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Title: Associations among eating behaviour traits, diet quality and food labelling: A mediation model

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Ethical Standards Disclosure: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures (of both studies) involving human subjects were approved by the Laval University ethics committee. Written informed consent was obtained from all subjects.

Abstract

Objectives: The aims of this study were to assess the associations among eating behaviour traits, food label use and diet quality and to evaluate if the association between eating behaviour traits and diet quality is mediated by food label use.

Design: Eating behaviour traits were assessed using the Three-Factor Eating Questionnaire (TFEQ), the Restraint Scale and the Intuitive Eating Scale whereas food label use was measured with the Label Reading Survey. Diet quality (Canadian Healthy Eating Index) was assessed with a food frequency questionnaire.

Setting: Cross-sectional study

Subjects: Three-hundred eighty-five adults (BMI=26.0±4.9 kg/m^2, age=41.1±15.0 years) involved in two previous experimental studies.

Results: When controlling for potential covariates, general food label use (β=1.18±0.26, P<0.0001) was the main determinant of diet quality, explaining 6.7% of its variance. General food label use partly mediated the association between TFEQ-cognitive restraint and diet quality and the indirect effect was stronger in men ($\beta_{indirect}$=0.32±0.10, 95%CI (0.15, 0.55)) than in women ($\beta_{indirect}$=0.16±0.05, 95%CI (0.08, 0.27)). General food label use also partly mediated the negative association between unconditional permission to eat and diet quality and the indirect effect was also stronger in men ($\beta_{indirect}$=-1.88±0.55, 95%CI (-3.11, -0.96)) compared with women ($\beta_{indirect}$=-1.03±0.33, 95%CI (-1.81, -0.49)).

Conclusions: General food label use was the main determinant of diet quality and partly mediated the association between eating behaviour traits and diet quality. The stronger mediating effect observed in men suggest that they rely more on food labeling when attempting to restrained themselves, which translate in a better diet quality.

Keywords: Eating behavior traits, Food label use, Diet Quality, Intuitive Eating, Restrained Eating

Introduction

Many factors are involved in the etiology of obesity, including behavioural and psychological factors. Among these, eating behaviour traits that have been widely studied in association with body weight are cognitive restraint, disinhibition and susceptibility to hunger[1,2]. Dietary habits are also involved in weight management. Improvements in diet quality have indeed been associated with a lower weight gain over a 20-year period[3]. One way that eating behaviours can influence body weight is through diet quality, which can impact energy intake. Accordingly, cognitive restraint, defined as the intent to restrain food intake in order to control body weight, has been associated with a higher intake of healthy foods such as green vegetables[4]. Moreover, flexible control, a more relaxed or graduated approach towards eating, dieting and weight, has been associated with a better diet quality[5]. Disinhibition, defined by a loss of control over eating, has been associated with a higher intake of energy-dense foods[2]. Susceptibility to hunger, which refers to the susceptibility to feel hungry triggered by internal or external cues, is strongly associated with disinhibition[6,7] and has been positively associated with energy intake[8]. Intuitive eating, an eating style that relies on hunger and satiety cues to determine when, what and how much to eat[9], showed a very weak, but positive association with vegetable intake[10] and a weak and positive association with self-reported food diversity[11], although research regarding this eating behaviour is more limited and no association with dietary intakes has also been reported[12]. Moreover, gender differences have been observed in these eating behaviour traits. Women generally have higher levels of cognitive restraint and disinhibition than men[13-15]. Gender difference for susceptibility to hunger is less clear, as studies observed either no difference between men and women[13,15] or that women present a lower[14] level of susceptibility to hunger than men. Finally, a higher level of intuitive eating has been observed in men compared to women[11,16,17].

In addition to eating behaviour traits, food labelling, which represents a primary source of nutrition information, may be another factor influencing diet quality. Accordingly, food labelling has been proposed as a tool to help individuals make better and informed food choices[18] and it has been reported that food label use was associated with a better diet quality[19,20]. Studies generally show that women report using food labels more frequently than men[20,21] and they are more likely to report that food labels influenced their food choices[20]. Despite this beneficial effect of food labels on food choices and diet quality, several studies have also shown that food labelling may be confusing for some individuals[18,20] and their use does not always translate into healthier food choices or eating habits[22]. These conflicting results may be explained by different uses of food labelling among individuals presenting diverse eating

behaviour traits. For instance, restrained individuals may be more receptive to food labels, since nutrition information could be viewed for them as salient cues to support dieting rules, which may not always be in accordance to healthy eating patterns[22]. Indeed, a greater use of the nutrition fact table has been associated with an increased likelihood of engaging in both healthy and unhealthy weight control behaviours[23] and individuals attempting to control their body weight have also reported a greater use of food labels[20,21]. Consistent with this previous result, Christoph et al. recently showed that while nutrition fact use was unrelated to intuitive eating among young women, it was associated with a lower level of intuitive eating in young men[23]. This study also observed that a greater nutrition fact use in women was associated with a greater likelihood of engaging in binge eating[23], an eating disorder that has been positively associated with disinhibition[2]. To our knowledge, Christoph et al. was the first study to specifically assess the associations between one of the specific eating behaviour traits presented above, i.e., intuitive eating, and the frequency of food label use[23] and no study has yet assessed the associations between the other eating behaviour traits presented above and food label use. While the need to better understand how individuals that may be at risk for disordered eating use food labels was recently emphasized[23], no study has yet examined the associations among eating behaviour traits, food label use and diet quality in a mediation model which allows to identify the indirect effects by which eating behaviour traits are associated with diet quality.

