THE EFFECT OF AN 8-WEEK AEROBIC EXERCISE PROGRAM ON THE DIET AND EATING BEHAVIOURS OF ADOLESCENTS WITH A NORMAL WEIGHT AND EXCESS BODY WEIGHT

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ABSTRACT

The Effect of an 8-Week Aerobic Exercise Program on the Diet and Eating Behaviours of Adolescents with a Normal Weight and Excess Body Weight

Introduction: Health-related behaviours of Canadian adolescents are generally suboptimal. Studies have assessed effectiveness of exercise interventions primarily from an energy balance perspective, but not from a health promotion standpoint. This study assessed the effect of an 8-week aerobic exercise program on dietary intake parameters and eating behaviours of adolescents with a normal weight and excess body weight.

Methods: This quasi-experimental study involved 13 male and 13 female adolescents between the age of 14-18 years old (17 normal weight, 9 with excess weight). The intervention consisted of an 8-week aerobic exercise program on cycle ergometers, aiming for 50-75% of heart rate reserve. Diet was assessed in pre- and post-intervention via 24-hour dietary recalls. Two recalls were collected for each condition: pre-intervention, post-intervention on exercise days and post-intervention on non-exercise days. Diet was assessed for the following dietary intake parameters: food quantity, diet quality and eating patterns.

Results: The 8-week exercise program led to a decrease in meal size at lunch and dinner, energy density at breakfast, carbohydrate intake as well as a slight shift in eating pattern of participants. At baseline, participants with excess weight had greater number of daily eating occurrences and portion sizes at evening snacks but consumed a smaller percentage of daily energy intake before school, compared to those with a normal weight. Participants with excess weight decreased their total number of eating occurrences, but not those with normal weight. The exercise program did not influence cognitive restraint, uncontrolled eating or emotional eating scores of participants.

Conclusion: Significant changes in food quantity and eating pattern parameters, but not in diet quality, were observed following the exercise program. Differences in pre-intervention and in response to the exercise program were observed based on weight status. Future studies with greater sample size are needed to confirm these findings.

RÉSUMÉ

L'effet d'un programme d'exercice aérobie de 8 semaines sur la diète et les comportements alimentaires d'adolescents avec un poids normal et un surpoids

Introduction: Les habitudes de vie des adolescents Canadiens sont généralement sous-optimales. Certaines études se sont penchées sur l'effet d'interventions d'exercice sur la balance énergétique et le poids, sans toutefois considérer leur effet sur les habitudes de vie et la santé des adolescents. Cette étude a évalué l'effet d'un programme d'exercice aérobie de 8 semaines sur des paramètres de l'apport alimentaire et des comportements alimentaires d'adolescents ayant un poids normal et un surpoids.

Méthodes: Cette étude quasi-expérimentale comptait 13 adolescents males et 13 adolescentes femelles âgés de 14-18 ans (17 avec un poids normal et 9 en surpoids). L'intervention impliquait un programme d'exercice de 8 semaines sur ergocycles, visant 50-75% de la fréquence cardiaque de réserve. La diète des participants a été évaluée via des rappels alimentaires de 24 heures. Deux rappels ont été complétés pour chaque condition expérimentale : pré-intervention, post-intervention lors de journées d'exercice et post-intervention lors de journées sans exercice. La diète a été évalué selon les paramètres suivants : la quantité d'aliments consommés, la qualité de la diète ainsi que les patrons alimentaires.

Résultats: Le programme d'exercice de 8 semaines a mené à une réduction de la grosseur des repas au dîner et au souper, de la densité énergétique au déjeuner, de l'apport en glucides ainsi qu'à un délai de l'apport alimentaire au courant de la journée. Au départ, les participants avec un surpoids avaient une fréquence de consommation alimentaire et des portions de collation en soirée plus élevées, mais leur pourcentage d'apport énergétique avant l'école était plus faible que ceux avec un poids normal. Les participants avec un excès de poids ont diminué leur fréquence de consommation alimentaire, ce qui n'était pas le cas pour ceux avec un poids normal. Le programme d'exercice n'a eu aucun effet sur les scores de restriction cognitive, de désinhibition ou d'apport alimentaire relié aux émotions des participants.

Conclusion : Des changements à la quantité des aliments consommés ainsi qu'aux patrons alimentaires, mais non à la qualité de la diète, ont été observés suite au programme d'exercice. De plus, certaines différences ont été observées selon le statut de poids. Des études futures impliquant un plus gros échantillon sont nécessaires pour confirmer ces résultats.

PREFACE

This thesis is presented in an article format. Two manuscripts are present in Part 4, outlining the main findings of this thesis project. The first manuscript focuses on the effect of exercise and the second on the effect of weight status on post-exercise energy intake compensation. Both manuscripts examined the dietary parameters of adolescents and have been formatted for submission to peer-reviewed journals: Journal of Nutrition Education and Behavior (manuscript 1) and Pediatric Obesity (manuscript 2).

This research project involved 2 master students, including Alyssa Biagé and myself. Alyssa Biagé assessed the effect of the exercise program on body composition as well as energy intake and energy expenditure[1], while I focused on the effects of the aerobic exercise program on specific dietary parameters and eating behaviours of the participants. I actively participated in data collection, data entry, verification and in the various dietary and statistical analyses related to this project.

