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EATING BEHAVIOURS AND BODY WEIGHT IN ADOLESCENTS

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Résumé

La plus grande augmentation de la prévalence d'obésité au Canada se retrouve parmi les adolescents. L'obésité chez les jeunes est associée à des problèmes de santé pendant l'adolescence et, parce qu'elle augmente fortement les chances d'être obèse à l'âge adulte, elle est aussi associée à des problèmes de santé plus tard dans la vie. Il y a plusieurs facteurs responsables de cette épidémie d'obésité. Les comportements alimentaires sont un aspect associé avec le poids chez les adultes, et moins connus, chez les jeunes. Le Three-Factor Eating Questionnaire, qui mesure le niveau de restriction, désinhibition et la susceptibilité à la faim, est le questionnaire le plus utilisé en recherche pour évaluer les comportements alimentaires. Toutefois, ce questionnaire n'a pas été beaucoup utilisé chez les adolescents et il n'y a aucune étude qui a mesuré les sous-échelles de comportements alimentaires chez cette population. Cette étude avait comme objectif d'identifier les comportements alimentaires associés au poids corporel chez un groupe d'adolescents faisant partie de l'Étude des familles de Québec. Le contrôle rigide, la désinhibition et la susceptibilité aux émotions étaient positivement associés à l'indice de masse corporelle (IMC; $p < 0.05$). L'association entre l'IMC et le contrôle rigide était plus forte pour les filles tandis que l'association entre l'IMC et la désinhibition était plus forte chez les garçons. Pour comparer l'interaction entre les comportements alimentaires et le poids corporel, les adolescents ont été classifiés en catégories selon leur niveau de contrôle rigide et leur désinhibition. Les adolescents qui présentaient les plus hauts scores pour ces deux comportements avaient un IMC plus élevé ($p < 0.05$). La restriction flexible n'était pas associée à l'IMC chez ce groupe d'adolescents. La susceptibilité à la faim était le seul comportement alimentaire qui était relié à l'apport calorique. Les adolescents avec un surplus de poids présentaient des niveaux de désinhibition et de contrôle rigide plus élevés que les adolescents de poids normal. Ces résultats démontrent l'importance d'évaluer ces comportements alimentaires chez les jeunes afin de développer des stratégies d'intervention efficace dans le traitement et la prévention de l'obésité.

Abstract

The prevalence of obesity is increasing at a faster rate among adolescents than any other age group in Canada. Adolescent obesity is not only associated with health problems and obesity in adulthood but we are now seeing similar weight-related health problems in youth. Obesity prevention measures are key in controlling the rise of this disease. Altered eating behaviours have been associated with body weight and weight gain in adults. The Three-Factor Eating Questionnaire (TFEQ) measures the eating behaviours of cognitive restraint, disinhibition and hunger in addition to various subscales, e.g. flexible and rigid control, dieting, emotional overeating. To our knowledge, these subscales to date have not been measured in adolescents. This study used the TFEQ to measure these behaviours in adolescents from the Québec Family Study. Both rigid control of eating and disinhibition with emotional susceptibility to overeat were positively related to BMI z-scores ($p < 0.05$). The relationship between rigid control and body weight was stronger among females while that of disinhibition and body weight was stronger among males. After categorizing the adolescents into median-split high and low eating behaviour groups (high disinhibition-high rigid control, low disinhibition-high rigid control, low disinhibition – high rigid control, high disinhibition-low rigid control) those having both high rigid control and high disinhibition were heavier than those with low values of both behaviours ($p < 0.05$). Flexible control was not related to weight in this group of adolescents. Aside from hunger scores, there were no significant associations between TFEQ scores and self-reported energy intake. Moreover, overweight and obese adolescents expressed higher disinhibition and rigid control scores than their lean counterparts. The control subscales are important and should be used to clarify the relationship between cognitive restraint and body weight. Educating successful weight control/maintenance strategies is imperative in the prevention of obesity in this age group.

Foreword

The Québec Family Study generated an enormous amount of data to which is still being used for publication today. Being a large community sample and longitudinal in design, its results are very pertinent to community health. This master's thesis analysed data from the Québec Family Study and was written over the course of the years 2009 and 2010. The article submitted within this document was written during the spring and fall of 2009. Without the previous work accomplished by the researchers of the Québec Family Study, this thesis and the important information it presents, would not exist.

The article submitted within this thesis was formatted, written in full and partially conceptualized (75%) by myself, Annette Gallant. As well as the writing, the data was analyzed statistically by myself with the help of Claude Leblanc and Dr. Vicky Drapeau. The following paragraphs will describe the roles of the other co-authors in the writing of this manuscript.

I would first like to thank my master's advisor Dr. Vicky Drapeau. Dr. Drapeau is an assistant professor of the department of Physical Education in the faculty of Educational Sciences Laval University. She derived the initial research question but allowed me to explore other options within this main idea. She supervised every aspect of the article, from the initial outline to the final steps of submission, with both patience and immaculate attention to detail. She taught me important aspects of critical thinking and stressed the weight of preciseness. I am overly grateful for her constant and continued guidance.

Dr. Angelo Tremblay is a professor of the Kinesiology division of the department of Social and Preventive Medicine at Laval University, Quebec and the holder of a Canada Research Chair in Physical Activity, Nutrition and Energy Balance. Dr. Tremblay is my master's co-advisor and, aside from being a principle researcher for the Québec Family Study, helped in the formatting and revising of the manuscript submitted within.

Dr. Jean-Pierre Després is a professor of the Kinesiology division of the department of Social and Preventive Medicine at Laval University, member of the Québec Heart and Lung Institute and holds an international Chair on Cardiometabolic risk. Dr. Després was also a principle researcher for the Québec Family Study and participated in the revision and data presentation of this manuscript.

Dr. Claude Bouchard is a researcher at the Pennington Biomedical Research Centre in Baton Rouge Louisiana, USA and the George A. Bray Jr. Chair in Nutrition Executive Director. Dr. Bouchard was a principle researcher in the Québec Family Study and helped with the revision of this manuscript. His suggestions regarding the rewording and scientific writing of the article were invaluable.

The article *The Three-Factor Eating Questionnaire and Body Mass Index in Adolescents: results from the Quebec Family Study* was accepted in the British Journal of Nutrition in March of 2010. The copy of the manuscript submitted in this thesis has not been changed from that which is to be published.

À David. Merci.

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Introduction

The obesity pandemic is a serious problem. It is associated with a plethora of diseases and regrettably, its prevalence remains to be on the rise. The World Health Organization (WHO) predicts that in 2015 2.3 billion adults will be overweight and 700 million will be obese – double of that calculated in 2005 (World Health Organization, 2010). In Canada, as per the 2004 Canadian Community Health Survey (CCHS), 23.1% of adults (5.5 million) were considered obese (Tjepkema, 2006). This was an increase in 9.3% from the measured data obtained in 1978/79, with the highest increases in those with class II and III obesity. Assuming similar increases during the past 6 years, the prevalence of obesity today could be as high as 32.4%. This increasing prevalence must be stopped and prevention measures must be strictly enforced.

Obesity is linked to type II diabetes (Kahn, Hull, et al., 2006), cardiovascular disease (Van Gaal, Mertens, et al., 2006), the metabolic syndrome (Despres and Lemieux, 2006), certain cancers (Polednak, 2003) and even premature death (Adams, Schatzkin, et al., 2006, Katzmarzyk, Janssen, et al., 2003). Obesity is also the cause of multiple musculoskeletal problems such as osteoarthritis, osteoporosis, lower back pain and fibromyalgia to name a few (Anandacoomarasamy, Caterson, et al., 2008). Not only is it detrimental to one's physical health, but it also plays havoc on one's mental health. Obesity has been associated with depression (Luppino, de Wit, et al., 2010), psychological distress and low quality of life (Algul, Ates, et al., 2009). To add to this dismal list, overweight and obese individuals face employment inequalities with respect to hiring, wage and promotions as well as stereotypes and negative attitudes from health professionals (Puhl and Heuer, 2009) and their peers with up to 40% of adults with a BMI >35 kg/m^2 experiencing weight discrimination (Andreyeva, Puhl, et al., 2008).

It is not only the individual who is suffering as a result of obesity, so is the Canadian health plan. In 2001, 4.3 billion dollars, representing 2.2% of the total health budget, was the indirect and direct health costs related to obesity (Katzmarzyk and Janssen, 2004). This increased from 1.8 billion in 1997 (Birmingham, Muller, et al., 1999) and in a study of Ontario, obese adults had between 14.7% and 18.2% higher physician costs per year than normal weight adults (these results did not reach significance)(Janssen, Lam, et al., 2009).

These results are not surprising as our sedentary-friendly, stressful, nutritionally-void environments create the perfect setting for obesity to be on the rise. Canadian adults who eat less fruit and vegetables, and who are sedentary are significantly more obese than those who are at least moderately active and who eat at least 3 servings of fruits and vegetables per day (Tjepkema, 2006). A Canadian study showed that individuals who live closer to fast-food restaurants and convenience stores compared to grocery stores and local produce vendors were significantly more obese (Spence, Cutumisu, et al., 2009).

The causes of obesity are numerous with an inexhaustive list including environmental, economical, familial, nutritional, behavioural, psychological and genetic factors. The causes are often cyclical, perpetuating further ill health among those suffering from obesity. With such an extensive array of possibilities, obesity treatment is complex and often compartmentalized and, at best, only slightly successful. Weight loss through diet and exercise, which is better than either alone, is only a partial and short-term solution to treating obesity (Wu, Gao, et al., 2009) and is considered by some to be even detrimental to the health of the individual because of the diet restrictions and obsessions with weight (Miller and Jacob, 2001). The addition of behavioural therapy has shown to create a 10% weight loss, but again is also only a short-term treatment as most return to initial weight after 5 years with even maintenance behavioural treatment delaying the inevitable – weight regain (Fabricatore, 2007). Obesity surgery has had more success yet is highly invasive and may not be a solution for the most obese of individuals (Picot, Jones, et al., 2009). Obesity prevention is the best treatment and action must be swift, efficient and age-targeted. The largest increase in Canadian obesity rates has been among adolescents. Adolescence is a critical time period where independence is gained and behavioural habits are formed (Maggs, Schulenberg, et al., 1997). It has also been shown that this age group is most likely to maintain their obese or overweight status into young adulthood (Serdula, Ivery, et al., 1993, Starc and Strel). In order to ensure that our population remains healthy, poor habits among this age group must be identified and corrected through proper educational prevention measures. This thesis will look into the factors associated with and potential causes of obesity, with a specific chapter dedicated to the eating behaviours among adolescents with the inclusion of a scientific article on the subject.

Chapter 1 – Adolescent Obesity

This section will briefly discuss the status of obesity among Canadian adolescents as well as the various causes and side effects of having a substantial weight surplus. Aspects of physical activity, nutrition and the family environment in the context of adolescent overweight will be briefly reviewed in addition to other factors that may be implicated in the etiology of obesity.

1.1 Prevalence and consequences of adolescent obesity

The rise of obesity is not only affecting adults, but has now spread to both children and adolescents, and Canadian youth are of no exception. Of 34 countries, Canadian adolescents (10-16yrs) had the 5th highest pre-obese and overweight rates with a high of 15.2% and 4.1%, respectively (Janssen, Katzmarzyk, et al., 2005). Within Canada, adolescents have shown the greatest increase in overweight and obesity prevalence compared to all other age-groups. In the past 25 years, the number of obese adolescents in Canada has tripled and in 2004, a third of adolescents aged 12-17 years were considered either overweight or obese (**Figure 1)** (Shields, 2006). As depicted in **Figure 1**, throughout the past 25 years obesity has now become present in even the youngest of children with its prevalence on the rise in adolescents.