The primary aim of this study was thus to assess the associations among eating behaviour traits (i.e., cognitive restraint, disinhibition, susceptibility to hunger and intuitive eating), food label use and diet quality in men and women. A second aim was to evaluate if the associations between eating behaviour traits and diet quality are mediated by food label use. Based on the previous but limited literature, three hypotheses were stated: 1) cognitive restraint and intuitive eating are positively associated with diet quality and conversely, disinhibition is negatively associated with diet quality while susceptibility to hunger is not associated with diet quality; 2) cognitive restraint, disinhibition and susceptibility to hunger are positively associated with food label use whereas intuitive eating showed a negative association with food label use; and 3) the use of food labels may partly mediate the association between cognitive restraint and diet quality. The first hypothesis is confirmatory but is a previous step for the other two hypotheses which are exploratory, except for the associations between intuitive eating and disinhibition with food label used since the association has been previously observed or a similar behaviour has been associated with food label use, respectively.

Methods

Participants

This cross-sectional study was conducted among participants resulting from *a posteriori* pooling of participants involved in two previous studies[24,25]. These studies aimed to assess the impact of food labelling on energy intake, appetite sensations and food perceptions during either a 10-day experimental period, where they received three *ad libitum* take-home meals per day[24] or a single *ad libitum* snack test[25]. In the 10-day experimental period, a label indicating either "low-fat" or the energy content of the meal, or no label as a control differentiated the three experimental groups [24]. In the snack test, oatmeal-raisin cookies were described either as healthy (i.e., high-fiber oatmeal), diet (i.e., satiating effect) or hedonic (less healthy ingredients i.e., brown sugar and butter), depending on the experimental groups[25]. Note that the experimental conditions of these two studies had no impact on measured energy intake[24,25]. Participants were recruited through different media at *Blinded for review* University or in the *Blinded for review* area. Inclusion criteria for the present study were as follows: age between 18 and 68 years, self-reported stable body weight (±2.5 kg) in the last two to three months prior to the study, no medications that could interfere with study outcomes (e.g., corticosteroids, antidepressants, antipsychotics), no weight-related or chronic health diseases (e.g., eating disorders, type 1 or type 2 diabetes, uncontrolled hypo- or hyperthyroidism, food allergies) and not being pregnant or lactating. Participants were blinded to the objectives of each study.

Measurements

Anthropometric measurements

Height was measured to the nearest 0.1 cm using a standard stadiometer and body weight was measured to the nearest 0.1 kg with a digital scale. Body mass index (BMI) was calculated as body weight divided by height squared (kg/m^2). Table 1 presents a summary of measurement times of the previous studies.

Diet quality assessment

Self-reported dietary intake was measured using a validated food frequency questionnaire (FFQ), either in interview (n=269)[26], or using a Web-based self-administered format (n=116)[27]. The Web-based FFQ contained 136 items and was developed based on the interviewer-administered FFQ which contained 91 items with a total of 33 subquestions. Both FFQs measure dietary intakes over the last month. The Web-based FFQ required approximately 45 minutes to complete and the interviewer-administered FFQ required between 30 and 45 minutes. The nutritional analysis was based on the Nutrition Data System for Research, version 4.03 for the interviewer-administered FFQ and on a food composition database created based on the Nutrition Data System for Research, version 4.03 and the Canadian Nutrient File,

version 2007b for the Web-based FFQ. Servings of the 2007 Canada's Food Guide were computed using an Excel File created for that purpose or electronically, depending on the FFQ. A reasonable agreement, as assessed by cross-classification between quartiles of dietary intake, has been demonstrated (i.e., mean of 84.3%±5.9 of participants classified within the same or adjacent quartiles of dietary intakes for all nutrients, with 2.5%±2.0 of subjects classified in non-adjacent quartiles), and significant correlations for the majority of nutrients (average of Pearson correlation coefficients, r=0.59±0.15) have also been shown between both FFQs[27]. Diet quality was assessed using the Healthy Eating Index (HEI) adapted for the Canadian nutrition recommendations[28]. This index reflects the global quality of the diet on a 100-point score comprising 10 components. The HEI score was calculated based on data obtained from the nutritional analysis.

Questionnaires

Eating behaviour traits were assessed using a validated French version[29] of the Three-Factor Eating Questionnaire (TFEQ)[1,15], the Restraint Scale[30] and the Intuitive Eating Scale[31] translated in French. The TFEQ measures cognitive restraint (21 items, Cronbach's alpha=0.81) and its two subscales, i.e., rigid and flexible control (7 items each, Cronbach's alpha=0.59 and 0.62, respectively), disinhibition (16 items, Cronbach's alpha=0.71), and susceptibility to hunger (14 items, Cronbach's alpha=0.72). The Restraint Scale (10 items, Cronbach's alpha=0.64) also assesses restrained eating but combined with a weight fluctuation factor[30]. The Intuitive Eating Scale measures total intuitive eating score (21 items, Cronbach's alpha=0.85) as well as three subscales, i.e., unconditional permission to eat (9 items), eating for physical rather than emotional reasons (6 items) and reliance on hunger and satiety cues to determine when and how much to eat (6 items) (Cronbach's alpha=0.79, 0.89 and 0.74, respectively)[31].