Results found in Part 6, pertaining to the effect of aerobic exercise and weight on eating behaviours and diet quality of adolescents, were presented as poster presentations at peer-reviewed conferences; The Obesity Society 2017 conference in Washington, DC, United States in November 2017 and The European Congress on Obesity 2018 in Vienna, Austria in May 2018. I also gave an oral presentation at the Human Kinetics Graduate Student Association's Annual Conference in April 2018, where I shared and discussed my thesis results related to eating patterns of adolescents in response to an aerobic exercise program. See conference abstracts in Appendix I.

Throughout my Master of Science degree, I was involved with the Institut du Savoir Montfort as a volunteer and founding member of the graduate student committee. I also gained experience as a research assistant on various projects, with the Institut du Savoir Montfort, Healthy Active Living and Obesity Research Institute as well as the University of Ottawa. Additionally, I collaborated with a research team, affiliated with Telfer School of Management at the University of Ottawa, to study the perspective of dietitians on interprofessional collaboration and primary care systems in the context of weight management. This has led me to collaborate on 6 research manuscripts (excluding the ones presented in this thesis); 3 accepted, 1 submitted and 2 in preparation for journal submission.

ACKNOWLEDGEMENT

I would like to thank Alyssa Biagé, with whom I collaborated on this project, as well as my supervisors, Isabelle Giroux and Dr Denis Prud'homme, for their tremendous support and mentorship in completing this thesis.

Additionally, this project would not have been possible without the help and support from research participants, their families as well as their school (Collège St-Alexandre de la Gatineau). I would also like to acknowledge the work of all University of Ottawa nutrition students having volunteered their time to help with various aspects of the project: Roxanne Brault, Véronique Corbeil, Sylvain Boislard, Mylène Rosa and Alexandra Bodnaruc, for participating in data collection, as well as Alexandra Otis, Laurence Viau and Miryam Duquet, for their help with data verification. I would also like to thank Eva Guérin, biostatistician from the Institut du savoir Montfort, for her guidance with statistical methods and analyses.

Finally, I would like to thank the Consortium national de formation en santé – Volet Université d'Ottawa, Institut du savoir Montfort and the University of Ottawa for their financial support related to this project.

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LIST OF ABBREVIATIONS, SYMBOLS & ACRONYMS

η_p^2	Partial eta-squared
%	Percentage
BMI	Body mass index
CCHS	Canadian Community Health Survey
CFG	Canada's Food Guide
cm	Centimeters
CR	Cognitive restraint
d	Cohen's D coefficient
EE	Emotional eating
EW	Excess weight
g	Grams
HEI-C	Healthy Eating Index (adapted to Canadian recommendations)
IPAQ	International Physical Activity Questionnaire
IQR	Interquartile range
ISCOLE	International Study of Childhood Obesity, Lifestyle and Environment
kcal	Kilocalories
kg	Kilograms
m	Meters
MET	Metabolic equivalent of task
NW	Normal weight
PAR-Q	Physical Activity Readiness Questionnaire
POST	Post-intervention
POST-EX	Post-intervention on exercise days
POST-NEx	Post-intervention on non-exercise days
PRE	Pre-intervention
RMR	Resting metabolic rate
SD	Standard deviation
TEE	Total energy expenditure
TEF	Thermal effect of food
TEI	Total energy intake
UE	Uncontrolled eating
VT	Ventilatory threshold
VO_{2max}	Maximum oxygen consumption
HRR	Heart rate reserve
HR_{max}	Maximum heart rate
TFEQ-18	Three Factor Eating Questionnaire (18 items)

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PART 1: INTRODUCTION

In the past decades, there has been much focus on the prevention and treatment of obesity and its comorbidities. Adoption of an active lifestyle as well as an adequate diet, as early as during adolescence, could have positive repercussions later in life, with regards to weight management and health status[2].

The 2012-2013 Canadian Health Measures Survey (CHMS)[3] and 2004 Canadian Community Health Survey (CCHS)[4,5] highlight the lifestyle habits of adolescents. An important proportion of the Canadian adolescent population engages in sedentary behaviour, low levels of moderate-to-vigorous physical activity, poor diet quality as well as poor adherence to Canada's Food Guide (CFG) recommendations[4–7]. These unhealthy habits are concerning from a weight management perspective, but more importantly from a global health and quality of life standpoint. There is still an obvious need for research to help improve efficacy and efficiency of health promotion interventions in adolescence in order to reduce the incidence of obesity and its comorbidities.

Research has turned to exercise, as a strategy for obesity prevention, due to its numerous benefits for overall health and its positive impact on energy balance and prevention of chronic diseases[8–14]. In fact, evidence suggests that regular exercise may lead to a decrease in energy intake of adolescents[15]. However, results are highly contradicting, as there is large inter-individual variability and a wide variety of methodologies used to document the impact of regular exercise in the literature. Additionally, it remains unclear whether the chronic adaptation of adolescents with a normal body weight and those with an excess weight respond differently to an exercise intervention.

Furthermore, the chronic effect of an exercise program on the diet of adolescents has only been studied from an energy balance perspective. Evidence is needed to identify potential chronic effect of an exercise intervention on the quantity of food consumed, the diet quality, as well as the daily eating patterns of adolescents. Additionally, we have yet to understand the determinants and mechanisms driving the acute post-exercise and the chronic effect of an exercise intervention on dietary energy compensation.

