis of diet data from 33 couples to assess concordance in diet quality and adherence to the CFG 2019 among middle-aged/older adult couples (Manuscript 3). Pearson correlation, cross-classification, kappa score, paired t-test, Bland-Altman, chi-square and McNemar tests were performed to assess the agreement between the three-day food diary and the plate-based tool (Manuscript 2) and to assess concordance in adherence to the CFG 2019 among couples (Manuscript 3). Pearson correlation and paired t-test adjusted by partial correlation for body weight, energy intake, age, length of time in the relationship, depression and physical activity,

were conducted to assess concordance in diet quality, nutrient and food group portion intakes among couples (Manuscript 3). The Healthy Eating Index-Canada (HEI-C) 2010 was used to assess diet quality.

Results: In the systematic review, six out of nine studies found concordance among members in a couple for diet ($r=0.29$-0.48, $p<0.05$; OR=4.8-21.5, $p\leq0.01$), all studies found concordance in body mass index ($r=0.12$-0.41, $p<0.05$; HR=1.78-1.84, 95% CI= 1.32-2.44) and four out of five studies found concordance for type 2 diabetes (OR=1.35-2.11, 95% CI= 1.25-5.1; HR=1.34-1.48, 95% CI= 1.01-1.79) (Manuscript 1). In the second study, there was an agreement between the three-day food diary and the plate-based tool for protein and grain portions, however there was a lack of agreement for fruit and vegetable portions and for adherence to the CFG 2019 (Manuscript 2). In the third study, there was concordance among members in a couple for HEI-C scores (adjusted (Adj) $r=0.63$, $p<0.01$), fruits and vegetable (Adj $r=0.71$, $p<0.01$), protein (Adj $r=0.50$, $p=0.03$) and grain portions (Adj $r=0.67$, $p<0.01$). There was concordance among members in a couple for the majority of nutrient intakes (Adj $r=0.49$-0.68, $p<0.05$) except for protein (Adj $r=0.34$, $p=0.16$), added sugar (Adj $r=0.38$, $p=0.11$) and total fat (Adj $r=0.38$, $p=0.11$). There was concordance in adherence to the CFG 2019 among couples (Manuscript 3).

Conclusion: The general findings from this thesis suggest that couples share health and health behaviours. This thesis found that there was agreement between the three-day food diary and the plate-based tool, suggesting that either of these tools may be used to assess adherence to the CFG 2019. Cross-sectional dietary analysis showed that there is concordance in diet quality, nutrient and food group portion intakes as well as adherence

to the CFG 2019 among middle-aged/older adult cohabitating couples. In order to obtain more statistically meaningful and generalizable results, future studies should analyze concordance in diet quality and adherence to the CFG 2019 among a larger sample of couples including various ethnicities.

Résumé

Contexte : La littérature concernant les interventions en couple pour le changement d'habitude alimentaire est mixte. L'évaluation de la concordance alimentaire chez les couples pourrait guider le développement d'intervention en couple plus efficace en nous faisons mieux comprendre la manière dont les couples partagent les habitudes alimentaires. L'objectif principale de cette thèse est d'évaluer la concordance alimentaire chez les couples âgées pour la qualité de la diète et l'adhérence au guide alimentaire canadien 2019. Puisqu'il n'y a aucun outil pour évaluer les apports basés sur le nouveau guide, nous avons aussi exploré l'accord entre le journal alimentaire et l'outil de l'assiette pour déterminer l'adhérence au nouveau guide alimentaire canadien.

Méthode: Ce projet comprend trois études; une revue systématique de concordance pour l'alimentation, l'indice de masse corporelle et le diabète du type 2 chez les couples (Manuscrit 1), une analyse secondaire des données alimentaires de 42 participants pour évaluer l'accord entre le journal alimentaire et l'outil de l'assiette pour les portions et l'adhérence au nouveau guide alimentaire canadien (Manuscrit 2), et une analyse des données alimentaires de 33 couples pour évaluer la concordance alimentaire chez les couples âgés pour la qualité de la diète et l'adhérence au nouveau guide alimentaire canadien. Les tests de corrélation de Pearson, classification croisée, kappa score, t-test, Bland-Altman, chi carré et McNemar ont été effectués pour évaluer l'accord entre le journal alimentaire et l'outil de l'assiette (Manuscrit 2) ainsi que pour évaluer la concordance en adhérence au nouveau guide alimentaire canadien parmi les couples âgés (Manuscrit 3). La corrélation de Pearson et le t-test ont été effectués, en ajustant pour le

poids, l'apport calorique, l'âge, la durée de la relation, la dépression et l'activité physique, pour évaluer la concordance parmi les couples pour la qualité de la diète, les apports nutritionnels et les portions (Manuscrit 3). Le Healthy Eating Index-Canada (HEI-C) 2010 a été utilisé pour évaluer la qualité de la diète.

Résultats: Dans la revue systématique, six sur neuf études ont constaté une concordance parmi les couples pour l'alimentation ($r=0.29-0.48$, $p<0.05$; $OR=4.8-21.5$, $p\leq0.01$), toutes les études ont constaté une concordance en indice de masse corporelle ($r=0.12-0.41$, $p<0.05$; $HR=1.78-1.84$, 95% CI= 1.32-2.44) et quatre sur cinq études ont constaté une concordance en diabète du type 2 ($OR=1.35-2.11$, 95% CI= 1.25-5.1; $HR=1.34-1.48$, 95% CI= 1.01-1.79) (Manuscrit 1). Dans la deuxième étude, il y avait un accord entre le journal alimentaire et l'outil de l'assiette pour les portions de protéines et de produits céréaliers ainsi qu'un manque d'accord pour les portions de fruits et légumes et pour l'adhérence au nouveau guide alimentaire canadien (Manuscrit 2). Dans la troisième étude, il y avait une concordance parmi les couples pour la qualité de la diète (ajusté (Aju) $r=0.63$, $p<0.01$), les portions de fruits et légumes (Aju $r=0.71$, $p<0.01$), protéine (Aju $r=0.50$, $p=0.03$) et produits céréaliers (Aju $r=0.67$, $p<0.01$). Il y avait une concordance parmi les couples pour la majorité des nutriments (Aju $r=0.49-0.68$, $p<0.05$) sauf pour la protéine (Aju $r=0.34$, $p=0.16$), le sucre ajouté (Aju $r=0.38$, $p=0.11$) et le gras total (Aju $r=0.38$, $p=0.11$). Il y avait une concordance parmi les couples pour l'adhérence au guide alimentaire canadien 2019 (Manuscrit 3).

Conclusion: Les résultats de cette thèse suggèrent que les membres dans un couple partagent la santé et les comportements liés à la santé. Les résultats démontrent qu'il y a un accord entre le journal alimentaire et l'outil de l'assiette suggérant que ces outils

peuvent être utilisés pour évaluer l'adhérence au nouveau guide alimentaire canadien. Les résultats démontrent une concordance parmi les couples âgés pour la qualité de la diète, les apports nutritionnels, les portions et l'adhérence au guide alimentaire canadien 2019. Afin d'obtenir des résultats plus significatifs et généralisables, d'autres études devraient analyser la concordance pour la qualité de la diète et pour l'adhérence du guide alimentaire canadien parmi un plus grand échantillonnage incluant plusieurs ethnies.

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Contribution to knowledge

It is hypothesized that couple-based interventions should be more effective than individual-based interventions for health behaviour change, as there is an increase in social support when implicating the spouse. However, some studies show otherwise. Investigating concordance in diet quality among couples allows us to better understand how couples share overall dietary behaviours. This will in turn help guide the development of more effective couple-based interventions that aim to create health behaviour changes. A current limitation to analyzing diet quality concordance is that the majority of diet quality tools reflect the old Canada's Food Guide (CFG) 2007, which recommends a specific number of portions from each food group (based on age and sex) to be consumed daily (portion-based recommendations). Current diet quality tools do not reflect the new CFG 2019 guidelines, which depict a visual way of healthy eating (plate-based recommendations). Therefore, analyzing concordance in diet quality would give us diet concordance information reflecting the old guidelines. However, it would be more relevant to explore diet concordance information reflecting the new CFG 2019 as these are Canada's new guidelines.

This thesis is composed of three projects. The first project aims to investigate concordance in diet, body mass index (BMI) and type 2 diabetes among legally married or cohabitating couples through a systematic review. The second project aims to assess the agreement in food group portions and adherence to the CFG 2019 between three-day food diaries and a plate-based tool. The third project aims to assess preliminary data on diet concordance among middle-aged/older adult couples reflecting the CFG 2007 (*i.e.*,

concordance in diet quality) and the new CFG 2019 (*i.e.*, concordance in adherence to the new food guide).

Overall, this thesis aims to investigate diet concordance in a novel way as to our knowledge, concordance in diet quality (reflecting the CFG 2007) or in adherence to the new food guide (reflecting the CFG 2019) has never been analyzed between members of a couple. As mentioned above, diet concordance research can help better guide the development of couple-based interventions by optimizing them for dietary behaviour change. After adequate testing, newly designed couple-based lifestyle interventions can be incorporated and become mainstream in the dietetics practice.

Contribution of authors

This thesis was written under the supervision of my co-supervisors Dr. Tamara R Cohen and Dr. Hugues Plourde and my committee member Dr. Kristine G Koski. They provided guidance on the design of the research, data analysis and the interpretation and presentation of results. The systematic review (Manuscript 1) was written by myself as well as three undergraduate students from the University of British Columbia (Amy Dong, Dorothy Dinh and Elena Kwan). The three undergraduate students replicated the search queries in the databases, assisted with the evaluation of full-text articles based on the inclusion/exclusion criteria, verified the extracted information from the articles and helped evaluate the quality of the articles included in the review. I was responsible for data entry and analysis for Manuscript 2 and for Manuscript 3. Overall, I was responsible for the preparation and the writing of the thesis.

List of abbreviations

The following list of abbreviations are used in this thesis:

Adj	Adjusted
BMI	Body mass index
CFG	Canada's Food Guide
Ct	Uncertain responses
FD	Food diary
FPG	Fasting plasma glucose
FV	Fruits and vegetables
HEI	Healthy Eating Index
HEI-C	Healthy Eating Index-Canada
HR	Hazard ratio
IRR	Incidence rate ratio
LI	Literal food diary interpretation
MMAT	Mixed Methods Appraisal Tool
N	Negative responses
NA	Not available
OGTT	Oral glucose tolerance test
OR	Odds ratio
OR_{MP}	Matched-pairs odds ratio
PASE	Physical Activity Scale for the Elderly
PLPG	Post-load plasma glucose
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomized controlled trial
SSB	Sugar sweetened beverage
SD	Standard deviation
UN	Unliteral food diary interpretation
WHO	World Health Organization
Y	Positive responses

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CHAPTER 1

OVERVIEW OF THESIS

1.1 Thesis rationale

Over the years, the prevalence of obesity has been increasing in Canada [17]. In 2019, it was observed that the largest prevalence of obesity was among middle-aged/older adults (50-64 years) at 33.2% (a 1.9% increase from 2018) [18]. In 2020, Canada released the new Canadian Adult Obesity Clinical Practice Guidelines [19]. According to the United Nations, an older adult is defined as an individual that is 60 years or older [50]. Middle aged adults are defined as individuals aged 36-55 years [74]. These guidelines suggest that the first treatment option for obesity are behaviour change interventions that target improving nutrition and physical activity behaviours. According to the guidelines [19], these interventions, over time, lead to regaining 80% of the weight that was lost which may not be enough to improve obesity-related comorbidities. In fact, a meta-analysis that included 18 studies showed that most adults living with an overweight condition or obesity regained some of the weight that was lost after receiving a minimum of 6-months of either a diet-only or a diet-plus-exercise intervention [20]. Indeed, obesity is a complex disease that is multifaceted, where diet and physical activity modifications (*i.e.*, increasing physical activity, decreasing caloric intake) are only one of the many rooted causes [19]. However, a possible explanation for weight regain is that current behaviour change interventions for weight loss are individual-based [21]. Meaning, there is very limited instruction given on ways to modify the environment in which physical activity and eating occurs in order to promote weight-regulating behaviours [21].

It is known that an obesogenic home environment plays a role in obesity development. In this context, an "obesogenic home environment" refers to a home that

encourages unhealthy behaviours such as the intake of unhealthy foods and sedentary behaviour which in turn promotes obesity [22]. Specifically, the partner with whom we cohabitate may play a role in creating a home obesogenic environment because partners influence each other's health behaviours [23, 24]. In fact, research shows that when one partner adopts a healthier behaviour, this can promote health behaviour change in the other partner [25, 26]. Studies that have examined concordance for health such as body mass index [27, 28] and type 2 diabetes [29] as well as for dietary behaviours [24, 30, 31, 32] among couples supports this hypothesis that partners influence each other's health behaviours. However, specifically for diet concordance studies, many are limited because they analyze concordance for specific nutrients or food groups and not diet quality. Diet quality is a measure of adherence to a specific dietary pattern (*i.e.*, the CFG 2007) and is assessed using a point system from a diet quality tool (*i.e.*, the Healthy Eating Index-Canada 2010) [69]. Analyzing diet quality gives a more global perspective for measuring diet which may truly quantify the impact of diet on chronic disease outcomes [33]. This is because one consumes a wide variety of nutrients that are both protective and harmful which, when combined, can act synergistically or antagonistically [33, 34]. While there is some literature supporting the hypothesis that partners influence each other's health and health behaviours [24, 27, 28, 29, 30, 31, 32], other studies do not show concordance for diet [55, 56, 57], body mass index [60] and type 2 diabetes [67, 68]. Evaluating the literature by way of a systematic review may allow us to determine if members in a couple truly share health and health behaviours.

Based on the literature above that supports partners sharing health and health behaviours, couple-based interventions have the potential to be more effective than

individual-based interventions for dietary behaviour change. This is because couple-based interventions may be able to leverage spousal influence to change a partner's health behaviour [35]. As suggested by Bandura's social cognitive theory, behaviour change is influenced by our environment [107]. Therefore, having optimal spousal/social support in our environment can enhance self-efficacy and can facilitate behaviour change [107]. However, many studies show that couple-based interventions are not more effective for improving dietary behaviours when compared to individual-based interventions [36, 37, 38]. This may be due to the fact that the increase in social support that occurs by implicating the spouse in the intervention may not be enough to elicit optimal changes in health behaviour [35, 39]. Diet concordance studies among couples that focus on diet quality in addition to specific food groups or nutrients may be able to better guide the development of more effective couple-based interventions by increasing our understanding of how couples share overall dietary behaviours. After adequate testing, newly designed couple-based lifestyle interventions can be incorporated and become mainstream in the dietetics practice. As mentioned above, the largest prevalence of obesity in Canada was seen among middle-aged/older adults (50-64 years) in 2019 [18]. Therefore, this population would greatly benefit from these optimized couple-based interventions.

In 2019, Canada released a new plate-based food guide [2] which is quite different from the portion-based CFG 2007 [51]. Current diet quality tools are based on the old CFG 2007 guidelines and are not adapted to the new CFG 2019 plate-based guidelines. However, it would be relevant to obtain diet concordance information reflecting the new plate-based CFG 2019 guidelines as these are the most up-to-date guidelines. There are

currently no dietary assessment tools that exist to assess adherence to the new CFG 2019 guidelines. Finding agreement between the three-day food diary and a plate-based tool for food group portions and adherence to the new food guide would suggest that the plate-based tool (visual drawing of dietary intake) is reflecting similar information to a three-day food diary (written dietary intake). In this case, agreement would suggest that dietary intake assessed based on food groups (plate-based tool) amounts to similar findings and therefore can be used in dietary behaviour analysis (i.e., assessing dietary intakes for food groups and not for nutrient intakes). Therefore, a study that explores this type of analyses would allow researchers to determine if dietary intakes analysed by food groups are similar among members of a couple (i.e., diet concordance). Plate tools that resemble the CFG 2019 have been analyzed for their effect on nutrition knowledge [3, 4, 5, 6, 7], dietary behaviours [4, 8, 9, 10], food cost [11, 12] and weight loss [13]. The population's awareness of the US *MyPlate* tool has been studied [14, 15] as well as attitudes towards the plate tool [8, 16]. To our knowledge, no studies have compared a plate-based tool to a three-day food diary for assessing food group portion intakes and adherence to the CFG 2019.

1.2 Study objectives and hypotheses

Objective 1 (*Manuscript 1*):

To assess the published literature for concordance in diet, body mass index and type 2 diabetes among couples.

> **Hypothesis 1:** There will be a concordance in diet, body mass index and type 2 diabetes among couples.

Objective 2 (*Manuscript 2*):

To assess the agreement in food group portions and adherence to the new CFG 2019 between the three-day food diary and a plate-based dietary assessment tool.

Objective 3 (*Manuscript 3*):

To assess diet concordance data reflecting the old CFG 2007 guidelines (*i.e.*, diet quality) and the new CFG 2019 guidelines (*i.e.*, adherance to the new food guide) among middle-aged/older adult cohabitating couples living with an overweight condition or obesity.

> **Hypothesis 3:** There will be a concordance in diet quality and adherence to the new food guide among middle-aged/older adult cohabiting couples living with an overweight condition or obesity.

Before addressing these objectives, the following comprehensive literature review aims to discuss the various ways that the plate-based tool has previously been studied. This review will also discuss the differences between the new and the old CFGs and the various implications for these changes when it relates to dietary assessment. In addition, this review will briefly discuss the current evidence on couple concordance in diet, body mass index and type 2 diabetes and the various theories supporting this evidence. Finally, a review of the current evidence for the efficacy of couple-based interventions will be explored.

CHAPTER 2

LITERATURE REVIEW

2.1 Canada's Food Guide 2019 and current diet quality tools

There are many differences between the old CFG 2007 [51] and the new CFG 2019 [2]. Current diet assessment tools (*i.e.,* food records, food frequency questionnaires and 24-hour recalls) are more adapted and therefore suitable to use when assessing adherence to the old CFG (portion-based recommendations) as they require individuals to report the portions of all foods consumed [1]. However, in 2019, the new CFG has transitioned away from portion-based recommendations towards plate-based recommendations [2]. The new food guide focuses on the proportion of the plate that should be represented by each food group: ½ of the plate with fruits and vegetables, ¼ of the plate with whole grains and ¼ of the plate with protein foods [2]. This information is presented to the public as a visual representation of a healthy plate [2]. The guide emphasizes that vegetables, fruits, whole grains and protein foods should be consumed on a daily basis as these patterns of eating have been shown to be beneficial for health (*i.e.,* reduces the risk of cardiovascular disease) [2].

Given that Canada has changed to plate-based recommendations, diet quality assessment tools based on previous CFG versions are not adapted to the new CFG 2019 plate-based guidelines. Therefore, there are currently no dietary assessment tools that can assess adherence to the new CFG 2019. It would be relevant to try to find a dietary assessment tool that can assess adherence to the new guidelines as these are the guidelines that the population should adhere to.

2.2 Background: The plate as a nutrition education tool

2.2.1 MyPlate

The plate tool was developed at the beginning of the 1970's in Sweden to educate the public about nutrition, more specifically meal planning [40]. Since then, the US developed their own plate tool called *MyPlate* [41]. The *MyPlate* tool includes five food groups; vegetables, fruits, grains, and protein on the plate with dairy in a separate circle [41]. The main messages being to fill half of the plate with fruits and vegetables [41].