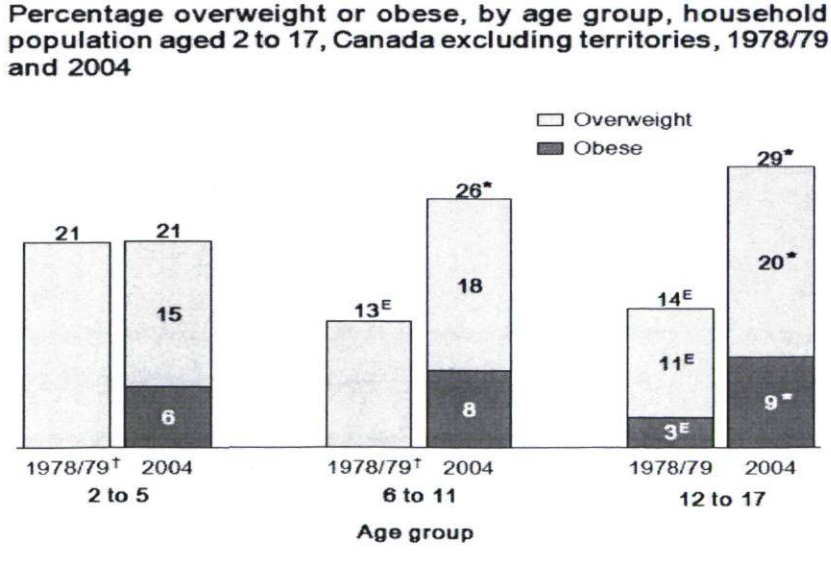

Figure 1. *Source :* Shields *et al.*, 2006 1978/79 Canada Health Survey; 2004 Canada Community Health Survey

Why is child and adolescent obesity so distressing? Obese children are at risk at becoming unhealthy adults. Tracking obesity from childhood to adulthood shows that the majority of overweight youth remain overweight as an adult. In a recent study, 83% of overweight adolescents were overweight adults and were 6.2 times more likely to becoming an overweight adult (Herman, Craig, et al., 2009). Maintaining a weight surplus into adulthood is harmful as adult obesity is associated with numerous physiological diseases, e.g. diabetes, cardiovascular disease, osteoarthritis (Guh, Zhang, et al., 2009). Childhood obesity has recently been independently associated with premature death as an adult (Franks, Hanson, et al.).

It is not only the effects of youth obesity on adulthood health that is worrying. The side effects of increased weight usually only seen among adults are now becoming more prevalent among youth. Type 2, "adult-onset" diabetes is increasing in children and adolescents and is expected to increase by 50% in the next 15 years (Canadian Diabetes Association, 2010). Cardiovascular risk factors, such as high blood cholesterol, glucose and insulin, and certain body weight parameters, have already emerged in overweight children and have been associated with increased body weight in this age group (Adegboye, Andersen, et al., 2009, Jago, Drews, et al.).

Psychological effects of obesity are not only present in adults. Body weight per se has not solidly been associated with depression nor low self-esteem in adolescents (Puhl and Latner, 2007) yet side effects of obesity, i.e. teasing, have been. Weight-based teasing during adolescence has been associated with depression, anxiety, anger and lower self-esteem and a variety of unhealthy eating behaviours and thoughts (Libbey, Story, et al., 2008, Young-Hyman, Tanofsky-Kraff, et al., 2006). These unhealthy eating behaviours may in turn perpetuate further weight gain, creating a vicious cycle in an already vulnerable population.

An important subject in obesity research is the social stigmatization of increased weight, specifically during adolescence. During this time, key social relationships are being formed and adolescents may be more vulnerable to negative weight stigmatization during this age because of this. For example, in a large study of more than 90 000 adolescents, overweight adolescents experienced more social isolation, were less likely to be at the

center of social networks and were less likely to be considered as "a friend" by their peers than non-overweight adolescents (Strauss and Pollack, 2003). A recent review (Puhl and Latner, 2007) revealed that overweight and obese adolescents are more often the victims of weight-based teasing and bullying. Also, weight-related negative attitudes directed towards overweight and obese adolescents included laziness, being stupid, ugly or selfish, being less popular and less happy and having fewer friends. These attitudes are more often felt by peers but can also be found in parents and teachers. These negative attitudes can have substantial consequences on aspects such as academics. Weight-based teasing has been found to mediate the negative relationship between obesity and academic performance (Krukowski, Smith West, et al., 2009) and obese adolescents are less likely to be accepted into college (Puhl and Latner, 2007) with those in college showing lower completion rates (Fowler-Brown, Ngo, et al., 2009).

1.2 Factors Associated with adolescent obesity

1.2.1 Physical activity and sedentary behaviours

Physical Activity

The Canada Guide to Physical Activity (Health Canada, 2002) recommends that children and youth increase their daily physical activity to attain 90 min/day while simultaneously reducing sedentary behaviours as this level of physical activity is required to maintain a healthy body weight. Physical activity levels among Canadian youth vary depending on the source and measure and several large studies have found very different results. A recent report (Canadian Health Measures Survey) indicates that measured fitness levels in Canadian youth during the years 2007-2009 have declined significantly since last measured in 1981 (Tremblay, Shields, et al., 2010). This is not surprising as only 13% of youth attained the physical activity guidelines as per measured (pedometer) data in 2008 (Acitve Healthy Kids Canada, 2009). These (measured) data differ greatly from self-reported physical activity levels obtained through large national studies. The Canadian Community Health Survey indicated that in 2007, 51% of 12-17year olds were considered as being "active" as per their physical activity journals (Acitve Healthy Kids Canada, 2009). During the same time frame, results from the Tell Them From ME (TTFM) survey stated that 42%

of youth reported accumulating at least 90 min of physical activity (Active Healthy Kids Canada 2009). This data suggests that there are large differences in measured and reported data, and even when looking at the reported results, i.e. the self-reported data, at least half of Canadian adolescents did not meet recommended guidelines suggested by Health Canada.

Although the overall numbers are low, data reveals that physical activity levels are increasing. Steps increased marginally where 13% of children and youth aged 5-19yrs met the guidelines in 2007/2008, an increase from 9% in 2005/2006 (**Figure 2**) (Active Healthy Kids Canada 2009). **Figure 3** shows self-reported data from the CCHS which indicates marginal increases for females from 2000-2001, yet decreases for males.

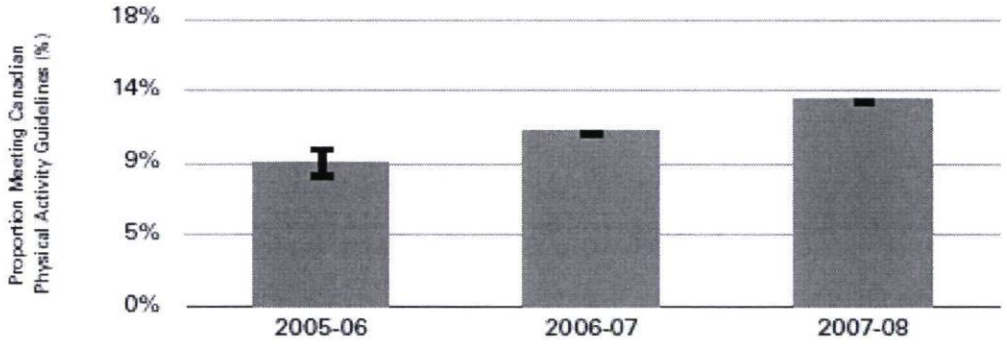

Figure 6: The proportion of Canadian children and youth meeting Canadian physical activity guidelines from 2005 to 2008 (Source: CFLRI CANPLAY).

Figure 2. Proportion of Canadian youth meeting physical activity guidelines (as per steps stepped per day) *Source:* The Active Healthy Kids Canada Report Card on Physical Activity for Children and Youth (Active Healthy Kids Canada 2009).

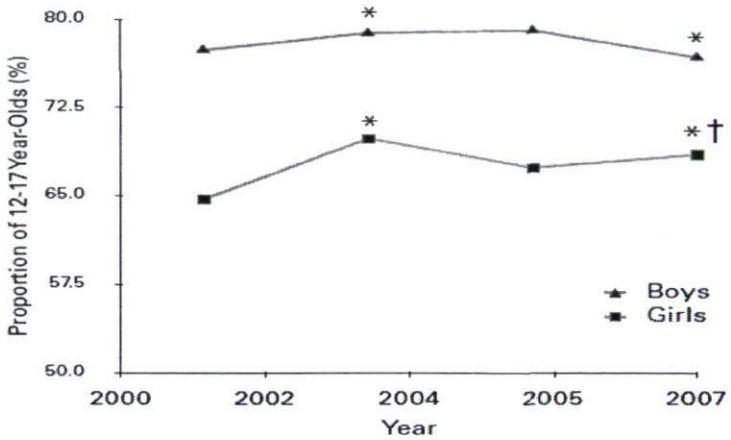

Figure 7: Change in proportion of 12- to 17-year-old boys and girls who report that they are moderately active or active, from 2000 to 2007 (Source: CCHS 2000-2007).

Note: Gender difference is statistically significant for all years (p <0 .05)
* Significantly different from 2000-2001 ($p < 0.05$)
† Significantly different from 2005 ($p < 0.05$)

Figure 3. Proportion of youth which met physical activity guidelines as per self-reported data. *Source:* The Active Healthy Kids Canada Report Card on Physical Activity in Children and Youth, 2009.

Another interesting trend unveiled by this report (**Figure 3**) is the enormous gender gap in physical activity. Repeatedly, data shows that girls are less active than boys (Canadian Fitness & Lifestyle Research Institute, 2009); 16% of boys but only 8% of girls attained at least 16,500 steps per day. On the contrary, more recent data stated that, as per measured fitness levels, more boys were in the "fair" health benefits zone, albeit there were fewer girls in the excellence zone (**Figure 4**) (Tremblay, Shields, et al., 2010).

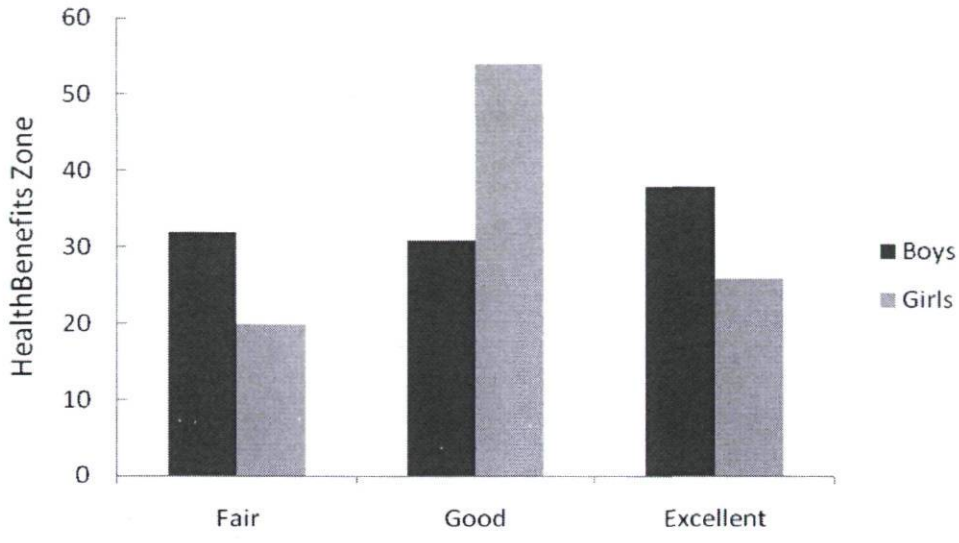

Figure 4. Proportion of 15-19 year olds who attained the "Health Benefits Zone" as per measured fitness levels. *Source:* 2007-2009 Canadian Health Measures Survey (Tremblay, Shields, et al., 2010).

In addition to the gender gap in physical activity, levels decrease with increasing age from childhood to late adolescence. The proportion of youth who met the daily requirements of steps per day were 15% of children (5-10yrs), 11% of early adolescents (11-14yrs) and finally a low of 7% of older adolescents (15-19yrs) (Canadian Fitness & Lifestyle Research Institute, 2009). Accompanying the declining physical activity levels in adolescents are even lower aerobic power (i.e. physical condition) measures in this age group (**Figure 5**).