PART 2: LITERATURE REVIEW

2.1 Health Behaviours of Canadian Adolescents

Adolescence is a period of great interest because of the biological, psychological, social as well as behavioural development[16]. A healthy environment is needed to allow for all these changes to take place naturally. Combined, adequate physical activity and a healthy diet allow for growth and bone integrity to be optimized during puberty[17]. Additionally, a healthy lifestyle may have protective effects later on in life[11]. Therefore, promoting daily physical activity and a healthy diet could contribute to treatment and the prevention of chronic diseases, including obesity and its comorbidities.

Comparisons between the 1978-79 and 2004 CCHS show a 70% increase in the rate of adolescents aged 12-17 years with overweight and obesity[18]. More importantly, heath behaviours of many Canadian adolescents are generally suboptimal. The reality is such that sedentary behavior is and lack of physical activity is increasingly common amongst Canadian adolescents. According to the 2012-2013 CHMS, only 9% and 24% of Canadian youth, between the ages of 5-17 years were meeting the 24-hour movement guidelines in relation to moderate-to-vigorous physical activity and sedentary behaviour guidelines, respectively[3]. Sedentary behaviours can be detrimental for adolescent health, as it has been positively associated with increased rosk of obesity and associated health problems[13]. Screen time certainly contributes to this problematic in youth and has also been associated with a poor diet quality[13,19], including consumption of high density snacks, lower intake of fruits and vegetables and a greater meal frequency[19]. This highlights the potential relationship between physical activity, sedentary behaviours, as well as the diet of adolescents.

Undoubtedly, eating habits of Canadian adolescents are concerning based on the 2004 CCHS. Garriguet reported that 22.3% of the daily energy intake of Canadian adolescents comes from the consumption of “other foods”[5]. This category includes food items such as fats, oils, spreads, candy, chips, soft drinks, and all other foods that do not fit in any of the four recommended CFG food groups. Phillips and colleagues[6] report that 61% of their participants, aged 13 to 17 years old, consumed at least one soft drink per day based on 24-hour dietary recalls. This represents an important source of free sugar, which should be limited to less than 10% of the total energy intake according to the World Health Organization guidelines[20].

Another common trend amongst adolescents includes snacking. This can be defined as the consumption of food between meals. Based on the 2004 CCHS, snacks contributed to 28% and 30% of female and male adolescents’ total daily energy intake, respectively[5]. This may be as a result of a high eating frequency or large consumption of high-density food choices between meals. However, this was not assessed in the 2004 CCHS. Snacking and distribution of energy intake are important factors to consider as they can influence total energy intake and potentially lead to overeating[21].

Consumption of ultra-processed foods is also prominent amongst the adolescent age group, contributing to 55% of their total energy intake[22]. In fact, children and adolescents had the highest consumption of processed food amongst all Canadians[22]. It may be related to their snacking habits, as there is an increasing amount of processed food products advertised as convenient snacks for children and adolescents[23].

Results from the 2004 CCHS also suggest that 53% of males and 63% of females, aged 14 to 18 years old, were not meeting their vegetables and fruit recommendations[5]. This is an indicator of low diet quality and suggests that adolescents may not be meeting their needs in dietary fibre or vitamins, which are essential nutrients for growth and/or metabolic health[24]. This partly explains the poor diet quality scores of Canadian adolescents, assessed using the Healthy Eating Index adapted to Canadians (HEI-C 2009), which assesses the adherence to CFG's recommendations. Indeed, 25% of 14-18 year olds were identified as having a poor diet quality, which was classified as a diet quality score of less than 50 percent[4].

Breakfast skipping is another dietary concern amongst adolescents. Barr and colleagues found that 18% of 14 to 18 years olds identified themselves as non-breakfast consumers[25]. Breakfast consumption was also found to be inversely associated with obesity, dieting and weight management behaviours[26–28]. Therefore, individuals with an excess body weight may be skipping breakfast as a strategy to lose weight. Furthermore, skipping breakfast could also lead to increased energy intake later in the afternoon and evening[29]. These results suggest that breakfast consumption plays an important role in total energy intake and weight management, potentially through hunger management. Additionally, breakfast may benefit overall diet quality, as it was found to be associated with greater daily nutrient intake adequacy[25].

The previously listed habits related to Canadian adolescents' sedentary behaviours, physical activity status and dietary intake highlight the need for health promotion and interventions amongst this age group.

2.2 Exercise and Energy Compensation

Exercise as a Strategy for Obesity Prevention

Exercise is known to help improve mental health status, bone health, cardiometabolic health and reduce risk of injuries[8–14]. Evidence also suggests that exercise interventions could influence energy expenditure and energy intake, leading to potential changes in body composition and/or anthropometric indices[9] and prevent or attenuate weight regain after a weight loss intervention[12]. This could certainly contribute to prevention of obesity and its comorbidities[10].

Evidence and clinical guidelines support the need to promote the adoption of an active lifestyle at an early age, for health and weight management benefits[30,31]. However, contradicting evidence exists, suggesting that initiation of exercise does not always lead to predicted weight management outcomes[32,33]. Energy balance and energy compensation theories may help explain these results.

Energy Balance

Weight management is very complex and difficult to achieve, due to the many factors influencing body weight. Energy balance is thought to be the only factor directly regulating body weight. All other factors may play an indirect role by influencing either side of the energy balance equation: energy intake and/or energy expenditure.

Total energy intake (TEI) refers to the total amount of energy consumed daily. Alternatively, total energy expenditure (TEE) is defined as the total amount of energy used by the human body to perform vital and physiological functions. TEE includes the energy expanded from the resting metabolic rate (RMR), thermic effect of food (TEF) as well as from any physical activity performed from daily activities of living and exercise. For weight to be maintained, both these variables must reach equilibrium.

