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Clinical Study

Influence of Physical Activity Participation on the Associations between Eating Behaviour Traits and Body Mass Index in Healthy Postmenopausal Women

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Available data reveals inconsistent relationships between eating behaviour traits and markers of adiposity level. It is thus relevant to investigate whether other factors also need to be considered when interpreting the relationship between eating behaviour traits and adiposity. The objective of this cross-sectional study was thus to examine whether the associations between variables of the Three-Factor Eating Questionnaire (TFEQ) and adiposity are influenced by the level of physical activity participation. Information from the TFEQ and physical activity was obtained from 113 postmenopausal women (56.7 ± 4.2 years; $28.5 \pm 5.9\,\mathrm{kg/m^2}$). BMI was compared between four groups formed on the basis of the physical activity participation and eating behaviour traits medians. In groups of women with higher physical activity participation, BMI was significantly lower in women who presented higher dietary restraint when compared to women who had lower dietary restraint (25.5 ± 0.5 versus $30.3 \pm 1.7\,\mathrm{kg/m^2}$, $P < .05$). In addition, among women with lower physical activity participation, BMI was significantly lower in women presenting a lower external hunger than in those with a higher external hunger (27.5 ± 0.8 versus $32.4 \pm 1.1\,\mathrm{kg/m^2}$, $P < .001$). Our results suggest that physical activity participation should also be taken into account when interpreting the relationship between adiposity and eating behaviour traits.

1. Introduction

The regulation of energy intake in humans is based on a series of complex mechanisms that is not solely driven by homeostatic factors such as hunger and satiety signals [1]. It has been suggested that cognitions and emotions are largely involved in the regulation of energy intake [2]. Different tools have been proposed to grasp the complexity of eating behaviour traits in humans. Among them, the Three-Factor Eating Questionnaire developed by Stunkard and Messick assesses three dimensions of eating behaviour traits: dietary restraint, disinhibition, and hunger [3]. Briefly, dietary restraint is defined as a conscious control of food intake with concerns about shape and weight, disinhibition refers to an overconsumption in response to a variety of stimuli associated with a loss of control on food intake, and hunger is the food intake in response to feelings and perception of hunger [4]. This questionnaire has been widely used to study the association between eating behaviour traits and body weight [3].

The association between dietary restraint and (BMI) is uncertain; some authors have found no association [5–8] while others have found that the two were inversely related [9–11]. Generally, weight-loss intervention studies have demonstrated that subjects who achieved larger weight losses when dieting are also those in whom the greatest increase in dietary restraint is noted [6, 9, 10, 12, 13]. In addition, the success of weight-loss interventions has also been associated to lower pre-weight-loss dietary restraint [10, 14]. Similarly, results from a longitudinal study have shown that a lower dietary restraint at baseline was associated with lower weight gain during a 6-year follow-up period [15]. Therefore in the long term, it is not clear whether it is preferable to have higher or lower dietary restraint for optimal body weight management. On the other hand, the association between disinhibition and BMI is more consistent as many studies have shown that higher dietary disinhibition is associated with higher BMI and a higher likelihood of weight gain over time [5, 7, 16–18]. Similarly, a positive correlation between hunger and BMI has been reported [5, 17].

It has also been demonstrated that physical activity, apart from its impact on energy expenditure, could also influence energy intake. In fact, studies have suggested that physically active individuals are more likely to eat a healthy diet than sedentary individuals are. Physically active individuals consume more fruits and vegetables and have higher intakes of fiber and calcium than sedentary individuals do [19, 20], which have been shown to favourably influence appetite and energy intake [21, 22]. As well, physical activity can influence eating behaviour by improving satiety, by altering macronutrient preference, and by modulating the hedonic response to foods [23–26].