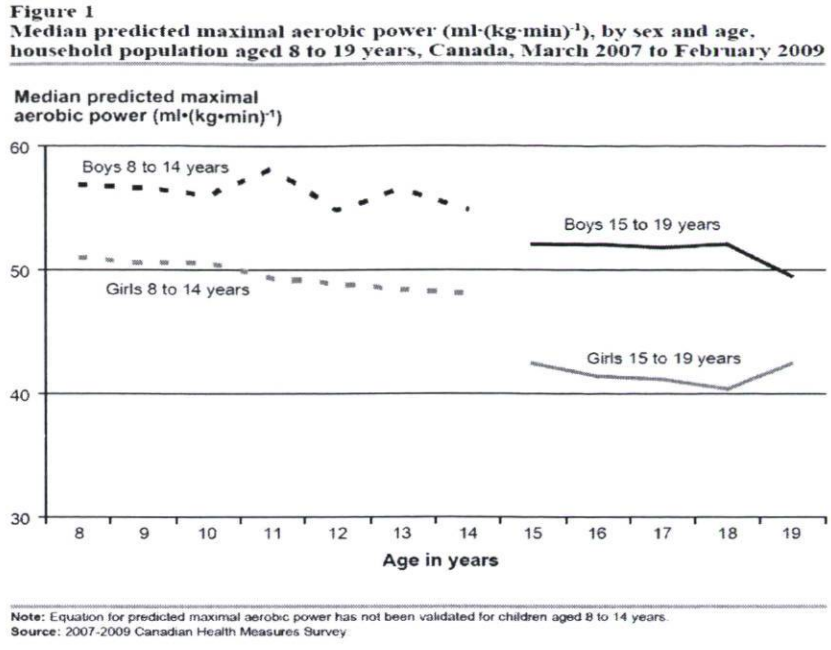

Figure 5. Maximum aerobic power (ml/kg-min) for Canadian youth. *Source*: Fitness of Canadian children and youth: 2007-2009 Canadian Health Measures Survey

Obesity levels are on the rise in Canadian youth. As described in the above data, physical activity levels are suboptimal yet the two (i.e. physical activity and obesity) are not necessarily related. A comprehensive review stated that although the majority of the research shows a protective effect of physical activity on obesity, most data is limited in its validity indicating the relationship between physical activity and body weight is not as concrete as the literature suggests (Reichert, Baptista Menezes, et al., 2009). The 2004 CCHS found that physical activity levels were not associated with overweight and obesity for children 6-11yrs, nor in adolescent girls (12-17yrs) (Shields, 2006). Physical activity was only related to body weight in adolescent boys. As we know the adolescent boys had higher physical activity levels than the girls in this cohort, perhaps the adolescent females did not attain a high enough level to create divergences in body weight which would then reveal a more distinct relationship between the two factors. On the contrary, earlier data revealed that the 2001/02 WHO HBSC study found that physical activity was lower in those considered either overweight or obese (Janssen, Katzmarzyk, et al., 2004). Participating in organized sport, either through the community of school has also been associated with lower risk of obesity (Boone-Heinonen, Gordon-Larsen, et al., 2008,

Tremblay and Willms, 2003) and increased steps per day (Canadian Fitness and Lifestyle Research Institute 2009).

When studying obesity and physical activity, one has to ask if being considered "active", defined by partaking in moderate to vigorous physical activity for at least 90 min per day 5 days per week, signifies an active person. Is an individual truly active if they partake in sedentary behaviours for most of the day yet manage to exercise for 90 min? An interesting study found that sedentariness and inactivity are not one and the same and that one can be both sedentary and active (Wong and Leatherdale, 2009). Data can verify this as certain sedentary behaviours, such as computer time for boys and reading for girls, have been associated with increased physical activity whereas TV watching has been associated with inactivity in both genders (Koezuka, Koo, et al., 2006). **Figure 6** represents data obtained from this study and shows that high sedentary behaviour, defined as "screen time" – watching TV or time spent in front of a computer or playing video games, coupled with high activity is quite prevalent in adolescents and that, further adding to the gender gap of physical activity, girls display more sedentary behaviours with low activity than boys.

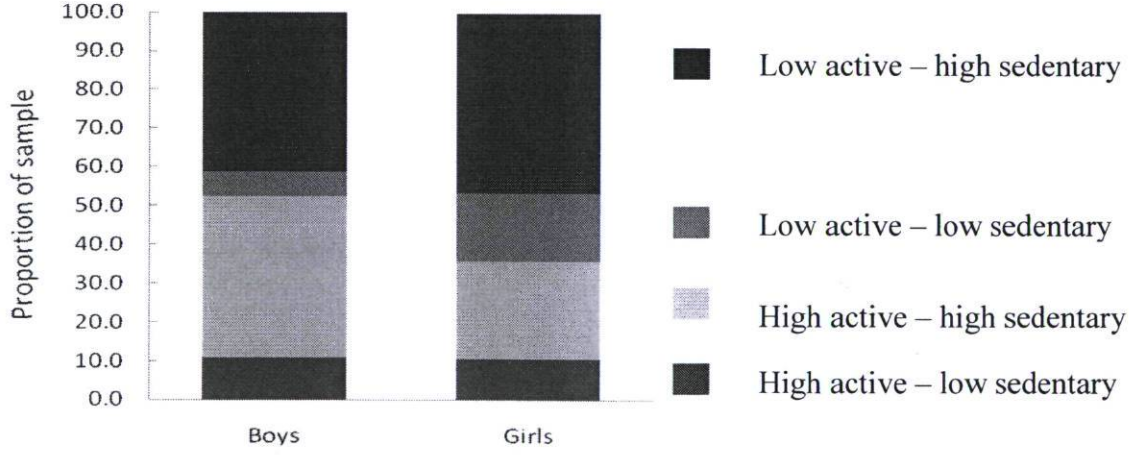

Figure 6. Proportion of adolescent males and females in each activity behaivour category. *Source:* Wong and Leatherdale (2009).

Regardless of the questionable relationship between physical activity and body weight, various health-related side effects of physical activity such as stress reduction, self-image, fat-free mass maintenance etc., may aid in the battle against obesity and is definitely one of the many factors intertwined in the complex etiology of obesity. With Canadian youth

physical activity levels and physical condition being low, increasing their daily amount of exercise should be one aspect of the fight against the rising obesity prevalence.

Sedentary Behaviours and body weight

With the inconsistencies in the relationship between physical activity and body weight, sedentary behaviours may play a mediating role. Physical activity in the accompaniment of sedentary behaviours may not be protective from obesity. The study by Wong & Leatherdale (2009) showed that sedentary behaviours may weaken the protective relationship between physical activity and body weight. As shown in **Figure 7,** adolescents considered low active - high sedentary had increased odds of being overweight, yet for females, high sedentary behaviour increased the odds of overweight regardless of the activity level, indicating that sedentary behaviour may be the culprit in the relationship with obesity.

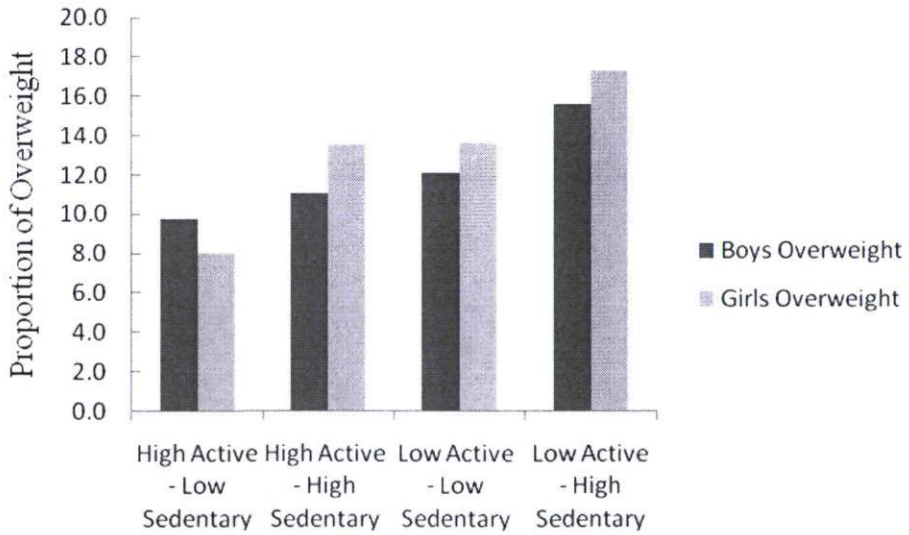

Figure 7. Low Active – High Sedentary boys were more likely to be overweight than High Active – Low Sedentary boys (OR 1.60); Low Active – High Sedentary and High Active – High Sedentary girls were more likely to be overweight than the High Active – Low Sedentary girls (OR 2.24, 1.9, respectively). *Source:* Wong & Leatherdale(2009).

Common sedentary behaviours studied in the literature are television watching (TV), computer time, video game playing and reading. Several large Canadian studies have found cross-sectional relationships between TV watching and body weight (Janssen,

Katzmarzyk, et al., 2004, Shields, 2006). In a longitudinal study using data from 1995, weekly screen time (i.e. computer, TV, video games) was an independent predictor of incident obesity after 5 years, with physical activity being a much weaker predictor (Boone, Gordon-Larsen, et al., 2007).

It is justified to measure these screen-related behaviours as a meta-analysis of the literature found a significant, albeit small, relationship between TV watching and body fatness (Marshall, Biddle, et al., 2004). This weak relationship indicates that perhaps the entire picture of sedentary behaviour and body weight is not being studied. As Biddle (2007) pointed out, there exist other sedentary behaviours which are not measured in the literature such as doing homework, transport time, sitting and talking. Biddle (2007) also found that television watching took up only 40% of "sedentary time", leaving 60% unexplored. Perhaps it is the negative connotation associated with television watching and computer time which makes them popular research variables. Although TV-watching has been shown to be the most important sedentary behaviour in youth (Biddle, Marshall, et al., 2009), this behaviour is not increasing as adolescent obesity is (Biddle, 2007). Reading or homework has not been overly studied in the context of obesity perhaps because it is considered a positive behaviour. Recently, knowledge-based work has been associated with an acute increase in energy intake, introducing another possible risk factor for obesity specifically now that our daily work is more mental than physical (Chaput and Tremblay, 2007b, Chaput, Drapeau, et al., 2008).

A review of longitudinal studies revealed that physical activity is a protector against obesity whereas sedentary behaviours are an obesity promoter (Must and Tybor, 2005). However, the relations were weak and imprecise methodologies and ineffective follow-ups weaken the strength of the results. Regardless, physical activity has other important health benefits associated with obesity and should be enforced in this age group whereas sedentary behaviours of all kinds should be limited.

1.2.2 Nutritional aspects

The theory that individuals are eating more and thus are more obese may not apply to Canadians. Although the obesity rate is rising, adolescents' caloric intake did not increase but rather decreased between two national surveys: the 2004 CCHS data and the Food Consumption Patterns Report of 1977 (Garriguet, 2007). These results may however be subject to methodology differences but may suggest other nutritional aspects, such as diet quality and not solely quantity, may be involved in the rise of obesity. Data from the late 1990s revealed that adolescents have poor dietary habits with low-nutrient, high-caloric foods topping the top-ten foods consumed by this age group (as per a 24-hour recall) (Phillips, Jacobs Starkey, et al., 2004). Breads had the highest mean intake followed by cakes/cookies/pies/granola bars. Carbonated beverages were the fourth highest consumed food whereas fruits and vegetables did not even make the list. This data accentuates the poor food habits of Canadian adolescents.

Does the macronutrient content of the diets of adolescents play a role in the prevalence of obesity? The cross-sectional data is conflicting – some indicating a positive relationship between body fat intake and body fatness while others report no associations (Rodriguez and Moreno, 2006). The results are also conflicting regarding carbohydrate intake: some show a negative relationship with body fat while others showing no relationship (Rodriguez and Moreno, 2006). A longitudinal study found that there was a weak relationship between fat intake and body fatness, in this case measured subscapular skinfold thickness, over the ages of 2-15 years yet fat intake was not related to BMI. Also, there were no associations found with dietary carbohydrates (Magarey, Daniels, et al., 2001). As many factors are intertwined in the diet quality of children and adolescents, other factors may be responsible for weight gain.

The Canada's Food Guide to Healthy Eating recommends adolescents consume 6-8 servings of fruit and vegetable per day (Canada's Food Guide to Healthy Eating 2007). Aside from the nutritional benefits justifying this consumption, these recommendations are also in place to maintain a healthy weight. In concordance with this, data from the CCHS in 2004 revealed that consuming fewer than 5 servings of fruit and vegetables per day has been associated with overweight in Canadian adolescents (Shields, 2006). Additionally,

data from the Health Behaviour in School-aged Children Study (HBSC) in 2002 revealed that fruit and vegetable intake on a daily basis (at least one serving per day) was not enough to significantly reduce the odds of becoming overweight or obese (Janssen, Katzmarzyk, et al., 2004). With over half of Canadian adolescents not attaining the Canadian guidelines (Garriguet, 2007), this does not aid in the battle against obesity for this age group.

Not only are adolescents not eating enough fruits and vegetables, but the consumption of milk products, which have shown a nationwide decline since the 1980s (Statistics Canada 2008) is specifically low among adolescents. It is recommended for teens between the ages of 10-16yrs to consume 3-4 servings of milk products per day. In a study of Québecois adolescents, between 74 - 93.2% of girls (depending on age) and approximately 60% of boys consumed less than 3 servings per day (Institute de la Statistique du Québec 2008). A recent review indicates that calcium and dairy food intake are implicated in energy balance (Major, Chaput, et al., 2008) and stress the importance of adequate intake for a healthy body weight. The fact that less than half of Canadian adolescents are consuming the recommended intake of dairy products is worrisome in obesity prevention.