Although RMR and TEF do play a role in TEE, the physical activity component is of interest as it is the component humans can mostly directly influence though behaviour. It contributes to 15-20% of the TEE, compared to RMR and TEF, which contribute to 65-75% and 7-10% of TEE respectively[34].

Weight management is possible through manipulation of energy intake, energy expenditure or both components of energy balance. This may be achieved by modifying lifestyle behaviours, which is the preferred clinical approach[30,31], as it focuses on modifiable cardiometabolic risk factors and overall health promotion rather than weight alone.

Energy Compensation

Despite our understanding of potential weight management strategies, some evidence suggests that an increase in physical activity does not lead to significant changes in body weight[32,33]. This may be partly explained through energy compensation, which has been observed following an exercise intervention[33,35,36]. This may be achieved through a decrease in total energy expenditure and/or an increase in total energy intake.

Nonetheless, energy intake compensation, specifically, remains contradicted in the literature. Studies have found energy intake to decrease, increase or remain unchanged following an exercise session or intervention[15,37]. This goes to show that the relationship between exercise and energy balance is extremely complex. There is a need for more research in this field, as it would contribute to increasing efficacy and effectiveness of obesity prevention strategies and weight management interventions.

2.3 Effects of Exercise on Energy Intake of Adolescents

Thus far, research conducted in the field of nutrition and energy compensation has looked at the acute and chronic effects of exercise on energy and macronutrient intake, in an attempt to understand how exercise may impact energy balance components and subsequent body weight.

Despite the large body of evidence published in this field, it is difficult to interpret results and draw conclusions. This is in part due to the high inter-individual variability in responses and heterogeneity in methodologies. Researchers have chosen varying lengths of exercise interventions, exercise protocols, dietary assessment and populations, leading to a great variety of results. This section will comment on the results published in the scientific literature as well as attempt to identify the existing knowledge gaps.

Heterogeneity in Methodologies

Firstly, there is a wide variety of exercise intervention types, frequencies and intensities used across the various studies. Evidence suggests that an increase in daily exercise frequency leads to increased energy intake[35]. Energy intake may also be decreased in response to higher exercise intensity[38,39]. On the contrary, some studies have found no significant difference in energy intake or appetite based on exercise intensity[40–42]. The differences in results between these studies may have to do with the type of exercise performed, as some interventions involved cycling, whereas others involved running. Moderate intensity exercise may be an optimal method for assessing the chronic impact of exercise on the diet, as it is most realistic for inactive individuals of various weight status initiating an exercise program.

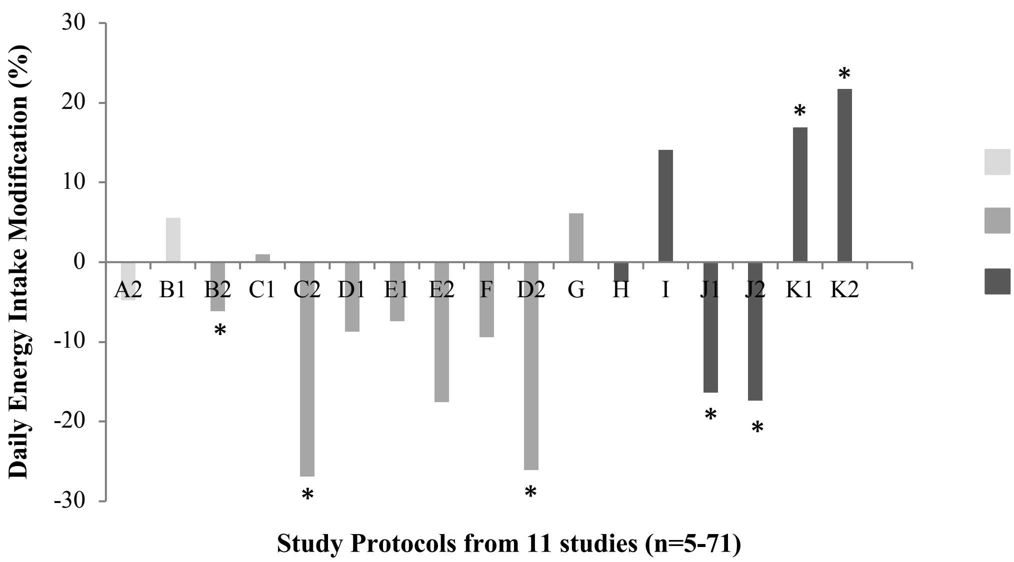

Figure 1. Percentage of Acute and Chronic Post-Exercise Energy Compensation in Children, Adolescents and Adults Relative to their Energy Intake in Control or Pre-Intervention Condition from 11 Selected Studies. (See table 1 for methodologies of studies A-K)

* indicates a significant change from baseline with intervention.

Limitations of many studies include the dietary assessment of a meal consumed promptly after an exercise session[42–45]. There are several advantages to assessing daily energy intake rather than only one meal following a single exercise session. In fact, energy balance varies throughout the day, which helps in justifying why daily averages matter most for weight management[46].