Considering the above-mentioned evidence suggesting that BMI is influenced by eating behaviour traits and that physical activity is generally associated with healthier food habits, the main objective of this paper was to investigate whether physical activity participation could influence the associations between eating behaviour traits and BMI in postmenopausal women. Since it has been reported that exercise exerts some effects on eating patterns and that it has been shown to be more effective to regulate energy intake in restrained compared to nonrestrained eaters [27], we hypothesized that a negative association between dietary restraint and BMI would only be observed in women with higher physical activity participation. In addition, based on the fact that exercise does not act as a disinhibitor but rather increases the preference for low-fat foods and reduces the motivation to eat [28, 29], we also hypothesized that the positive associations between disinhibition and hunger with BMI would be attenuated with increased physical activity participation.

2. Experimental Methods

2.1. Participants. The main objective of this cross-sectional study, conducted between 2000 and 2003, was to determine the relative contribution of visceral adipose tissue and insulin resistance to the cardiovascular risk profile of postmenopausal women [30]. A total of 386 women responded to the local newspapers of the Québec City metropolitan area [31]. As described by Major et al., one hundred ninety women were found to be eligible [31]. Among them, 69 dropped out of the study for personal reasons after having received a complete description of the research protocol [31]. Eight women who have either not totally completed the physical activity questionnaire or have answered less than 80% of each factor (restraint, disinhibition and hunger) were not included in the database. Specifically, having answered to at least 17/21, 13/16, and 12/14 items for restraint, disinhibition and hunger were respectively needed to include the data in our analysis. In case of missing data, the scores were then calculated by extrapolation using a rule of three. Therefore, a total of 113 Caucasian women aged between 46 and 67 years were included in the analyses for this paper. Women were individually interviewed to evaluate whether they satisfied study's inclusion criteria for age, postmenopausal status (confirmed by absence of menses for at least 1 year and levels of follicle-stimulating hormone between 28 and $127\,\mathrm{IU{\cdot}L^{-1}}$), absence of any hormone therapy (HT), and other medication, except a stable dose of thyroxine that well-controlled a hypothyroidism's diagnosis. At the time of inclusion, women had a stable weight for at least 2 months (± 2.5 kg), were not dieting, had no chronic diseases, and were not taking medication that could impact on the study outcome. Women with cardiovascular disease, dyslipidemia, or endocrine disorders were excluded. This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all the procedures involving human subjects were approved by the Université Laval Medical Ethics Committee. Written informed consent was obtained from all subjects/patients.

2.2. Anthropometry. Body weight was measured to the nearest 0.1 kg using a calibrated weighing device including a tension gauge (Intertechnology Inc.) and a Digital Panel Indicator (Beckman industrial series 600). Fat mass was evaluated with the hydrostatic weighing technique, as described elsewhere [32]. Standing height was measured to the nearest millimeter using a wall stadiometer without shoes. Waist circumference was assessed in duplicate at the mid-distance between iliac crest and last rib margin with a flexible steel metric tape to the nearest 0.1 cm.

2.3. Eating Behaviour Traits. Eating behaviour traits were evaluated using the Three-Factor Eating Questionnaire, a 51-item validated questionnaire [3, 33]. It assesses 3 factors and specific subscales that refer to cognitions and behaviours which have been reported to show good test—retest reliability [3, 6, 33, 34]. Dietary restraint is a conscious control of food intake to control body weight [3–5]. This factor can be divided into rigid dietary restraint (dichotomous, all-or-nothing approach to eating, dieting, and weight) and flexible dietary restraint (gradual approach to eating, dieting, and weight) [6]. Dietary disinhibition is characterized by an overconsumption of foods in response to a variety of stimuli (e.g., emotional stress) associated with a loss of control on food intake [3–5]. It is further divided into three specific subscales: habitual susceptibility to disinhibition (behaviours that may occur when circumstances predispose to recurrent disinhibition), emotional susceptibility to disinhibition (disinhibition associated with negative affective states), and situational susceptibility to disinhibition (disinhibition initiated by specific environmental cues) [34]. Hunger represents food intake in response to feelings and perceptions of hunger. Internal hunger (hunger interpreted and regulated internally) and external hunger (triggered by external cues) are the two specific subscales that can be derived from the hunger factor [4, 34].