A French version of the validated Label Reading Survey[32] was used to measure a general (i.e., general food label use) and specific behaviour (i.e., item seeking on food labels) towards food label use. The Cronbach's alpha coefficient for the whole questionnaire, that also measures attitudes and knowledge towards food labels, was 0.78, which was similar to the value of the original questionnaire (i.e., 0.80)[32]. Cronbach's alpha coefficients were 0.57 and 0.81 for general food label use and item seeking on food labels, respectively. General food label use is measured as the sum of three items on a 5-point scale (never, 1 to always, 5), e.g., "When you purchase a food product for the first time, do you look at the Nutrition Facts label on the package?". Item seeking is measured as the sum of 15 items appearing on the Nutrition Facts table (e.g., serving size, calories, sodium, etc.) and 2 items related to health and nutrition claims on food labels. Participants were asked to indicate whether they used each item when

looking at food labels (No, 1; Yes, 2). This French version of the Label Reading Survey was adapted to the Canadian food labelling context (e.g., by replacing the word "Americans" for "Canadians" and modifying examples of American Nutrition Facts labels for Canadian labels), but these adaptations did not change the nature of the questionnaire. No changes were made to the items related to general food label use and the only change to item seeking on food labels related items was modifying "Calories from fat" for "percentage of daily value from fat" as the former do not appear on the Canadian Nutrition Facts Table. Participants also completed a sociodemographic questionnaire.

Statistical analyses

Descriptive statistics (mean ± SD or frequency) were computed to assess participant characteristics and eating behaviour traits in the whole sample. T-test and chi-square analyses were performed to assess differences between men and women. To account for the possibility of under- and overreporting of dietary intakes, participants having a ratio of self-reported energy intake to estimated basal metabolic rate (BMR), calculated with the Harris-Benedict equation, lower than 1.14 and higher than 2.4 were excluded from the analyses[33]. A ratio below 1.14 rather than 1.35 was chosen to identify underreporters of energy intake as it represents the lowest energy intake to BMR ratio that may reflect actual energy intake over a given period of time[34]. Moreover, this ratio was chosen because restrained eaters and individuals with obesity are more likely to underreport dietary intake[33,35] and excluding these individuals was not desired given the objectives of this study. A total of 88 and 35 participants were identified as under- and overreporters, respectively. Therefore, 385 participants were included in the analyses. Analyses were adjusted for the experimental conditions of the two previous studies by creating five indicator variables (i.e., experimental groups 1 to 3 were assigned to the three groups of *Blinded for review* et al. study[24] and experimental groups 4 to 6 were assigned to the three groups of *Blinded for review* et al. study[25]. The indicator variables were created for experimental conditions 1, 2, 4, 5, 6 and the control group of *Blinded for review* et al. study[24] (experimental condition 3) was used as the reference). These indicator variables were added as covariates in each analysis, even though no difference was observed in the main eating behaviour traits and food label use among the different experimental groups of the two previous studies (data not shown, $P>0.05$).

Partial Pearson's correlations were used to assess the associations among eating behaviour traits, diet quality and food label variables. These associations were first tested in a model that was only adjusted for experimental conditions and then in a model that was further adjusted for potential confounders (i.e., experimental conditions, age, gender, BMI, education level and household income)[20]. Age, BMI,

gender, education level [2 to 5 (no participant reported having no education level or not having completed elementary school which was coded as 1)] and household income (1 to 6) were treated as continuous variables while gender (men, 0; women, 1) was treated as a binary variable. Total scores of the main eating behaviour traits and food label variables that were significantly associated with HEI score were included in multiple stepwise regression analyses. These analyses were performed using an unadjusted model except for experimental conditions, and a fully adjusted model considering experimental conditions, BMI, age, gender, education level and household income as covariates. A second series of multiple stepwise regressions was run using the subscales of eating behaviour traits and food label variables that were significantly associated with HEI score, again in an unadjusted model, except for experimental conditions, and a fully-adjusted model for potential confounders.

Moderated mediation analyses were conducted to assess whether food label use mediate the association between eating behaviour traits and diet quality, and whether the mediation effect vary according to gender since gender differences have been observed in eating behaviour traits, food label use and diet quality[5,20]. These analyses were conducted with the use of model 58 in the Process macro version 2.16.3 for SAS that calculates bias-corrected 95% confidence intervals (CI) using bootstrapping with 5,000 samples[36]. Based on the location of the gender interaction identified, the analysis was rerun using the most suitable model (i.e., models 14 or 7) and if no moderated mediation was observed, the simple mediation model was used (i.e., model 4). The mediations were only tested in the model that was fully adjusted for covariates while considering gender as a potential moderator rather than a covariate. In cases where no moderating effect was observed, gender was thereafter considered as a covariate. Statistical significance was set to a $P<0.05$. Bonferroni adjustments for multiple comparisons were not used because of the exploratory nature of this study[37], particularly regarding mediation analyses among diet quality, eating behaviour traits and food label use, since correlation analyses are generally a previous step for mediation analyses. It is however possible that chance associations are presented for some findings, especially for those close to a *P* value of 0.05. However, to minimize this possibility, the only mediation models tested were those where significant associations between the independent and dependent variables (path c), between the independent variable and the mediator (path a) and between the mediator and the dependent variable (path b) were observed, according to the traditional view of interpretation of mediation analysis according to Baron and Kenny[38]. This rational was used because the aim of this study was to better understand the observed associations between eating behaviour traits and diet quality. All statistical analyses were performed using SAS software version 9.4 (SAS Institute, Cary, NC, USA).