Common methods used for energy intake assessment consist of providing unlimited food access (*Ad libitum* diet) to participants[41,47–49], through the use of buffets, food menus or large portioned meals. Although this may allow proper assessment of adaptive eating behavior following an acute exercise intervention, this method does not reflect free-living conditions and often does not take into account food preferences. The use of dietary assessment questionnaires is encouraged as it reflects intake of adolescents based on their usual diets and can allow for assessment of individual factors influencing the diet. Additionally, there are ways to limit the risks of misreporting associated with these tools (i.e. repeating 24-hour dietary recalls or using the Multiple Pass Method)[50,51]. Certain studies having assessed post-exercise energy intake compensation have opted for dietary assessment questionnaires, which further contributes to the inconsistency in methodologies[32,33,36].

Additionally, there is a variety of age groups that have been assessed with regards to post-exercise energy compensation, following both a single exercise session or an exercise program. Such evidence exists for children, adolescents and adults. However, results remain contradicting for all ages. Figure 1 highlights the potential differences that may exist between children, adolescents and adults, in terms of the post-exercise dietary compensation. Therefore, results found in adults may not be directly transposable to children and adolescent population.

Table 1. Description of Methodologies from Selected 11 Studies Assessing the Total Daily Energy Intake of Children, Adolescents and Adults in Response to an Exercise Session or Intervention (illustrated in Figure 1)

	Study	Length of Exercise Intervention	Participant Characteristics		Exercise Intensity	
			Age Group	Weight Status	Category	Standard
A1	Moore et al. (2004)[42]	Acute	Children	Normal Weight	Moderate	50% VO_{2max}
A2	Moore et al. (2004)[42]	Acute		Normal Weight	High	70% VO_{2max}
B1	Thivel et al. (2012)[38]	Acute	Adolescents	Overweight	Low	40% VO_{2max}
B2	Thivel et al. (2012)[38]	Acute	Adolescents	Overweight	High	75% VO_{2max}
C1	Thivel et al. (2014)[43]	Acute	Adolescents	Normal Weight	High	75% VO_{2max}
C2	Thivel et al. (2014)[43]			Overweight		
D1	Prado et al. (2015)[39]	Chronic	Adolescents	Overweight	Low	20% below VT1
E1	Biagé et al. (2016)[1]	Chronic	Adolescents	Normal Weight	Moderate to High	50-75% HRR
E2				Overweight	Moderate to High	
F	Thivel et al. (2014)[32]	Chronic	Adolescents	Overweight	Moderate to High	60-100% VO_{2max}
D2	Prado et al. (2015)[39]	Chronic	Adolescents	Overweight	High	At VT1
G	Ambler et al. (1998)[33]	Chronic	Adolescents	Normal & Overweight	Various	Various
H	King et al. (1997)[52]	Acute	Adults	Normal Weight	Moderate	70% HR_{max}

I	Martins et al. (2014)[40]	Acute	Adults	Overweight	Moderate	70% HR_{max}
J1	Stubbs et al. (2002)[36]	Acute	Adults	Normal Weight	Various	2 x 40min sessions
J2				Normal Weight	Various	3 x 40min sessions
K1	Woo & Pisunyer (1985)[35]	Chronic	Adults	Normal Weight	Low	110% Sedentary Expenditure
K2				Normal Weight	Moderate	125% Sedentary Expenditure

VO_{2max}, maximum oxygen consumption; VT, ventilatory threshold; HR_{max}, heart rate; HHR, heart rate reserve.

Acute Dietary Response to an Exercise Session

Most researchers, to this day, have looked at the acute effect of an exercise session on energy intake of adolescents, as opposed to the chronic effect of a long-term exercise intervention. Investigating the acute effect of exercise involved protocols that are easier to perform as they usually only involve one exercise session for each condition assessed. The change in energy compensation of adolescents, between sedentary and exercise conditions, in response to various single exercise sessions are presented below (see Figure 2). Results from studies having reached significance suggest there may be a decrease in energy intake of adolescents with an excess weight following an acute exercise session[38,43,53]. However, evidence is lacking with regards to normal weight adolescents and their dietary response to an acute exercise session.