2.4. Physical Activity Participation. Physical activity participation was defined using the 3-day activity diary record by Bouchard et al. [35] that was administered during two weekdays and one weekend day. Each day (24 hours) is divided into 96 periods, 15-minutes each. As previously described by Major et al., [31] women reported the dominant activity that they were engaged in for each 15-minute period and indicated the corresponding number (from 1 to 9). If their specific activities were not included into the list, they were instructed to choose an activity with similar intensity. As an example, category 1 refers to activities of very low energy expenditure (e.g., sleeping and resting in bed), category 6 refers to leisure activities and sports in a recreational environment (e.g., golf, baseball, and volleyball), and category 9 refers to activities of very high energy expenditure (e.g., running) [35]. Our study focused on mean daily energy expenditure from activities in categories 6, 7, 8, and 9 (EE6–9), which have an energy cost $>1.2\,\text{kcal}\cdot\text{kg}^{-1}\cdot 15\,\text{min}^{-1}$ (>4.8 METs) (i.e., 1.2, 1.4, 1.5, and $2\,\text{kcal}\cdot\text{kg}^{-1}\cdot 15\,\text{min}^{-1}$ for categories 6, 7, 8, and 9, resp.). As previously described by Major et al., [31] EE6–9 was calculated by multiplying the number of 15-minute periods of categories 6 to 9 by the approximate median energy cost of each category. As such, the following formula was used: EE6–9 = (number of 15-minute periods of category 6×1.2) + (number of 15-minute periods of category 7×1.4) + (number of 15-minute periods of category 8×1.5) + (number of 15-minute periods of category 9×2). The result was then used to calculate the mean EE6–9 value for 3 days ($\text{kcal}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$) and was used for further analyses [35]. The main limitation of this physical activity diary relates to the approximation of the energy cost since each categorical value is the approximate median amount of energy expended when engaged in the activities of the specific category [35]. The 3-day activity diary record has nonetheless been validated [35], and results suggest that it represents an appropriate way to estimate mean daily energy expenditure and frequency of participation in activities from different categories. In addition, it has been suggested, in a study conducted in the same cohort, that women with higher physical activity participation had a better metabolic profile (insulin sensitivity and lipid levels) for a given level of visceral adipose tissue, which is concordant with the well-known beneficial effects of a higher physical activity participation on metabolic profile [31].

2.5. Food Record. Dietary intakes were collected using a 3-day weighed food record, which was completed during two weekdays and one weekend day (same days as the 3-day activity diary). Guidelines for completing the food record were explained to participants by the study's registered dietitian. Women were asked to weigh foods with a scale provided by the research team. The evaluation of nutrient intakes derived from the food record was performed using the Nutrition Data System for Research software (version 4.03, developed by the Nutrition Coordination Center, University of Minnesota, Minneapolis, MN, Food and Nutrient Database 31, released in November 2000) [36]. All records were reviewed by the study's registered dietician upon collection. In order to control for underreporting in our study population, subjects who reported an energy intake of less than 1 standard deviation from the mean reported energy intake were excluded from the dietary analysis (22 and 14 subjects in the lower and higher physical activity participation group, resp.). Thus, the number of subjects included in the dietary analysis (42 and 35 subjects in the lower and higher physical activity participation group, resp.) is different from the numbers included for the main outcome of the study (64 and 49 subjects in the lower and higher physical activity participation group, resp.).

2.6. Statistical Analyses. Statistical analyses were performed with the use of SPSS software (version 11.5; SPSS Inc, Chicago, IL). The median value of EE6–9 ($2\,\text{kcal}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$) was used to form two groups: women with lower and higher physical activity participation. Difference between the two groups for anthropometric variables, eating behaviour traits, and dietary intakes were assessed using Student *t*-tests. Pearson correlations were used to examine associations between BMI and eating behaviour traits within women characterized by lower and higher physical activity participation. Comparisons of the correlation coefficient strength between groups were performed using MedCalc software [37]. BMI was compared between the four groups formed on the basis of the physical activity participation median and of the dietary restraint median ($2\,\text{kcal}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$ and a score of 9, resp.), by using an analysis of variance (ANOVA), followed by Tukey *post hoc* tests. The same analyses were performed with groups formed on the basis of the physical activity participation median and external hunger median ($2\,\text{kcal}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$ and a score of 2, resp.). A general linear model was also performed to compare the interactions between variables. Eating behaviour traits that were significantly correlated with BMI were used in multivariate linear regressions analyses (i.e., enter) with BMI as a dependent variable. In addition, when a given TFEQ factor and some of its subscales were significantly related to BMI, we chose to enter the subscales rather than the main factor in the multivariate model in order to avoid problems related to multicollinearity. Values are presented as means ± standard deviation. Differences with P-values <.05 were considered statistically significant.