Sugar-sweetened beverages are known to be associated with obesity and to cause weight gain (Malik, Schulze, et al., 2006). In Canadian adolescents a positive trend was seen between soft drink consumption and increased risk for obesity (Janssen, Katzmarzyk, et al., 2004). Although soft-drink consumption in Canada has dropped since 1998, in 2005 Canadians drank 95.2L per person per year of soft drinks. When looking at age-specific data, we see that adolescents have higher intake than younger children with adolescent boys consuming more than any other beverage besides water (**Figure 8a,b**) (Garriguet, 2008).

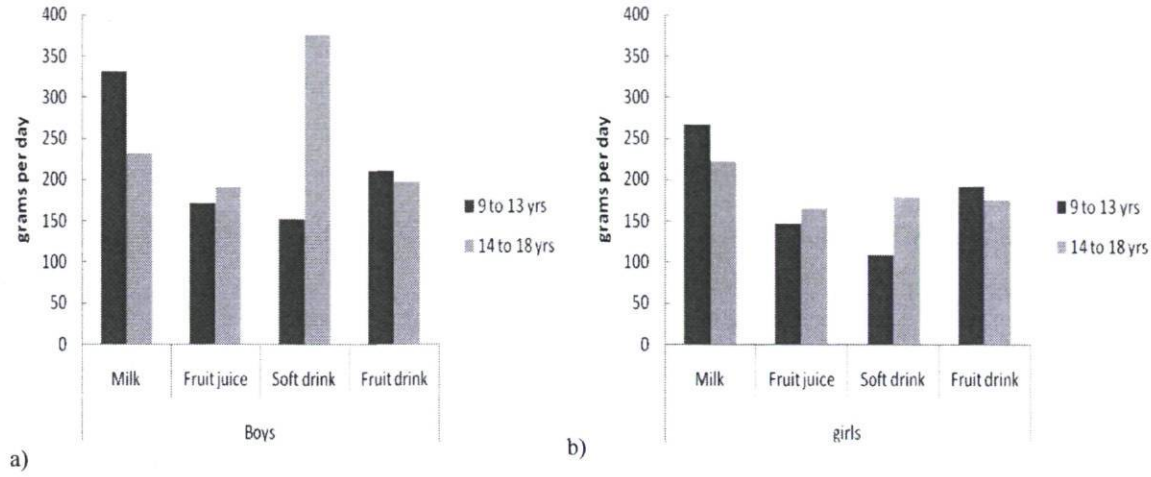

Figure 8. Average daily consumption of beverage intake in boys (a) and girls (b). *Source:* Beverage Consumption of Children and Teens, Garriguet (2008).

Adding to the list of unhealthy eating habits, adolescents consumed the most amount of calories between meals (i.e. snacks, approximately 30% of total intake) than any other age group in Canada (**Figure 9**) and accounted for more calories than what was eaten for breakfast. Specific data concerning breakfast intake among adolescents is lacking, but 10% of Canadians (all age groups) reported that they did not eat breakfast the day before the interview (Garriguet, 2007). Breakfast skipping has been cross-sectionally associated with obesity (Affenito, Thompson, et al., 2005, Cho, Dietrich, et al., 2003, Merten, Williams, et al., 2009, Niemeier, Raynor, et al., 2006), and associated with weight gain in normal weight adolescents (Berkey, Rockett, et al., 2003). It is also associated with both poor diet quality (Storey, Forbes, et al., 2009, Storey, Hanning, et al., 2009) and poor academics (Berkey, Rockett, et al., 2003). Decreasing snack and increasing breakfast consumption may be important behaviours to enforce in this age group.

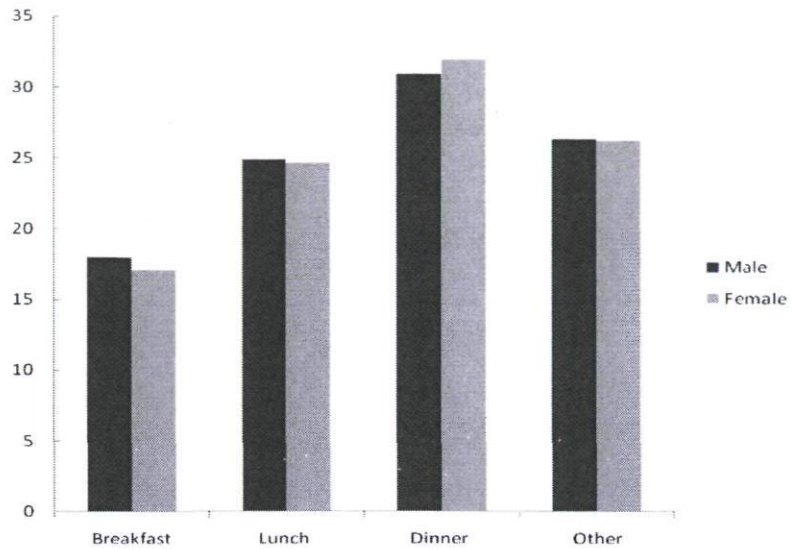

Figure 9. Percentage of caloric intake for adolescents separated by meal. *Source :* Canadian's Eating Habits Garriguet, D (2007)

1.2.3 Other Factors

Sleep

Sleep has been especially important in maintaining a healthy weight, specifically in children yet the details of this relationship are still unknown (Nielsen, Danielsen, et al., , Patel and Hu, 2008). Chaput and Tremblay (2007a) found that short sleep duration was independently related to increased abdominal obesity in young children and another study showed that each additional hour of sleep decreased BMI by 0.16kg/m^{2}in children of 10-12 yrs (Wells, Hallal, et al., 2008). Adolescents tend to experience a circadian delay – they go to bed later and wake earlier – due to biological and environmental changes occurring during adolescence (Crowley, Acebo, et al., 2007). With early school start times coupled with later bed times, adolescents can lose as much as 120 minutes of sleep per night (Hansen, Janssen, et al., 2005). This age group may be at a higher risk for obesity related side effects of reduced sleep. National data on sleep trends in adolescents is limited and it is uncertain whether Canadian adolescents are getting less sleep than decades past.

Family Environment and Parental Behaviours

Overweight and obese parents are more likely to have overweight and/or obese children (Carriere, 2003), which indicate potential genetic susceptibility to obesity, but the family environment, specifically parental behaviours, are also involved in this complex relationship. Parents are both role models and caregivers who in turn have a direct and indirect effect on the child's health-related habits and, in turn, body weight, both on a daily basis, such as nutrition and physical activity, and in the long-term implementation of these behaviours.

Regarding physical activity, the family environment plays a larger role than the physical environment (i.e. neighbourhoods) (Crawford, Cleland, et al., 2010). Sibling and parental participation or role modeling were important predictors of the child's participation in moderate-vigorous physical activity over the long term and more parental sedentary behaviours predicted larger BMI z-scores (Crawford, Cleland, et al., 2010). In addition to parental participation, a longitudinal study found parental encouragement, family cohesion i.e. understanding, paying attention to and having fun with their adolescent children, and parent-child communication to have a large affect on physical activity levels of their adolescent children (Ornelas, Perreira, et al., 2007).

As with physical activity, parental encouragement is important to the daily nutrition of the child. Encouragement to eat fruits and vegetables, with increased family rules concerning what foods are allowed, were positively associated with their child's consumption of these foods (Pearson, Biddle, et al., 2009). A review of this subject indicated that authoritative parental style, that is being both responsive to (attuned and supportive) and demanding of (rules, structure, discipline (Berge, Wall, et al., 2010)) the child, was associated with both lower BMI and a more healthy diet in the children (Berge, 2009). On the contrary, parental restriction of food may, in turn, lead to unhealthy eating patterns, such as eating in the absence of hunger (Birch, Fisher, et al., 2003). The disruption of the child's response to innate satiety cues is unfavourable and may cause further weight problems in the future. Also, forcing children to eat healthy foods may cause dislike for these foods (Birch and Fisher, 1998).

Parental eating behaviours also influence the eating behaviours of the child and were shown to be associated with the child's longitudinal weight change. Parental disinhibition, otherwise known as overeating, and restraint have been associated with greater increases in body fatness of their children over a 6-year period (Hood, Moore, et al., 2000) and these behaviours influence and/or are associated with the eating behaviours of their children (de Lauzon-Guillain, Romon, et al., 2009, Francis, Ventura, et al., 2007), which in turn may affect the child's weight. It is not just what one eats, but their attitude towards eating that plays a role in weight gain and parental modeling of unhealthy eating behaviours is putting their children at risk for adopting, perhaps for the long-term, these unhealthy behaviours as well.

Parental modeling of various behaviours also affects the nutrition of their children. Modelling and intake was shown to be positively associated with their child's fruit and fruit juice consumption (Pearson, Biddle, et al., 2009) as was parental breakfast skipping the most correlated factor for adolescent breakfast skipping (Keski-Rahkonen, Kaprio, et al., 2003).

Family meals, i.e. meals eaten together as a family, seem to play an indirect role on adolescent obesity. Higher family meal frequency was cross-sectionally and longitudinally associated with better quality dietary intake (Neumark-Sztainer, Larson, et al.). Family meal frequency may need to during most days of the week as greater than 5 family meals per week was associated with 2.8 times lower odds of adolescent obesity (Fulkerson, Kubik, et al., 2009) whereas only 3 times per week was not associated with the child's weight status (Fulkerson, Neumark-Sztainer, et al., 2008).

Adolescent obesity is complex and many of the above factors associated with its evolvement are interconnected and difficult to isolate. There is no one single factor to blame. It is difficult to select one of these factors and delegate it as the culprit in obesity prevalence. Nonetheless, in order to understand these relationships, each factor, from the environment to the individual, must be first researched in isolation and only after will the entire picture of obesity be more clear. Adolescent eating behaviours, something that is tangible to the individual, is one of these factors where further research will benefit, not

only in understanding the relationships between psychology and weight but also in order to implement proper, efficient and long-term weight control.

Chapter 2 – Adolescent Eating Behaviours

Eating behaviours in adults have been researched for decades yet the research on adolescent and children and their attitudes toward eating is not as developed. Eating behaviour research deals with the individual's attitude towards eating and the psychology behind different eating patterns and habits. These behaviours are often related to both the caloric intake and to what is ingested. More common behaviours which are studied are dietary restraint, overeating with and without and emotional component and response to hunger cues. The media is bombarded with distorted images of the "ideal body" and conflicting messages of what are considered healthy and unhealthy behaviours and with the rise of obesity and disease, it is not surprising that the psychology towards how one eats is affected. Research on macronutrient intake is important in obesity research but what is just as important is *how* one eats. Understanding eating behaviours and how they relate to weight gain in adolescents is a tangible, practical goal in the prevention of obesity.

2.1 Assessing eating behaviours in adolescents

The study of eating behaviours appeared in the literature in the early 1970's under the context of its relationship with obesity. The first measuring tool was the Restraint Scale (Herman and Polivy, 1975) which measured dietary restraint, and was later found to measure also a component of overeating (Laessle, Tuschl, et al., 1989). In 1985, the Three-Factor Eating Questionnaire (TFEQ, **Figure 10**) emerged and incorporated a more detailed look at eating behaviour, successfully separating the restraint and overeating components; it measures cognitive restraint, disinhibition and hunger (Stunkard and Messick, 1985). Other versions of the TFEQ have been created to accommodate various languages, such as the TFEQ-R18, and through time various subscales have been added to the questionnaire for added detail.