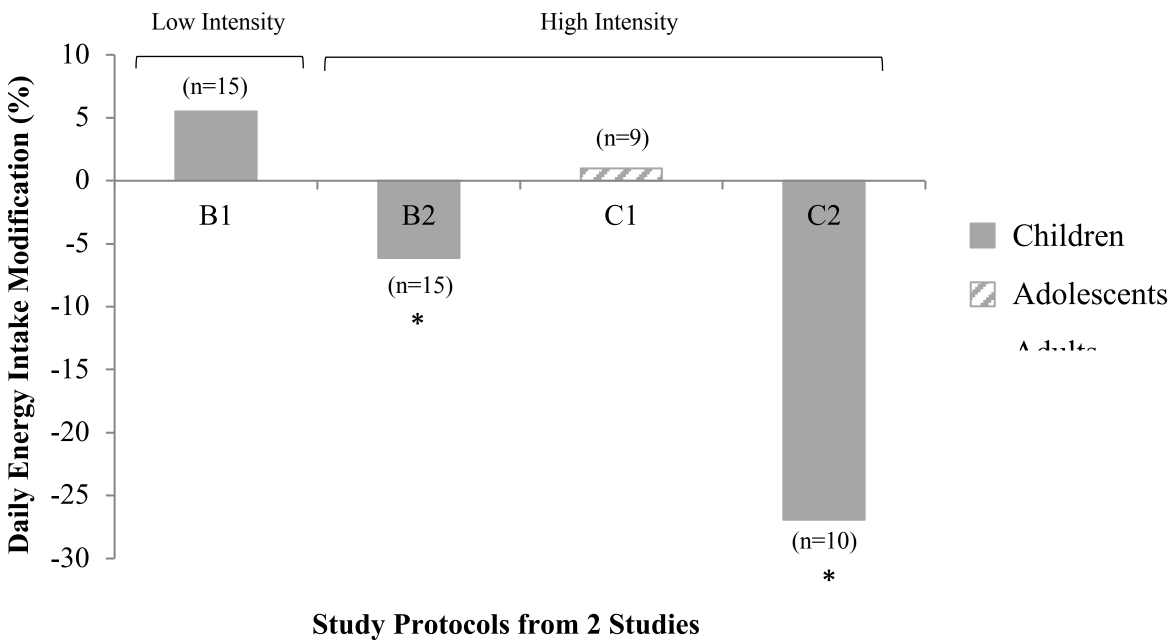

Figure 2. Percentage Energy Compensation of Adolescents Relative to their Energy Intake in Control Condition in Response to an Exercise Session of Low or High Intensity from 2 Studies. (See table 2 for methodologies of studies B and C)

* indicates a significant change from baseline with intervention.

Exercise intensity is thought to play a role in acute energy compensation. In fact, Thivel and colleagues' study[43,53], which involved a high intensity exercise protocol, showed the greatest decrease in post-exercise energy intake. Researchers have also suggested a potential delay in compensation, which would explain why acute exercise interventions leads to highly variable dietary energy compensation[38,43,53]. In fact, physiological responses to physical activity may be responsible for suppressing appetite immediately following exercise[54]. Moreover, there may be a decrease in leptin on the day following an acute bout of exercise[55], leading to delayed feeling of hunger. Thus, there are advantages in looking at the effect of a chronic exercise intervention on energy intake of adolescents, specifically when it comes to better understanding the relationship between these variables over time.

Table 2. Description of Methodologies from 2 Studies Assessing the Total Daily Energy Intake of Adolescents Following an Exercise Session (illustrated in Figure 2)

	Article	Sample Size	Significance	Participant Characteristic		Exercise Intensity	
				Age (years)	Weight Status	Category	Standard
B1	Thivel et al. (2012)[38]	15	NS	12-15	Overweight	Low	40% VO_{2max}
B2			$P < 0.05$		Overweight	High	75% VO_{2max}
C1	Thivel et al. (2014)[43]	9	NS	12-15	Normal Weight	High	75% VO_{2max}
C2	Thivel et al. (2014)[43]	10	$P < 0.05$	12-15	Overweight	High	

VO_{2max}, maximum oxygen consumption.

Chronic Dietary Response to an Exercise Intervention

Few studies have addressed the chronic effect of a long-term exercise intervention on energy intake of adolescents. The dietary energy compensation of adolescents, relative to the energy intake in sedentary condition, in response to chronic exercise interventions are presented below (See Figure 3).

Based on studies reporting significant results, there seems to be a decrease in energy intake of adolescents following an exercise intervention[1,39]. These two studies[1,39] involved participants with a normal and excess weight, as well as different intensities of exercise. As previously mentioned, these factors could affect dietary energy compensation. Thus, there is a need to better understand the effect of exercise, specifically the effect of a chronic exercise intervention, on the energy intake of adolescents with a normal weight and excess weight.

There is also the question of whether there is an acute effect of exercise, following the initiation of an exercise program. In other words, it remains unclear whether the diet of adolescents with a normal weight and those with an excess body weight differs on days with exercise, compared to days with no exercise. Some preliminary evidence suggests there may be a difference in energy intake between these two conditions[1]. However, more evidence is needed to support this statement, particularly when it comes to specific aspects of the diet.

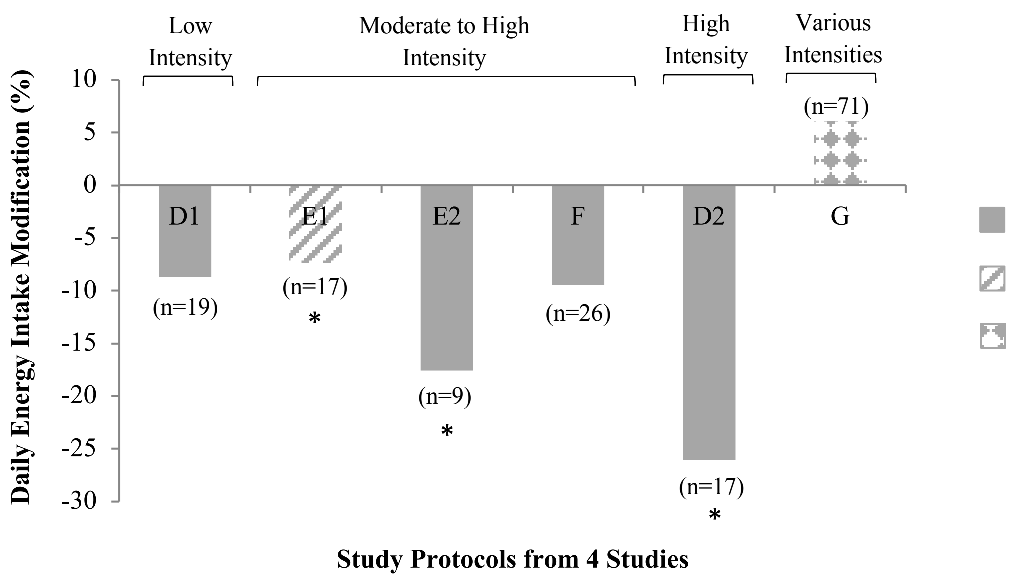

Figure 3. Percentage Energy Compensation of Adolescents Relative to their Energy Intake in Pre-Intervention in Response to an Exercise Intervention of Various Intensity Levels from 4 Studies. (see Table 3 for methodologies of studies D-G)

* indicates a significant change from baseline with intervention.