2.2.2 MyPlate: Food-purchasing and nutrition knowledge

The *MyPlate* tool has been associated with positive interventions. One study showed that *MyPlate* increased food-purchasing knowledge ($p<0.001$) among a Latina population [42] whereas others showed that *MyPlate* increased nutrition knowledge [3, 4, 5, 6, 7]. For instance, *MyPlate* increased knowledge about portions ($p<0.001$) (*i.e.*, being able to distinguish the difference between a portion and a serving size and being able to name three tips to control portions) among 264 mixed major university students who were peer taught by undergraduate nutrition majors about *MyPlate* [6]. These studies suggest that the plate tool is effective in improving nutrition knowledge which may allow individuals to make healthier choices.

2.2.3 MyPlate: Diet

Many studies analyzed *MyPlate* for its influence on dietary intake [4, 8, 9, 10]. One study showed that *MyPlate* increased fruit ($p<0.05$) and vegetable intake among 150 (18-24 years old) non-health major college students that received biweekly text messages of the *MyPlate* icon and the United States Department of Agriculture's Dietary Guidelines for seven weeks [4]. One limitation of this study was that the responses from the surveys for food intake were not validated with a validated dietary assessment tool

such as a three-day food diary. An alternative version of *MyPlate* called *Spice MyPlate* was created which focused on incorporating more spices and herbs to meals [8]. The study showed that it was a useful tool which created modest but significant improvements ($p<0.05$) for intakes of whole grain (31.2g/week) and protein foods (13.2oz/week) consumption among 110 students from grades nine to twelve [8]. One limitation of this study was that participants were taken from two schools and the results may therefore not be generalizable. One study, conducted among a nationally representative sample of 3194 adults > 18 years from the National Health and Nutrition Examination Survey (NHANES) dataset, showed that users of *MyPlate* had a significantly lower dietary energy density (1.8 vs 1.9 kcal/day, p=0.0003), consumed less refined grains (5.9 vs 6.5 oz equivalents/day, p=0.0007), added sugars (18 vs 21 tsp/day, p=0.0005) and solid fats (34 vs 39 g/day, $p<0.0001$) and consumed more whole grains (1.1 vs 0.8 oz equivalents/day, p=0.007) and dark green vegetables (0.2 vs 0.1 cups/day, p=0.006) after adjusting for age, sex, race or ethnicity, education, household size, family income, smoking status, beverage energy density, and physical activity [9]. One limitation of this study was that participants provided one day of dietary intake by way of a 24-hour recall which may not be representative of their usual intake. However, this study tried adjusting for this through a complex sampling method. The results from the studies above suggest that the plate tool is effective for improving dietary behaviours.

2.2.4 MyPlate: Weight loss

One study compared a calorie counting method versus a *MyPlate* intervention among 261 low-income patients for long-term weight loss after 12 months [13]. The calorie counting intervention consisted of patients carefully monitoring their energy

intake through calorie counting as well as increasing physical activity in order to achieve a daily energy deficit [13]. The *MyPlate* intervention consisted of changing the proportion of the plate reserved for each food group such as increasing the proportion of the plate reserved for fruits and vegetables [41]. The study results showed that both interventions improved satiety, however only the calorie counting intervention reduced hunger ($p=0.004$) [13]. Neither intervention produced a significant weight loss [13].

Waist circumference decrease significantly in both the *MyPlate* intervention ($p<0.01$) and the calorie counting intervention ($p=0.02$) [13]. There was a significant decrease in systolic blood pressure at 6-months for the *MyPlate* intervention, but not at 12-months [13]. One limitation of this study is selection bias as 33% of baseline participants were not included in the 12-month follow-up analyses. This study showed that using a plate tool instead of the traditional method of weight loss (*i.e.*, calorie counting) is not more effective for long term weight loss [13].

2.2.5 The Healthy Diabetes Plate

Another plate tool was developed in 2009 from the University of Idaho, *The Healthy Diabetes Plate*. It includes a quarter of the plate as starch, a quarter of the plate as lean protein and half of the plate as non-starchy vegetables as well as two separate circles representing fruit and milk/yogurt [44]. *The Healthy Diabetes Plate* focuses on educating individuals living with diabetes on how to properly plan their meals [45]. This plate produced a significant increase in fruit ($p=0.02$) and vegetable intake ($p=0.01$) [45] and allowed for individuals to better plan their meals [45, 46].

A study tested a program including the Idaho Plate Method on 22 adults living with type 2 diabetes with limited health literacy for improving dietary behaviours [47]. This study found a significant increase in fruit ($z = -1.98$, $p = 0.05$), vegetable ($z = -2.58$, $p=0.01$) and skim milk intakes ($z = -2.094$, $p=0.04$) at the 3-month follow-up. Participants reduced their intakes of french-fries and fried potatoes ($z = -2.26$, $p=0.02$), butter or margarine on bread or pancakes ($z = -2.494$, $p=0.01$), regular fat hot dogs ($z = -2.693$, $p<0.01$) and total fat intake ($z = -2.50$, $p=0.01$) [47]. In addition, there was a significant increase in participant's self-efficacy to prepare or share food with non-diabetics ($z = -3.10$, $p=0.002$), to make better food choices when hungry ($z = -2.72$, $p=0.006$), to reduce their portions at dinner ($z = -2.46$, $p=0.014$) and to add less fat in recipes ($z = -2.10$, $p=0.035$) [47]. There was a near significant difference between the hemoglobin A1c pre and post intervention ($p=0.055$) [47]. Another study evaluating a program including the Idaho Plate Method among 430 patients living with type 2 diabetes showed a statistically significant decrease in hemoglobin A1c ($p=0.012$), fasting blood sugar ($p=0.022$), body mass index ($p=0.001$) and albumin/creatinine ratio ($p<0.0001$) after 12 months [48]. Overall, these studies show that the plate tool is effective for improving dietary behaviours and diabetes management.

2.2.6 Other plate models

Other plate models have been developed and studied. For instance, The *Healthy Eating Plate* was developed by the Harvard T.H. Chan School of Public Health [43]. It includes 4 food groups; ¼ of the plate whole grains, ¼ of the plate healthy protein, ½ of the plate fruits and vegetables (majority vegetables) in addition to healthy oils and water as the beverage of choice [43]. This plate tool was found to improve migraine

management by reducing migraine frequency and disability [49]. The main limitation of this plate tool was that it has not been tested for improving dietary behaviours.

2.2.7 Summary of plate tools

Overall, the plate tool has been studied and has been used as a nutrition education tool. These studies showed that when the plate is being used as a nutrition education tool, it is effective for improving nutrition knowledge and improving dietary behaviours. The main gap in the literature is that the plate tool has never been studied/used as a dietary assessment tool. As mentioned in section 1.1 of this thesis, there are no dietary assessment tools that mirror the new guide. It would be relevant to study a plate-based tool (based on the CFG 2019) as a dietary assessment tool so that it can potentially be used to assess adherence to the new plate-based CFG 2019. Finding an agreement between the three-day food diary and a plate-based tool may possibly allow us to use the plate-based tool to assess dietary intake and determine adherence to the new plate-based CFG 2019.

2.3 Concordance in diet, body mass index and type 2 diabetes among couples and the Independence Theory

There are many studies that have investigated familial concordance in health and show that health concordance exists between parents and their children [52, 53, 54]. For example, studies have shown that father-son and mother-daughter dyads are often concordant for blood pressure levels and cholesterol [52, 54]. Although genetics influence concordance, their shared environment may also play a role [54].

Part of the current literature on behaviour concordance focuses on the impact of sharing a common living environment on health and health behaviour concordance,

specifically among cohabitating couples. In this context, couples are individuals that do not share any genetic links [54]. It is proposed that partners influence each other's health behaviours [25, 26, 58].

The Interdependence Theory may explain how partners in a couple influence each other's health behaviours [24, 35]. It suggests that in a dyad, one partner's behaviour is not free from the influence of the other partner's behaviour and this can be health-compromising or health-enhancing [23, 24]. The theory further suggests that when one partner interprets their partner's health behaviour as meaningful for the relationship, they may adopt this behaviour [24]. Therefore, when an individual adopts a healthy behaviour, their partner is more likely to also adopt this behaviour [58]. In addition, couples tend to have a similar level of readiness to change health risk behaviours and have more confidence in their ability to change if their partner is ready to change [26, 59]. Therefore, behavioural change interventions may be more successful in couples where both partners change together (*i.e.,* couple-based interventions) [26].

An indicator of partner influence that is included in the Interdependence Theory is *correspondence/concordance* which is defined as the degree of agreement in health behaviours among couples [23, 24, 35]. Partner influence may explain why health is often similar among spouses. For instance, many studies show concordance among couples for body mass index [27, 28, 60, 61] and an increased risk of one spouse being classified as living with obesity if the other is living with obesity [62]. Furthermore, longitudinal studies have shown that spouses' weight trajectory is similar over time [61, 63]. In addition, studies show concordance for diseases such as diabetes [29, 64, 65, 66]. Indeed, genetics plays a role in the development of diabetes [29], however other factors such as

environment and behavioural/lifestyle behaviours (i.e., physical activity practices and dietary intake) influence the expression of the genetic risk for diabetes [29].

Research shows that couples who share a common living environment also share health behaviours, such as have similar dietary intake [30, 31, 32]. For instance, a European study demonstrated that the within-pair correlation was moderate for percentage of calories coming from dietary fat among spouses (n=802 couples; r=0.37, $p< 0.0001$) [30]. In addition, one study from the US explored concordance in fruit and vegetable intake among 231 spouses between the ages of 45-75 years [31]. This study found that when one partner met the ideal fruit and vegetable intake goal of ≥3 servings/day, the other partner had greater odds of also meeting that goal showing strong odds of concordance among spouses (OR= 4.8, 95% CI= 2.5-9.3, p=0.01) [31]. While diet concordance studies exist [30, 31, 32, 55, 56, 57], they are limited because they analyze concordance for specific nutrients or food groups and not diet quality. Analyzing diet quality is a valid measure for diet in order to truly quantify the impact of diet on chronic disease outcomes [33]. This is because one consumes a wide variety of nutrients that are both protective and harmful which, when combined, can act synergistically or antagonistically [33, 34].

Overall, there is evidence to suggest that members in a couple share health (*i.e.*, body mass index and type 2 diabetes) and health behaviours (*i.e.,* dietary intake). However, it is important to consider that the literature on concordance in diet [55, 56, 57], body mass index [60] and type 2 diabetes among members in a couple [67, 68] is conflicting. Evaluating the literature by way of a systematic review may allow us to

determine if members in a couple truly influence each other's health and health behaviours.

2.4 The Healthy Eating Index-Canada 2010

Specific to diet quality, Jessri, Ng, & L'Abbé (2017) [69] created the Healthy Eating Index-Canada (HEI-C) 2010 scoring criteria based on the HEI-2010 scoring criteria [70]. The HEI-C 2010 reflects the serving sizes and the age and sex-specific recommendations of the CFG 2007 [51]. The HEI-C score ranges between zero to 100, with higher scores meaning a better diet quality [69]. The total score is calculated by the addition of an eight-component adequacy (should be consumed in adequate amounts to achieve optimal health) and a three- component moderation (to be limited in the diet to achieve optimal health) sub-scores [69].

One study evaluated the validity and reliability of the HEI-C 2010 for assessing diet quality using a nationally-representative sample of Canadian adults [69]. In this study, dietary intake was assessed using two 24-hour recalls and face validity of the tool was confirmed by the consistent associations between the index score and the lifestyle and socioeconomic profile of the participants as hypothesized. For example, older women taking a multivitamin that engaged in physical activity and did not smoke were more likely to obtain higher scores [69]. In addition, index internal reliability was confirmed with a high standardized Cronbach's coefficient α value of 0.78 [69]. One of the limitations of the HEI-C 2010 is that it does not take into account energy intake in its scoring criteria [69]. As a result, overconsumption of calories can lead to a higher index score [69]. However, when energy intake and measurement errors were controlled for,

closer adherence to the CFG 2007, as assessed by the HEI-C 2010, was associated with better diet quality and reduced risk of obesity [69]. Therefore, energy intake is a factor that must be taken into consideration when using this tool for diet analysis.

2.5 Couple-based interventions

As previsouly mentioned, based on the current literature that explores partner influence and diet/health concordance among couples that cohabitate, couple-based interventions should be more effective than individual-based interventions for dietary behaviour change. However, some studies show otherwise. For instance, a randomized controlled trial (RCT) randomized patients living with obesity and diabetes (n=49) with their spouses also living with obesity (n=49) to either a "together" (subjects and spouses treated together) or "alone" (subjects treated alone) behavioural weight control program intervention for 20 weeks [36]. Dietary intake was assessed using a three-day food diary [36]. This study found a significantly greater reduction in caloric intake (lower overall caloric intake) in the "alone" condition compared to the "together" condition (1306 vs. 1382 kcal/d, $p<0.05$, respectively) and no differences were found between conditions for changes in fat intake ($p>0.10$) posttreatment [36]. For the spouse, there were no statistically significant differences between conditions for change in caloric ($p>0.10$) and fat intake ($p>0.10$) posttreatment [36]. Another RCT randomized adults living with hypertension (n=107) and a household partner to either an active or passive partner condition for 30 weeks to evaluate the effects of social support on success with adherance to a dietary sodium restriction (≤80mmol/day) [37]. Using 24-hour urine collections to analyzed for sodium content (reflecting sodium intake), this study found that the type of

support from the partner (passive or active) did not influence adherence to the sodium restriction over time among patients (F-value=0.1, p=0.711).

One RCT randomized 80 patients diagnosed with coronary artery disease or had a significant cardiac event/intervention and their spouse/intimate partner (married or cohabitating) to either a couple-based or individual-based intervention for 18 months [38]. The aim of the study was to investigate if a couple-based intervention is more effective for eliciting changes in health behaviours (*e.g.,* dietary behaviours) [38]. The individual-based group received nutrition, exercise & medication information [38]. The couple-based intervention group received nutrition, exercise & medication information with the additional components of communication strategies, social support strategies, & general couples issues [38]. Twenty-four-hour recalls were used to obtain information about total energy, saturated fat and sodium intake [38]. This study showed that there were no significant changes over time or between the two groups for any of the nutrients analyzed.

Once again, couple-based interventions should be more effective for dietary behaviour change, however the studies mentioned above show otherwise. This may be due to the fact that the majority of couple-based intervention studies focus on increasing social support from the spouse [36, 37, 38] which may not be enough to elicit optimal changes in health behaviours [35, 39]. Other limitations of the studies that may have impacted the results are that there could have been some discrepancies between the subjects' actual and reported intake (poor intake assessment) [36]. Another important limitation is that the passive (alone) and active partner (couple-based) conditions could not be created effectively [37]. This is because among some couples, the passive partner

(which was not intended to participate) tried to actively participated in the nutrition sessions which created a couple-based condition instead of an alone condition [37]. In addition, there were no changes found for certain nutrients (*i.e.*, calories and sodium) which may have been caused by the long lag time (up to 36 months) between the intervention and the cardiac event [38]. Meaning that dietary changes may have already been made before the intervention began and may have plateaued during the time of the intervention [38]. Furthermore, this study had sufficient power (power=0.80) to detect large effect sizes only (d~ .65) [38]. This made is difficult to determine the absence of meaningful treatment condition effects in comparison to the lack of power to detect the effects [38].

Bridge statement 1

The literature review of this thesis briefly discussed the current literature on couple concordance in diet, body mass index and type 2 diabetes and the various theories supporting this concordance. It also explained that there is some conflicting evidence. The following chapter will explore this topic in more detail through a systematic literature review in order to form an overall conclusion in regards to concordance research.

CHAPTER 3

CONCORDANCE IN DIET, BODY MASS INDEX AND TYPE 2 DIABETES AMONG COUPLES: A SYSTEMATIC LITERATURE REVIEW

(MANUSCRIPT 1)

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3.1 Abstract

Background: Couple concordance is defined as the degree of agreement between partners who cohabitate for health behaviours. There are many studies that have found concordance among couples for health and health behaviours, however the literature is conflicting. The aim of this review is to investigate concordance in diet, body mass index and type 2 diabetes among legally married or cohabitating couples.

Method: This systematic review followed the PRISMA guidelines. Literature searches were conducted using PubMed, Web of Science, Scopus and FSTA databases. Studies that were unavailable in English, meta-analyses and systematic reviews were excluded. A total of 22 eligible research articles were identified.

Results and Conclusion: Six out of nine studies found concordance among members in a couple for diet ($r=0.29$-0.48, $p<0.05$, $OR=4.8$-21.5, $p\leq0.01$), eight out of eight studies found concordance in body mass index ($r=0.12$-0.41, $p<0.05$, $HR=1.78$-1.84, 95% CI= 1.32-2.44) and four out of five studies found concordance for type 2 diabetes ($OR=1.35$-2.11, 95% CI= 1.25-5.1, $HR=1.34$-1.48, 95% CI= 1.01-1.79). It is unclear if couple-based interventions are more effective than individual-based interventions for health behaviour change and this review contributes to the growing body of literature. The concordance results from this review suggest that we should continue to research couple-based interventions as partners in a couple do share health and health behaviours. However, based on the current knowledge gaps and limitations of the studies included in this review, further concordance research is required.

3.2 Introduction

There are many studies that have investigated familial concordance in health conditions and show that health concordance exists between parents and their children [52, 53, 54]. More specifically, studies have shown that father-son and mother-daughter dyads are the most concordant for blood pressure levels and cholesterol [52, 54]. Although genetics influence concordance within a family unit, shared environment may also play a role [54].

Current literature focuses on the impact of sharing a common living environment on health and health behaviour concordance, specifically among couples. In this context, couples are individuals that do not share any genetic links [54]. Research shows that couples who share a common living environment also share health behaviours such as dietary intake [30, 31, 32]. However, the evidence is conflicting. For instance, some studies show dietary concordance for certain nutrients or food groups and not for others among a Taiwanese population (n=82 couples) [55] and an American population (n=111 couples) [56]. On the other hand, diet concordance was not found for any food groups among another Taiwanese population (n=901 couples) [57].

A possible explanation for the shared health behaviours among couples whom cohabitate is that spouses influence each other's health behaviours [25, 26, 58]. The Interdependence Theory provides a framework that explains how partners in a couple may influence each other's health behaviours [24, 35]. It suggests that in a dyad, one partner's behaviour is not free from the influence of the other partner's behaviour and this can be health-compromising or health-enhancing [23, 24]. The theory further suggests

that when one partner interprets their partner's health behaviour as meaningful for the relationship, they may adopt this behaviour [24]. Therefore, when an individual adopts a healthy behaviour, their partner is more likely to also adopt this behaviour [58]. In addition, couples tend to have a similar level of readiness to change health risk behaviours and have more confidence in their ability to change if their partner is ready to change [26, 59].