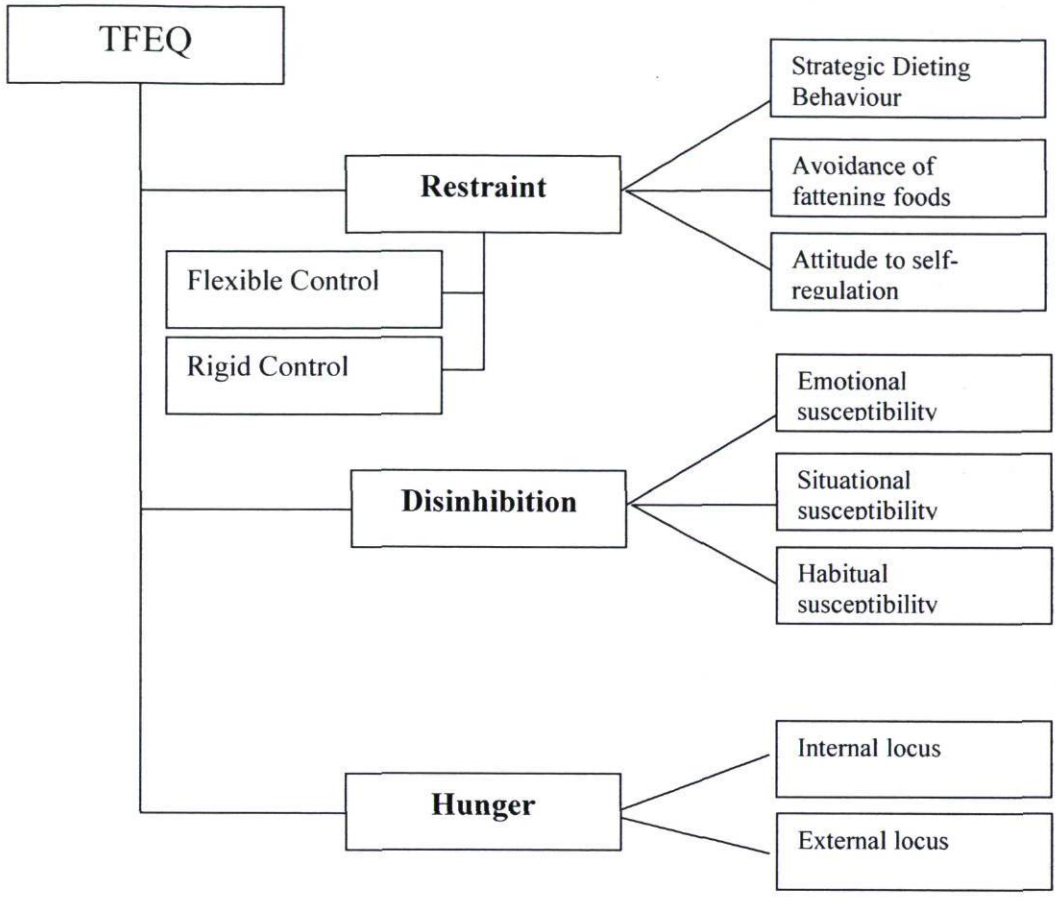

Figure. 10. Eating behaviours measured by the Three-Factor Eating Questionnaire (TFEQ). Note: behaviours in bold are main eating behaviours.

The original TFEQ cognitive restraint scale measures intention and actual restriction of food intake (van Strien, 1999). It also tends to measure both successful and unsuccessful restrained eaters (van Strien, Herman, et al., 2007) without distinguishing one from another. These two constructs have been separated by the addition of two control subscales: flexible and rigid control (Westenhoefer, Stunkard, et al., 1999). The former is associated with lower BMI, less disinhibition and is thought to be a healthy approach to dietary restriction. The latter is associated with higher BMI and disinhibition and is thought to be an unhealthy approach dietary restriction (Westenhoefer, Stunkard, et al., 1999). Within the cognitive restraint scale, 3 subscales were isolated: strategic dieting behaviour, attitude to self-

regulation and avoidance of fattening foods, to give further detail to this behaviour (Bond, McDowell, et al., 2001).

Disinhibition is defined as a lapse in inhibition and in the TFEQ it signifies episodes of overeating or uncontrolled eating. The original article termed this factor "disinhibition of control" which has been shortened to disinhibition (Stunkard and Messick, 1985). In a recent review, disinhibition was described as "opportunistic eating" (Bryant, King, et al., 2008) and has also been suggested to be called "susceptibility to eating problems" as the author stated it can be present without having dietary restraint, removing the need to be disinhibited from something (Westenhoefer, Broeckmann, et al., 1994). Similarly, one study suggested that disinhibition measures overeating and not disinhibition (as described as inhibition of restraint) as cognitive restraint was just that cognitive and it did not affect ingestion where as the disinhibition scale was related to increased rate of eating, excessive eating, eating disorder symptomatology and perceived hunger (Smith, Geiselman, et al., 1998). Bond *et al.* (Bond, McDowell, et al., 2001) identified three sub-factors within this scale: habitual, emotional and situational susceptibility to disinhibition. The TFEQ-R18, created with an obese Swedish population, does not include a disinhibition scale but rather has uncontrolled eating and emotional eating scales (Karlsson, Persson, et al., 2000).

The susceptibility to hunger is the third and least studied principle scale of the TFEQ. It measures one's ability to cope with the hunger sensation. It is not found in the revised TFEQ-R18. Although the hunger scale is related to the disinhibition scale (Stunkard and Messick, 1985), which is frequently associated with body weight, it is rarely used in the study of obesity.

A second popular questionnaire is the Dutch Eating Behaviour Questionnaire (DEBQ) which was published in 1986 (van Strien, 1986) and measures dietary restraint, emotional and external eating. The DEBQ has been more widely used in children and adolescents. Similar to the TFEQ cognitive restraint scale, the DEBQ restraint scale has also been shown to measure both intention and actual food restriction but in the past has been described as being more homogenous than the restraint scale of the TFEQ (David B. Allison, 1993). More recently, two constructs were distinguished within this scale – the intention and the behaviour of restricting food intake, putting into question its homogeneity

(Larsen, van Strien, et al., 2007). A downfall of this scale is that, unlike the TFEQ, longitudinal changes in eating behaviour scores have not been a good indicator of actual caloric restriction (Williamson, Martin, et al., 2007). Regardless, the TFEQ and DEBQ restraint scales are highly correlated in validation studies (Laessle, Tuschl, et al., 1989, Williamson, Martin, et al., 2007) which allows for general comparison between studies using the two questionnaires.

The overeating scale in this questionnaire is related to emotions and seems to be comprised of two factors: eating in response to clearly labelled emotions and eating in response to diffuse emotions (van Strien, 1986). The overeating scales of the TFEQ and the DEBQ (i.e. disinhibition with both external and emotional eating of the DEBQ) have been shown to be correlated in normal weight and overweight women (van Strien, Herman, et al., 2007)

There is no hunger component in the DEBQ yet the external eating scale measures the individual's likeliness to eat after external cues such as smell and sight. Recently however, the validity of the external eating scale has been put into question. In an experimental study, those with lower external eating scores ate more after food cues whereas those with high external eating ate the same amount with or without the cue therefore showing low predictive and discriminatory abilities of this scale (Jansen, Nederkoorn, et al., 2010).

Most eating behaviour research in the past has been on female participants which removes any possibility of observing gender differences. Gender comparison shows adolescent girls having higher cognitive restraint scores than adolescent boys using the TFEQ (de Lauzon, Romon, et al., 2004, Vagstrand, Linne, et al., 2009) and the DEBQ (Bearman, Martinez, et al., 2006, Lluch, Herbeth, et al., 2000, Snoek, van Strien, et al., 2008). On the contrary, no differences in restraint were found using the DEBQ in children (9yrs) (Roemmich, Wright, et al., 2002) and this behaviour has been shown to increase with increasing age in girls only (Lluch, Herbeth, et al., 2000). Perhaps younger boys and girls have similar dietary restraint values and as they get older, girls develop more dietary restraint over time which creates the gender divergence in middle adolescence. Regardless, restraint should be measured in both sexes as this behaviour does exist, albeit to a lower extent, among young males.

Gender differences in overeating measures, such as disinhibition, emotional overeating and uncontrolled eating, are less precise than what is seen with dietary restraint. Girls have been shown to have higher emotional eating than boys (de Lauzon, Romon, et al., 2004, Lluch, Herbeth, et al., 2000, Snoek, van Strien, et al., 2008) with boys having higher uncontrolled eating than girls (de Lauzon, Romon, et al., 2004). External eating has been shown to be the same between genders (Lluch, Herbeth, et al., 2000) or reported to be higher among boys than girls (Snoek, van Strien, et al., 2008). To date there are no studies which measured the TFEQ disinhibition subscales, e.g. emotional susceptibility, in adolescents. Identifying overeating triggers are important for behaviour correction and prevention for both genders.

2.2 Eating behaviours associated with body weight

Whereas the DEBQ has been frequently used in adolescents, the TFEQ subscales have only been used in adults (e.g. Drapeau, Provencher, et al., 2003, Provencher, Drapeau, et al., 2003, Provencher, Drapeau, et al., 2004) and to date has not been measured in any younger age groups. The two main eating behaviours measured in adolescents in the context of obesity are dietary restriction and overeating. This section will look at the relationship between body weight and eating behaviours and will contain results from both questionnaires as there is a lack of research on this topic among adolescents. As previously described, the scales in these two questionnaires measure similar constructs and are correlated, permitting general comparison.

2.2.1 Restraint

In adults, the cognitive restraint scale has had varying results with its association with body weight – some report it as being an eating behaviour associated with lower weight (Williamson, Lawson, et al., 1995) whereas others have reported the opposite (Shearin, Russ, et al., 1994) or having no relation with weight at all (Provencher, Drapeau, et al., 2003, Schubert and Randler, 2008).

The relationship is more concrete in adolescents. Most studies using the TFEQ have found cognitive restraint to be positively associated with body weight (Angle, Engblom, et al.,

2009, Bas, Bozan, et al., 2008, Chanoine, Mackelvie, et al., 2008, de Lauzon-Guillain, Basdevant, et al., 2006, Elfhag and Linne, 2005, Mulvihill, Davies, et al., 2002, Vogels, Posthumus, et al., 2006, Wardle, Marsland, et al., 1992). The positive association between body weight and dietary restraint in adolescents is surprising since high dietary restraint would theoretically be associated with low caloric intake which would in turn result in a lower body weight. Studies on adolescents have shown that dietary restraint is negatively related to energy intake, meaning that high restrained individuals report eating less (Hill and Robinson, 1991, Lluch, Herbeth, et al., 2000, Mulvihill, Davies, et al., 2002, Wardle, Marsland, et al., 1992). There could be several possible explanations for this: 1. they are not accurately reporting their energy intake (under-reporting) 2. they are accurately reporting their energy intake but require less energy physiologically or 3. they do not know how to accurately report their intake or the measure of energy-reporting is misrepresentative.

The most likely cause of the contradictory relationship between high BMI and lower energy intake among high restrained eaters would be under-reporting. Under-reporting has been associated with BMI (Vance, Woodruff, et al., 2009) as well as restrained eating (Babio, Canals, et al., 2008, Ventura, Loken, et al., 2006) and has been found to be as high as 34% in among adolescents (Rennie, Jebb, et al., 2005). Not only is under-reporting prevalent in this age group, but restrained eaters (Ventura, Loken, et al., 2006), females and overweight adolescents (Vance, Woodruff, et al., 2009) all have been shown to under-report. As overweight/obese adolescents have higher restraint scores and females are known to have increased restraint in adolescence, the statistics suggest it is more likely for these individuals to under-report their intake.

There have been studies which have attested the under-reporting theory among restrained eaters. They report that those with high restraint do not under-report but instead require less energy. In adults, high restrained individuals have been associated with lower basal metabolism (Platte, Wurmser, et al., 1996, Tuschl, Platte, et al., 1990) and therefore require less energy than low restrained individuals. Their restriction is a behavioural adaptation to maintain their weight because of their lower metabolic rate which is not necessarily a product of past weight cycling (Platte, Wurmser, et al., 1996) or recent diminishes in

caloric intake (Tuschl, Platte, et al., 1990). Although the restrained eaters are heavier, they would probably be even heavier if they did not restrain their intake. Further caloric restraint would cause an adaptation to reduce their energy requirements even further, creating a vicious cycle with deleterious effects on basal metabolism. To date, this theory has not been tested in adolescents.

The relationship between restraint and body weight change has been studied more thoroughly in adults. Increases in cognitive restraint, as measured by the TFEQ, have been associated with increased weight loss (Dalle Grave, Calugi, et al., 2009, Teixeira, Silva, et al., 2009), reduced weight gain (Savage, Hoffman, et al., 2009) and has been shown to attenuate the relationship between overeating and weight gain (Hays, Bathalon, et al., 2002). On the contrary, restraint did not predict weight change in a group of post-menopausal women (Hays, Bathalon, et al., 2006). Changes in restrictive behaviour have also been associated with weight changes. Decreases in restraint have been associated with weight gain (Drapeau, Provencher, et al., 2003) whereas increases have been negatively associated with percentage of weight regain (Vogels, Diepvens, et al., 2005, Westerterp-Plantenga, Kempen, et al., 1998). The former study showed that those who decreased their restrictive behaviour also had high initial restraint indicating that dietary restraint may be difficult to maintain for long periods of time (6 years) (Drapeau, Provencher, et al., 2003).