Results

Participant characteristics

Mean age of participants (women n=265; men n=120) was 42.9±15.1 and 37.0±14.1 years for women and men, respectively, and slightly more than two third of the sample were women (**Table 2**). Women were significantly older, had a higher BMI, HEI score and level of restrained eating, as assessed with the TFEQ or with the Restraint Scale, compared with men. Women also presented a higher level of disinhibition and a lower intuitive eating score than men (Table 2).

Associations of eating behaviour traits and food label use with diet quality

TFEQ-cognitive restraint and its subscales were positively associated with HEI score in the model adjusted only for experimental conditions and in the fully-adjusted model (**Table 3**). Intuitive eating was negatively, but weakly, associated with HEI score in the model adjusted for experimental conditions (P=0.03) whereas the association was no longer significant in the fully-adjusted model (P=0.052). A negative association was observed with one of the intuitive eating subscales, i.e., unconditional permission to eat, and diet quality in both models. Scores reflecting general food label use and item seeking on food labels were all positively associated with HEI score in each model (Table 3).

Associations among eating behaviour traits and food label use

Positive correlations were observed for the association of TFEQ-cognitive restraint, rigid control and flexible control with general food label use and item seeking on food labels (**Table 4**). Small but positive correlations were also observed for disinhibition and susceptibility to hunger with general food label use in the fully-adjusted model. Restrained eating, assessed with the Restraint Scale, was positively associated with general food label use but not with item seeking on food labels. Intuitive eating and its subscale unconditional permission to eat were negatively associated with general food label use and with item seeking on food labels in both statistical models while the subscale eating for physical rather than emotional reasons was negatively associated with general food label use in the fully-adjusted model (Table 4).

Multiple regression analyses

The first multiple regression model tested for diet quality (HEI score) included TFEQ-cognitive restraint, intuitive eating, general food label use, item seeking on food labels as well as experimental conditions. General food label use (β=1.21±0.26, P<0.0001) and TFEQ-cognitive restraint (β=0.39±0.15, P=0.009) explained 6.4% and 2.1% of the variance in the HEI score, respectively. The model explained 11.9% of the variance in the HEI score (P<0.0001). Adding potential confounders (i.e., age, gender, BMI,

education level and household income) into the model increased the percent of variance explained in HEI score to 18.2% (P<0.0001). General food label use (β=1.18±0.26, P<0.0001) remained the only significant variable among the main eating behaviour traits and food label variables and it explained 6.7% of the variance in HEI score, although a tendency was observed for TFEQ-cognitive restraint (β=0.28±0.15, R^2=1.2% P=0.06). Gender (β=4.71±1.30, P=0.0004) and BMI (β=-0.32±0.12, P=0.01) explained respectively 4.3 and 2.2% of the variance in HEI score respectively, indicating that women and those with a lower BMI had a higher diet quality. Age and experimental conditions 1 and 2 remained in the model but were not significant (P>0.05).

The model was also tested with the subscales that were significantly correlated with the HEI score. The first model thus included rigid and flexible control, unconditional permission to eat, general food label use, item seeking on food labels and experimental conditions. General food label use (β=1.26±0.26, P<0.0001) and flexible control (β=0.85±0.38, P=0.03) respectively explained 6.9 and 1.5% of the variance in HEI score. The model explained 10.3% of the variance in HEI score (P<0.0001). In the fully-adjusted model, the percentage of variance explained in HEI score increased to 17.5% (P<0.0001). Among the eating behaviour traits and food label variables, general food label use (β=1.09±0.26, P<0.0001) remained again the only significant determinant of HEI score, explaining 5.7% of its variance. Gender (β=4.88±1.31, P=0.0002) and BMI (β=-0.42±0.12, P=0.0006) explained 4.6 and 4.0% in the variance in HEI score, respectively, again suggesting that women and individuals with lower BMI had a better diet quality. Unconditional permission to eat and experimental conditions 1 and 2 remained in the model but did not significantly contribute to explain the HEI score (P>0.05*)*.

Additional analyses were performed to test whether food label variables could mediate the association between eating behaviour traits (i.e., cognitive restraint and its two subscales, and unconditional permission to eat) and diet quality since these eating behaviour traits were associated with food label use variables and diet quality **(Figure 1, Table 5)**. Results showed that general food label use was a partial mediator of the associations between TFEQ-cognitive restraint, flexible control and unconditional permission to eat and HEI score and that general food label use mediated the association between rigid control and HEI score. Moreover, the index of moderated mediation indicates that the mediating effects were stronger in men than in women except for the model with rigid control since the index of moderated mediated did not reach significance [95% bootstrap IC (-1.46, 0.02)]. A similar pattern of association was observed in the models testing the mediating effect of item seeking on food labels. Indeed, item seeking on food labels partially mediated the association of TFEQ-cognitive restraint and rigid control

with HEI score, but this was observed only in men. Item seeking on food labels partially mediated the association between flexible control and HEI score with no moderating effect of gender. Finally, item seeking on food labels partially mediated the association between unconditional permission to eat and HEI score and the mediating effect was stronger in men than in women (Table 5).

Discussion

This study aims to assess the associations among eating behaviour traits, food label use and diet quality and to examine whether the association between eating behaviour traits and diet quality was mediated by food label use. Among the variables examined in this study, general food label use appears to be the main determinant of diet quality although correlation analyses also showed positive associations between TFEQ-cognitive restraint, and its subscales, and diet quality (HEI score) and negative associations for intuitive eating (in the model that was only adjusted of experimental condition), and its subscale unconditional permission to eat, with diet quality. Results also revealed that the associations between most of these eating behaviour traits and diet quality were partially mediated by general food label use and item seeking on food labels and the mediating effect was stronger in men than in women in most models.