An indicator of partner influence that is included in the Interdependence Theory is *correspondence/concordance*, which is defined as the degree of agreement in health behaviours among couples [23, 24, 35]. Partner influence explains why health is often concordant among spouses. For instance, many studies show concordance among couples for body mass index [27, 28, 60, 61] and an increased risk of one spouse being classified as living with obesity if the other is living with obesity [62]. Furthermore, longitudinal studies have shown that spouses' weight trajectory is similar over time [61, 63]. On the other hand, one study, through a series of cross-sectional surveys, showed that the body mass index correlation decreases with marriage duration [60].

The sharing of a common living environment and health behaviours among couples may also explain why studies show concordance for diseases such as diabetes [29, 64, 65, 66]. Indeed, genetics plays a role in the development of diabetes [29], however other factors such as environment and behavioural/lifestyle behaviours (i.e., physical activity practices and dietary intake) influence the expression of the genetic risk for diabetes [29]. Interestingly, the literature on the concordance between couples and development of diabetes are mixed [67,68].

Based on the current literature for partner influence and couple concordance for health and health behaviours, couple-based interventions should be more effective than individual-based interventions for health behaviour change. This is because couple-based interventions may be able to leverage partner influence to change a partner's health behaviour [35]. However, studies show that couple-based interventions are not more effective for changing dietary behaviours [36, 37, 38]. The current conflicting literature for diet, body mass index, and diabetes concordance among couples does not encourage further research on couple-based interventions and therefore a review of the literature is warranted. Conducting this review will present the overall evidence for concordance among couples which do not share any genetic links [54] and therefore will provide insight about the environmental factors (*i.e.*, spousal/partner influence) that may influence health behaviour change. Finding evidence for concordance in diet, body mass index and type 2 diabetes among couples in this review can encourage further research and the potential use of couple-based interventions which may be more effective for health behaviour change [58]. This may subsequently affect the incidence of chronic diseases affected by health behaviours, such as obesity [100] and type 2 diabetes [29] among couples. Therefore, the aim of this paper is to investigate concordance in diet, body mass index and type 2 diabetes among couples that are legally married or cohabitate. The literature is divided into three categories: diet concordance, body mass index concordance and type 2 diabetes concordance.

3.3 Method

3.3.1 Search strategy

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [75]. Online literature searches were conducted in the PubMed, Web of Science, Scopus and FSTA databases. Keywords for each category analyzed (*i.e.*, diet, body mass index, or type 2 diabetes) **(Table 1)** were used in three separate search queries. Each search query also included the words couple* or spouse* or dyad* or married or newlywed or "mother-father dyad". When searches revealed a results list of greater than 200, the additional words concord* or cohabit* or "liv* together" were added to further narrow the search. Restrictions included date (1960-2020) and article type (review articles or journal articles) for all databases. Only research articles published in peer-reviewed journals were included. A reverse search was conducted on the articles found in the databases. All search processes began in December 2020 and the last search was conducted in April 2021 by three other reviewers who replicated the search queries mentioned above. The search queries were able to be replicated on all databases mentioned above except for Scopus as the three other reviewers did not have access to this database. This systematic review is registered with Prospero (CRD42021286202A).

3.3.2 Eligibility criteria

Peer-reviewed literature was collected based on the following inclusion criteria: concordance among couples had to be the focus of the study, the article had to explore concordance for either one of the following: diet or body mass index or type 2 diabetes, couples needed to be legally married or cohabitating with both partners alive, the article needed to be available in English, articles needed to have been published between 1960-2020, food frequency questionnaires needed to be used to collect information about

nutrient or food group intakes (diet concordance articles only), the effect size needed to be reported as incidence rate ratio (IRR), hazard ratio (HR), beta values, odds ratio (OR) or correlation coefficient and the definition of obesity needed to be BMI≥30kg/m^2 (body mass index concordance articles only). Studies that were not available in English, systematic reviews and meta-analyses were excluded from this review.

The study criteria were limited to legally married or cohabitating couples with the goal of determining how a shared environment with a spouse can affect dietary behaviours and health. In addition, the study criteria were limited to studies using food frequency questionnaires to collect dietary data. Food frequency questionnaires are not as accurate as food records for capturing the details and the quantity of the food and beverages consumed [73]. Therefore, making these two tools very different for measuring dietary intake. In order to allow for the uniformity of the results in this review, only the studies using food frequency questions were included. The main outcome of the diet concordance studies included in this review was to find diet concordance for specific food groups or nutrient intakes.

3.3.3 Selection of studies

All articles retrieved from the databases were screened by title and abstract by one reviewer. After the initial screening, full-text articles were evaluated independently by four reviewers. Studies were excluded based on the eligibility criteria. A reverse search was conducted on the systematic reviews and meta-analyses. One reviewer screened the title and abstracts and four reviewers independently evaluated the full-text articles based on the inclusion/exclusion criteria.

3.3.4 Data extraction

Data extraction was conducted by one author and was independently verified by three authors. The following data were extracted and put into an excel spreadsheet: author, year of publication, geographical location/country, study objectives, methods (*i.e.*, study design & sample), results and strengths/limitations.

3.3.5 Quality assessment

The quality assessment of included articles was guided by the Mixed Methods Appraisal Tool (MMAT) [76], and was independently conducted by four reviewers (**Table 2**). This tool was used to assess the methodological quality of the studies included in this review as it was used in previous systematic reviews [77, 78]. The tool includes two general screening questions (i.e., 1. Are there clear research questions? 2. Do the collected data allow to address the research questions?). There are five additional questions corresponding to the specific study design of the article being assessed. In this review, all studies were non-randomized. Therefore, the questions were: 1. Are the participants representative of the target population? 2. Are measurements appropriate regarding both the outcome and intervention (or exposure)? 3. Are there complete outcome data? 4. Are the confounders accounted for in the design and analysis? 5. During the study period, is the intervention administered (or exposure occurred) as intended? **Table 2** presents the final scores in addition to the number of negative and positive scores that the majority (i.e., 3 out of 4 or all reviewers) of reviewers voted for each study. Positive (Y) responses counted for 20%, uncertain (Ct) responses counted for 10% and negative (N) responses counted for 0%. All articles scored 60% or higher. The overall methodological quality score was 100% for 10 articles, 80-90% for 9 articles, and 60-

70% for 3 articles. This means that the majority of the studies have sound methodologies, however they still have some limitations.

3.4 Findings

3.4.1 General study characteristics

Figure 1 shows the PRISMA [75] flow diagram of the selection of studies. The search queries mentioned above were independently conducted by four reviewers. However, three out of the four reviewers did not have access to the Scopus database. Therefore, the initial search queries conducted with the Scopus database were not verified by three reviewers. Initially, the search identified a total of 1136 articles from all databases. After duplicates were removed, 671 articles remained, out of which 637 articles were excluded during the screening process conducted by one reviewer. Of the 34 articles that remained, 18 articles were excluded upon full-text screening conducted by four reviewers independently; eight did not focus on concordance of diet, body mass index or type 2 diabetes, four full texts were not available, three did not present the effect size as an IRR, HR, beta value, OR or correlation coefficient, one was removed as the obesity criteria was not defined as a BMI≥30kg/m^2, one did not collect diet information using a food frequency questionnaire and one had a member of the couple that was deceased. This resulted in 16 articles remaining in addition to six articles found through reverse searches. Thus, a total of 22 articles were included in this review; nine for diet concordance, eight for body mass index concordance and five for type 2 diabetes concordance.

3.4.2 Couple concordance: Dietary intake

Six out of nine studies in this review found diet concordance among couples (**Table 3**). For instance, a European study demonstrated that the within-pair correlation was moderate for percentage of calories coming from dietary fat among spouses ($r=0.37$, $p< 0.0001$) [30]. Another study from the US that measured the degree of concordance among prostate cancer survivors and their spouses for fruit and vegetable consumption showed a positive correlation ($r = 0.42$, $p < 0.001$) [24]. In addition, one study from the US measuring the probability of one partner meeting the ideal fruit and vegetable intake goal (≥3 servings/day) found that the other partner was at a greater odds of also meeting that goal, showing a strong odd of concordance among spouses (OR= 4.8, 95% CI= 2.5-9.3, p=0.01) [31]. In addition, one study conducted in a rural Ecuadorian village (Atahualpa) showed that the odds of a spouse having a poor diet (OR= 21.5, 95% CI= 4.5-101.6, $p < 0.001$) were significantly greater when the other spouse had a poor diet after adjusting for age [32].

Conversely, one study conducted in Taiwan demonstrated that out of all the nutrients investigated **(Table 3)**, only saturated fat ($r= 0.29$, $p<0.05$) was significantly correlated between husbands and wives [55]. This study suggests that the low correlation for nutrient intakes (except for saturated fat) between husbands and wives can be attributed to a high eating out frequency. Another study also showed a positive association for portions of certain foods among mother-father dyads such as fruits/vegetables ($r = 0.363$, $p < 0.001$) and fast-food ($r = 0.476$, $p < 0.001$), however it did not find a significant correlation for the consumption of other foods such as sugar sweetened beverages (SSBs) ($r = 0.125$, $p = 0.199$) [56]. On the other hand, another study from Taiwan did not show any degree of concordance for dietary intake among spouses

(n=901 couples) [57]. This study showed that husbands were less likely to report intakes (in servings) of high-fiber food ($OR_{Matched\ Pairs\ (MP)}$ =0.30, p < 0.0001), fish (OR_{MP} =0.74, p = 0.0128), biscuits or cakes (OR_{MP}= 0.60, p < 0.0001), and fast food (OR_{MP}= 0.65, p = 0.01) compared with their wives. This study also found no significant OR_{MP} for red meat intake (OR_{MP} =1.17, p=0.2286), processed food intake (OR_{MP} =1.07, p=0.6041) or high-fat food intake (OR_{MP} =0.84, p=0.1707) among spouses. These results may be biased by social desirability bias which occurs when participants state that they eat healthy foods in order to positively portray themselves [57].

Two studies from Hawaii found concordance in dietary intake among spouses, however the statistical significance of these results was unclear as there were no p-values reported [79, 80]. For example, one study demonstrated concordance (r=0.33-0.55) between husbands and wives for many foods (**Table 3**) [79]. The other study showed spousal-pair correspondence for all nutrients analyzed (**Table 3**) using intraclass correlation (r=0.35 to 0.59) and Spearman's rank correlation (r=0.45 to 0.59) for absolute nutrient intake [80]. In this same study, the intraclass correlation adjusted for body weight (r=0.41 to 0.76) showed that, with the exception of vitamin C, spousal concordance in nutrient intake was higher when adjusted. On the other hand, Spearman's rank correlation that was adjusted for body weight (r=0.42 to 0.57) did not show higher concordance [80].

3.4.3 Couple concordance: Body mass index

Eight out of eight studies in this review found concordance in body mass index among couples **(Table 4)**. For instance, one study showed a significant correlation for body mass index among spouses from the UK (R(0)=0.407, p<0.01) [28]. Furthermore,

one Japanese study found a significant correlation for body mass index among full-time male employees of a large company and their wives ($r=0.13$, $p<0.01$) [81]. Another study demonstrated that body mass index is positively associated among Mexican-American spouses ($r =0.19$, $p<0.001$) [82]. In agreement, an additional study found a significant concordance in body mass index among men with coronary heart disease and their spouses ($r=0.23$, $p=0.003$) [27]. An Australian study that analyzed correlations for body mass index among spouses based on marriage duration showed that the overall estimated (from 0 to greater than 40 years of marriage) correlation for body mass index was 0.12 which was statistically significant ($p<0.001$) after adjusting for age and sex [60]. This study also demonstrated decreasing correlations in body mass index as marriage duration increased, however this trend was not statistically significant ($p=0.14$). Another study conducted a cross-sectional (adjusted for age) and a retrospective longitudinal (adjusted for age and baseline body mass index of both spouses) analysis of body mass index concordance among spouses from the Minneapolis–St. Paul metropolitan area over a two-year period [63]. This study showed that participant and spousal body mass indices were positively associated and statistically significant for both men and women ($p< 0.001$), but were modest in magnitude (unstandardized $\beta = 0.12$ for men and 0.14 for women). This study also showed that body mass index trajectory among spouses was significantly associated for both men and women (both $\beta = 0.11$) after two years [63]. Furthermore, a Canadian study that analyzed cross-sectional and longitudinal data over 7-years showed that there were significant body mass index spousal correlations for both the cross-sectional observations ($r=0.17$, $p<0.05$) and 7-year follow up ($r=0.17$, $p<0.05$) after adjusting for age [61]. One study investigated body mass index trajectories among

spouses over 25 years and found that a 1-unit increase in the body mass index of either spouse was associated with a $\beta = 0.10$ unit increase in the husband's body mass index (95% CI= 0.09-0.12) and a $\beta = 0.15$ unit increase in the wife's body mass index (95% CI=0.13-0.18) after adjusting for age, time between visits, race, study site, employment, educational level, smoking status, calorie intake, cardiovascular diet score, alcohol intake, leisure and sport physical activity level, coronary heart disease, hypertension, diabetes, cancer, and lung disease [83]. This study also showed that non-obese partners at baseline whose spouses became obese after 25 years had a higher risk of becoming obese, for both men (HR= 1.78, 95% CI= 1.32-2.41) and women (HR=1.84, 95% CI=1.35-2.44), after adjusting for baseline body mass index.

3.4.4 Couple concordance: Type 2 diabetes

Four out of five studies included in this review found concordance among couples for type 2 diabetes **(Table 5)**. One study from London showed that spouses of patients with type 2 diabetes have a significantly increased risk of type 2 diabetes (OR= 2.11, 95% CI= 1.74–5.1) compared to a spouse of an individual with no diabetes after adjusting for body mass index and age of the patient [64]. Similarly, an Iranian study found that after more than 15 years of follow-up, having a husband with diabetes was associated with an increased risk of type 2 diabetes (HR= 1.34, 95% CI= 1.01-1.79, $p<0.05$) for the wife after adjusting for age [84]. However, there were no significant associations found for diabetes risk among husbands of wives living with type 2 diabetes [84]. Another longitudinal study analyzing diabetes concordance among spouses living in the US found that adults who had a spouse living with diabetes at baseline had an increased risk for diabetes compared to those without a spouse living with diabetes after a

median follow up of 22 years (HR =1.48, 95% CI= 1.30–1.67) [29]. Another study found that Chinese individuals whose spouses were living with diabetes were more likely to have diabetes (for men OR= 1.35, 95% CI= 1.25-1.47; for women OR= 1.37, 95% CI= 1.27-1.48) compared to individuals whose spouses were not living with diabetes [85].

One study from England found contradicting results [68]. This study showed that having a spouse living with diabetes was not statistically significantly associated with a greater risk of type 2 diabetes among men (IRR= 1.02, 95% CI= 0.64-1.65, p = 0.92) or women (IRR= 1.40, 95% CI= 0.95-2.08, p = 0.09) after a median follow up of 11.5 years. This study explains their findings by suggesting that couples tend to share health behaviours over time which can lead to the development of the same risk factors for type 2 diabetes (i.e., obesity). However, different underlying physiological predispositions for type 2 diabetes between the spouses may result in only one spouse developing the disease [68].

3.5 Discussion

Overall, the studies included in this review provide evidence to support concordance among members in a couple for diet (six out of nine studies), body mass index (all studies) and type 2 diabetes (four out of five studies). This suggests that partners share health and health behaviours which is in line with the Interdependence Theory [24, 35]. Meyler, Stimpson & Peek (2007) [54] found similar results in their systematic review as their review demonstrates that there is concordance for dietary behaviours among couples [54]. Couple-based interventions for health behaviour change (*i.e.*, improving dietary habits) have the potential to be more successful than individual-based interventions and evidence from this review suggests that we should continue

researching these types of interventions. However, due to the cross-sectional nature of the majority of studies included in this review, we cannot infer that couple-based interventions are more effective for creating changes in dietary intake in comparison to individual-based interventions.

Six out of nine studies in this review found diet concordance among members of a couples. Nonetheless, there are important limitations to consider. For instance, many studies analyzed concordance for specific nutrients or food groups but not overall diet quality. Analyzing the entire diet quality is a more effective method for quantifying the true impact of diet on chronic disease outcomes [33]. This is because one consumes a wide variety of nutrients that are both protective and harmful which when combined, can act synergistically or antagonistically [33, 34]. Another limitation of the diet concordance studies in this review is that they used food frequency questionnaires to collect dietary intake data. Some food frequency questionnaires used in the studies asked participants to recall food intake during the previous week [24, 79, 80] or even in the previous year [31, 55] which may be difficult to recall. Using a food record to gather data may be a better option because participants record their food as it is being consumed, thereby reducing the chance of forgetting certain foods [73]. In addition, some studies analyzed diet concordance among specific populations such as prostate cancer survivors and their spouses [24] or used a convenience sample [55], therefore making the results not generalizable. Furthermore, diet concordance has never been studied among a Canadian population. Future studies should analyze diet quality among Canadian couples focusing on a wide variety of participants. In addition, future studies should consider using a tool that relies less on recollection of food intake, such as food records [73], to collect data.

Eight out of eight studies in this review found a concordance for body mass index among members in a couple. Some studies are not generalizable to the general public as they focused only on older Mexican-American adult couples [82], only included heterosexual couples [83], primarily included Caucasian couples (90% of study population) [27] or only focused on couples where husbands were working at a specific manufacturing plant and their wives mostly stayed at home [81]. Future studies should investigate body mass index concordance among diverse populations, especially immigrants, as there is evidence suggesting that their lifestyles in regards to health may differ from native-born residents [82, 88]. In addition, there should be more studies investigating correlations in BMI among same sex couples to see if they would differ from the correlations among heterosexual couples. Weight changes may differ among men and women and may be more similar among the same gender. Furthermore, some studies did not include lifestyle characteristics such as diet [61, 81, 82] and physical activity [81] in their analyses which can affect spousal concordance for body mass index [61]. Therefore, future studies should ensure to include these confounding variables in their analyses. Furthermore, a weaker relationship was seen among the men participants and their spouses in comparison to the women participants and their spouses for body mass index possibly because the participants needed to report their spouses' height and weight at baseline and at follow-up [63]. There is evidence to support that women are able to accurately report their spouses' height and weight [89], however there is a lack of evidence of this for men [63]. Therefore, it is possible that men are less accurate in reporting their spouse's weight [63]. Future studies should thus encourage participants and their spouses to report their own height and weight or simply have direct measures.

Four out of five studies in this review found a concordance for type 2 diabetes among members in a couple. The studies for type 2 diabetes in this review have limitations. Some studies included specifically Chinese [85] or Iranian couples with at least one child [84], thus results may not be generalized to all couples or to other nationalities. In addition, some studies did not consider diet [29, 64, 68, 84] in their analysis. However, it would be important to consider this factor because previous studies show similarities among couples for dietary intake [30, 31, 32]. Furthermore, some studies did not consider marital duration [64, 68, 84] and therefore the effect of shared lifestyle habits on diabetes similarities among couples could not be evaluated [84]. For one of the studies, there were no significant associations found for diabetes risk among husbands of wives living with type 2 diabetes, however there was a significant association found for diabetes risk among wives of husbands living with type 2 diabetes [84]. This study explains that the sex difference could possibly be due to the dominant role of men in Iranian families. For example, men are in control of the foods that are brought into the home [90]. In addition, Iranian husbands often forbid their wives from cycling or doing other outdoor physical activities [91]. Future studies should investigate the impact of gender roles in diabetes concordance among spouses [84]. In addition, future studies should investigate type 2 diabetes concordance among diverse nationalities and should control for dietary intake and marital duration as confounders.