Table 3. Description of Methodologies from 4 Studies Assessing the Total Daily Energy Intake of Adolescents Following an Exercise Intervention (illustrated in Figure 3)

	Article	Sample Size	Significance	Participant Characteristic		Exercise Intensity	
				Age (years)	Weight Status	Category	Standard
D1	Prado et al. (2015)[39]	19	NS	13-18	Overweight	Low	20% below VT1
E1	Biagé et al. (2016)[1]	17	P = 0.008	14-18	Normal Weight	Moderate to High	50-75% HRR
E2	Biagé et al. (2016)[1]	9			Overweight		
F	Thivel et al. (2014)[32]	26	NS	12-17	Overweight	Moderate to High	60-100% VO_{2max}
D2	Prado et al. (2015)[39]	17	P = 0.024	13-18	Overweight	High	At VT1
G	Ambler et al. (1998)[33]	71	NS	15-17	Normal & Overweight	Various	Various

VO_{2max}, maximum oxygen consumption; VT, ventilatory threshold; HHR, heart rate reserve.

2.4 Effect of Exercise on Diet Adequacy

Exercise and Macronutrient Intake

Researchers have started to look at potential changes in macronutrient intakes, in response to exercise sessions and interventions. Most of these studies were conducted in adult populations[36,40,44,46,56–58], with only a few involving adolescents[32,33,38,53].

When combining results for all age groups, there seems to be a greater change in carbohydrate intake following exercise sessions as well as long-term exercise interventions, compared to protein or fat intake. Interestingly, carbohydrate intake was found to increase in normal weight adults[36,56] and decrease in adults, adolescents and children with an excess weight[32,33,48,53]. Two of the four studies[32,33] having found a decrease in carbohydrate intake involved an exercise intervention. Carbohydrates is a macronutrient of interest in this context, as it is an important source of fuel during exercise[59]. Insulin, which regulates the metabolism of carbohydrates, also plays a role in appetite signaling[60].

An increase in protein intake was also found in two studies involving an exercise session[48,53]. The latter were performed amongst children and adolescents, respectively, having excess body weight. Finally, three studies with various methodologies reported an increase in fat intake following an exercise intervention[33,36,53].

These potential acute and chronic changes in post-exercise macronutrient intake suggest that exercise may also have an effect on food choices of adolescents. Now that we have highlighted the potential effect of exercise on energy and macronutrient intake, it would be pertinent to identify the chronic effect of exercise on diet adequacy of adolescents.

Exercise and Diet Adequacy

The chronic effect of an exercise intervention on the diet quality and adequacy of adolescents has yet to be examined. Diet quality refers to the adherence to nutrition recommendations (i.e. Canada's Food Guide, macronutrient distribution, etc.), whereas diet adequacy also takes into account other aspects of the diet such as eating patterns and portion sizes. A few studies have looked at associations between physical activity status and diet adequacy[61–63]. However, they were conducted in an adult population and had many flaws, explained below. Nonetheless, they form a basis for future adolescent studies.

The first observational study, conducted by Gillman and colleagues[61], involved 1322 adults aged 25 to 91 years old. Participants were categorized into three groups, based on the intensity and duration of exercise they typically engaged in. Physical activity levels were found to be inversely associated with diet quality indicators, which were based on adequacy of nutrient intake and food choices[61]. That study also suggests that physical activity had not only an impact on diet quality, but also on the quantity of food consumed by adolescents. However, it is unclear whether a greater intake of nutrients was related to increased portion sizes or eating frequency, or if it was driven by a change in the quality of food choices and their nutrient density. Exercise intensity was also positively associated with nutrient intake, which may have been driven by an increase in food quantity and/or a change in diet quality. This study does not consider all aspects of diet quality and adequacy, such as food processing and variety of food choices. Additionally, since that study followed a cross-sectional research design involving no intervention, it is unclear whether the dietary changes were a direct result of exercise, or due to other cofounding factors.

Another study by Rhew and colleagues[62] looked at the chronic effect of an exercise intervention on dietary intake of adults. It involved 173 sedentary post-menopausal women. It consisted of a randomized control trial, where participants were randomly assigned to participate in the exercise intervention group or stretching group, which served as control. Frequency of dietary intake and usual portion sizes were collected using food frequency questionnaires. Results showed that changes in fat intake were significantly different between groups[62]. Increased vegetable intake was also observed in the intervention group in post-exercise condition, compared to baseline results. This suggests that diet quality may have increased over time with the initiation of the exercise program even if no significant change in energy intake was observed between the intervention and the control group. Moreover, this study only took into account frequency of eating occurrences as well as portions sizes. It did not take into account adequacy of food intake for all food groups. Finally, a randomized control trial may not be the best choice of study design in this context, as it does not allow for individual differences in eating behaviours to be controlled. Therefore, intra-individual diet comparisons should be considered.