Cognitive restraint has cross-sectional relationships with body weight in adolescents, but whether it leads to weight gain or weight loss in this age group is uncertain. The only longitudinal study using the TFEQ on adolescents and children revealed that initial cognitive restraint is not associated with changes in BMI but rather initial BMI predicted a greater change in cognitive restraint (de Lauzon-Guillain, Basdevant, et al., 2006). A study using the Dutch Eating Behaviour Questionnaire (DEBQ) (van Strien, 1986), measured dietary restraint in a longitudinal design and found similar results: BMI predicted restrained eating more consistently rather than restrained eating predicting BMI (Snoek, van Strien, et al., 2008). On the contrary, one study using the DEBQ showed that increased restraint among young teenage girls increased their risk for obesity onset (Stice, Presnell, et al., 2005). This data suggests that the relationship may be bidirectional – the increased body

weight can bring forth the behaviour and the behaviour, once established, may perpetuate weight gain.

Aside from being associated with increased weight in adolescents, is dietary restraint is associated with other potential harmful behaviours which may in turn effect body weight? Rigid control, one of the main subscales of cognitive restraint in the TFEQ, is often positively associated with disinhibition (Westenhoefer, Stunkard, et al., 1999). Having high levels of both behaviours simultaneously has proven to have a stronger effect on weight than either alone, albeit to date this has not be verified in adolescents (Westenhoefer, Stunkard, et al., 1999). Restraint has also been shown to be independently related to and longitudinal predictors of abnormal "weight and eating attitudes", as per the Child Eating Attitudes Test (Johnson and Wardle, 2005). As well, adolescent girls with high restraint, as per the TFEQ, had higher "unhealthy weight control behaviours such as skipping meals, eating little, vomiting, using diet pills or laxatives and fasting" and they dieted more during the past year (Bas, Bozan, et al., 2008). Dietary restraint is also involved in the complex relationships among body dissatisfaction, depression and bulimic symptoms. High initial restraint predicted larger increases in body dissastisfaction in both adolescent girls and boys (Bearman, Martinez, et al., 2006) and it seems to mediate the relationship between body dissatisfaction with both depression and bulimia in adolescent girls (Ricciardelli and McCabe, 2001, Stice and Bearman, 2001). Dieting has in itself also been associated with depression, body dissatisfaction and unhealthy weight control behaviours (Crow, Eisenberg, et al., 2006, Eisenberg and Neumark-Sztainer, 2010) and binge eating after 5 years in females (Eisenberg and Neumark-Sztainer, 2010).

Higher cognitive restraint scores were found among those with Binge Eating Disorder (BED) compared to those without the disorder (Bas, Bozan, et al., 2008) and dietary restraint predicted binge eating in a longitudinal study in young adolescents (Allen, Byrne, et al., 2008). Restraint has been related to stress (Johnson and Wardle, 2005) and to increased snacking under stressful conditions in adolescents (Roemmich, Wright, et al., 2002). Results on whether dietary restraint causes unhealthy weight control behaviours is not solidified but its involvement in these behaviours is likely and because of this, as well as its association with increased body weight, should be monitored in this age group.

2.2.2 Disinhibition/overeating

Unfortunately, there has been little research on disinhibition as measured by the TFEQ among adolescents. Emotional overeating, a subscale of the original disinhibition scale and as a primary scale in the TFEQ-R18, as well as overeating measures in the DEBQ, have been more researched in this age group.

Unlike in adults where there is ample research linking disinhibited eating with increased body weight (Bryant, King, et al., 2008), disinhibition has been associated with increased weight only in younger adolescents (12 years) (Vogels, Posthumus, et al., 2006) with no cross-sectional relationship found among adolescents (Bas, Bozan, et al., 2008, Chanoine, Mackelvie, et al., 2008, de Lauzon-Guillain, Basdevant, et al., 2006). Studies using the TFEQ-R18 scale have found similar results in that uncontrolled eating was not related to body weight in adolescents (Angle, Engblom, et al., 2009, Elfhag and Linne, 2005) and neither was it associated with increased energy intake(Bas, Bozan, et al., 2008). The only longitudinal study using the TFEQ was in group of older teenage females (mean age 18 ± 0.2 years) which revealed the initial disinhibition did not predict weight gain (Lowe, Annunziato, et al., 2006).

The positive relationship between emotional overeating and body weight has been shown to exist in adolescents using both the TFEQ-R18 (Angle, Engblom, et al., 2009, Elfhag and Linne, 2005) but not in adolescents using the DEBQ (Braet, Claus, et al., 2008, de Lauzon-Guillain, Basdevant, et al., 2006, Lluch, Herbeth, et al., 2000). Initial emotional eating did not predict weight gain (Lowe, Annunziato, et al., 2006) but it did decrease post weight loss in adolescents (de Lauzon, Romon, et al., 2004, Sabet Sarvestani, Jamalfard, et al., 2009).

With few studies using the TFEQ to measure disinhibition in adolescents it is difficult to deduce concrete conclusions with respect to its involvement with body weight. Also, the varying results are not specific to a single questionnaire therefore further research is needed to ensure that these questionnaires are valid in this age group.

2.2.3 Hunger

Inconsistencies are found among adults with regards to the relationship between this behaviour and body weight. Hunger has been associated with obesity (Provencher, Drapeau, et al., 2003) but also has been associated with a decrease in body weight (in women) (Drapeau, Provencher, et al., 2003). In adolescents, one study found no differences in hunger scores between the lean and overweight (Vogels, Posthumus, et al., 2006). Similar results were found in adolescent boys – hunger scores did not differ between weight groups (Chanoine, Mackelvie, et al., 2008). Opposing results were found among adolescent females with the overweight group having higher hunger levels than the normal weight group although a linear trend did not reach significance (Bas, Bozan, et al., 2008). Increased hunger scores, as per the TFEQ, may indicate an eating disorder as it has been associated with BED (Bas, Bozan, et al., 2008) and bulimia (Braet, Claus, et al., 2008, Shearin, Russ, et al., 1994) in adolescents. As few studies have measure the TFEQ hunger scale among adolescents, the associations with this eating behaviour are far from being understood. Further research is needed using this measure in these age groups, specifically in testing its relationship to obesity and eating pathology.

The DEBQ has an external eating scale which measures the susceptibility of an individual to eat in response to food-related stimuli (smell, sight etc.). Although this is not the same as the TFEQ hunger scale, it has been studied in the context of body weight and has therefore been added to this section. External eating has been positively associated with energy intake (Lluch, Herbeth, et al., 2000, Wardle, Marsland, et al., 1992) and shown to be higher in overweight children than normal weight children (Braet, Claus, et al., 2008). Children have also been shown to have higher scores than adults (Lluch, Herbeth, et al., 2000). Using a child form of the DEBQ, external eating was the most prevalent behaviour in the group of 7-12 year olds, with exception among the overweight children where dietary restraint was in par with external eating (van Strien and Oosterveld, 2008).

These results, the presence of a positive relationship between cognitive restraint and body weight and the lack of one between disinhibition and body weight, seem to be partly opposing as to what is seen in adults. The hunger score, albeit lacking in the literature, seems to follow similar trends as what is seen in adults. Most research on adolescent eating behaviour has pertained to restrained eating yet more research is needed to clarify the

relationships between these eating behaviours with body weight, specifically that of disinhibited eating.

2.2.4 Objectives and Hypotheses

The aim of this thesis is to identify eating behaviour, as measured by the TFEQ, in relation to body weight among adolescents in the community sample The Québec Family Study. Also, as the relationship between cognitive restraint and body weight is inconsistent, the impact of the control scales (flexible and rigid control) on body weight will be assessed. We hypothesized that eating behaviours of cognitive restraint, rigid control and disinhibition would be positively associated with body weight, similar to results found among adults. As a secondary hypothesis, we predicted flexible control would be either negatively related to body weight in this group of adolescents. Finally, we hypothesized the susceptibility to hunger would be positively related to body weight.

The following chapter includes the article *The Three-Factor Eating Questionnaire and BMI in adolescents: results from the Québec Family Study*. Gallant AR, Tremblay A, Bouchard, C, Després JP, Drapeau V. For this study, data from the Québec Family Study was used in statistical analyses to determine the relationship between Three-Factor Eating Questionnaire scores, body weight and dietary data in the adolescent subset of this cohort.

Chapter 3 - Article

The Three-Factor Eating Questionnaire and Body Mass Index in Adolescents: results from the Quebec Family Study.

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Abstract

Eating behaviour traits are associated with body weight variations in adults. The Three-Factor Eating Questionnaire (TFEQ) measures cognitive restraint, disinhibition and hunger, as well as their corresponding subscales, e.g. rigid and flexible control. The TFEQ has not been widely used in adolescents to investigate eating behaviour traits associated with body weight. The aim of this study was whether eating behaviour traits were associated with body mass index (BMI) in male and female adolescents. Sixty adolescents (30F; 30M; mean age 15.0 SD 2.4 years) from the Québec Family Study completed the TFEQ and 3-day dietary records. There were no gender differences in TFEQ scores. Rigid control, disinhibition and emotional susceptibility (to overeat) were positively related to BMI z-scores for the entire sample ($r = 0{\cdot}3$, $p < 0{\cdot}05$). There was a positive relationship between BMI z-scores and rigid control ($r = 0{\cdot}39$, $p < 0{\cdot}05$) in females, while male BMI z-scores were positively related to emotional susceptibility ($r = 0{\cdot}42$, $p < 0{\cdot}02$) and disinhibition ($r = 0{\cdot}41$, $p < 0{\cdot}03$). Adolescents characterized by both high disinhibition and high rigid control had significantly higher BMI z-scores than those with both low disinhibition and low rigid control. There were no significant differences in BMI z-scores between the flexible control categories. Dietary macronutrient content was not consistently related to eating behaviour traits. These results show that the eating behaviour traits of disinhibition and rigid control are independently related to BMI z-scores in this group of adolescents.

Introduction

The obesity pandemic is sweeping every age group. Children and adolescents are increasingly heavier than those of previous generations. In 1978, 3% of Canadian adolescents between the ages of 12-17 years were obese. The prevalence had increased to 9% by 2004, the largest increase of all Canadian age groups[1]. Obesity causes are numerous and include environmental, cultural, familial, behavioural, metabolic and genetic factors. In the last 30 years, research on behavioural issues associated with obesity has expanded yet many questions remain unanswered and most conclusions are only tentative.

A number of research questionnaires are used to assess eating behaviour traits. One of the most widely used is the Three-Factor Eating Questionnaire (TFEQ)[2], which measures cognitive restraint, disinhibition, and hunger in adults. In 1991, Westenheofer[3] suggested that cognitive restraint, as measured by the TFEQ, could be divided into two subscales depending on their relationships with body mass index (BMI) and disinhibition: flexible and rigid control. The former, a more relaxed version of restraint, is associated with both low disinhibition and low BMI. Rigid control is a more severe restrictive state and is associated with both high disinhibition and high BMI[4]. In addition to the control subscales, Bond *et al.*[5] expanded on the three main categories by defining more specific subscales for each behaviour trait e.g. strategic dieting behaviour, emotional susceptibility and avoidance of fattening foods. These TFEQ subscales have been measured in adults[4, 6-11]; however, to the best of our knowledge, they have never been assessed in adolescents.

The TFEQ has been shown to measure cognitive restraint and disinhibition independently[10, 12], yet these behaviours work in combination as well. Studies have shown that high susceptibility to overeat (disinhibition) combined with low restriction is associated with higher body weight[8, 13-15]. These interactions have been studied in women using the TFEQ control subscales[10], in adolescent females using the Dutch Eating Behaviour Questionnaire (DEBQ)[12], with varying results concerning body weight. Thus eating behaviour traits in adolescents have not been largely studied. The aim of this study was to assess eating behaviours and their associations with body weight in adolescents.

Methods

The volunteers for this study participated in the Québec Family Study (QFS), a prospective study which started in 1978 and continued until 2001 (phase 1: 1978 – 1982, phase 2: 1989-1995, phase 3: 1997-2001). All methods relevant to the present report are described elsewhere[11]. Sixty adolescents completed the TFEQ at the end of phase 2. Self-reported, 3-day dietary records[16] (2 week days, 1 weekend day) were collected and the Canadian Nutrient File[17] was used to estimate energy intake and diet macronutrient content. Body weight and height were measured using standardized laboratory methods. In addition to the original 51-question TFEQ, subscales for disinhibition, hunger and cognitive restraint[5], as well as the rigid and flexible control subscales[3], were also measured. Lean and overweight/obese categories were determined by obesity cutoffs suggested by Cole et al.[18] The adolescents were grouped into four categories defined by their levels of restraint (cognitive restraint, flexible and rigid control) and disinhibition: 1) high disinhibition-high restraint; 2) high disinhibition-low restraint; 3) low disinhibition-high restraint and 4) low disinhibition-low restraint. High and low scores were defined as being above or below the group median with equal group sizes. We selected this method of classification because there are currently no TFEQ score norms for adolescents by which to classify them.