For some of the studies [79, 80], the statistical significance of the findings was unclear because there were no p-values or confidence intervals provided. This made it difficult to draw conclusions. Future studies should clearly report the statistical significance of their findings.

One limitation of the review process was that three out of the four reviewers did not have access to the Scopus database. Therefore, the initial search queries conducted with the Scopus database were not verified by three reviewers. Another limitation was that the scores for the quality assessment of the articles may have been biased by the fact that most of the studies were cross-sectional and they therefore all received the answer "yes" for question five (During the study period, is the intervention administered (or exposure occurred) as intended?). Future systematic reviews should consider choosing studies with a variety of study designs to limit this issue.

3.6 Conclusion

The studies included in this review demonstrate evidence for concordance in diet, body mass index and type 2 diabetes among members in a couple. Results from this review suggest that we should continue to research couple-based interventions as these interventions have the potential to be more effective than individual-based interventions for health behaviour change. This is because partners in a couple share health and health behaviours. However, based on the current knowledge gaps and limitations of the studies included in this review, further concordance research is required.

Table 1. Keywords for diet, body mass index and type 2 diabetes for search query

Diet	"food habit*" OR "food choice*" OR "diet* quality" OR "food intake" OR "diet* resemblance" OR "beverage intake" OR "dietary intake" OR "nutrient intake" OR "dietary assessment" OR "food consumption" OR "food preferences" OR "dietary habit*" OR "dietary practice*" OR "diet* concordance" OR nutrition OR diet* OR "healthy eating index" OR sugar OR fat OR energy OR fruit* OR vegetable*
Body mass index	obes* OR overweight OR "body mass index"
Type 2 diabetes	diabetes OR “diabetes mellitus” OR “type 2 diabetes” OR “blood sugar” OR “blood glucose” OR glucose OR glycemia

Table 2. Quality assessment of diet, body mass index and type 2 diabetes concordance studies

Article	Screening questions[1]		Other questions[2]					Score
	1	2	1	2	3	4	5	
Kolonel & Lee (1981) [79]	Y	Y	Y	Y	Y	Y	Y	100%
Lee & Kolonel (1982) [80]	Y	Y	Y	Y	Y	Y	Y	100%
Lyu et al. (2004) [55]	Y	Y	N	Y	Y	Ct	Y	70%
Di Castelnuovo et al. (2007) [30]	Y	Y	Y	Y	Y	Y	Y	100%
Virtue et al. (2015) [24]	Y	Y	Y	Y	Y	Y	Y	100%
Erqou et al. (2018) [31]	Y	Y	Y	Y	Y	Y	Y	100%
Del Brutto & Mera (2019) [32]	Y	Y	Y	Y	Y	Y	Y	100%
Figueroa et al. (2020) [56]	Y	Y	Y	Y	Y	Y	Y	100%
Shih et al. (2020) [57]	Y	Y	Ct	Y	Y	Y	Y	90%
Knuiman et al. (1996) [60]	Y	Y	Ct	Y	Ct	Ct	Y	70%
Katzmarzyk et al. (1999) [61]	Y	Y	Y	Y	Y	N	Y	80%
Macken et al. (2000) [27]	Y	Y	Y	Y	Y	Ct	Y	90%
Jeffery & Rick (2002) [63]	Y	Y	Y	N	Y	Y	Y	80%
Stimpson et al. (2006) [82]	Y	Y	Y	Y	Y	N	Y	80%
Okuda et al. (2014) [81]	Y	Y	N	Y	Y	N	Y	60%
Cobb et al. (2015) [83]	Y	Y	Y	Y	Y	Y	Y	100%
Davillas & Pudney (2017) [28]	Y	Y	Y	Y	Y	Y	Y	100%
Khan et al. (2003) [64]	Y	Y	Y	Y	Y	N	Y	80%
Sun et al. (2016) [85]	Y	Y	Y	Y	Y	Y	Y	100%

Nielsen et al. (2018) [68]	Y	Y	Y	Y	Y	N	Y	80%
Ramezankhani et al. (2019) [84]	Y	Y	Y	Y	Y	N	Y	80%
Appiah et al. (2019) [29]	Y	Y	Y	Y	Y	N	Y	80%

Positive (Y) responses count for 20%, uncertain (Ct) responses count for 10% and negative (N) responses count for 0%.

[1]**Screening questions:** 1. Are there clear research questions? 2. Do the collected data allow to address the research questions?

[2]**Other questions:** 1. Are the participants representative of the target population? 2. Are measurements appropriate regarding both the outcome and intervention (or exposure)? 3. Are there complete outcome data? 4. Are the confounders accounted for in the design and analysis? 5. During the study period, is the intervention administered (or exposure occurred) as intended?

Table 3. Chronological order of diet concordance articles

Year	Author	Number of couples (Age range)	Study design [a]	Diet data analyzed	Concordant?
1981	Kolonel & Lee [79]	281 (all ages)	C	Processed meat, beef, pork, poultry, salted fish, other fish, eggs, rice, pickled vegetables, raw vegetables & fresh fruit (number of times/week)	Unclear[b]
1982	Lee & Kolonel [80]	1428 (≥ 45 years)	C	Calories, total protein (g), animal protein (g), total fat (g), animal fat (g), carbohydrate (g), cholesterol (mg), vit C (mg) & vitamin A (IU) (weekly nutrient intake)	Unclear
2004	Lyu et al. [55]	82 (23-73 years)	C	Energy, fat, protein, carbohydrate, fiber, animal protein, plant protein, animal fat, plant fat, dietary fiber, saturated fat, monounsaturated fat, polyunsaturated fat & cholesterol (Chinese food frequency questionnaire, portions based on 1000kcal)	Yes, but only for saturated fat (acceptable correlation r= 0.29, $p<0.05$)
2007	Di Castelnuovo et al. [30]	802 (25-74 years)	C	Percent of calories from fat (EPIC semi-quantitative food	Yes (acceptable correlation r=0.37, $p< 0.0001$)

				frequency questionnaire)	
2015	Virtue et al. [24]	132 (≥18 years)	C	Fruits/vegetables (computed into a dichotomous variable (yes/no) indicating whether the individual met recommended weekly guidelines).	Yes (acceptable correlation r = 0.42, $p < 0.001$)
2018	Erqou et al. [31]	231 (45-75 years)	C	Prime Screen questionnaire, classified individuals as having an ideal (≥3 servings/day) or intermediate-poor (<3 servings/day) consumption of fruits and vegetables.	Yes (OR= 4.8, 95% CI= 2.5-9.3, p=0.01)
2019	Del Brutto & Mera [32]	268 (≥ 40 years)	C	Classified as ideal (4-5 healthy components), intermediate (2-3 healthy components) and poor (0-1 healthy component); based on 5 health dietary components (≥4.5 cups fruits and vegetables/day, ≥3.5-oz servings fish/week, ≥three 1-oz equivalent servings fiber-rich whole grains/day, <1,500 mg sodium/day, and ≤450 kcal sugar-sweetened beverages/week).	Yes (OR= 21.5, 95% CI= 4.5-101.6, $p < 0.001$)

2020	Figueroa et al. [56]	111 (NA)	C	Fruit/vegetable, fast food, & SSBs[c] (frequency of consumption in the past 7 days: 0 = never, 1=once per week, 2=2–4 times per week, 3=nearly daily or daily, 4=2–4 times per day, or 5 = 5 or more times a day)	Fruits/vegetables (acceptable correlation r = 0.363, p < 0.001) and fast-food (acceptable correlation r = 0.476, p < 0.001), however not for SSBs (poor correlation r = 0.125, p = 0.199)
2020	Shih et al. [57]	901 (majority >50 years)	C	Vegetables/fruits, fish, red meat, processed food, biscuits or cakes, high-fat food, & fast food ("Have you had fiber food intake in the past one month?" If the answer was 'always' or 'often', then this dietary behavior was coded as being present. If the answer was 'sometimes', 'seldom', or 'never', then the dietary behavior was coded as not being present)	No

[a] C indicates cross-sectional data were used, L indicates longitudinal data were used

[b] Unclear indicates that statistical significance for the results was unclear in the study (no p-values or confidence intervals were provided)

[c]SSBs: Sugar sweetened beverages

Good correlation ≥0.50, acceptable correlation 0.20-0.49, poor correlation <0.20 [72]

Table 4. Chronological order of body mass index concordance articles

Year	Author	Number of couples (Age range/mean age)	Study design [a]	Method of collecting height & weight information	Concordant?
1996	Knuiman et al. [60]	2,836 (mean age husbands: 48.7 & wives: 45.2 years)	C	Measured	Yes (poor correlation r=0.12, p<0.001)
1999	Katzmarzyk et al. [61]	376 (20-69 years)	C & L	Measured	Yes (cross-sectional and 7-year follow up: poor correlation r=0.17, p<0.05)
2000	Macken et al. [27]	177 (mean age spouses: 58.2 +/- 9.3 & patients: 61.9 +/- 8.5 years)	C	Self-reported	Yes (acceptable correlation r=0.23, p=0.003)
2002	Jeffery & Rick [63]	2528 (mean age: late 30s)	C & L	Measured for participants & reported for spouses	Yes (β = 0.12 for men and 0.14 for women, p< 0.001)
2006	Stimpson et al. [82]	553 (65-94 years)	C	Unclear	Yes (poor correlation r =0.19, p<0.001)
2014	Okuda et al. [81]	756 (40-65 years)	C	Unclear	Yes (poor correlation r=0.13, p<0.01)
2015	Cobb et al. [83]	3,889 (45–65 years)	L	Measured	Yes (β = 0.10 unit increase in the husband's BMI (95% CI= 0.09-0.12) and a β = 0.15 unit increase in the wife's BMI (95% CI=0.13-0.18)

2017	Davillas & Pudney [28]	4308 (mean age husband: 51.2 & wives: 48.7 years)	C	Unclear	Yes (acceptable correlation R(0)=0.407, p<0.01)

[a] C indicates cross-sectional data were used, L indicates longitudinal data were used

Good correlation ≥0.50, acceptable correlation 0.20-0.49, poor correlation <0.20 [72]

BMI: Body mass index

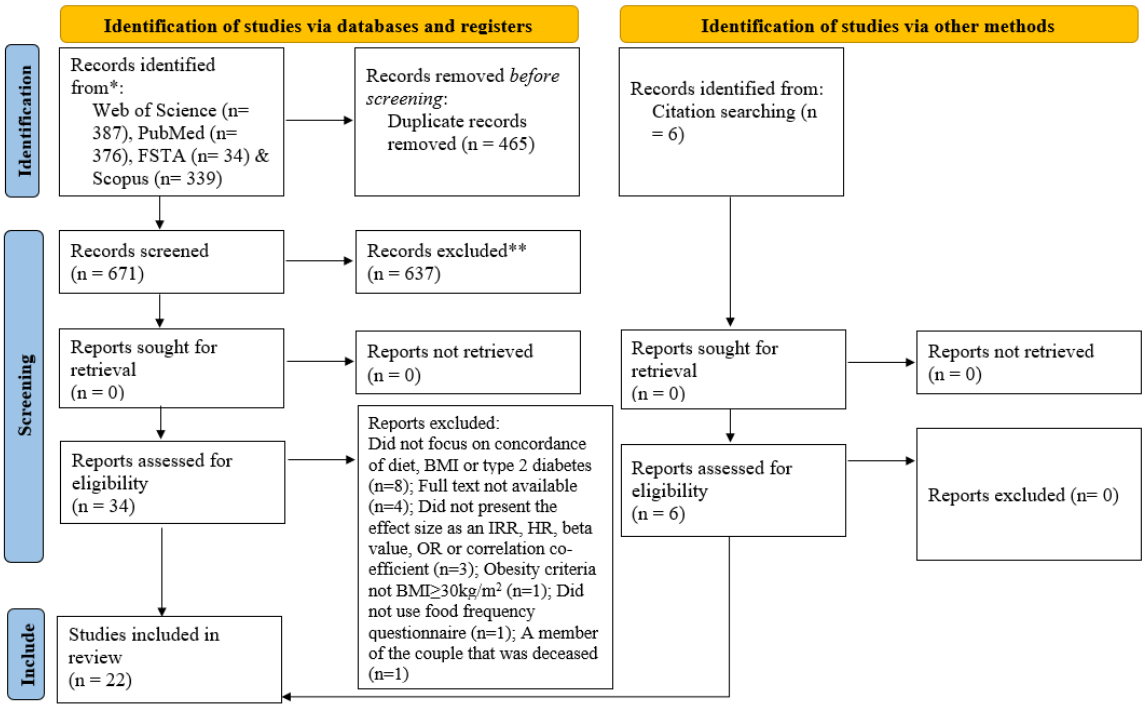
Table 5. Chronological order of type 2 diabetes concordance articles

Year	Author	Number of couples (Age range/mean age)	Study design [a]	Method of identifying diabetes	Concordant?
2003	Khan et al. [64]	479 (mean ages of diabetic patients & their spouses: 57.6 +/- 7.4 years)	C	≥2 fasting plasma glucose levels >7.0 mmol/l or random plasma glucose levels >11.1 mmol/l, and type 2 diabetes defined by the lack of absolute requirement for insulin, absence of ketonuria, and treatment with adequate control without insulin for at least 6 months from diagnosis of diabetes	Yes (OR= 2.11, 95% CI= 1.74–5.1)
2016	Sun et al. [85]	34,805 (≥ 40 years)	C	WHO 1999 criteria: 1) self-reported physician's diagnosis of diabetes or receipt of antidiabetic medications or 2) fasting plasma glucose measurement of ≥7.0 mmol/L or 3) OGTT 2-hour plasma glucose measurement of ≥ 11.1 mmol/L	Yes (for men OR= 1.35, 95% CI= 1.25-1.47; for women OR= 1.37, 95% CI= 1.27-1.48)

2018	Nielsen et al. [68]	7127 (mean age men: 60 & women: 59 years)	L	Self-reported or screen-detected based on FPG (≥7.0 mmol/l) or hemoglobin A1c (≥6.5%)	No (men IRR= 1.02, 95% CI= 0.64-1.65, p = 0.92; women IRR= 1.40, 95% CI= 0.95-2.08, p = 0.09)
2019	Ramezankhani et al. [84]	3785 (≥20 years)	L	FPG ≥7mmol/l or 2h-PLPG ≥11.1mmol/l or using glucose-lowering medication	Yes, but only if husband has diabetes (HR= 1.34, 95% CI= 1.01-1.79, p<0.05)
2019	Appiah et al. [29]	8077 (45-64 years)	L	FPG ≥7.0 mmol/L, non–fasting blood glucose ≥ 11.1 mmol/L, self reported physician diagnosis of diabetes, or reported current use of antidiabetic medication	Yes (HR =1.48, 95% CI= 1.30–1.67)

[a] C indicates cross-sectional data were used, L indicates longitudinal data were used

Figure 1. PRISMA flow diagram[3]



[3]PRISMA flow diagram for the selection of studies. The majority of studies were selected from the databases and six were selected through reverse search. Overall, 22 aricles were included in this review.

Bridge statement 2

To date, different plate tools have been used in research to explore their effect on nutrition knowledge [3, 4, 5, 6, 7], dietary behaviours [4, 8, 9, 10], food cost [11, 12] and weight loss [13]. The population's awareness of the US *MyPlate* tool has been studied [14, 15] as well as attitudes towards the plate tool [8, 16]. To our knowledge, no studies have compared a plate-based tool to a three-day food diary for assessing food group portion intakes and adherence to the CFG 2019.

The literature review explained how the HEI-C 2010 diet quality tool was developed based on the CFG 2007 and is validated. However, there are currently no diet quality tools that have been developed to reflect the new CFG 2019 plate-based guidelines. Therefore, analyzing concordance in diet quality among couples will allow us to obtain diet concordance information reflecting the old CFG 2007 guidelines. However, it would be relevant to obtain information about diet concordance among couples reflecting the new CFG 2019 guidelines as these are the guidelines that Canadians should now be adhering to.

The following chapter includes a secondary analysis of cross-sectional dietary intake data from a qualitative study which enrolled 42 healthy middle-aged/older adults ages 50 or older living in Montreal, Qc. Multiple tests, including Pearson coefficient, cross-classification, kappa score, paired t-test, Bland-Altman, chi-square and McNemar tests, were performed to assess the agreement between the three-day food diary and the plate-based tool for food group portions and adherence to the CFG 2019. Findings from this study allowed us to use the three-day food diary to assess adherence to the CFG 2019

and subsequently assess concordance in adherence to the CFG 2019 among members of a couple in Manuscript 3. This allowed us to obtain diet concordance information reflecting the new CFG 2019 guidelines.

CHAPTER 4

ASSESSING THE AGREEMENT BETWEEN THE THREE-DAY FOOD DIARY AND THE PLATE-BASED TOOL FOR INTAKES OF FOOD GROUP PORTIONS AND ADHERANCE TO THE CANADA'S FOOD GUIDE 2019

(MANUSCRIPT 2)

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4.1 Abstract

Background: The 2019 Canada's Food Guide (CFG) is now depicted as a plate and has transitioned away from portion-based recommendations. Dietary assessment tools (*i.e.*, three-day food diaries) are often based on portions, which do not reflect the new plate-based recommendations of the CFG 2019. The aim of this study was to assess the agreement between the three-day food diary and the plate-based tool for food group portion intakes and adherence to the CFG 2019.

Methods: This study was a secondary analysis of cross-sectional dietary intake data from a qualitative study which enrolled 42 healthy middle-aged/older adults ages 50 or older. Participants recorded their dietary intake using the three-day food diary for three non-consecutive days for one week and then using the plate-based tool for three days the following week. Multiple tests, including Pearson coefficient, cross-classification, kappa score, paired t-test, Bland-Altman, chi-square and McNemar tests, were performed to assess the agreement between the three-day food diary and the plate-based tool for food group portions and adherence to the CFG 2019.

Results: The majority of the tests conducted received an acceptable or good agreement result for the protein (six out of seven tests) and grain portions (five out of seven tests). The majority of the tests received a poor agreement result for fruit and vegetable portions (five out of seven tests) and for adherence to the CFG 2019 (four out of five tests).

Conclusion: There was an agreement between the three-day food diary and the plate-based tool for protein and grain portions, however there was a lack of agreement for fruit and vegetable portions and for adherence to the CFG 2019. This study suggests that while

there are limitations, three-day food diaries or simply the plate-based tool itself can be used to assess adherence to the new CFG 2019.