3. Results

Participant characteristics' from the 2 groups formed on the basis of physical activity participation (according to the EE6–9 median value of $2\,\text{kcal}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$) are shown in Table 1. Participants with lower physical activity participation had

Table 1: Anthropometric variables, eating behaviour traits, and dietary intakes in women characterized by either lower or higher physical activity participation.

	Lower physical activity participation		Higher physical activity participation		P-value
n	64		49		
	Mean	SD	Mean	SD	
Age (y)	57.1	4.5	56.2	3.9	.30
EE6–9 (kcal·kg^{-1}·day^{-1})	0.5	0.7	6.6	3.9	<.0005
Antropometric variables					
Body weight (kg)	74.1	14.7	71.3	17.7	.37
BMI (kg/m^2)	29.1	5.7	27.8	6.3	.23
Fat mass (%)[1]	40.2	7.7	37.4	7.1	.05
Waist circumference (cm)[2]	93.0	13.7	88.4	12.7	.07
Eating behaviour traits					
Dietary restraint	9.0	4.6	9.7	4.3	.44
Flexible dietary restraint	3.2	1.8	3.3	1.9	.84
Rigid dietary restraint	2.6	1.6	2.6	1.7	.98
Disinhibition	6.4	3.6	6.0	3.9	.55
Habitual disinhibition	1.3	1.5	1.1	1.4	.45
Emotional disinhibition	1.3	1.2	1.4	1.3	.77
Situational disinhibition	2.2	1.7	1.9	1.6	.28
Hunger	4.6	3.6	4.6	3.8	.98
Internal hunger	1.8	2.0	1.5	1.8	.41
External hunger	2.0	1.6	2.1	1.8	.93
n	42		35		
Dietary intakes					
Energy (kcal)	1981.4	275.6	1870.8	190.5	.05
Dietary fat (% of energy)[3]	32.8	4.9	31.3	4.5	.17
Carbohydrate (% of energy)[3]	48.8	5.3	49.7	5.0	.44
Protein (% of energy)[3]	16.4	2.7	16.8	2.2	.50
Cholesterol (mg)	274.8	119.5	227.8	85.9	.06
Fiber (g·1000 kcal^{-1})	11.3	3.4	12.5	2.6	.09

Values are means ± SD. Groups were formed according to the EE6–9 median value (2 kcal·kg·day^{-1}).
[1]for fat mass, $n = 61$ in lower physical activity participation, and $n = 47$ in higher physical activity participation;
[2]for waist circumference, $n = 48$ in higher physical activity participation;
[3]for dietary fat, carbohydrate and protein, $n = 41$ in lower physical activity participation.

significantly higher percentage of body fat (40.2 ± 7.7 versus 37.4 ± 7.1%, $P < .05$) and tended to have greater waist circumference (93.0 ± 13.7 versus 88.4 ± 12.7 cm, $P = .07$). No significant differences in eating behaviour traits were noted between groups divided based on physical activity participation. With regards to dietary intakes, it was found, after removing underreporters from the sample, that women with lower physical activity participation consumed significantly more energy when compared to women with higher physical activity participation (1981.4 ± 275.6 versus 1870.8 ± 190.5 kcal, $P < .05$). No significant group differences were noted for macronutrient intakes. Trends were also found for dietary cholesterol and fiber consumption and suggested a higher cholesterol (274.8 ± 119.5 versus 227.8 ± 85.9 mg, $P = .06$) and a lower fiber consumption (11.3 ± 3.4 versus 12.5 ± 2.6 g·1000 kcal^{-1}, $P = .09$) in women with lower physical activity participation when compared to women with higher physical activity participation.