Statistical analyses were performed using JMP 7.0 Statistical Software from Statistical Analysis Systems (SAS Institute, Cary, NC, USA). Means, standard error (SE) and interquartile ranges (IQR) were calculated and Student t-tests were used to test for gender and weight category differences in mean TFEQ values with the significance level set at $p \leq 0{\cdot}05$. Pearson correlation coefficient was used to quantify linear relationships. When appropriate, correlations were adjusted for confounding factors such as age and BMI (reported energy intake). As the median split method has been criticized[19], full-factorial multiple regression analysis using the continuous variables restraint and disinhibition was also used to test for variable interaction. An ANOVA was used to compare BMI z-scores between various TFEQ categories. When the ANOVA was significant, a post-hoc Turkey-Kramer test was used to detect which conditions were statistically different from each other. To account for the variation in growth rate observed at adolescence, values were transformed into BMI z-scores using the US CDC 2000 growth charts for children, age of

2-20 years[20]. This study was approved by the Medical Ethics Committee of Université Laval.

Results

Characteristics of the study population are shown in Table 1. There were no significant gender differences neither in physical characteristics nor in mean TFEQ scores, except for avoidance of fattening foods which was higher in females than in males ($p < 0{\cdot}05$). Rigid control, disinhibition and emotional susceptibility to overeat were all positively related to BMI z-score (Table 3). Among females, but not among males, there was a positive relationship between rigid control and BMI z-scores ($p \leq 0{\cdot}04$). Among males, but not among females, there were significant correlations between emotional susceptibility and disinhibition on the one hand, and BMI z-scores on the other ($p \leq 0{\cdot}02$, $p \leq 0{\cdot}03$, respectively). Mean values of rigid control, disinhibition and the disinhibition subscales were all higher among the overweight/obese adolescents (Table 2). In the total sample, rigid and flexible control were positively correlated after adjusting for age and BMI ($r^2 = 0{\cdot}11$; $p < 0{\cdot}01$).

The adolescents were grouped into four categories according to their levels and type of restriction (flexible and rigid) and disinhibition. Mean TFEQ scores were all significantly different between low and high categories ($p < 0{\cdot}05$, Table 4). Gender distributions within the TFEQ categories were not significantly different and for this reason we did not separate the categories by gender. Full-factorial multiple regression analysis revealed no significant effect of the interaction between disinhibition and cognitive restraint, flexible or rigid control on BMI z-score (data not shown). However, adolescents characterized by high cognitive restraint – high disinhibition had significantly higher BMI z-scores than those with low disinhibition – low cognitive restraint (Figure 1a), as did those with high disinhibition – high rigid control when compared to the group characterized with low disinhibition - low rigid control (Figure 1b). There were no significant differences between BMI z-scores for the flexible control categories (Figure 1c).

Hunger was positively correlated to self-reported energy intake for the entire sample (r^2 = 0·01, $p \leq 0·02$). No other TFEQ scales were related to either energy intake or macronutrient content estimated from the dietary records.

Discussion

To our knowledge, the present study was the first to assess the TFEQ, and its subscales, on an adolescent population of both sexes. The results showed that the rigid control trait was positively related to BMI z-scores in females, while emotional susceptibility and disinhibition were associated with male BMI z-scores. In addition to individual TFEQ associations with body weight, eating behaviour categories were also associated with BMI z-scores. When the cognitive restraint scale is divided into the restraint subscales (rigid and flexible), the deleterious effect of rigid control on body weight is seen. Although there was no interaction effect of rigid control and disinhibition on BMI z-scores, those with both high restraint and high disinhibition had significantly higher BMI z-scores than those with low eating behaviour scores, with the negative affect deriving from high rigid control. These behaviours had significant and independent affects on BMI z-scores and a trend toward an additive affect was visible.

Disinhibition, or overeating, is known to be associated with increased body weight[21] whereas the relationship between body weight and dietary restraint varies in adults; some showing an inverse relationship[9, 10, 14], while others showing no relationship[15, 22, 25, 26]. A positive relationship between restrained eating and body weight has been found among adolescents[24, 27] and children[28]. In this study, there was no linear relationship between cognitive restraint per se and BMI z-score, but the heavier the adolescents, the higher their rigid control towards eating, a result concordant with previous findings in adults[4, 6, 7, 11, 22, 23]. The conflicting results of dietary restraint in the literature coupled with data emerging regarding rigid dietary control shows the importance of using the restraint subscales. In this study, flexible control did not seem to affect body weight as it has no relation to BMI z-scores.

In accordance with results obtained in adult men[11], there was a positive relationship between disinhibition and BMI z-scores among adolescent males, a relationship not found among females in this study. Male adolescent eating behaviour studies are rare. One study has shown that male adolescents have higher uncontrolled eating, a derivative of the disinhibition measure in a revised TFEQ (TFEQ-R18)[27] and another showing higher external hunger, which is eating in the absence of hunger from the Dutch Eating Behaviour Questionnaire, DEBQ[29]. Not only was disinhibition related to body weight in the present study, but the male adolescents had higher mean disinhibition scores when compared to adult norms[30]. Restrained eating seems to be more prevalent in adolescent females[24, 27, 29], whereas overeating may play an important role in both genders. Accordingly, large adolescent study showed that 7.8% of boys and 17.3% of girls reported objective overeating revealing its affects on both genders[31]. A recent review[21] confirms the poor health associations of disinhibited eating and stresses the importance of including young males in eating behaviour/disorder research as the problem is now being seen in young males[32].

Analyses by high and low eating behaviour categories revealed that having both high disinhibition and high restraint, specifically high rigid control, were related to higher BMI z-scores. The individuals in the high disinhibition - high rigid control category may be characterized as being unsuccessful in their restrained attempts, which could explain their increased body weight. The fundamental purpose of the rigid control subscale was to show that some individuals are so severely controlled that this behaviour is unable to be maintained and uncontrolled eating episodes occur[3]. It was shown that young females with high dietary restraint in combination with other eating behaviours, specifically disinhibition, were more likely to fail at their restrained efforts and had more eating disorder symptoms such as binging[12]. Disinhibited and rigid control towards eating are the strongest distinguishing factors for obesity in this group of adolescents since only those with both high disinhibition and high rigid control had significantly higher BMI z-scores than those with low levels of both behaviours. As there were no significant differences between the flexible control categories, flexible control may have moderating affect on BMI. This is not surprising as flexible control is known to be a more successful approach

to weight loss[4]. Several studies have found that restraint has a moderating affect on the interaction between disinhibition and body weight[14, 15, 25] yet these studies did not use the restraint subscales. Using the restraint subscales may shed more light on the potential moderating affect of restraint.

Various factors could explain the trends observed herein. The categories were formed on the basis of the study sample means. The lack of TFEQ research on adolescents limits comparisons. However, when comparing these values with US adult TFEQ norms[30] and results in children (12y) [28], it suggests overall high disinhibition scores among these adolescents, specifically among the males. In contrast, cognitive restraint, rigid and flexible control scores were all lower in this population than in adults[4, 6, 11] and children[28]. Thus, the high disinhibition scores coupled with the low restraint scores may be largely responsible for the lack of significant differences between restraint and disinhibition categories.

In this study, hunger was the only TFEQ score which was associated with absolute energy intake. One study also reported a similar lack of associations between TFEQ scores and energy intake[33], however, most have reported associations[13, 26, 24, 34] . Discrepancies could be explained in part by under-reporting in adolescents which has been found to be as much as 34%[35]. BMI values[36] and eating restraint scores (for females) are also positively correlated with under-reporting in dietary analysis in adolescent populations[37, 38]. The lack of associations between the TFEQ scores and self-reported energy intake could be in part explained by these phenomena, yet further research is needed in this area.

There are other limitations with this study. The lack of high and low norms for eating behaviours resulted in using group-specific separations and this should be taken into account when interpreting the present results. A larger sample size would be needed to generate more definitive tests of the trends observed herein. Finally, because of the cross-sectional nature of these associations, it is impossible to establish cause and effect relationships.

In conclusion, eating behaviours in adolescents are associated with body weight, similar to what is seen in adult studies. The TFEQ is able to identify relevant eating behaviour traits associated with higher BMI in this mixed-gender age group. Disinhibition and rigid control should be targeted in adolescent in order to characterize youth at risk for obesity and implement proper weight control strategies or to predict success or failure in weight-loss participants.

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Authors' contributions

AG carried out the literature review, data extraction, interpretation of the data, and drafted the manuscript. VD participated in the conceptualization, data extraction, interpretation of the data and helped to draft the manuscript. AT, LP, CB J-PD contributed to the conceptualization and data interpretation. All authors revised the manuscript.

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Table 1. Mean (IQR) physical characteristics of the study population by sex

Physical Characteristics	Females (n = 30)		Males (n = 30)	
	Mean	IQR	Mean	IQR
Age (years)	15·6	13·7 - 17·7	14·4	12·7 - 16·3
Weight (kg)	65·2	49·6 - 84·4	74·8	49·5 - 90·9
Height (cm)	161·1	155·8 - 170·4	166·2	152·7 - 175·9
BMI (kg/m^2)	25·7	20·3 - 28·4	26·1	19·8 - 30·8

BMI, body mass index; IQR, interquartile range

Table 2. Mean TFEQ scores with corresponding subscales for adolescents

Eating Behaviours	Total (n = 60)		Lean (n = 27)		Overweight/ obese (n = 33)	
	Mean	IQR	Mean	IQR	Mean	IQR
Cognitive dietary restraint	5·1	2·0 - 7·0	4·1	2.0 - 6.0	5·9	3.0 - 8.5
Flexible control	1·9	1·0 - 3·0	1·8	1.0 - 3.0	2·0	1.0 - 3.0
Rigid control	1·0	0·0 - 2·0	0·52	0.0 - 1.0	1·4	0.0 - 2.0**
Attitude to self-regulation	1·6	1·0 - 2·0	1·4	1.0 - 2.0	1·8	1.0 - 3.0
Strategic dieting behaviour	0·58	0·0 - 1·0	0·41	0.0 - 1.0	0·72	0.0 - 1.0
Avoidance of fattening foods	1·3	1·0 - 2·0	1·1	0.0 - 2.0	1·4	1.0 - 2.0
Disinhibition	6·1	3·0 - 9·0	4·7	2.0 - 6.0	7·3	3.5 - 10.0**
Habitual susceptibility	0·95	0·0 - 1·2	0·60	0.0 - 1.0	1·2	0.0 - 2.0*
Emotional susceptibility	1·25	0·0 - 3·0	0·78	0.0 - 1.0	1·6	0.0 - 3.0**
Situational susceptibility	2·1	1·0 - 3·0	1·6	0.0 - 3.0	2·5	1.0 - 4.0*
Hunger	6·6	4·3 - 9·0	6·9	5.0 - 10.0	6·4	4.0 - 9.0
Internal locus for hunger	2·9	1·0 - 5·0	3·3	1.0 - 5.0	2·8	1.0 - 5.0
External locus for hunger	2·6	1·0 - 4·0	2·7	1.0 - 4.0	2·4	1.0 - 4.0

TFEQ, Three-Factor Eating Questionnaire; IQR, inter-quartile range
*$p < 0·05$, **$p < 0·01$ significantly different from Lean

Table 3. Correlations between eating behaviours and BMI z-scores† in adolescents

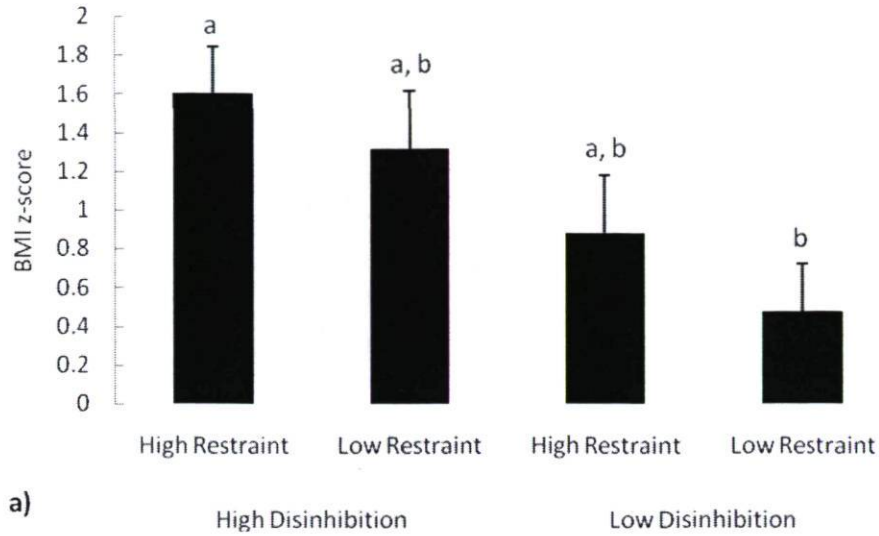
TFEQ scores	BMI z-score					
	Total (n = 60)		Females (n = 30)		Males (n = 30)	
	r^2	p value	r^2	p value	r^2	p value
Rigid control	0·09 (+)	0·02	0·15(+)	0·04	0·06 (+)	0·18
Disinhibition	0·09 (+)	0·02	0·07(+)	0·17	0·17 (+)	0·03
Emotional susceptibility	0·08 (+)	0·03	0·07(+)	0·16	0·18 (+)	0·02

BMI, body mass index; TFEQ, Three-Factor Eating Questionnaire;
†BMI z-scores were calculated from the Centre for Disease Control and Prevention 2000 Growth Charts

Table 4. Mean (IQR) TFEQ scores for *high* and *low* categories of cognitive restraint, its subscales and disinhibition.