4.2 Introduction

The 2007 version of the Canada's Food Guide (CFG) recommended a specific number of portions from each food group, based on age and sex, to be consumed daily (*e.g.,* eight portions of fruits and vegetables/day for females aged 19-30 years) [51]. Current diet assessment tools (*i.e.,* food records, food frequency questionnaires and 24-hour recalls) are suitable to the old CFG (portion-based recommendations) as they require individuals to report the portions of all foods consumed [1]. However, the new CFG, released in 2019, has transitioned away from portion-based recommendations towards plate-based recommendations [2]. For instance, the new food guide focuses on the proportion of the plate that should be represented by each food group: ½ of the plate with fruits and vegetables, ¼ of the plate with whole grains and ¼ of the plate with protein foods [2]. This information is presented to the public as a visual representation of a healthy plate [2]. The lack of dietary assessment tool adapted to the new food guide makes it difficult to assess dietary intake and subsequently adherence to the new CFG 2019. Agreement between the three-day food diary and the plate-based tool for food group portions and adherence to the new food guide would suggest that the three-day food diary reflects similar information to the plate-based tool. This may allow us to use three-day food diary or simply the plate-based tool itself to assess dietary intake and subsequently assess adherence to the new CFG 2019 plate-based guidelines.

Plate tools have been analyzed for their effect on nutrition knowledge [3, 4, 5, 6, 7], dietary behaviours [4, 8, 9, 10], food cost [11, 12] and weight loss [13]. The population's awareness of the *MyPlate* tool has been studied [14, 15] as well as attitudes towards the plate tool [8, 16]. To our knowledge, the plate tool has never been compared to a three-

day food diary for assessing food group portion intakes and adherence to the new CFG 2019. Therefore, the objective of this study is to assess the agreement between a three-day food diary and a plate-based tool for food group portions and adherence to the new CFG 2019.

4.3 Method

4.3.1 Study design

This study is a secondary analysis of cross-sectional dietary intake data from a qualitative study which enrolled 42 participants. The initial study used a cross-over study design to test the usability of a traditional three-day food diary compared to a simplified plate tool based on the CFG 2019 among healthy middle-aged/older adults living in Montreal, QC [71]. The methods of this study have been described previously [71]. Eligibility criteria included adults aged 50 years and older with access to a computer and the technology required to use Zoom [71]. All participants provided informed consent [71]. Ethics was approved by Concordia University (certificate number 30012869) [71].

4.3.2 Data collection

Participants completed online demographic questionnaires including questions pertaining to age, gender, height, weight, education, cultural background, marital status, and income level [71]. All participants recorded their dietary intake using the traditional three-day food diary for three non-consecutive days for one week and then using the plate-based tool for three non-consecutive days the following week [71]. This plate-based tool is based on the new CFG 2019 and is mostly used, at the moment, as a self-monitoring tool. It allows individuals to visually track their dietary intake. In this study,

participants were provided a booklet that had blank circles. They were asked to draw the proportion of their plate that was filled with each food group (*i.e.,* fruits and vegetables, protein or grains) for every meal and snack over three non-consecutive days. All participants received training from a registered dietitian on how to use both tools via Zoom [71]. All completed three-day food diaries and plate tools were collected [71].

4.3.3 Dietary assessment

As shown in **Table S1,** the reported intake from the three-day food diary was translated into portions from the CFG 2007 (**Figure 2**) in order to determine the number of portions consumed per day for each food group (*i.e.,* fruits and vegetables, meat and alternatives, milk and alternatives and grains products). All of the portions on **Figure 2** equal to one food guide portion. The new CFG 2019 has three food groups (*i.e.,* fruits and vegetables, grains and protein foods) instead of four food groups like the CFG 2007 (*i.e.,* fruits and vegetables, meat and alternatives, milk and alternatives and grains products) [51]. Therefore, the translated CFG 2007 portions were then categorized into the three food groups of the CFG 2019 (*i.e.,* fruits and vegetables, grains and protein foods) by putting the meat and alternative and the milk and alternative portions together to form the protein portion (**Table S1**). The mean number of portions from each food group from the CFG 2019 (*i.e.,* fruits and vegetables, grains and protein foods) per day was calculated over three days of intake.

The three-day food diaries were analyzed in two ways; unliteral and literal interpretations (**Table 6**). This was done because at times it is difficult to determine if a specific food should count as a portion from the CFG. The unliteral interpretation of the three-day food diary was more lenient in terms of food items that were considered as part

of the CFG, whereas the literal interpretation was stricter. For instance, some individuals may believe that proteins (*i.e.,* cold cuts, cured meats like prosciutto, salami, sausage) and healthy desserts (*i.e.*, oatmeal cookies) should be included as portions from the food guide because they are good sources of protein and fibre. Therefore, these foods were counted as portions of protein and whole grains in the unliteral interpretation of the food diary. However, these foods were not counted as portions of protein or whole grains in the literal interpretation of the food diary as they are high in sugar, fat and sodium (A rubric was followed as described in **Table 6**).

Figure 3 shows how the new CFG 2019 plate recommendations can be converted into portions from the CFG 2007. Looking at **Figure 2**, we can see that one portion of protein (*i.e.,* 75g meat) or one portion of grain (*i.e.,* one slice of bread) fits in a quarter of the CFG 2019 plate. Furthermore, looking at **Figure 2**, we can see that two portions of fruits and vegetables (*i.e.,* 2 cups of leafy greens vegetables) fits in half of the CFG 2019 plate. The plate can therefore be organized into proportions of 2:1:1 and we interpreted that for every two CFG 2007 portions of fruits and vegetables, there should be one CFG 2007 portion of protein and one CFG 2007 portion of grain. Based on this assumption, a standard plate information to CFG 2007 portion translation system was created (**Table S2**). As shown in **Table S3**, this translation system (**Table S2**) was used to translate data drawn on the plate tool into portions from the CFG 2007 by assuming that a quarter of the plate equaled one CFG 2007 portion from any food group**.** It was assumed that the participant did not fill their plate completely with food if there was empty space left in the plate tool drawing. A portion was therefore not counted for that section of the plate. It is important to note that both the plate tool and the three-day food diary used this same

translation system (1/4 of the plate equaled to one portion, ½ of the plate equaled to two portions, ¾ of the plate equaled to 3 portions and the whole plate equaled to 4 portions) and therefore used the same references for portion size from the CFG 2007. The CFG 2007 portions were then categorized into the three CFG 2019 food groups (*i.e.*, fruits and vegetables, protein and grains) (**Table S3**). The mean number of portions from each food group from the CFG 2019 (*i.e.,* fruits and vegetables, protein and grains) per day was calculated based on three days of intake.

Based on the mean number of portions consumed per day from the CFG 2019 food groups (*i.e.,* fruits and vegetables, protein and grains), adherence to the new CFG 2019 was assessed for both the food diaries and the plate tools by a registered dietitian (SS). This was based on two questions: "Is the greatest number of mean portions per day coming from the fruits and vegetables group?" and "Are the number of mean grain portions and mean protein portions per day equal?" A scoring system was created (**Table S4**) in order to represent different levels of adherence. The answer of "no" to both questions means no adherence (food diary or plate tool received a score of 1). The answer of "yes" to one of the two questions (food diary or plate tool received a score of 2) or "yes" to both questions (food diary or plate tool received a score of 3) means adherence to the new food guide. These questions were created based on the main principles of the new CFG 2019 which demonstrates that: ½ of the plate (i.e., majority) should be filled with fruits and vegetables, ¼ of the plate should be filled with whole grains and ¼ of the plate should be filled with protein foods [2].

4.3.4 Statistical analysis

To assess the agreement between the three-day food diary and the plate-based tool for the food group portions and adherence to the CFG 2019, the analyses presented here followed those performed by Lombard et al [72]. Specifically, Pearson correlation, chi-square, McNemar, cross-classification and kappa score tests were performed for both the food group portion and the adherence analysis. The Bland-Altman and the paired t-test were performed only for the food group portion analysis and not for the adherence analysis as these tests are not suitable for categorical data.

The Pearson correlation analysis was used to determine if food group portion intakes/adherence is correlated between the food diary and the plate-based tool (*i.e.,* if the grain portion increases for the food diary, does it increase for the plate-based tool?). Agreement between the food diary and the plate-based tool was considered good (G), acceptable (A) or poor (P) based on the following criteria: good, $r \geq 0.50$; acceptable, r=0.20-0.49; poor, $r < 0.20$. Categorical analyses (*i.e.,* chi-square, McNemar, cross-classification and kappa score) were performed with the goal of determining if the three-day food diary and the plate-based tool demonstrate similar results for classifying individuals as having an overall high or low adherence to the CFG 2019 (adequate or inadequate dietary intake). By separating the data into tertiles, the first category was defined as $\leq 33^{rd}$ percentile, the second category was defined as being between the 33^{rd} and the 66^{th} percentile and the third category was defined as $\geq 66^{th}$ percentile. Agreement was determined based on the following criteria: chi-square (good, $p \leq 0.05$; poor, $p > 0.05$), McNemar (good, $p > 0.05$; poor, $p \leq 0.05$), cross-classification (good, ≥50% in the same tertile and ≤10% in opposite tertile; poor, <50% in same tertile and >10% in opposite tertile) and kappa score (good, ≥0.61; acceptable, 0.20-0.60; poor, <0.20). The Bland-

Altman test was used to identify systematic differences between the food group portions from the food diary and the plate-based tool (*i.e.,* fixed bias or outliers). Agreement was determined based on the following criteria: good, $p>0.05$; poor, $p\leq0.05$. The paired t-test was used to determine if the mean absolute portion intakes from each food group from the food diary is similar to the mean absolute portion intakes from the plate-based tool. Agreement was determined based on the following criteria: good, $p>0.05$; poor, $p\leq0.05$.

The total number of poor results were calculated. If the majority of the tests (at least four out of seven tests for the food group portions or three out of five tests for adherence) receive a result of poor, this means that there is a lack of agreement between the food diary and the plate-based tool [72]. If the majority of the tests (at least four out of seven tests for food group portions or three out of five tests for adherence) receive a result of acceptable or good, this means that there is an agreement between the food diary and the plate-based tool [72]. All analyses were performed in SPSS version 27 (IBM Inc, Armonk, NY) with p values <0.05 considered statistically significant.

4.4 Results

Analyses included the dietary data of 42 participants. **Table 7** presents participant characteristics. The mean (standard deviation) age of the participants was 63.5 ± 5.3 years [71]. The mean (standard deviation) body mass index of the participants was 26.1 ± 4.8 kg/m^2 [71]. The majority of participants were white (88%), had a university degree (76%), were married or in a domestic partnership (69%) and 60% reported an annual household income of ≥ $ CAD 75, 000 [71].

Given that the unliteral and literal interpretations of the food diary presented similar results, all data presented here are for the literal interpretation unless stated otherwise.

Results for assessing the agreement in food group portions between the three-day food dairy and the plate-based tool are presented in **Table 8**. Pearson correlations for fruits and vegetables ($r=0.49$, $p<0.01$), grain ($r=0.47$, $p<0.01$) and protein ($r=0.40$, $p<0.01$) resulted in an acceptable agreement. The cross-classification test for fruits and vegetables (45% same tertile and 14% opposite tertile) resulted in a poor agreement. The cross-classification test for grain (50% same tertile and 12% opposite tertile) resulted in a good agreement for the same tertiles and a poor agreement for opposite tertiles. The cross-classification test for protein (55% same tertile and 5% opposite tertile) resulted in a good agreement. The kappa score for fruits and vegetables (0.18, $p=0.10$) resulted in poor agreement whereas it resulted in an acceptable agreement for grain (0.25, $p=0.02$) and protein (0.32, $p<0.01$). The chi-square test for fruits and vegetables ($p=0.26$) resulted in a poor agreement whereas it resulted in a good agreement for grain ($p=0.05$) and protein ($p<0.01$). The McNemar test for fruits and vegetables ($p=0.75$), grain ($p=0.92$) and protein ($p=0.25$) resulted in good agreement. The paired t-test for all food groups ($p<0.01$) resulted in poor agreement. The Bland-Altman test for fruits and vegetables ($p<0.01$) resulted in poor agreement whereas it resulted in a good agreement for grain ($p=0.1$) and protein ($p=0.88$). The majority of tests resulted in an acceptable (A) or good (G) agreement for protein (six out of seven tests) and grain (five out of seven tests) portions. However, five out of seven tests (the majority) had a result of poor (P) agreement for the fruit and vegetable portions. This implies that there is agreement

between the three-day food diary and the plate-based tool for grain and protein portions, however not for fruits and vegetable portions.

Results for assessing the agreement in adherence scores to the new CFG 2019 between the three-day food dairy and the plate-based tool are presented in **Table 9**. The Pearson correlation (r=0.16, p=0.31), kappa score (0.19, p=0.07), chi-square (p=0.17) and McNemar tests (p=0.02) resulted in a poor agreement. The cross-classification test (50% were in the same tertile and 9.5% were in opposite tertiles) resulted in a good agreement. Overall, four out of five tests (the majority) resulted in poor (P) agreement implying that there is a lack of agreement between the three-day food diary and the plate-based tool for estimating adherence to the CFG 2019.

4.5 Discussion

This study aimed to assess the agreement between a three-day food diary and a plate-based tool for food group portions and adherence to the new CFG 2019. There is a lack of diet assessment tools that are suitable to the new CFG 2019 making it difficult to assess dietary intake and adherence to the new CFG 2019 plate-based guidelines. Agreement between the three-day food diary and the plate-based tool for food group portions and adherence to the CFG 2019 may allow us to use the three-day food diary or simply the plate-based tool itself to assess adherence to the new CFG 2019. The agreement between the three-day food diary and the plate-based tool for protein and grain portions found in our study suggests that the food diary is reflecting some similar information to the plate-based tool. However, the lack of agreement between the three-day food diary and the plate-based tool for fruit and vegetable portions and for adherence

to the CFG 2019 suggests that the food diary and plate-based tool may be limited if we were to use them to assess adherence to the new food guide. It is important to consider that the lack of agreement for fruit and vegetable portion intakes between the plate tool and the three-day food diary may have allowed for a lack of agreement in adherence to the new CFG 2019 between the three-day food diary and the plate-based tool. This is because one of the two questions to assess adherence to the new food guide pertains to the fruits and vegetable intake (*i.e.*, is the greatest number of portions per day coming from the fruits and vegetables group?).

4.5.1 Strengths

The findings from this study highlight how the plate-based tool may be used as a dietary assessment tool to assess adherence to the new food guide in the dietetics practice which would be much simpler to use among patients/clients than a three-day food diary. One study that explored the perceptions of healthy middle-aged/older adults (n=45) with regards to the usability of a traditional three-day food diary compared to a plate-based tool (based on the CFG 2019) found that 62% of participants preferred using the plate as a self-monitoring tool to change their dietary habits as it is “easy”, “visual” and “quick” [71]. Therefore, if we were to implement a plate-based dietary assessment tool in the dietetics practice, clients/patients may be more willing to adhere to the idea of drawing their dietary intake instead of recording it using words and measurements.

4.5.2 Limitations

A limitation of the plate-based tool used in this study is that it is two-dimensional. This means that when using the assumption of a quarter of the plate equals to one food

guide portion from any food group, we are assuming that participants are not overflowing their plates (placing more than one portion in the quarter of the plate). For instance, participants could have drawn their fruit and vegetable portion (*i.e.,* berries) as occupying a quarter of the plate (therefore assumed as one portion of fruit and vegetable for our analysis), however we do not know the height at which the berries were pilled onto the plate (could have been two portions in reality). In addition, some individuals may not put certain foods on their plate (*i.e.,* fruit) which may lead to forgetting to report this food item on the plate tool. This could explain the lack of agreement for the fruit and vegetable portions between the plate-based tool and the three-day food diary in our study. Another limitation of the plate-based tool is that it requires participants to have adequate knowledge of which foods fit into each food group. In the study [71], participants were instructed by a registered dietitian on which foods fit in each food group, however errors were apparent when participants recorded their food intake using the plate-based tool. For instance, some participants put milk in the beverage section instead of in the protein section of the plate. In addition, some participants put nuts and seeds in the "other foods" group instead of the protein section of the plate. Indeed, our analysis shows an agreement for protein portions between the plate tool and the three-day food diary, however this issue can affect the results of future studies that test the agreement between the three-day food diary and the plate-based tool. Therefore, proper training of individuals is crucial for the proper use of the plate-based tool.

This study has its limitations. Firstly, the three-day food diary and the plate-based tool were completed on two different weeks and not on the same days. Therefore, it was assumed in this study that participants consume the same quantity of food from each food

group, on average, per week. It is important to note that we cannot confirm that the participants were weight stable. Meaning, some participants may have been gaining or losing weight which could have affected dietary intake on a weekly basis (*i.e.*, increasing or decreasing caloric intake). This could have affected the results because participants may have been eating more in one week and less in the other week. As a results, this could explain the lack of agreement for the fruit and vegetable intakes between the plate-based tool and the three-day food diary in our study because the fruits and vegetables intake may vary more than protein and grain intakes on a weekly basis. Future studies should compare food diaries and plate-based tools completed on the same days. In addition, most of the study population was Caucasian and has a university degree which limits the generalizability of our findings. Therefore, future studies should continue to assess the agreement between the three-day food diary and the plate tool among various ethnicities and socioeconomic statuses. Another limitation to this study is the small sample size (n=42) which may have limited the power of the statistical tests that were conducted. In order to increase the power of the statistical tests, future studies should study the agreement between the plate tool and the food diary among a larger sample of individuals.

4.6 Conclusion

There is an agreement between the three-day food diary and the plate-based tool for protein and grain portions. However, there is a lack of agreement between the three-day food diary and the plate-based tool for fruit and vegetable portions and for adherence to the new CFG 2019. Therefore, a three-day food diary or simply the plate-based tool

itself may be used to assess adherence to the new food guide, however it is important to consider that these tools are limited in doing so. Future studies that assess the agreement between the three-day food diary and the plate-based tool should compare food diaries and plates completed on the same days to increase the accuracy of the results. In addition, future research should focus on further developing the plate tool to be able to measure the height of the foods on the plate. Lastly, future studies should continue to explore this agreement among a larger sample of individuals with various ethnicities and socioeconomic statuses.