The pattern of associations between eating behaviour traits and diet quality is consistent with the literature. Indeed, the positive association between cognitive restraint and diet quality has been previously reported by studies showing that cognitive restraint and flexible control were associated with higher intakes of foods that are components of healthy eating such as green vegetables, fish and yogurts or with a higher diet quality score based on fruit and vegetables, whole-grain products and fish intakes, respectively[4,5]. The positive association between rigid control and diet quality must although be interpreted with caution since restrained eaters may be more prone to social desirability bias when reporting eating habits[35]. Because rigid control is characterized by a dichotomous (all or nothing) approach towards eating and has been positively associated with disinhibition[13-15], it may not be a positive determinant of diet quality in the longer term. Accordingly, it has been suggested that a high level of cognitive restraint in women may be difficult to sustain over time[14]. In contrast to rigid control, flexible control represents an approach towards eating that is characterized by a higher probability of successful weight reduction or weight management and by a negative association with disinhibition[14,15]. Such literature suggests that flexible control may be easier to maintain over time, so individuals may be less likely to show important deviations from their usual dietary habits and thus, they may eat less unhealthy foods as supported by a positive association with diet quality[5]. Although the negative

association between unconditional permission to eat and diet quality has not been previously reported, this intuitive eating subscale has been associated with lower fruit and vegetables and whole-grain intakes[39], which represent important components of diet quality.

Food label use, as measured by both general food label use and item seeking on food labels, was associated with a better diet quality. This is in line with the majority of studies on this topic demonstrating that food label use benefit eating habits[20]. Considering the cross-sectional nature of the present study, it is also possible that individuals having a better diet quality pay more attention to food labels, as it has been reported that individuals having better eating habits report a greater use of food labels[20]. To our knowledge, this study is one of the first to document the associations between eating behaviour traits and food label use. The positive associations among restrained eating and food label use were expected since restrained eating requires cognitive effort to adhere to a diet in order to lose or to maintain body weight, and nutritional information found on food labels could support that effort. Similarly, the negative association between intuitive eating and food label use suggests that because intuitive eating relies more on internal sensations of hunger and satiety, it could be less related to cognitive processes towards eating such as using food labels when purchasing or consuming food. Disinhibition and susceptibility to hunger were both positively, but weakly, associated with general food label use in the fully-adjusted model, suggesting that individuals presenting a higher level of disinhibition or susceptibility to hunger may use food labels to select food products that seem healthier or lower in fat or in calories to compensate for their overeating tendencies. Likewise, individuals with susceptibility to hunger may also use food labels to choose foods that seem more satiating, but is it also possible that choosing low-fat or low-calorie foods triggers hunger sensations.

Although eating behaviour traits and food label use only explained a small proportion of the variance in diet quality, this study suggests that food label use greater explains diet quality than eating behaviour traits. Given the myriad of factors influencing dietary habits[40], the percentage of variance explained in diet quality by the different models and, mainly by food label use, is nonetheless considerable. Moreover, using food labels seems to represent a tool that explained a greater part of the association between cognitive restraint and diet quality in men than in women. In contrast, not using food labels seems to greater explain the negative association between unconditional permission to eat and diet quality in men compared with women. Considering that men are more prone to give themselves an unconditional permission to eat compared with women[39], this latter result suggests that when men allow themselves to eat unconditionally, they use food labels less often, which contribute to a lower diet quality. This result

368 is in line with Christoph et al. study showing that a higher level of intuitive eating was associated with a
369 lower level of food label use in men[23]. The fact that women usually eat less intuitively [11,16,17], are more
370 restrained [13-15], and use food labels more often than men[20,21] may explain why the mediating effect of
371 food label use was weaker in women. Similarly, restrained eating and dieting represent a cultural norm
372 for women in western countries[41,42], suggesting that women may more importantly internalize these
373 behaviours. This context might explain why the association between cognitive restraint and diet quality
374 is less mediated by food label use in women as opposed to restrained men who more essentially need to
375 rely on such tool to achieve a better diet quality.

376 Nonetheless, and irrespective of gender, the mediating effect of food label use in the association between
377 cognitive restraint and diet quality is in line with the use of dietary restraint as a self-regulation strategy
378 as proposed by Schaumberg et al.[43]. Accordingly, our results suggest that food labelling could support
379 self-monitoring among restrained eaters, helping them to implement their dieting rules and reach a better
380 diet quality, which is in line with a previous study showing that the association between attitude toward
381 healthy meal preparation and diet quality was mediated be a greater use of food labels among college
382 students[44]. Christoph et al. also showed that food label use was associated with a greater likelihood of
383 engaging in healthy weight control behaviours, but also, and to a lesser extent, to a greater likelihood of
384 engaging in unhealthy weight control behaviours[23], suggesting that some individuals may use food
385 labels to implement unfavorable eating behaviours. It is important to note that the associations observed
386 in the present study are not causal due to its cross-sectional nature.