TFEQ Classification		Total (n = 60)		Females (n = 30)		Males (n = 30)	
		Mean	IQR	Mean	IQR	Mean	IQR
Cognitive Restraint	High	7·9	6·0 - 9·0	8·0	6·0 - 9·5	7·8	5·3 - 9·0
	Low	2·3	1·0 -3·0	2·9	2·0 - 4·0	1·9	1·0 - 3·0
Flexible control	High	3·0	2·0 - 3·6	3·0	2·0 - 4·0	3·0	2·0 - 3·5
	Low	0·8	0·0 - 1·9	0·8	1·0 - 1·0	0·8	0·0 - 1·0
Rigid control	High	1·9	1·0 -2·3	1·9	1·0 - 2·3	1·8	1·0 - 2·8
	Low	0·13	0·0 - 0·0	0·1	0·0 - 0·0	0·2	0·0 - 0·0
Disinhibition	High	9·1	7· 0 - 10·8	9·4	7·8 - 11·3	8·7	7·0 - 10·0
	Low	3·2	2·0 - 4·3	2·8	2·0 - 3·8	3·4	2·0 - 5·0

TFEQ, Three-Factor Eating Questionnaire, IQR, interquartile range
All *high-low* pairs are significantly different from each other $p < 0·05$


BMI z-score
2
1.8
1.6
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1
0.8
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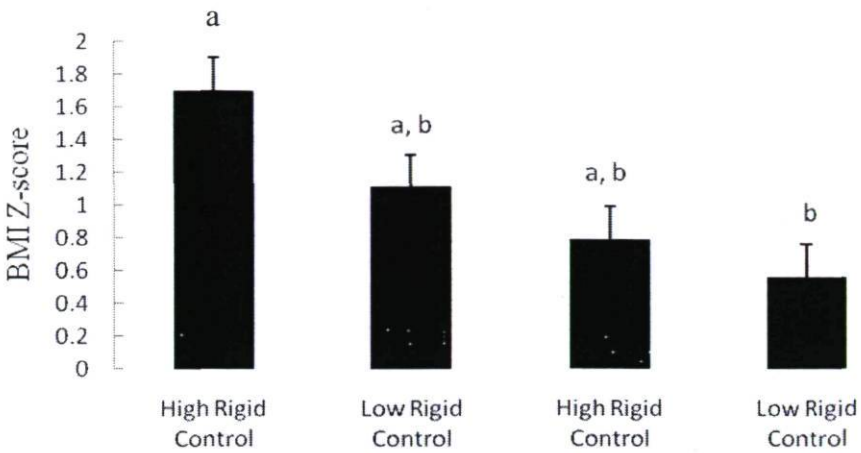
b
High Restraint
Low Restraint
High Restraint
Low Restraint
High Disinhibition
Low Disinhibition

a)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BMI Z-score
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Low Rigid Control
High Disinhibition
Low Disinhibition

b)

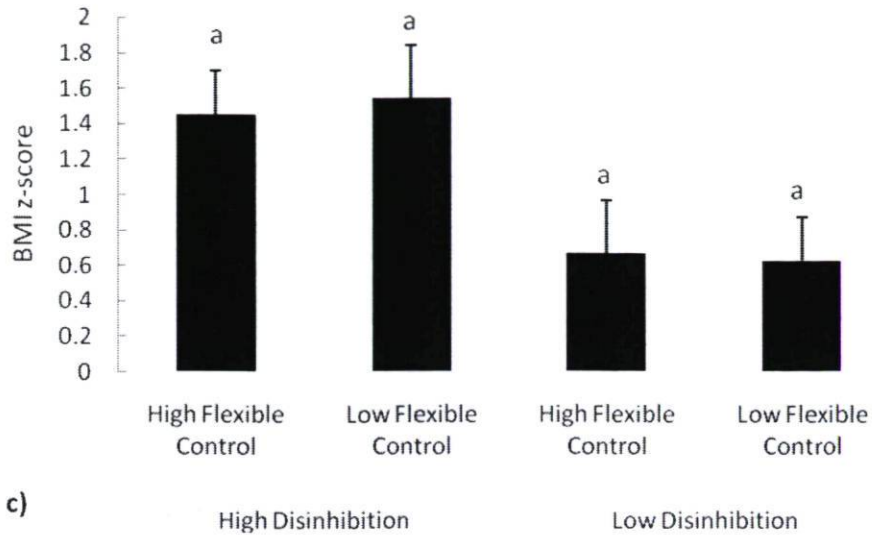

Figure 1. Mean (SE) BMI z-scores for cognitive restraint **(a)** /rigid **(b)** and flexible **(c)** control – disinhibition eating behaviour categories for male and female adolescents. Categories were significantly different as per one-way ANOVA ($p \leq 0{\cdot}05$) and columns with different letters are significantly different from each other as per post-hoc Turkey-Kramer test ($p \leq 0{\cdot}05$).

Chapter 4 - Discussion

The main hypothesis of this study was that eating behaviours, as measured by the TFEQ, would be related to body weight, similar as to what is seen among adults. This is the first study to measure flexible and rigid control and the TFEQ subscales, e.g. strict dieting behaviour, emotional susceptibility, among adolescents. As predicted, both rigid control and disinhibition, specifically with emotional susceptibility, were positively related to body weight in this age group. Although in this sample there were no significant differences between male and female mean eating behaviour scores (aside from higher avoidance of fattening foods among females), their correlations with BMI were different. The relationship between rigid control and body weight was stronger among females than males while the relationship between disinhibition and body weight was stronger among males than females. Adolescents with both high rigid control and high disinhibition were the heaviest of all the adolescents and the only group to be significantly heavier than adolescents with neither rigid control nor disinhibition.

Due to the cross-sectional nature of this study, directionality of the weight-behaviour relationship is impossible to decipher. What we can say is that the overweight and obese adolescents in this study express higher scores of unhealthy eating behaviours. Are overweight adolescents developing unhealthy eating behaviours as a result of their increased weight or do these unhealthy eating behaviours cause the weight surplus? This is not known. As previously mentioned, longitudinal studies in adolescents reported that it is the change in BMI which precedes the restriction (Snoek, van Strien, et al., 2008) or high initial BMI which predicted changes in cognitive restraint (de Lauzon-Guillain, Basdevant, et al., 2006). On the contrary, one study in adolescent girls revealed that those with high restraint at 11 years had 3.16 increased odds of being overweight at age 15 (Stice, Presnell, et al., 2005). These results indicate that in adolescents, a weight surplus may bring forth deleterious eating behaviours. This study sheds further light on these behaviours as it shows that, in addition to disinhibition, it was the rigid component of restraint which was associated with the increased weight in these adolescents. Therefore, in attempt to control or reduce one's weight, overweight and obese adolescents adopt unhealthy eating

behaviours, specifically rigid control and disinhibition, which in turn may cause further weight gain.

Not only do the overweight/obese adolescents portray an unhealthy eating behaviour but the heaviest portray both rigid control and disinhibition. Therefore, although these behaviours have an independent effect on weight, it is strongest when they work in concert. The distribution of eating behaviours in this sample was as follows: 31.7% portrayed low scores in both eating behaviours, 31.7% of the adolescents had both high disinhibition and high rigid control and a *total* of 36.6% had high of either behaviour. This indicates that the rigid control and disinhibition are just as likely to be together as apart. Unlike in adults (Westenhoefer, Stunkard, et al., 1999), there was no linear relationship between rigid control and disinhibition but this could have been due to the low number of participants. Rigid control is an extreme behaviour, difficult to maintain over time and thus usually accompanied by disinhibition (Westenhoefer, Stunkard, et al., 1999), these results reveal that the heaviest adolescents have the most troubled eating behaviours. The lack of flexible control relationships in this study indicates that adolescents may not partake in successful weight management strategies.

These results indicate that eating behaviour and body weight are related without showing directionality. If rigid control and disinhibition were to perpetuate increases in weight, what would be the physiological reasons? As previously mentioned, it could be due to the increased caloric intake or low physiological needs. Unlike in other adolescent studies (Hill and Robinson, 1991, Lluch, Herbeth, et al., 2000, Mulvihill, Davies, et al., 2002, Wardle, Marsland, et al., 1992), in this study the measured eating behaviours were not related to energy intake. Why is this group heavier and not reporting more energy intake? This may be due to under-reporting issues as adolescents have been known to under-report by as much as 34% (Rennie, Jebb, et al., 2005) or that a 3-day dietary journal not be sufficient enough to show cyclical dietary patterns between restriction and disinhibition. For example, it may capture solely the restraint and leave out the overeating. Also, aside from intentional under-reporting or conscious healthy eating throughout the duration of the dietary journal, adolescent energy reporting accuracy may be a factor; 50% of 11 year old

girls inaccurately reported their energy intake (Ventura, Loken, et al., 2006) and energy reporting accuracy declined in girls from 10years to 15 years old (Bandini, Must, et al., 2003). Energy reporting is difficult and it is unlikely that every study allots enough reporting education time to ensure accurate reports.

If the adolescents are not under-reporting, then the reason for their increased weight could be physiological. As the largest adolescents have both high disinhibition and high rigid control, reported energy intake may not reveal the restriction or the overeating as the two behaviours may balance each other out in terms of caloric intake. Then there must be a physiological attribute of this type of eating pattern which is independently responsible for weight gain. Reduced energy intake in the short-term, but not the long term, has been shown to reduce the metabolic rate beyond that of weight loss (Wadden, Foster, et al., 1990). Therefore, not being able to maintain the reduced intake of a rigidly controlled diet may put the body more at risk for weight gain during the periods of disinhibition. Tuschl *et al.* (1990) reported that high restrained eaters can be accurate energy reporters but have lower metabolic rates responsible for their increased weight. However, the adolescent eating behaviour groups in this study did not differ in resting metabolic rate (data not shown) nor in energy expenditure.

A third possibility could be that the overweight/obese adolescents adopted these behaviours as a result of their increased weight and, as rigid control is an unsuccessful weight loss method (Westenhoefer, Stunkard, et al., 1999), they failed at their weight-loss attempt. It has been shown that in adolescents, higher BMI occurred prior to increased restraint (de Lauzon-Guillain, Basdevant, et al., 2006).

Conclusion

Eating behaviours, as measured by the Three-Factor Eating Questionnaire, are present in adolescents with 68.3% of this population expressing either high rigid control, high disinhibition or both. Not only are these behaviours present, they are related to body weight: the heaviest adolescents had both high rigid control and disinhibition. Slight gender differences arose in that the rigid control BMI z-score relationship was stronger in females than males while the disinhibition with tendencies to emotionally overeat, being stronger among males. These behaviours are not conducive to weight maintenance and could potentially perpetuate further weight gain. Adolescent obesity prevention measures should include education on successful weight maintenance or weight loss strategies and such detrimental eating behaviours should be identified and corrected.

The best treatment for obesity is prevention and with the disheartening data seen among children and adolescents, prevention must start at an early age. The youth of today face an ominous future if prevention measures are not strictly enforced throughout our country. There is no one cause of youth obesity. The spectrum of associations with obesity can go from environmental influences to familial and individual influences. A tangible level to begin the fight against obesity is the individual. People can be educated on how to prevent obesity through exercise, diet and behaviour modification, the latter being of interest to this thesis. Before behaviour modification can be attempted, the behavioural aspects associated with obesity must be further understood. It is not only what or what isn't eaten, but one's attitude towards how one eats which affects weight.

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