Table 6. Unliteral versus literal food diary interpretation examples

Food item reported in food diary	Unliteral interpretation	Literal interpretation
Cold cuts	Counted as a portion of protein	Not counted as a portion of protein in food guide because high in sodium
Fruit tart	Counted as a portion of fruit	Not counted as a portion of fruit in food guide because high in added sugar and fat
Chocolate covered mangos	Counted as a portion of fruit	Not counted as a portion of fruit in food guide because high in added sugar
Apple pie	Counted as a portion of fruit	Not counted as a portion of fruit in food guide because high in added sugar and fat
Ham	Counted as a portion of protein	Not counted as a portion of protein in food guide because high in sodium

Table 7. Characteristics of participants

Characteristics (n=42)	**Results (Mean ± SD)**
Age (years)	63.5 ± 5.3
BMI (kg/m^2)	26.1 ± 4.8
Characteristics (n=42)	**Results (n %)**
Sex	
Female	25 (60%)
Male	17 (40%)
Education levels	
University level	32 (76%)
Other	10 (24%)
Household income	
$ CAD 75,000 or more	25 (60%)
Other	17 (40%)
Marital Status	
Married or domestic partnership	29 (69%)
Other	13 (31%)
Ethnicity	
White	37 (88%)
Other	5 (12%)

Table 8. Results for assessing the agreement in food group portions between the three-day food diary and the plate-based tool, based on criteria levels for good (G), acceptable (A), and poor (P) outcomes

Food group									**Total # of poor results**
	Association	Agreement						Presence of bias	
	Pearson coefficient [a]	Cross-classification [b]		Kappa score [c]	Chi square [d]	McNemar [e]	t-test [f]	Bland-Altman [g]	
		Same	Opposite						
[h]Unliteral fruit & vegetables interpretation	A	P	P	P	P	G	P	P	5
[i]Literal fruit & vegetables interpretation	A	P	P	P	P	G	P	P	5
Unliteral grains interpretation	A	P	G	A	G	G	P	G	2
Literal grains interpretation	A	G	P	A	G	G	P	G	2
Unliteral proteins interpretation	A	G	G	A	G	G	P	G	1
Literal proteins interpretation	A	G	G	A	G	G	P	G	1

[a]Good, r≥0.50; acceptable, r=0.20-0.49; poor, r<0.20

[b]Good, ≥50% in the same tertile and ≤10% in opposite tertile; poor, <50% in same tertile and >10% in opposite tertile (Three tertiles: ≤ 33rd percentile, between the 33rd and the 66th percentile and ≥ 66th percentile)

[c]Good, ≥0.61; acceptable, 0.20-0.60; poor, <0.20

[d]Good, P value ≤0.05; poor, P value>0.05

[e]Good, P value >0.05; poor, P value ≤0.05

[f]Good, P value >0.05; poor, P value ≤0.05

[g]Good, P value >0.05; poor, P value ≤0.05

[h]Unliteral: Unliteral interpretation of three-day food diary

[i]Literal: Literal interpretation of three-day food diary

P: Poor agreement

A: Acceptable agreement

G: Good agreement

Table 9. Results for assessing the agreement in adherence to the new Canada's Food Guide 2019 between the three-day food diary and the plate-based tool, based on criteria levels for good (G), acceptable (A), and poor (P) outcomes

Food group							**Total # of poor results**
	Association	Agreement					
	Pearson coefficient[a]	Cross-classification[b]		Kappa score[c]	Chi square[d]	McNemar[e]	
		Same	Opposite				
[f]Unliteral food diary adherance	P	G	G	P	P	P	4
[g]Literal food diary adherance	P	G	G	P	P	P	4

[a]Good, r≥0.50; acceptable, r=0.20-0.49; poor, r<0.20.

[b]Good, ≥50% in the same tertile and ≤10% in opposite tertile; poor, <50% in same tertile and >10% in opposite tertile (Three tertiles: ≤ 33rd percentile, between the 33rd and the 66th percentile and ≥ 66th percentile)

[c]Good, ≥0.61; acceptable, 0.20-0.60; poor, <0.20.

[d]Good, P value ≤0.05; poor, P value>0.05

[e]Good, P value >0.05; poor, P value ≤0.05.

[f]Unliteral: Unliteral interpretation of three-day food diary

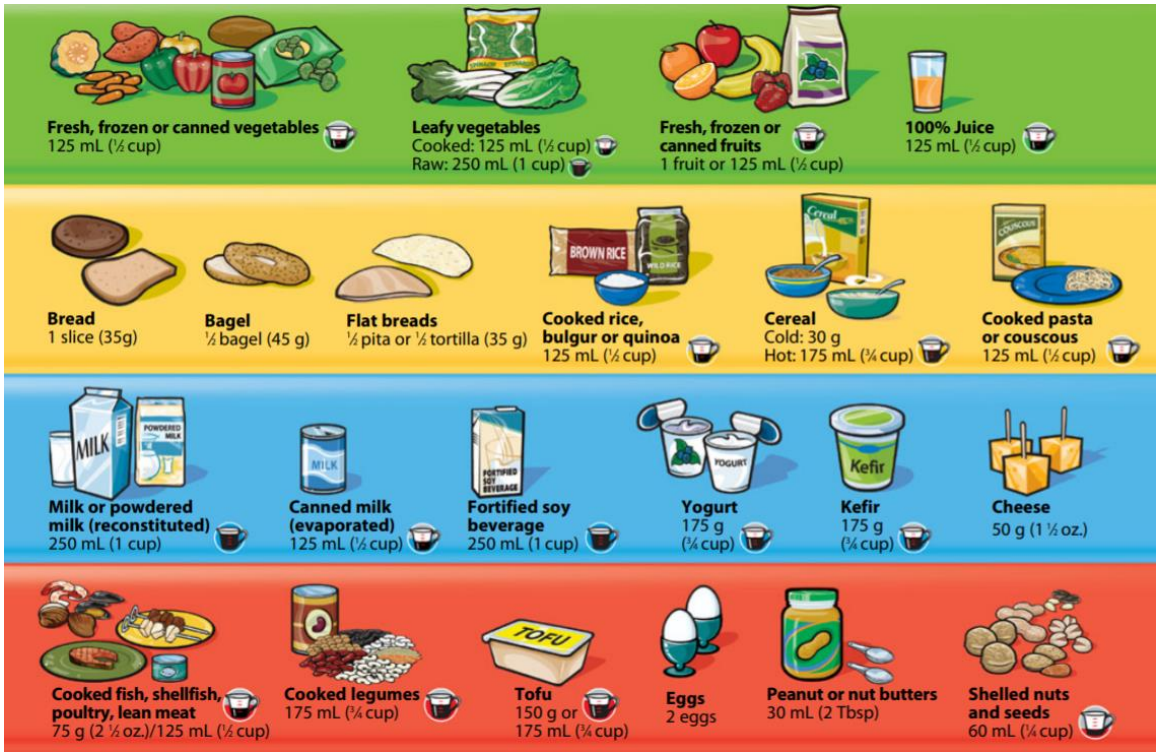
[g]Literal: Literal interpretation of three-day food diary

P: Poor agreement

A: Acceptable agreement

G: Good agreement

Figure 2. Canada's Food Guide 2007[4]



[4]Canada's Food Guide 2007 [51]

All of the portions on this figure equal to 1 portion

Green: Fruits and vegetables

Yellow: Grain products

Blue: Milk and alternatives

Red: Meat and alternatives

Figure 3. Translating the Canada's Food Guide 2019[5] plate recommendations to portions from the Canada's Food Guide 2007

[5]Canada's Food Guide 2019 [2]

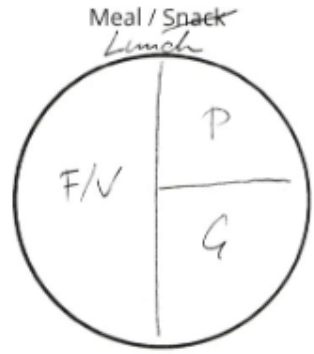
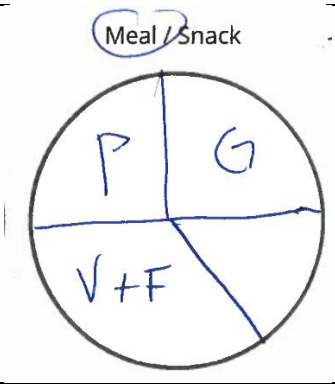
Table S1: Translating reported food diary intake to Canada's Food Guide 2019 plate portions

Participant's reported intake from food diary	CFG 2007 portion	CFG 2019 plate portion
e.g., Breakfast: 1 banana + 30g cereal + 1/2 cup milk + 30ml peanut butter	1 fruit & vegetable + 1 grain product + **0.5 milk and alternative + 1 meat and alternative**	1 fruit & vegetable + 1 grain product + **1.5 protein**

Table S2: Standards for translating plate information to Canada's Food Guide 2007 portions

Participant draws on the plate tool	Number of portions from the CFG 2007
¼ of the plate	1 portion
½ of the plate	2 portions
¾ of the plate	3 portions
1 whole plate	4 portions

Table S3: Translating plate information to portions

Reported intake from plate tool	CFG 2007 portion	CFG 2019 plate portion
	2 fruit & vegetables + 1 grain product + **1 milk and alternative or meat and alternative**	2 fruits & vegetables + 1 grain product + **1 protein**
	**1 milk and alternative or meat and alternative** + 1 grain product+ 1.25 fruit and vegetable	**1 protein** + 1 grain product + 1.25 fruit and vegetable

P: Protein

G: Grain product

V+F or F/V: Fruits and vegetables

Table S4: Scoring criteria for assessing adherence to the Canada's Food Guide 2019

Answers to questions[6]	Adherence? (Points)
Both "no"	No (1)
1 "no" + 1 "yes"	Yes (2)
Both "yes"	Yes (3)

[6]**Questions:** "Is the greatest number of mean portions per day coming from the fruits and vegetables group?" and "Are the number of mean grain portions and mean protein portions per day equal?"

Bridge statement 3

The results presented in the systematic review are promising and suggest that concordance among couples who cohabitate or are legally married does exist for diet, body mass index and type 2 diabetes. The systematic review identified a major limitation of diet concordance studies in that these studies focused on concordance in food groups or nutrients, but have never investigated concordance in diet quality among couples. Therefore, the following chapter aims to assess both concordance in diet quality and concordance in adherance to the new CFG 2019 among middle-aged/older adult cohabitating couples.

CHAPTER 5

ASSESSING DIET CONCORDANCE AMONG COHABITATING MIDDLE-AGED/OLDER ADULT COUPLES LIVING WITH AN OVERWEIGHT CONDITION OR OBESITY

(MANUSCRIPT 3)

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5.1 Abstract

Background: Investigating diet concordance among cohabitating couples could guide the development of more effective couple-based lifestyle behaviour interventions by increasing our understanding of how couples share dietary behaviours. The aim of this study was to assess both concordance for diet quality and concordance in adherance to the Canada's Food Guide (CFG 2019).

Method: This cross-sectional study included dietary data from 33 couples from Montreal (QC) that had been cohabitating for at least 2 years, aged 50-75 years and one of the two partners was obese (BMI 30-45kg/m^2) and the other partner was living with an overweight condition (BMI 25-30kg/m^2) or obesity. Dietary data was collected through three-day food diaries. The Healthy Eating Index-Canada (HEI-C) 2010 was used to assess diet quality. Statistical analyses for diet concordance among members in a couple (*i.e.,* diet quality, nutrient and food group portion intakes) included paired t-test and Pearson correlation analysis. All results were adjusted by partial correlation for body weight, energy intake, age, length of time in the relationship, depression level and physical activity level. Statistical analyses for concordance in adherence to the CFG 2019 among members in a couple included chi-square, McNemar, Pearson correlation, cross-classification and kappa score tests.

Results: There was concordance among members in a couple for HEI-C scores (adjusted (Adj) r=0.63, p<0.01), energy (Adj r=0.54, p=0.01), carbohydrate (Adj r=0.61, p<0.01), total fibre (Adj r=0.68, p<0.01), saturated fat (Adj r=0.59, p=0.01), vitamin D (Adj r=0.66, p<0.01), calcium (Adj r=0.66, p<0.01), sodium (Adj r=0.49, p=0.03), fruits and

vegetable (Adj r=0.71, p<0.01), protein (Adj r=0.50, p=0.03) and grain portions (Adj r=0.67, p<0.01). However, there was a discordance among members in a couple for protein (Adj r=0.34, p=0.16), added sugar (Adj r=0.38, p=0.11) and total fat (Adj r=0.38, p=0.11). There was an agreement and therefore concordance in adherence to the CFG 2019 among members in a couple (at least three out of five tests received a result of acceptable or good agreement).

Conclusion: These results suggest that there is concordance in diet quality, nutrient intakes, food group portion intakes and in adherence to the CFG 2019 among members in a couple. Therefore, partners share overall dietary behaviours which may help guide the development for more effective couple-based interventions for improving dietary behaviours.

5.2 Introduction

Over the years, the prevalence of obesity has been increasing in Canada [17]. In 2019, the largest prevalence of obesity was among middle-aged/older adults aged 50-64 years at 33.2% (a 1.9% increase from 2018) [18]. Obesity is known to be a substantial health burden as it is related to many chronic diseases such as type 2 diabetes [92] and multiple types of cancers [93].

In 2020, Canada released the new clinical practice guidelines for obesity in adults [19]. These guidelines suggest that the main treatment option for obesity are behaviour change interventions that target improving nutrition and physical activity behaviours. Behaviour change interventions are effective for producing a modest (5-10%) weight loss among individuals with overweight and obesity and should be included in obesity treatment programs [94]. However, it is said that health behaviour change interventions are effective for no more than 20% of weight loss maintenance which may not be enough to improve obesity-related comorbidities [19]. In fact, a meta-analysis including 18 studies showed that most adults living with an overweight condition or obesity tend to regain some of the weight that was lost after receiving a minimum of 6-months of either a diet-only or a diet-plus-exercise intervention [20]. A possible explanation for this is that current behaviour change interventions for weight loss are individual-based, suggesting that there is very limited instruction given on ways to modify the environment in which physical activity and eating occurs in order to promote weight-regulating behaviours [21].

Some individuals live in an obesogenic home environment which has the ability to encourage unhealthy behaviours such as the intake of unhealthy foods and sedentary

behaviour which promotes obesity [22]. In this context, health behaviour change is the "shift from risky behaviours to the initiation and maintenance of healthy behaviours and functional activities, and the self-management of chronic health conditions" [95]. The home obesogenic environment is concerning as in order to curb the obesity pandemic, health behaviour changes need to be maintained in order for weight loss to be maintained. Finding effective ways to modify the home environment to better support healthy choices can possibly allow for more effective obesity prevention interventions.

The partner with whom one cohabitates may play a role in creating a home obesogenic environment because spouses influence each other's behaviours [23, 24]. Therefore, the spouse may be a potential target of interest for obesity interventions. In fact, research shows that when one partner adopts a healthier behaviour, this can promote health behaviour change in the other partner [25, 26]. For instance, a prospective study from the English Longitudinal Study of Ageing, found that when one partner adopted a healthy behaviour, the other partner was more likely to make a positive health behaviour change for smoking, physical activity and weight loss [26]. In addition, couples tend to have a similar level of readiness to change health risk behaviours for diet, physical activity and weight loss [59]. This is why behavioural change interventions might be more successful in couples where both partners change together (*i.e.*, couple-based interventions) [26].

An indicator of partner influence is correspondence/concordance [23, 24, 35] which is defined as the degree of agreement in health behaviours among couples [23, 24]. Partner influence can possibly explain why studies show that couple's health is often similar [27, 28, 29]. For instance, many studies show concordance among couples for body mass

index [27, 28, 60, 61] and the increase in risk of one spouse becoming obese if the other becomes obese [62]. In addition, there are many studies that show concordance for diabetes among couples [29, 64, 65, 66]. Furthermore, partner influence can also possibly explain why studies show concordance for health behaviours, such as dietary intake, among couples [24, 30, 31, 32]. However, these studies are limited because they analyze concordance for specific nutrients or food groups and not diet quality. Analyzing the entire diet quality is a better method to measure diet in order to truly quantify the impact of diet on chronic disease outcomes [33]. This is because one consumes a wide variety of nutrients that are both protective and harmful which, when combined, can act synergistically or antagonistically [33, 34]. Current diet quality tools [69] are based on the old CFG 2007 guidelines and are not adapted to the new CFG 2019 plate-based guidelines. Specifically, the CFG 2007 is portion-based [51] whereas the CFG 2019 is plate-based (the proportion of the plate filled with each food group; fruits and vegetable, protein and grains) [2]. The guidelines have been updated and it would therefore be more relevant to obtain diet concordance information reflecting the new plate-based CFG 2019 guidelines. Chapter 4 of this thesis showed that the plate-based tool reflects some similar information to the three-day food diary. This means that we can possibly use the plate-based tool to assess adherence to the new plate-based CFG 2019 guidelines because, just like the plate-based tool, it is a visual representation of dietary intake. This would subsequently allow us to determine concordance for adherence to the new food guide among members of a couple. We would therefore be able to obtain diet concordance information reflecting the new CFG 2019. In addition, the plate-based tool itself can

possibly be used in intervention research that is based on changing dietary behaviours according to the new CFG

Based on the current literature about partner influence and diet concordance among couples, one could assume that couple-based interventions are more effective than individual-based interventions for dietary behaviour change. However, some studies show otherwise [36, 37, 38]. This may be due to the fact that the increase in social support that occurs by implicating the spouse in the intervention may not be enough to elicit optimal changes in health behaviour [35, 39]. Therefore, further research is required in this field in order to determine the specific techniques (*i.e.*, strategies to support partner goal achievement, goal-setting, problem-solving, increasing self-efficacy [106]) that are needed in order to optimized couple-based interventions for dietary behaviour change. Investigating diet concordance in a novel way (*i.e.*, concordance in diet quality and adherence to the new food guide) may be able to better guide the development of more effective couple-based intervention techniques by increasing our understanding of how couples share overall dietary behaviours. Therefore, the objective of this study is to assess diet concordance reflecting the old CFG 2007 (*i.e.*, concordance in diet quality) and the new CFG 2019 (*i.e.*, concordance in adherance to the new food guide) among middle-aged/older adult cohabitating couples living with an overweight condition or obesity. We are hypothesizing that there will be a concordance in diet quality and adherence to the new CFG 2019 among middle-aged/older adult couples living with an overweight condition or obesity.

5.3 Method

5.3.1 Study design

This study reported a cross sectional analysis of baseline data from a pilot study called the "Dyadic Approach to Active Living and Eating Healthy: The DATE Study" [96]. This on-going study will last a total of 17 months with the purpose of comparing two different intervention programs (*i.e.*, a couple-based intervention based on psychological principles of behaviour change versus a nutrition education control) to help couples make sustainable lifestyle changes [96]. Eligibility criteria included adults aged 50-75 years old in which one of the two partners was obese (body mass index between 30-45 kg/m^2) and the other partner was living with an overweight condition (25-30 kg/m^2) or obesity [96]. In addition, participants must have been cohabitating for at least 2 years [96]. Cohabitation in this context refers to two individuals who are living together [97]. In addition, participants needed to understand and speak French or English and needed to have access to internet and a computer or a tablet with a web camera at home in order to be able to participate in the online interventions via Zoom [96]. Subjects who met any of the following criteria were excluded from participation in this study [96]: uncontrolled diabetes or cardiovascular disease, pregnancy, active cancer treatment, substance abuse, limited mobility and participants who are currently enrolled in a weight loss program, following a special medical-prescribed diet or have an eating disorder.

All participants provided informed consent [96]. Ethics for the DATE study was approved at the Centre de recherche de l'Institut universitaire de gériatrie de Montréal and through Concordia University (registration number: NCT04660968) [96].

5.3.2 Data collection

Participants needed to complete baseline questionnaires which included demographic questions (*i.e.,* age, ethnicity, level of education, household income, and length of time in the relationship) [96]. In addition, pertinent information such as the Physical Activity Scale for the Elderly (PASE) [98] and the Center of Epidemiologic Studies Depression Scale revised (Cronbach's coefficient α value = 0.94) [99] was included in our analysis. One of the pre-treatment assessments for the DATE study included participants recording their dietary intakes using a three-day food diary for three non-consecutive days (two weekdays and one weekend day) [96]. Templates for the three-day food diaries were delivered to the participants' homes along with other study materials [96]. All participants received training from a registered dietitian on how to correctly use the three-day food diary via Zoom [96]. The completed three-day food diaries were collected at the participants' homes and were uploaded onto a secured server [96].