387 This study has several strengths and limitations that need to be outlined. First, it is the first study to assess
388 the associations of many eating behaviour traits with food label use and global diet quality in the same
389 sample of men and women and to our knowledge, the mediating effect of food label use in the association
390 between these eating behaviour traits and diet quality has never been explored. As previously discussed,
391 the main limitation of this study is its cross-sectional nature that does not allow to determine causality
392 among variables. Therefore, it is not possible to confirm if restrained individuals use food labels because
393 of their dieting behaviours or if using food labels when making food choices can lead to restrained eating.
394 Moreover, because of the rather conservative strategy used regarding mediation analyses, it is possible
395 that other mediating effects could have been observed for eating behaviour traits that were not directly
396 associated with diet quality (HEI score). However, this was beyond the scope of this study and therefore
397 remain to be investigated. Dietary intake was self-reported, implying that potential social desirability
398 bias could have influenced the results. The use of a FFQ may be implicated in the small proportion of

the variance in diet quality explained by eating behaviour traits and food label use variables. While the Cronbach's alpha coefficient of one of the TFEQ subscales is rather low (i.e., <0.60) and could be considered as a limitation, the TFEQ remains an established questionnaire used to measure eating behaviour traits and the Cronbach's alpha coefficients of its three main components were adequate in this sample. With regards to the low Cronbach alpha coefficient for general food label use (i.e., 0.57), the validity of the Label Reading Survey has been previously reported[32], and as mentioned earlier, the Cronbach's alpha coefficient for our adapted questionnaire was similar to the value of the original one. It is also likely that the different contexts specified in the questions (i.e., using food labels when purchasing a food for the first time or when eating food) are implicated in this relatively low internal consistency for the general food label use variable since one could only use food labels at the point of purchase. The Label Reading Survey covered the main food label components (i.e., nutrition fact table, health and nutrient-related allegations), but did not cover all information included on food labels (e.g., ingredients list and other types of allegations), and this may reduce the accuracy of the food label use measure. The high education level of participants could limit the generalization of the results to other populations. Finally, it is important to mention that this is a cross-sectional study that was conducted among participants of two previous studies. One could argue that this design implicated priming which can impact the results of the present study. However, as previously mentioned, no experimental conditions effect was observed for the main eating behaviour traits, food label use variables, measured energy intake in the main studies (i.e., *ad libitum* snack test or 10-d energy intake). Moreover, this potential priming effect was considered in all analyses by adding the experimental conditions of the main studies as a covariate, so it is likely that the results observed in the present study are not explained by the priming effect of the main studies or that this bias is therefore greatly reduced.

Conclusions

This study showed that food label use was a better determinant of diet quality than eating behaviour traits. Moreover, food label use partially mediated the association between cognitive restraint or unconditional permission to eat and diet quality and the mediating effects were stronger in men than in women. While food labels could be helpful to adopt a healthy diet, the psychobehavioural profile of individuals seen in a clinical context should be assessed to individualize strategies used to facilitate healthy eating. It is indeed important to support appropriate self-regulation strategies and not favour the adoption of unhealthy eating behaviour traits that may result in conterregulatory eating[43]. Future studies

429 should assess the impact of food label use on eating behaviour traits and diet quality in an intervention
430 context.

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Figure legend.

Figure 1. Mediating effect of general food label use on the association between cognitive restraint (A) or unconditional permission to eat (B) and diet quality.
a= ß coefficient for the association between cognitive restraint (A), or unconditional permission to eat (B) and general food label use.
b= ß coefficient for the association between general food label use and diet quality (HEI score).
c'= ß coefficient for the association between cognitive restraint (A) or unconditional permission to eat (B), and diet quality (HEI score) when the mediator (general food label use) is in the model. Data obtained from Process model 7 for A and B. Adjusted for experimental conditions, age, BMI, household income and education level. Prefer not to answer for education level and household income were recoded as missing data. Education level and household income were treated as continuous variables. Five indicator variables were created for experimental conditions and the control group of *Blinded for review* et al. study was used as reference). Cognitive restraint was assessed with the TFEQ. A) n=329, B) n=336.

552 Table 1. Summary of measurement times (before or after experimentation) of the two previous
553 studies.

Measures	*Blinded for review* et al. 2012		*Blinded for review* et al. 2015	
	Before	After	Before	After
Height		x	x	
Weight		x	x	
FFQ		x	x	
Questionnaires				
TFEQ		x		x
Restraint Scale		x		x
Intuitive Eating Scale		x		x
Food label use		x	x	
Sociodemographic		x		x

554

555 Table 2. Participant characteristics, eating behaviour traits, diet quality and food label use of the
556 whole sample (n=385) and of women and men

Variables	Total (n=385)		Women (n=265)		Men (n=120)		*P* ‖
	mean or frequency	SD	Mean or frequency	SD	Mean or frequency	SD	
Gender (%)	-		68.8		31.2		<0.0001
Age (years)	41.1	15.0	42.9	15.1	37.0	14.1	0.0004
BMI (kg/m^2)	26.0	4.9	26.4	5.5	25.1	3.3	0.006
Overweight/obese (%)	50.4		49.8		51.7		0.74
Education level (%) *							
Elementary school	0.8		1.2		0.0		
High school	12.5		11.7		14.4		
College	30.7		28.4		35.6		0.34 ¶
University	55.7		58.4		50.0		
Prefer not to answer	0.3		0.4		0.0		
Household income ($CA) (%) †							
<20 000	21.3		19.7		24.8		
20 000-39 999	17.8		17.3		18.8		
40 000-59 999	20.0		20.5		18.8		
60 000-79 999	14.6		13.8		16.2		0.71
80 000-99 9999	7.3		8.3		5.1		
≥100 000	11.9		12.2		11.1		
Prefer not to answer	7.3		8.3		5.1		
HEI score (scale 0 to 100)	79.3	11.0	80.5	10.5	76.6	11.5	0.001
Eating behaviours							
Cognitive restraint (scale 1 to 21)‡	7.6	4.3	8.2	7.7	6.2	3.8	<0.0001
Rigid control (scale 1 to 7)	2.1	1.6	2.4	1.7	1.6	1.3	<0.0001
Flexible control (scale 1 to 7)	2.8	1.7	3.0	1.7	2.4	1.5	0.002
Disinhibition (scale 1 to 16)	5.5	2.9	5.8	3.0	4.8	2.6	0.002
Susceptibility to hunger (scale 1 to 14)	4.5	3.0	4.7	3.0	4.3	3.1	0.27
Restraint (scale 0 to 35) §	13.2	4.7	13.9	4.6	11.6	4.6	<0.0001
Intuitive eating (scale 1 to 5)	3.4	0.5	3.3	0.5	3.6	0.5	<0.0001
Unconditional permission to eat (scale 1 to 5)	3.2	0.7	3.1	0.6	3.4	0.7	<0.0001
Eating for physical rather than emotional reasons (scale 1 to 5)	3.4	0.9	3.2	0.9	3.8	0.9	<0.0001
Reliance on internal hunger and satiety cues (scale 1 to 5)	3.6	0.6	3.6	0.6	3.6	0.5	0.42
General food label use (scale 3 to 15)	9.7	2.3	9.8	2.2	9.4	2.5	0.07
Item seeking on food labels (scale 17 to 34)	26.7	3.8	27.0	3.5	26.2	4.3	0.08