Significant correlations were observed between eating behaviour traits and BMI in both groups of women separated on the basis of physical activity participation (Table 2). In women with lower physical activity participation, flexible dietary restraint was negatively associated with BMI ($r = -0.24$, $P < .05$) while disinhibition ($r = 0.55$, $P < .0001$) and its subscales (habitual ($r = 0.49$, $P < .0001$), emotional ($r = 0.58$, $P < .0001$), and situational ($r = 0.35$, $P < .005$)) as well as hunger ($r = 0.45$, $P < .0001$) and its subscales (internal ($r = 0.41$, $P < .001$) and external hunger ($r = 0.49$, $P < .0001$)) were all positively associated with BMI. In the group with higher physical activity participation, dietary restraint ($r = -0.54$, $P < .0001$) and its subscales (flexible ($r = -0.55$, $P < .0001$) and rigid ($r = -0.37$, $P < .01$) dietary restraint) were negatively associated with BMI. In contrast, disinhibition ($r = 0.42$, $P < .005$), emotional ($r = 0.41$, $P < .005$) and situational susceptibility to disinhibition ($r = 0.30$, $P < .05$) as well as susceptibility to hunger ($r = 0.33$, $P < .05$)

Table 2: Pearson's correlation coefficients for the associations between eating behaviour traits, and BMI in women characterized by either lower or higher physical activity participation.

	Pearson correlations with BMI		Comparison of correlation strength
	Lower physical activity participation	Higher physical activity participation	P-values
Eating behaviour traits			
n	64	49	
Dietary restraint	-0.16^{NS}	-0.54^{***}	.02
Flexible dietary restraint	-0.24^{*}	-0.55^{***}	.06
Rigid dietary restraint	-0.04^{NS}	-0.37^{ζ}	.07
Disinhibition	0.55^{***}	0.42^{**}	.38
Habitual disinhibition	0.49^{***}	0.24^{NS}	.14
Emotional disinhibition	0.58^{***}	0.41^{**}	.25
Situational disinhibition	0.35^{**}	0.30^{*}	.77
Hunger	0.45^{***}	0.33^{*}	.47
Internal hunger	$0.41^{\S}$	0.20^{NS}	.23
External hunger	0.49^{***}	0.14^{NS}	.04

*, $P < .05$; $^{\zeta}$, $P < .01$; **, $P < .005$; §, $P < .001$; ***, $P < .0001$; ^{NS}, not significant.

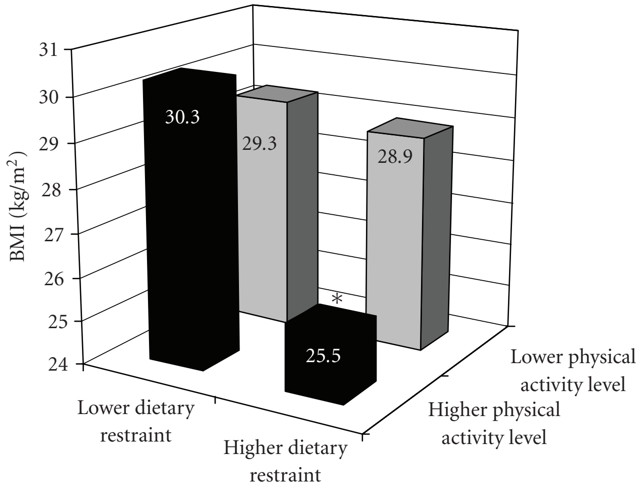

Figure 1: Body mass index in the group of postmenopausal women is separated on the basis of dietary restraint and physical activity participation. Lower and higher physical activity participation are presented in grey and in black respectively. *indicates a significant difference in women with lower dietary restraint and higher physical activity participation. For lower physical activity participation and lower dietary restraint, $n = 37$, and mean BMI = $29.3 \pm 1.0\,kg/m^2$; for lower physical activity participation and higher dietary restraint $n = 27$, and mean BMI = $28.9 \pm 0.9\,kg/m^2$; for a higher physical activity participation and lower dietary restrain, $n = 23$, and mean BMI = $30.3 \pm 1.7\,kg/m^2$ and for a higher physical activity participation and higher dietary restraint, $n = 26$, and mean BMI = $25.5 \pm 0.5\,kg/m^2$.

were all positively associated with BMI. Similar results were obtained when percent body fat was correlated with eating behaviour traits (results not shown).