5.3.3 Diet assessment

All dietary assessments were done using the three-day food diaries that the participants completed.

Primary outcome

Diet quality: The HEI-C 2010 was used to calculate diet quality scores over three non-consecutive days of intakes reported in the food diaries. The HEI-C 2010 reflects the serving sizes and the age and sex-specific recommendations of the CFG 2007 [51]. Two scores were obtained for the HEI-C for each participant as the three-day food diaries were interpreted in two ways (*i.e.,* unliteral and literal). The three-day food diaries were interpreted in two ways because at times it is difficult to determine if a specific food

should count as a portion from the CFG. The unliteral interpretation of the three-day food diary was more lenient in terms of food items that were considered as part of the CFG, whereas the literal interpretation was stricter. For instance, some individuals may believe that proteins (*i.e.*, cold cuts, cured meats like prosciutto, salami, sausage) and healthy desserts (*i.e.*, oatmeal cookies) should be included as portions from the food guide because they are good sources of protein and fibre. Therefore, these foods were counted as portions of protein and whole grains in the unliteral interpretation of the food diary. However, these foods were not counted as portions of protein or whole grains in the literal interpretation of the food diary as they are high in sugar, fat and sodium (a rubric was followed as described in **Table 10**).

Secondary outcomes

Food group portion intakes and adherence to the new CFG 2019 (the plate): As shown in **Table S5,** the reported intake from the three-day food diary was translated into portions from the CFG 2007 (**Figure 4**) in order to determine the number of portions consumed per day for each food group (*i.e.*, fruits and vegetables, meat and alternatives, milk and alternatives and grains products). All of the portions on **Figure 4** equal to one food guide portion. The new CFG 2019 has three food groups (*i.e.*, fruits and vegetables, grains and protein foods) instead of four food groups like the CFG 2007 (*i.e.*, fruits and vegetables, meat and alternatives, milk and alternatives and grains products) [51]. Therefore, the translated CFG 2007 portions were then categorized into the three food groups of the CFG 2019 (*i.e.*, fruits and vegetables, grains and protein foods) by putting the meat and alternative and the milk and alternative portions together to form the protein portion (**Table S5**). The mean number of portions from each food group from the CFG

2019 (*i.e.*, fruits and vegetables, grains and protein foods) per day was calculated over three days of intake.

Based on the mean number of portions consumed per day from the CFG 2019 food groups (*i.e.*, fruits and vegetables, protein and grains), adherence to the new CFG 2019 was assessed for all participants by a registered dietitian (SS). This was based on two questions: "Is the greatest number of mean portions per day coming from the fruits and vegetables group?" and "Are the number of mean grain portions and mean protein portions per day equal?" A scoring system was created (**Table S6**) in order to represent different levels of adherence. The answer of "no" to both questions means no adherence (food diary received a score of 1). The answer of "yes" to one of the two questions (food diary received a score of 2) or "yes" to both questions (food diary received a score of 3) means adherence to the new food guide. These questions were created based on the main principles of the new CFG 2019 which demonstrates that: ½ of the plate (i.e., majority) should be filled with fruits and vegetables, ¼ of the plate should be filled with whole grains and ¼ of the plate should be filled with protein foods [2]. The three-day food diaries were analyzed in two ways; unliteral and literal interpretations in the same way mentioned above.

Nutrient intake: ESHA's Food Processor® Nutrition Analysis software was used to calculate the mean total energy (kcal), total fat (g), saturated fat (g), carbohydrate (g), fibre (g), protein (g), sugar (g), calcium (mg), vitamin D (IU) and sodium (mg) intakes per day over three non-consecutive days of intakes.

5.3.4 Statistical analysis

The final analyses included data from 33 couples (66 participants). Two analyses were performed (*i.e.,* paired t-test and Pearson correlation analysis) in order to determine concordance in HEI-C scores (diet quality scores), nutrient intakes and CFG 2019 food group portion intakes among members of a couple. The paired t-test was not used to determine concordance but rather was used to determine if the mean absolute dietary intakes among members in a couple were similar or different. Concordance in the context of this study was defined as both members in the couple having the same association of food intake (*i.e.,* if energy intake increases for one partner, energy intake increases for the other partner). Discordance was defined as members in a couple having opposite food intake associations (*i.e.,* if energy intake increases for one partner and decreases for the other partner). The Pearson correlation analysis can determine if the association of food intake is the same or if it differs among members in a couple. This type of analysis was therefore used to determine concordance for dietary intake among members in a couple. Analyses were adjusted using partial correlations for body weight [80], energy intake [69], age [24], length of time in the relationship [24] and physical activity level [69] as these factors were taken into account in previous diet concordance studies as they are associated to changes in food intake. Depression level was also included in the analysis as it has been associated to appetite changes [101, 102]. Correlations and therefore concordance was considered as being good when $r \geq 0.50$, acceptable when $r = 0.2\text{-}0.49$ and poor when $r < 0.20$, as according to Lombard et al [72].

Statistical analyses for concordance in adherence scores to the new CFG 2019 among members in a couple included chi-square, McNemar, Pearson correlation, cross-classification and kappa score tests. For this analysis, the data was categorical (adherence

scores of 1, 2 or 3) and therefore the paired t-test was not suitable to perform. Various categorical analyses (*i.e.*, chi-square, McNemar, cross-classification and kappa score) were performed with the goal of classifying an individual as having a high or low adherence to the CFG 2019 (adequate or inadequate dietary intake). These results were not adjusted because adherence was determined by whether or not participants adhered to the plate proportions of the CFG 2019 (*i.e.*, the majority of the plate filled with fruits and vegetables and equal portions of grains and protein foods). Therefore, controlling for variables that may influence the difference in food intake among members in a couple (*i.e.*, age, depression, physical activity etc.) was not applicable given the new Canadian guidelines.

Numerical results obtained for each analysis were then classified as "good (G)," "acceptable (A)," or "poor (P)" agreement/concordance between the members in a couple for adherence scores [72]. The criteria for determining the level of agreement (good, acceptable or poor) based on the numerical results obtained for each analysis were: Pearson correlation (good, $r \geq 0.50$; acceptable, $r = 0.20\text{-}0.49$; poor, $r < 0.20$), cross classification (good, ≥50% in the same tertile and ≤10% in opposite tertile; poor, <50% in same tertile and >10% in opposite tertile), kappa score (good, ≥0.61; acceptable, 0.20-0.60; poor, <0.20), chi-square (good, $p \leq 0.05$; poor, $p > 0.05$) and McNemar (good, $p > 0.05$; poor, $p \leq 0.05$). The total number of poor results was calculated. If the majority of the tests (at least three out of five tests) receive a poor result, this suggests a lack of agreement and therefore a lack of concordance between members in a couple for adherence scores [72]. If the majority of the tests (at least three out of five tests) receive a result of acceptable or good, this suggests an agreement and therefore concordance between members in a

couple for adherence scores [72]. All analyses were performed in SPSS version 27 (IBM Inc, Armonk, NY) with p values <0.05 considered statistically significant.

5.4 Results

Table 11 presents participant characteristics. Mean (standard deviation) age was 61.8 ± 6.8 years for the women and 63.7 ± 6.3 years for the men. The mean (standard deviation) for body mass index was 31.2 ± 3.7 kg/m^2 for the women and 32.2 ± 4.2 kg/m^2 for the men. There was a difference between men and women for age (p=0.002) and weight (p<0.001), however not for body mass index (p=0.27). The majority of participants were Caucasian (94%), reported never participating in moderate (86%) or strenuous (86%) physical activity and reported to have felt depressed rarely or none of the time (less than 1 day) (64%). The dietary intake information at baseline of 33 couples (66 participants) was included in this analysis.

Given that the unliteral and literal interpretations of the food diary presented similar results, except for the chi-square test, all data will be presented for the literal interpretation unless stated otherwise.

Table 12 shows the paired t-test results and mean differences between men and women in a couple for diet quality scores (HEI-C scores), nutrient and food group portion intakes. Mean absolute HEI-C scores (p=0.26), calcium (p=0.70), vitamin D (p=0.14), total fibre (p=0.22) and added sugar intakes (p=0.95) were similar among members in a couple. However, mean absolute intakes of all the food groups (p≤0.01), energy (p<0.01), protein (p<0.01), carbohydrates (p=0.01), total fat (p=0.02), saturated fat (p=0.02) and sodium intakes (p<0.01) differed among members in a couple.

Table 13 shows the Pearson correlation coefficients for diet quality scores (HEI-C scores), nutrient and food group portion intakes among members in a couple. Having adjusted by partial correlation for body weight, energy intake, age, length of time in the relationship, depression and physical activity level, there was concordance among members in a couple for HEI-C scores (Adj r=0.63, p<0.01), energy (Adj r=0.54, p=0.01), carbohydrate (Adj r=0.61, p<0.01), total fibre (Adj r=0.68, p<0.01), saturated fat (Adj r=0.59, p=0.01), vitamin D (Adj r=0.66, p<0.01), calcium (Adj r=0.66, p<0.01), sodium (Adj r=0.49, p=0.03), fruit and vegetable (Adj r=0.71, p<0.01), protein (Adj r=0.50, p=0.03) and grain intakes (Adj r=0.67, p<0.01). However, there was a discordance among members in a couple for protein (Adj r=0.34, p=0.16), added sugar (Adj r=0.38, p=0.11) and total fat intakes (Adj r=0.38, p=0.11).

Table 14 shows the results for the concordance in adherence scores to the CFG 2019 between members in a couple. The kappa score (0.04, p=0.81) resulted in a poor agreement. Pearson correlation (r=0.25, p=0.15) resulted in an acceptable agreement. The cross-classification (58% of the results were classified in the same tertile and none were classified in opposite tertiles) and McNemar tests (p=0.85) resulted in a good agreement. The chi-square test resulted in a poor agreement for the literal food diary interpretation (p=0.23), whereas it resulted in a good agreement for the unliteral food diary interpretation (p=0.04). The majority of the tests received an acceptable (A) or good (G) agreement result for the literal (three out of five tests) and unliteral (four out of five tests) food diary interpretations. This suggests an agreement and therefore concordance in adherence scores to the new food guide among members in a couple.

5.5 Discussion

The objective of this study was to investigate diet concordance reflecting the old CFG 2007 guidelines (*i.e.*, concordance for diet quality) and the new CFG 2019 guidelines (*i.e.*, concordance in adherence to the new food guide) among cohabitating middle-aged/older adults couples living with an overweight condition or obesity.

The paired t-test showed different absolute mean intakes among members in a couple for all food groups, energy, carbohydrate, saturated fat and sodium intakes whereas the Pearson correlation analysis showed significant correlations for these nutrients and all food groups among members in a couple. The difference in absolute mean intakes among men and women was expected as men consume more calories than women as they have higher energy requirements. The Pearson correlation analysis results are more meaningful in the context of this study as this test is able to determine concordance for dietary intake (*i.e.*, having the same association of food intake) whereas the t-test can only determine similarities in the mean absolute dietary intakes among members in a couple.

One study that analyzed similar nutrients to our study demonstrated that out of all the nutrients analyzed, only saturated fat ($r=0.29$, $p<0.05$) was significantly correlated between husbands and wives [55]. Overall, most of the correlation coefficients found in this study are considered to be poor (ranged from r=0.02-0.21) [55]. This study suggests that the low correlation for nutrient intakes between husbands and wives was attributed to a high eating out frequency [55]. The correlation coefficients for the nutrients analyzed in our study were much greater in magnitude and are considered to be acceptable to good (Adj r=0.49-0.68). The stronger correlation found in our study may have occurred due to the various social changes due to the COVID-19 pandemic (*i.e.*, closing of restaurants,

confinement at home). As a result, couples may have eaten their meals together more often and therefore eating the same meals more often.

This study showed concordance in adherence scores to the new CFG 2019 in couple which aligns with the other concordance results found in this study (*i.e.*, diet quality, nutrient and food group portions). These findings suggest that couples in this study share dietary behaviours related to the new plate-based guidelines and therefore the proportion of their plate that is filled with fruits and vegetables, protein and grain is similar. These findings are impactful because it reflects diet concordance information about the new food guide guidelines. These results encourage the use of the plate-based tool in couple-based interventions as both partners will either adhere or not to the changes in dietary behaviours related to this plate.

5.5.1 Strengths

Previous studies focused on analyzing concordance among couples for specific food groups or nutrients and not diet quality or adherence to the new CFG 2019. To our knowledge, this is the first study to analyze diet concordance reflecting the old CFG 2007 (*i.e.*, diet quality) and the new CFG 2019 (*i.e.*, adherence to the new food guide). Finding novel diet concordance information, as what was done in this study, provides evidence to suggest that members in a couple who cohabitate share overall dietary behaviours. Diet concordance in this study was not only demonstrated for the old CFG 2007 (*i.e.*, diet quality), but also for the new CFG 2019 (*i.e.*, adherence to the CFG 2019) which makes the results more relevant to current recommendations. These results help us better understand the couple dynamics that are often found in certain types of interventions (*i.e.*, couple-based interventions) for health behaviour change. Couple-based interventions are

often based on increasing social support for health behaviour change which some studies show is not more effective than individual-based interventions [36, 37, 38]. Based on the results found in this study, in order to optimize couple-based interventions for dietary behaviour change, we should be focusing on developing techniques tailored to modifying partner dynamics instead of solely focusing on social support.

5.5.2 Limitations

This study has its limitations that could have affected the results. For instance, our data is preliminary as we are working with a small sample size (n=33 couples). In addition, the majority of the sample was Caucasian which limits the generalizability of our findings to various ethnicities. Future studies should analyze concordance in diet quality and adherence to the new food guide in members of a couple among a larger sample including various ethnicities. Another limitation of this study is that three-day food diary information was used to assess adherence to the new food guide. Indeed, this study showed an agreement and therefore concordance in adherence to the new food guide among members in a couple. However, it is important to consider that there was a lack of agreement between the three-day food diary and the plate-based tool for adherence to the new CFG 2019. This suggests that the plate-based tool may not reflect similar information to a three-day food diary for adherence to the new food guide and therefore may not be very accurate to capture adherence to the CFG 2019 plate-based guide. Perhaps the lack of agreement between the food diary and the plate-based tool was related to the fact that there are key differences when tracking diet using the two different tools. For instance, individuals tracking their intake using the food diary will measure all items consumed, whereas individuals tracking using the plate-based tool estimate the

proportion of their plate filled with each food group visually. The precision of measurements may have been an issue in this case. The new healthy eating index for the Canada's Food Guide 2019 was not used in this study as it has just been released in 2022 [103]. Future studies should consider using this index to determine diet quality scores and therefore adherence to the new guidelines.

5.6 Conclusion

These results suggest that there is concordance in diet quality, nutrient intakes, food group portion intakes and in adherence to the CFG 2019 among members in a couple. This suggests that partners share overall dietary behaviours. Therefore, in order to optimize couple-based interventions for dietary behaviour change, we should be focusing on developing techniques tailored to modifying partner dynamics instead of solely focusing on social support.

Table 10. Unliteral versus literal food diary interpretation examples

Food item reported in food diary	Unliteral interpretation	Literal interpretation
Cold cuts	Counted as a portion of protein	Not counted as a portion of protein in food guide because high in sodium
Fruit tart	Counted as a portion of fruit	Not counted as a portion of fruit in food guide because high in added sugar and fat
Chocolate covered mangos	Counted as a portion of fruit	Not counted as a portion of fruit in food guide because high in added sugar
Apple pie	Counted as a portion of fruit	Not counted as a portion of fruit in food guide because high in added sugar and fat
Ham	Counted as a portion of protein	Not counted as a portion of protein in food guide because high in sodium

Table 11. Basic characteristics of men and women

Characteristics (n=66)	**Results (Mean±SD)**
Age (years)	
Women	61.8 ± 6.8
Men	63.7 ± 6.3
Weight (kg)	
Women	81.8 ± 10.6
Men	100.5 ± 16.6
BMI (kg/m^2)	
Women	31.2 ± 3.7
Men	32.2 ± 4.2
Characteristics (n=66)	**Results (n %)**
Sex	
Male	33 (50%)
Female	33 (50%)
Ethnicity	
White	62 (94%)
Other	4 (6%)
Education levels	
University degree (*i.e.*, Bachelor, Master or Doctorate)	34 (52%)
CEGEP or some university classes	19 (29%)
High school graduate	10 (15%)
Primary school or some high school	3 (4%)
Household income	
$ CAD 160,000+	16 (24%)
$ CAD 100K-159,999	22 (33%)
$ CAD 50K-99,999	20 (30%)
$ CAD <50K	8 (12%)
Length of time in relationship (years)	
31-45	31 (47%)
21-30	13 (20%)
11-20	12 (18%)
1-10	10 (15%)
[7]Moderate physical activity	
Never	57 (86%)
Other	9 (14%)
[8]Strenuous physical activity	
Never	57 (86%)
Other	9 (14%)
Depression level	

Rarely or none of the time (less than 1 day)	42 (64%)
Some or a little of the time (1-2 days)	16 (24%)
Occasionally or a moderate amount of time (3-4 days)	8 (12%)

[7]**Moderate physical activity**: Over the past 7 days, how often did you engage in moderate sport or recreational activities such as doubles tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball, or other similar activities?

[8]**Strenuous physical activity:** Over the past 7 days, how often did you engage in strenuous sport and recreational activities such as jogging, swimming, cycling, singles tennis, aerobic dance, skiing (downhill or cross-country) or other similar activities?