557 BMI, body mass index; HEI score, Healthy Eating Index score.
558 * Missing values n=10 (women n=8, men n=2); † Missing values n=14 (women n=11, men n=3)
559 ‡Assessed with the TFEQ; § Assessed with the Restraint scale
560 ‖ *P* values indicate gender differences
561 ¶ *P* value from Fisher exact test
562 Values are presented as mean (SD) or as frequency

563 Table 3. Associations of eating behaviour traits and food label use with diet quality (HEI score)

Variables	Unadjusted model		Fully-adjusted model	
	r	*P*	r	*P*
Cognitive restraint*	0.26	<0.0001	0.20	0.0004
Rigid control	0.19	0.0003	0.13	0.02
Flexible control	0.24	<0.0001	0.17	0.003
Disinhibition	-0.05	0.31	-0.03	0.59
Susceptibility to hunger	0.01	0.90	0.06	0.32
Restraint†	0.03	0.62	0.00	0.98
Intuitive eating	-0.11	0.03	-0.11	0.052
Unconditional permission to eat	-0.20	0.0001	-0.16	0.003
Eating for physical rather than emotional reasons	0.02	0.72	0.03	0.55
Reliance on internal hunger and satiety cues	-0.03	0.57	-0.10	0.07
General food label use	0.30	<0.0001	0.27	<0.0001
Item seeking on food labels	0.20	0.0002	0.19	0.0009

564 HEI score, Healthy eating index score.
565 * Assessed with the TFEQ;
566 † Assessed with the Restraint scale
567 Values are partial Pearson's correlation coefficients (r).
568 Unadjusted model: adjusted only for experimental conditions; Fully-adjusted model: adjusted for
569 experimental conditions, age, gender, BMI, education level and household income. Prefer not to answer
570 for education level and household income were recoded as missing data. Education level and household
571 income were treated as continuous variables. Five indicator variables were created for experimental
572 conditions and the control group of *Blinded for review* et al. study was used as reference).
573 Unadjusted model: n=349 to 384; Fully-adjusted model: n=317 to 342.
574

575 Table 4. Associations between eating behaviour traits and food label use.

Variables	General food label use				Item seeking on food labels			
	Unadjusted model		Fully-adjusted model		Unadjusted model		Fully-adjusted model	
	r	*p*	r	*p*	r	*p*	r	*p*
Cognitive restraint*	0.37	<0.0001	0.32	<0.0001	0.26	<0.0001	0.17	0.004
Rigid control	0.35	<0.0001	0.30	<0.0001	0.22	<0.0001	0.13	0.03
Flexible control	0.33	<0.0001	0.27	<0.0001	0.22	<0.0001	0.14	0.02
Disinhibition	0.06	0.27	0.11	0.04	0.01	0.87	0.00	0.96
Susceptibility to hunger	0.03	0.53	0.12	0.03	-0.05	0.34	0.01	0.84
Restraint†	0.19	0.0002	0.22	<0.0001	0.06	0.24	0.01	0.84
Intuitive eating	-0.23	<0.0001	-0.24	<0.0001	-0.19	0.0004	-0.17	0.003
Unconditional permission to eat	-0.35	<0.0001	-0.33	<0.0001	-0.33	<0.0001	-0.27	<0.0001
Eating for physical rather than emotional reasons	-0.08	0.12	-0.12	0.04	-0.06	0.30	-0.08	0.18
Reliance on internal hunger and satiety cues	0.04	0.45	0.00	0.98	0.06	0.28	0.05	0.36

576 * Assessed with the TFEQ; † Assessed with the Restraint scale

577 Values are partial Pearson's correlation coefficients (r).

578 Unadjusted model: Adjusted only for experimental conditions; Fully-adjusted model: Adjusted for
579 experimental conditions, age, gender, BMI, education level and household income. Prefer not to answer
580 for education level and household income were recoded as missing data. Education level and household
581 income were treated as continuous variables. Five indicator variables were created for experimental
582 conditions and the control group of *Blinded for review* et al. study was used as reference).