Because correlations obtained with percentage of body fat were similar to those with BMI and that BMI represents an easily accessible proxy of adiposity, further analyses were conducted with BMI. Comparisons of correlation coefficients for the associations between eating behaviour traits and BMI were performed between women with lower and higher physical activity participation. Results showed significant differences in correlation coefficient for dietary restraint ($P = .02$) and for external hunger ($P = .04$). For dietary restraint, a stronger correlation with BMI was found in women in the higher physical activity participation compared to those in the lower physical activity participation group ($r = -0.54$ versus $r = -0.16$, $P = .02$). For external hunger, a stronger correlation was found in women from the lower physical activity participation group than in those from the higher physical activity participation group ($r = 0.49$ versus $r = 0.14$, $P = .04$). Trends were also found for flexible and rigid dietary restraint ($P < .06$ and $P < .07$, resp.) whereas stronger correlations observed with BMI were found in the higher physical activity participation group. As such, analyses were performed with eating behaviour traits for which a significant difference in the strength of correlation with BMI was observed between women in the lower and higher physical activity participation groups (i.e., dietary restraint and external hunger). Figure 1 shows the difference in the association between dietary restraint and BMI according to physical activity participation. Among women with lower physical activity participation, BMI was not different between women with either lower (mean: $29.3 \pm 1.0\,kg/m^2$) or higher dietary restraint (mean: $28.9 \pm 0.9\,kg/m^2$). On the other hand, among women with higher physical activity participation, BMI was significantly higher in women with lower dietary restraint (mean: $30.3 \pm 1.7\,kg/m^2$) when compared to women with higher dietary restraint (mean: $25.5 \pm 0.5\,kg/m^2$). Finally, it was also found that physical activity participation had an impact on the association between external hunger and BMI (Figure 2). Among women with lower physical activity participation, BMI was significantly lower in women with lower external hunger (mean: $27.5 \pm 0.8\,kg/m^2$) than in those with higher external hunger (mean: $32.4 \pm 1.1\,kg/m^2$). No such differences were observed in women with higher physical activity participation (mean: 27.2 ± 1.3 and $28.6 \pm 1.1\,kg/m^2$ for groups with lower and higher external hunger group, resp.).

In order to investigate the relative and independent contribution of eating behaviour traits to the variability of BMI in both the lower and higher physical activity participation groups, multiple regression analysis (i.e., enter) was performed. Eating behaviour traits were included in the regression analyses if they were significant correlates of BMI. When both the subscales and the main TFEQ

Table 3: Independent predictors of BMI in women with lower physical activity participation (n = 64).

Variables	Beta	P-value
Emotional disinhibition	0.387	.004
External hunger	0.259	.103

r^2 = 0.411 (adjusted = 0.349), F = 6.618, $P < .0001$.
Note: Variables included in the model were those which were significantly correlated with BMI (flexible dietary restraint, habitual disinhibition, emotional disinhibition, situational disinhibition, internal hunger, and external hunger). In addition, when a given TFEQ factor and some of its subscales were significantly related to BMI, we chose to enter the subscales rather than the main factor in the multivariate model in order to avoid problems related to multicollinearity.

Table 4: Independent predictors of BMI in women with higher physical activity participation (n = 49).

Variables	Beta	P-value
Flexible dietary restraint	−0.343	.016
Rigid dietary restraint	−0.300	.017
Emotional disinhibition	0.317	.057

r^2 = 0.443 (adjusted = 0.378), F = 6.845, $P < .0001$.
Note: Variables included in the model were those which were significantly correlated with BMI (flexible dietary restraint, rigid dietary restraint, emotional disinhibition, situational disinhibition, and hunger). In addition, when a given TFEQ factor and some of its subscales were significantly related to BMI, we chose to enter the subscales rather than the main factor in the multivariate model in order to avoid problems related to multicollinearity.