Table 12. Mean differences between men and women for Healthy Eating Index-Canada 2010 scores, nutrient intake and food group portions

	Mean women	Mean men	Mean difference	t value	P value
[a]Unliteral HEI	69.3	67.5	1.8	0.83	0.41
[b]Literal HEI	67.6	65.1	2.5	1.14	0.26
Energy (kcal)	1811.5	2129.7	-318.2	-3.83	<0.01*
Protein (g)	79.5	93.0	-13.5	-3.35	<0.01*
Carbohydrate (g)	201.8	227.5	-25.7	-2.74	0.01*
Total fibre (g)	19.0	17.5	1.5	1.25	0.22
Added sugar (g)	26.9	26.7	0.2	0.06	0.95
Total fat (g)	71.3	83.1	-11.8	-2.58	0.02*
Saturated fat (g)	22.5	27.3	-4.9	-2.56	0.02*
Vitamin D (IU)	476.2	365.9	110.3	1.50	0.14
Calcium (mg)	933.1	958.7	-25.6	-0.38	0.70
Sodium (mg)	2809.8	3371.8	-562.0	-3.36	<0.01*
Unliteral FV[c] portions	4.7	3.9	0.8	3.01	0.01*
Unliteral protein portions	4.1	5.2	-1.0	-3.43	<0.01*
Unliteral grains portions	4.2	5.3	-1.1	-4.75	<0.01*
Literal FV portions	4.6	3.8	0.7	2.78	0.01*
Literal protein portions	3.9	4.7	-0.8	-2.68	0.01*
Literal grains portions	4.1	5.2	-1.1	-4.99	<0.01*

[a]Unliteral: Unliteral food diary interpretation

[b]Literal: Literal food diary interpretation

[c]FV: Fruits and vegetables

*Signficant

Table 13. Correlation coefficients (r) for Healthy Eating Index-Canada 2010 scores, nutrient intake and food group portions among members in a couple

	Correlation	P value	Adjusted correlation	P value
[c]Unliteral HEI	0.67	<0.01*	0.67[a]	<0.01*
[d]Literal HEI	0.67	<0.01*	0.63[a]	<0.01*
Energy (kcal)	0.61	<0.01*	0.54[b]	0.01*
Protein (g)	0.32	0.07	0.34[a]	0.16
Carbohydrate (g)	0.61	<0.01*	0.61[a]	<0.01*
Total fibre (g)	0.51	<0.01*	0.68[a]	<0.01*
Added sugar (g)	0.41	0.02*	0.38[a]	0.11
Total fat (g)	0.43	0.01*	0.38[a]	0.11
Saturated fat (g)	0.37	0.03*	0.59[a]	0.01*
Vitamin D (IU)	0.66	<0.01*	0.66[a]	<0.01*
Calcium (mg)	0.46	0.01*	0.66[a]	<0.01*
Sodium (mg)	0.55	<0.01*	0.49[a]	0.03*
Unliteral FV[e] portions	0.66	<0.01*	0.73[a]	<0.01*
Unliteral protein portions	0.18	0.31	0.51[a]	0.03*
Unliteral grains portions	0.67	<0.01*	0.69[a]	<0.01*
Literal FV portions	0.63	<0.01*	0.71[a]	<0.01*
Literal protein portions	0.22	0.23	0.50[a]	0.03*
Literal grains portions	0.66	<0.01*	0.67[a]	<0.01*

[a]Adjusted for weight (kg), age (years), energy (kcal), length of time in relationship, physical activity level (moderate and strenuous) and depression level

[b]Adjusted for weight (kg), age (years), length of time in relationship, physical activity level (moderate and strenuous) and depression level

[c]Unliteral: Unliteral food diary interpretation

[d]Literal: Literal food diary interpretation

[e]FV: Fruits and vegetables

*Significant

Table 14. Concordance in adherence to the new Canada's Food Guide 2019 among members in a couple, based on criteria levels for good (G), acceptable (A), and poor (P) outcomes

Food group							**Total # of poor results**
	Association	Agreement					
	Pearson coefficient[a]	Cross-classification[b]		Kappa score[c]	Chi square[d]	McNemar[e]	
		Same	Opposite				
Unliteral food diary interpretation	A	G	G	P	G	G	1
Literal food diary interpretation	A	G	G	P	P	G	2

[a]Good, r≥0.50; acceptable, r=0.20-0.49; poor, r<0.20.

[b]Good, ≥50% in the same tertile and ≤10% in opposite tertile; poor, <50% in same tertile and >10% in opposite tertile (Three tertiles: ≤ 33rd percentile, between the 33rd and the 66th percentile and ≥ 66th percentile)

[c]Good, ≥0.61; acceptable, 0.20-0.60; poor, <0.20.

[d]Good, P value ≤0.05; poor, P value>0.05

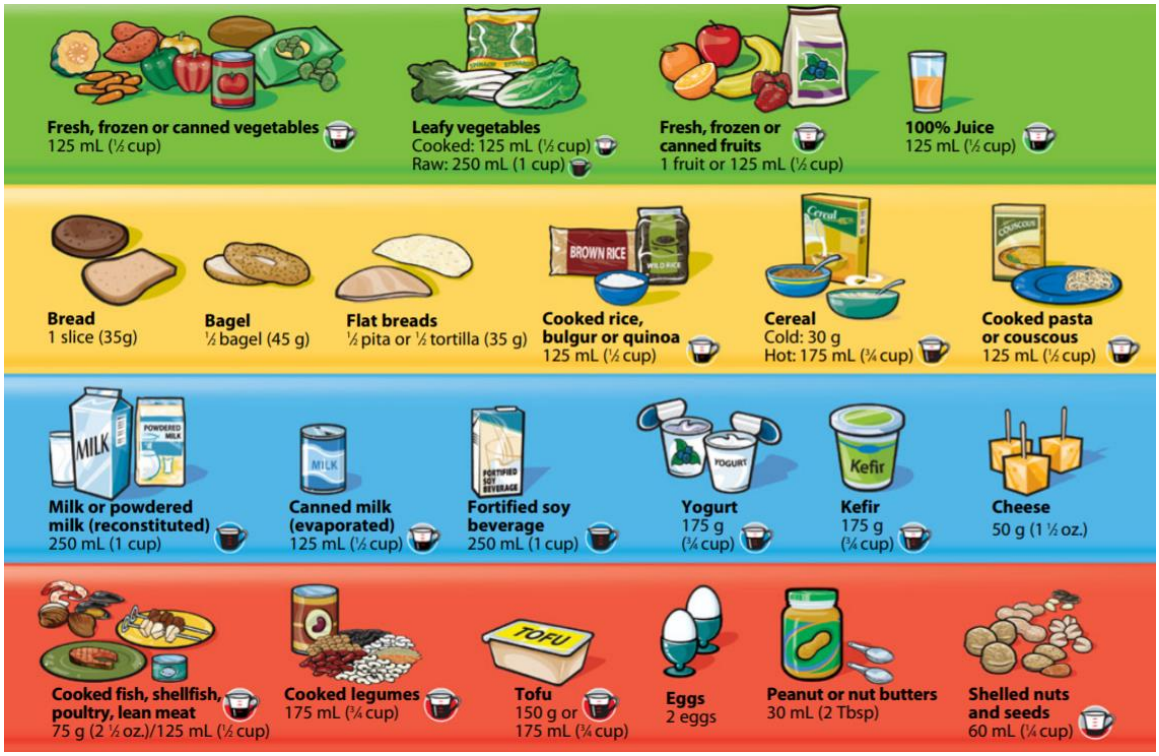
[e]Good, P value >0.05; poor, P value ≤0.05

P: Poor agreement

A: Acceptable agreement

G: Good agreement

Figure 4. Canada's Food Guide 2007[9]



[9]Canada's Food Guide 2007 [51]

All of the portions on this figure equal to 1 portion

Green: Fruits and vegetables

Yellow: Grain products

Blue: Milk and alternatives

Red: Meat and alternatives

Table S5: Translating reported food diary intake to Canada's Food Guide 2019 plate portions

Participant's reported intake from food diary	CFG 2007 portion	CFG 2019 plate portion
e.g., Breakfast: 1 banana + 30g cereal + 1/2 cup milk + 30ml peanut butter	1 fruit & vegetable + 1 grain product + **0.5 milk and alternative + 1 meat and alternative**	1 fruit & vegetable + 1 grain product + **1.5 protein**

Table S6: Scoring criteria for assessing adherence to the Canada's Food Guide 2019

Answers to questions[10]	Adherence? (Points)
Both "no"	No (1)
1 "no" + 1 "yes"	Yes (2)
Both "yes"	Yes (3)

[10]**Questions:** "Is the greatest number of mean portions per day coming from the fruits and vegetables group?" and "Are the number of mean grain portions and mean protein portions per day equal?"

CHAPTER 6

GENERAL DISCUSSION AND CONCLUSIONS

6.1 General discussion

The literature suggests that couples share dietary behaviour practices. Manuscript 1 of this thesis presented a systematic review that provided an in-depth overview of the current studies that have been conducted in diet concordance among couples and the various limitations of these studies as well as gaps in the knowledge. Based on these limitations and the identified gaps, the main objective of this thesis was to assess diet concordance reflecting the old CFG 2007 (*i.e.,* concordance in diet quality) and the new CFG 2019 (*i.e.,* concordance in adherence to the new food guide) among cohabitating middle-aged/older adult couples living with an overweight condition or obesity. The HEI-C 2010 (based on CFG 2007) was used to assess diet quality and subsequently diet quality concordance among members in a couple. However, there are currently no dietary assessment tools available to determine adherence to the new CFG 2019 plate-based guidelines making it difficult to determine adherence and subsequently concordance in adherence to the new food guide. In order to determine if a three-day food diary or the plate-based tool itself can be used as a dietary assessment tool to assess adherence to the new food guide, Manuscript 2 of this thesis presents the results of a study that shows some agreement between the three-day food diary and the plate-based tool.

Finally, Manuscript 3 presented the results of a cross-sectional couple-based dietary analysis which showed an overall acceptable to good concordance in diet among members of a couple. Despite some limitations, this thesis has important implications to dietetic practice for obesity management and is positioned to extend recommendations for future related investigation.

Objective 1 (*Manuscript 1*):

The first aim of this thesis was to investigate the previous literature pertaining to concordance in diet, body mass index and type 2 diabetes among legally married or cohabitating couples through a systematic review of the literature. The review showed concordance for diet, body mass index and type 2 diabetes among members in a couple. This suggests that partners in a couple share health (*i.e.*, body mass index and type 2 diabetes) and health behaviours (*i.e.*, dietary intake). This systematic review allowed for the identification of a major limitation in diet concordance studies. This limitation is that previous studies focused on analyzing concordance among couples for specific food groups or nutrients and not diet quality.

Based on the literature presented in the systematic review, couple-based interventions should be more effective than individual-based interventions for dietary behaviour change because there was evidence to suggest concordance for diet, body mass index and type 2 diabetes among members in a couple. However, it is important to consider that the articles included in this review were limited in terms of the generalizability of the results and their statistical analyses were not adjusted for important confounders such as physical activity and diet (*i.e.*, for the body mass index and type 2 diabetes studies). Despite the findings from this review, many studies show that couple-based interventions are not more effective for improving dietary behaviours when compared to individual-based interventions [36, 37, 38]. This may be due to the fact that the increase in social support that occurs by implicating the spouse in the intervention may not be enough to elicit optimal changes in health behaviour [35, 39]. Therefore, further research is required in this field in order to determine the specific techniques that are needed in order to

optimized couple-based interventions for dietary behaviour change. Investigating diet concordance in a novel way (*i.e.,* concordance in diet quality and concordance in adherence to the new food guide), as was done in this thesis, may help to better guide the development of more effective couple-based interventions by increasing our understanding of how couples share overall dietary behaviours.

Objective 2 ***(Manuscript 2)*****:**

The second aim of this thesis was to assess the agreement between a three-day food diary and a plate-based tool for food group portion intakes and adherence to the new CFG 2019. Finding an agreement between the three-day food diary and the plate-based tool would suggest that the three-day food diary is able to reflect similar information to a plate-based tool. Therefore, the three-day food diary or simply the plate-based tool itself may be able to be used as a dietary assessment tool to assess adherence to the new plate-based CFG 2019.

The results of this study showed that there is an agreement between the three-day food diary and the plate-based tool for protein and grain portions. This suggests that the three-day food diary is able to reflect similar information to a plate-based tool for protein and grain portions. However, this study also showed that there is a lack of agreement between the three-day food diary and the plate-based tool for fruit and vegetable portions and for adherence to the new CFG 2019. This suggests that the three-day food diary does not reflect similar information to a plate-based tool for fruit and vegetable portions and for adherence to the new food guide. Overall, we can use the three-day food diary or the plate-based tool itself to assess adherence to the new CFG 2019 because they reflect similar information (*i.e.,* for protein and grain portions). However, it is important to

consider that these tools are limited in assessing adherence to the new food guide because they do not reflect similar information for fruit and vegetable portions and adherence to the new food guide. The findings from this study highlight how the plate-based tool may be used as a dietary assessment tool to assess adherence to the new food guide in the dietetics practice which would be much simpler to use among patients/clients than a three-day food diary. One study that explored the perceptions of healthy middle-aged/older adults (n=45) with regards to the usability of a traditional three-day food diary compared to a plate-based tool (based on the CFG 2019) found that 62% of participants preferred using the plate as a self-monitoring tool to change their dietary habits as it is "easy", "visual" and "quick" [71]. In addition, other studies have shown that individuals have a positive attitude towards using a plate tool for monitoring dietary intake [6,8,16]. The results from these studies are encouraging because if we were to implement a plate-based dietary assessment tool in the dietetics practice, clients/patients may adhere to the idea of drawing their dietary intake instead of recording it using words and measurements. Furthermore, some studies show that using a plate tool improves dietary behaviours [4,8,9]. Therefore, a plate-based tool may not only be easier to use, but may also facilitate improvements in dietary behaviours among clients/patients.

One main limitation of this study is that it is a secondary analysis of a previous study [71] which was not designed for the objective of our study; assessing the agreement between the three-day food diary and the plate-based tool for food group portions and adherence to the new CFG 2019. This is because the previous study's [71] design was for participants to complete their three-day food diaries for three days one week and the plate tool for three days the next week. Therefore, in our study, we needed to assume that

participants were consuming on average a similar number of portions from each food group per day. This limitation could have caused for the lack of agreement between the three-day food diary and the plate-based tool for fruits and vegetables because this is the food group that varies the most daily. In addition, the lack of agreement between the three-day food diary and the plate-based tool for the fruit and vegetable portion intakes may have caused for the lack of agreement in adherence to the new food guide. This is because one of the questions to determine adherence to the new food guide was related to the fruit and vegetable portion intakes.

Objective 3 ***(Manuscript 3)*****:**

The third aim of this thesis was to investigate preliminary diet concordance data reflecting the old CFG 2007 (*i.e.*, concordance in diet quality) and the new CFG 2019 (*i.e.*, concordance in adherance to the new food guide) among cohabitating middle-aged/older adult couples living with and overweight condition or obesity. Based on the results from the systematic review, it was hypothesized that there would be a concordance in diet quality and in adherence to the new food guide among middle-aged/older adult couples living with an overweight condition or obesity. The preliminary data in our study shows that there is a concordance in diet quality and food group portion intakes among members in a couple. In addition, there is a concordance in nutrient intakes among members in a couple. The completion of Manuscript 2 allowed us to use the three-day food diary to assess adherence to the new food guide in Manuscript 3. We were therefore able to find an agreement and therefore concordance in adherence to the new food guide among members in a couple in Manuscript 3.

One of the limitations for this study was the small sample size (n=33 couples). In addition, the majority (94%) of the sample was Caucasian which limits the generalizability of our findings to various ethnicities. Another limitation of this study is that three-day food diary information was used to assess adherence to the CFG 2019. Indeed, Manuscript 3 showed an agreement and therefore concordance in adherence to the new food guide among members in a couple. However, it is important to consider that there was a lack of agreement between the three-day food diary and the plate-based tool for adherence to the CFG 2019 in Manuscript 2. This suggests that the three-day food diary may not reflect the same information as a plate-based tool for adherence to the new food guide. Therefore, it is important to consider that the three-day food diary is limited when assessing adherence to the new food guide. It is also important to consider that this study was conducted during the COVID-19 pandemic (unusual context) where participants were confined to their home. This could have allowed couples to be eating their meals together more often than usual which could have subsequently caused for consumption of the same foods. Overall, this could have caused for a greater concordance in dietary intake. For instance, a study that analyzed concordance for similar nutrient intakes among members in a couple found poor correlations (ranged from 0.02-0.21) which may have been attributed to a high eating out frequency [55].

There are other factors, such as assortative mating and duration of time in the relationship, that could have affected concordance in dietary intake. Assortative mating which is defined as the tendency for people to choose partners who are more similar to themselves than would be expected by chance [104]. One aspect of assortative mating that was investigated in a study was similarities in social factors and personality traits

among couples [105]. This study found significant spousal correlations for the level of education attained (an indicator of social economic status) which is related to disease development. In addition, the duration of the relationship may also influence correlations because not only was the correlation significant, but it increased with time (r=0.292, r=0.356, r=0.587 for ≤5 years, >5 years and >15 years, respectively) [105]. Furthermore, there were significant correlations for inhibition (a personality trait associated with increased risk behaviour) (r=0.39, r=0.33, r=0.37 for ≤5 years, >5 years and >15 years, respectively) [105]. However, these correlations were not affected by the duration of time in the relationship [105].

6.2 Implications and future directions

The findings from Manuscript 2 suggest that the plate-based tool can be used to assess adherence to the CFG 2019. This tool would be much simpler to use for not only the patient/clients, but would also be much simpler to interpret for the dietitian as it is in line with the plate-based guidelines. However, it is important to consider that this tool is limited in assessing adherence to the new food guide. Further research is required to assess the agreement between the three-day food diary and the plate-based tool while addressing the limitations found in Manuscript 2. For instance, future studies should compare three-day food diaries and plate-based tools that are completed on the same days to increase the accuracy of the results. In addition, future research should focus on further developing the plate-based tool to be able to measure the height of the foods on the plate. Lastly, future studies should continue to explore the agreement between the three-day food diary and the plate-based tool among a larger sample of individuals with various ethnicities and socioeconomic statuses.

Current couple-based interventions are based on increasing social support to enhance health behaviour change. This may be the reason why couple-based interventions are not more effective than individual-based interventions for dietary behaviour change [36, 37, 38]. The results from Manuscript 3 show preliminary evidence suggesting that couples do share similar dietary behaviours which is in line with the Interdependence Theory [24, 35]. Therefore, in order to optimize couple-based interventions for dietary behaviour change, we should be focusing on developing techniques tailored to modifying partner dynamics instead of solely focusing on social support. Once these techniques are integrated into couple-based interventions, studies will need to be conducted to test their effectiveness for dietary behaviour change. One possible way to facilitate the evaluation of these interventions in the future is to use a plate-based dietary assessment tool to determine how the couples' dietary behaviours change over time. If they prove to be more effective, then these optimized couple-based interventions can be implemented into the dietetics practice to allow for more effective obesity interventions. It is important to consider that this is a pilot study which consisted of a small sample size of mostly Caucasian individuals. Therefore, future studies should consider analyzing concordance for diet quality and adherence to the new food guide among a larger sample of couples including various ethnicities in order to obtain generalizable and clinically significant results. In addition, the cross-sectional nature of this study did not allow for the establishment of one partner influencing another partner's dietary behaviours. Future studies should investigate concordance in dietary intake over time (*i.e.,* longitudinal study design) in order to establish partner influence.

6.3 Conclusion

This thesis showed that there is an agreement between the three-day food diary and a plate-based tool for protein and grain portions. However, there is a lack of agreement between the three-day food diary and a plate-based tool for fruit and vegetable portions and for adherence to the CFG 2019. Overall, we can use the three-day food diary or the plate-based tool to assess adherence to the new food guide because they reflect similar information (*i.e.*, for protein and grain portions). However, it is important to consider that these tools are limited in assessing adherence to the new CFG 2019. Therefore, further research is required in this field while addressing the limitations specified in Manuscript 2 before we can use the three-day food diary or the plate-based tool to assess adherence to the new food guide in the dietetics practice.

This thesis also showed preliminary evidence for concordance in diet quality and food group portion intakes among members in a couple. Furthermore, there is concordance in nutrient intakes among members in a couple. In addition, it showed an agreement and therefore concordance in adherence to the new food guide among members in a couple. The concordance findings from this thesis encourages the integration of specific techniques for changing dietary behaviours that are tailored towards modifying partner dynamics into couple-based interventions. As a result, this can potentially optimize couple-based interventions for dietary behaviour change thereby creating more effective obesity interventions.

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