583 General food label use: Unadjusted model: n=359 to 379; Fully-adjusted model: n=323 to 339

584 Item seeking on food labels: Unadjusted model: n=333 to 346; Fully-adjusted model: n=302 to 314.

585 Figure 1.
586
587
588

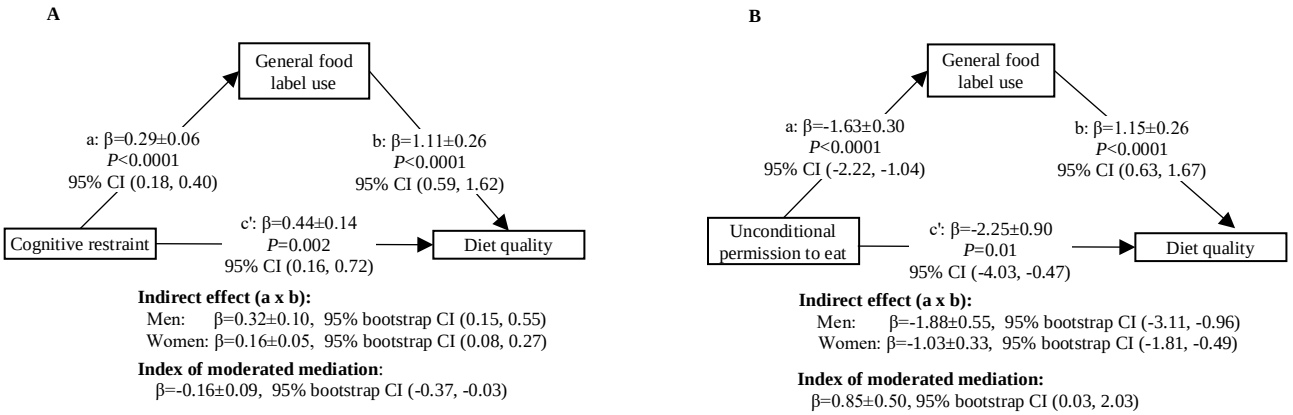

Table 5. Mediation models between eating behaviour traits, food label use and diet quality (HEI score)

	a *				b †				Direct effect (c') ‡				Indirect effect (a x b)				Index of moderated mediation			Process model used
	β	SE	*p*	95% CI	β	SE	*p*	95% CI	β	SE	*p*	95% CI		β	SE	95% Bootstrap CI	β	SE	95% Bootstrap CI	
Mediator: General food label use																				
Rigid control §	0.45	0.08	<0.0001	(0.29, 0.62)	1.14	0.26	<0.0001	(0.63, 1.65)	0.37	0.39	0.35	(-0.41, 1.15)		0.52	0.14	(0.28, 0.83)	-0.63	0.38	(-1.46, 0.02)	4‖
Flexible control	0.61	0.14	<0.0001	(0.33, 0.89)	1.21	0.26	<0.0001	(0.70, 1.73)	0.90	0.37	0.01	(0.18, 1.62)	Men	0.74	0.23	(0.37, 1.30)	-0.39	0.23	(-0.93, -0.03)	7
													Women	0.36	0.13	(0.15, 0.64)				
Mediator: Item seeking on food labels																				
Cognitive restraint ¶	0.35	0.09	0.0002	(0.16, 0.53)	0.59	0.16	0.0004	(0.27, 0.92)	0.53	0.14	0.0003	(0.24, 0.81)	Men	0.21	0.10	(0.06, 0.44)	-0.17	0.09	(-0.40, -0.02)	7
													Women	0.04	0.03	(-0.02, 0.12)				
Rigid control	0.90	0.27	0.001	(0.37, 1.43)	0.61	0.17	0.0004	(0.27, 0.94)	1.07	0.39	0.007	(0.30, 1.85)	Men	0.54	0.26	(0.14, 1.18)	-0.48	0.27	(-1.11, -0.06)	7
													Women	0.07	0.09	(-0.08, 0.28)				
Flexible control §	0.31	0.13	0.02	(0.05, 0.58)	0.52	0.16	0.002	(0.20, 0.85)	0.75	0.38	0.047	(0.01, 1.49)		0.16	0.09	(0.03, 0.40)	-0.29	0.23	(-0.86, 0.08)	4**
Unconditional permission to eat	-2.54	0.50	<0.0001	(-3.52, -1.56)	0.50	0.17	0.003	(0.17, 0.83)	-2.81	0.94	0.003	(-4.67, -0.96)	Men	-1.27	0.50	(-2.51, -0.46)	0.82	0.44	(0.14, 1.96)	7
													Women	-0.45	0.26	(-1.16, -0.08)				

* a= ß coefficient for the association between eating behaviour traits and general food label use/item seeking on food labels.

† b= ß coefficient for the association between general food label use/item seeking on food labels and diet quality (HEI score).

‡ c'= ß coefficient for the association between eating behaviour traits and diet quality (HEI score) when the mediator (general food label use/item seeking on food labels) is in the model. Adjusted for experimental conditions, age, BMI, household income and education level. Prefer not to answer for education level and household income were recoded as missing data. Education level and household income were treated as continuous variables. Five indicator variables were created for experimental conditions and the control group of *Blinded for review* et al. study was used as reference).

§ This model was also adjusted for gender as gender did not moderate the mediation effect.

‖ Index of moderated mediation was obtained from model 58, but it was also non-significant in other moderated mediation models (i.e., models 14 and 7).

¶ Assessed with the TFEQ.

** Index of moderated mediation was obtained from model 7, but it was also non-significant in other moderated mediation models (i.e., models 58 and 14).

Models using general food label use as a mediator: n=323 to 325; Models using item seeking on food labels as a mediator: n=302 to 312.