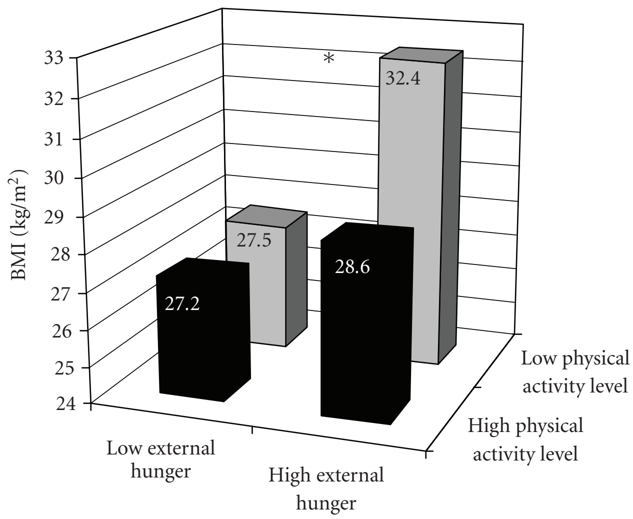

Figure 2: Body mass index in the group of postmenopausal women is separated on the basis of external hunger and physical activity participation. Lower and higher physical activity participation are presented in grey and in black respectively. *indicates a significant difference in women with lower external hunger and lower physical activity participation. For lower physical activity participation and lower external hunger, n = 43, and mean BMI = 27.5 ± 0.8 kg/m^2; for lower physical activity participation and higher external hunger, n = 21, and mean BMI = 32.4 ± 1.1 kg/m^2; for higher physical activity participation and lower external hunger, n = 31, and mean BMI = 27.2 ± 1.3 kg/m^2 for a higher physical activity participation and higher external hunger, n = 18, and mean = 28.6 ± 1.1 kg/m^2.

factor were significant correlates, only the subscales were entered into the model. As such, emotional disinhibition and to a lesser amount external hunger were found to be independent contributors to BMI (35% of the variance after adjustment) in women with lower physical activity participation (Table 3) while flexible dietary restraint, rigid dietary restraint, and to a lesser amount emotional disinhibition were the independent contributors to BMI (38% of the variance after adjustment) in women with higher physical activity participation (Table 4).

4. Discussion

The main objective of this paper was to investigate whether physical activity participation could interrelate with the associations between eating behaviour traits and BMI. Our results suggest, for the first time, that dietary restraint is more strongly correlated with BMI in women with higher physical activity participation than in women with lower physical activity participation. Moreover, flexible dietary restraint and rigid dietary restraint are independent predictors of BMI only in women with higher physical activity participation. Our analyses also revealed that emotional disinhibition contributes to the variance in BMI in women with lower physical activity participation and only marginally in women with higher physical activity participation. Finally, hunger, and more particularly external hunger, is strongly correlated with BMI in women with lower physical activity participation.

It is well documented that both physical activity and dietary restraint impact body weight management. However, the influence of physical activity on the association between dietary restraint and weight has not been well established. Our results show that postmenopausal women with higher physical activity participation and higher dietary restraint have a lower BMI when compared to women with higher physical activity participation and lower dietary restraint. This suggests that physical activity participation influences the relationship between dietary restraint and BMI. This may be partially explained by the observation that women with higher physical activity participation seem to present healthier food habits (lower cholesterol intakes and higher ber intake) when compared to women with lower physical activity participation, and this, despite similar dietary restraint. These findings are concordant with other studies showing that women with higher physical activity participation are more likely to consume a healthy diet and to be characterized by healthier eating patterns [19, 20, 23–25]. The observation that women who exercise seem to have the capacity to better regulate their appetite and that exercise can also possibly raise the perceived pleasantness of low-fat foods may partly explain why active women are more likely to chose a healthier diet, including foods with a low fat content [23, 25, 38].

Another explanation to how physical activity participation could influence the association between dietary restraint and BMI relates to the association between dietary restraint and disinhibition. In fact, some studies have underlined the heterogeneity of the association between dietary restraint and disinhibition, with results reporting negative [5, 39, 40], positive [39, 40], or no association [5, 41, 42] between these variables. Our results have shown an association between dietary restraint and disinhibition in women with higher physical activity participation while no significant correlation between these variables was found for women with lower physical activity participation ($r = -0.29$, $P < .05$; $r = -0.16$, $P =$ NS; higher and lower physical activity participation, resp.). This observation is also strengthened by the fact that disinhibition, in the higher physical activity participation group, was significantly lower in women who displayed a higher dietary restraint when compared to women with a lower dietary restraint (4.9 ± 3.1 versus 7.2 ± 4.4, $P = .04$, resp.). No such significant differences in disinhibition were noted when women with either lower or higher dietary restraints were compared with women in the lower physical activity participation groups. Since a lower disinhibition level has been reported in many studies to be predictive of a lower BMI [5, 7, 16–18], the inverse association between dietary restraint and disinhibition among women with a higher physical activity participation could explain, at least in part, the fact that a higher dietary restraint is associated to a lower BMI among this group of women.

Our results also showed that although flexible dietary restraint and rigid dietary restraint were both significant predictors of BMI, flexible dietary restraint was the strongest predictor, explaining 34% of the variance in BMI among women with higher physical activity participation. These results are concordant with previous studies showing that flexible dietary restraint is a better predictor of lower BMI than rigid dietary restraint [5]. For example, longitudinal studies showed that changes in flexible dietary restraint, but not changes in rigid dietary restraint, correlated negatively with changes in body weight [8, 15].

It has been previously shown that a higher disinhibition level predicts higher BMI and higher likelihood of weight gain [5, 7, 16–18]. Our results add to this literature by showing that in women with higher physical activity participation, disinhibition does not predict the variability in BMI ($P = .06$) while it predicted 39% of BMI variability among women with lower physical activity participation ($P < .005$). Therefore, in women with higher physical activity participation, disinhibition does not seem to have as much of an impact on BMI when dietary restraint is taken into account. In fact, it can be hypothesized that after a disinhibition episode, women with a higher physical activity participation are able to respond by reducing their energy intake over the course of the following meals in order to minimize the impact of disinhibition on energy balance and/or increase their physical activity.

Among women with lower physical activity participation, a higher BMI was noted in women characterized by higher external hunger when compared to those with lower external hunger. In contrast, no difference in BMI was observed according to external hunger value among women with higher physical activity participation. Interestingly, we found that among women with lower physical activity participation, external hunger was positively associated with energy intake ($r = 0.36$; $P < .005$), the percent of energy from dietary lipids ($r = 0.29$; $P < .05$), and cholesterol intake ($r = 0.32$; $P < .01$). No such associations were noted in women with higher physical activity participation. Therefore, women with lower physical activity participation and higher external hunger, increased energy and dietary fat intake could explain, at least in part, their increased BMI. The reasons why external hunger is not associated with dietary factors potentially leading to positive energy balance among women with higher physical activity participation will have to be further elucidated.

Our findings are limited to a small population of postmenopausal women and should thus be interpreted accordingly. In addition, even if it remains that the 3-day activity diary record has been previously validated and that the use of self-reported physical activity and dietary data are, to some extent, a limitation. Furthermore, the cross-sectional nature of this study makes it difficult to underline the possible interactions between behaviour, environment, and genes. Thus, it does not exclude the possibility that other variables might influence interactions between eating behaviour traits and BMI. Because of the cross-sectional nature of this study, it is obvious that we cannot allude to any causality for physical activity participation on the association between eating behaviour traits and BMI. It is nonetheless tempting to speculate that depending on their level of physical activity participation, some individuals could react differently to eating behaviour interventions aimed at preventing weight gain or inducing weight loss. For example, it might be suggested that increasing dietary restraint might be a more efficient approach to lose weight or to avoid weight gain among women with higher physical activity participation than in those with lower physical activity participation. Of course, this remains to be tested in well-designed weight management interventions.

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