The third study, by Wilcox and colleagues[63], was very similar to the previous study by Rhew and colleagues[62], in its design and methodologies. They both used food frequency questionnaires to measure diet quality and food quantity indicators. However, this tool did not allow for analysis of daily eating patterns. Therefore, these studies do not give an overall picture of the diet in response to an exercise intervention. Additionally, some effects may not have been observed, as researchers did not measure all aspects of the diet, such as timing of meals, energy intake distribution, variety of food choices and the degree of food processing. Moreover, adolescents are expected to respond differently to similar exercise interventions, compared to adults, as presented in Figure 1. It would be relevant to study the chronic effect of an exercise intervention on specific diet parameters of adolescents.

2.5 Effect of Weight Status on Dietary Response to Exercise

Studies have found differences in both energy[48,58] and macronutrient[32,48,53] intake between individuals with a normal or excess body weight in response to exercise. Physiological as well as psychological differences between groups may lead to differences in subsequent daily energy intake[46,64]. Two recently published meta-analyses[15,37] suggest that adolescents with an excess weight decrease their total energy intake in response to exercise. However, the effect of exercise on energy intake of adolescents with a normal weight remains unclear. Two of the three studies having observed an increase in energy intake of adolescents following an exercise intervention, involved normal weight participants[33,43]. This leads to the hypothesis that there is perhaps a difference in dietary energy compensation between adolescents with a normal weight and those with an excess weight. More research is needed, specifically regarding the chronic exercise effects of an exercise intervention, to confirm these observations.

2.6 Potential Drivers for Post-Exercise Dietary Energy Compensation

Two main theories could help explain the post-exercise dietary energy compensation, one that is perhaps driven by physiological mechanisms and the other being potentially triggered by a potential change in behaviour. With regards to the physiological responses to exercise, some researchers believe that acute post-exercise energy compensation may be due to the exercise-induced energy deficit. This deficit may initiate physiological processes, such as hormonal responses and subsequent hunger to compensate for the increased TEE[46,65]. This is thought to lead to dietary energy compensation for reestablishing energy balance and weight maintenance.

On the other hand, a behavioural shift may partly explain changes in energy intake following an exercise intervention, despite the absence of nutrition intervention[66,67]. Evidence suggests that lifestyle interventions, combining changes in diet and physical activity, may influence eating behaviours. More precisely, it may lead to an increase in cognitive restraint[68–70]. However, little evidence exists on potential changes in eating behaviours following an exercise intervention alone. This is especially the case in the adolescent population. Researchers have also alluded to the potential effect of weight status on the behavioural response to an exercise intervention[71,72]. In fact, cognitive restraint was found to be greater amongst the adolescents with an excess body weight, compared to adolescents with a normal weight, in a male population[72]. Thus, eating behaviours may help in predicting the diet of adolescents with a normal and excess body weight in response to an exercise intervention[67,71].

2.7 Summary and Knowledge Gaps

Evidence is lacking when it comes to the acute and chronic effect of exercise on the diet of adolescence. So far, research has mainly focused on energy and macronutrient intake, which is certainly helpful in understanding energy balance and potential weight changes. To our knowledge, there has not been any study that has looked at the food quantity, diet quality as well as daily eating patterns of adolescents in response to a chronic exercise intervention. The mechanisms driving these potential changes in diet are also unclear. There is a need to know if and how the diet of adolescents may be modified following an exercise intervention. This would help guide future interventions involving inactive adolescents.

PART 3: THEORETICAL FRAMEWORK

This theoretical framework (Figure 4) allows for better understanding of post-exercise dietary energy compensation. It combines the concept of energy balance as well as the potential factors mediating the relationship between energy expenditure and energy intake.

Identifying the acute and chronic effect of exercise on the diet would allow consolidation of the information gathered so far in the field of energy compensation. We know that changes in energy intake are driven by changes made to the diet. Evidence suggests that exercise may have an effect on the physical and social environment, as well as on individual characteristics of adolescents[14]. Those variables are thought to give rise to changes in dietary choices and subsequent energy intake. This is the proposed pathway that could explain how energy, macronutrient intake and distribution is modified through an exercise intervention. This proposed mechanism outlines the complexity of the processes that regulate energy intake and health. The present thesis project focused on relationships illustrated in A, B and C (see Figure 4).

3.1 Dietary Intake Parameters

Energy intake is thought to be influenced by three dietary intake parameters: food quantity, diet quality and adequacy, as well as daily eating patterns. These variables may also influence one another, highlighting the difficulties encountered when trying to control daily energy intake.

Food quantity can be defined as the total amount of food consumed daily. It is influenced by the frequency of daily eating occasions, as well as the average volume and density of food consumed daily[73]. In contrast, diet quality refers to an individual's adherence to dietary recommendations. It takes into account macronutrient distribution, degree of food processing, as well as the adherence to CFG recommendations. Finally, the daily eating pattern can be defined as the distribution of energy intake throughout the day. This takes into account the percentage of total energy intake consumed at various time periods.

3.2 Factors Influencing the Diet of Adolescents

Many factors have been identified to explain the current eating habits of Canadian adolescents. These can be categorized as environmental and individual factors, which hold different levels in the framework (see Figure 4.). Environmental factors take into account the macro-level, physical environment, as well as the social environment. On the other hand, individual factors include demographics, biological, behavioural, cognitive and affective characteristics. The latter are thought to have a direct influence on eating behaviours and subsequently on the three dietary parameters defined above[74].

As previously mentioned, adolescents engage in a significant amount daily screen time[18]. This include, TV viewing, social media, video games, etc. Participation in most of these activities leads to prompting by food or weight loss advertisement. Schools are also surrounded with various fast food restaurants, and the school cafeteria may not always offer the healthiest food

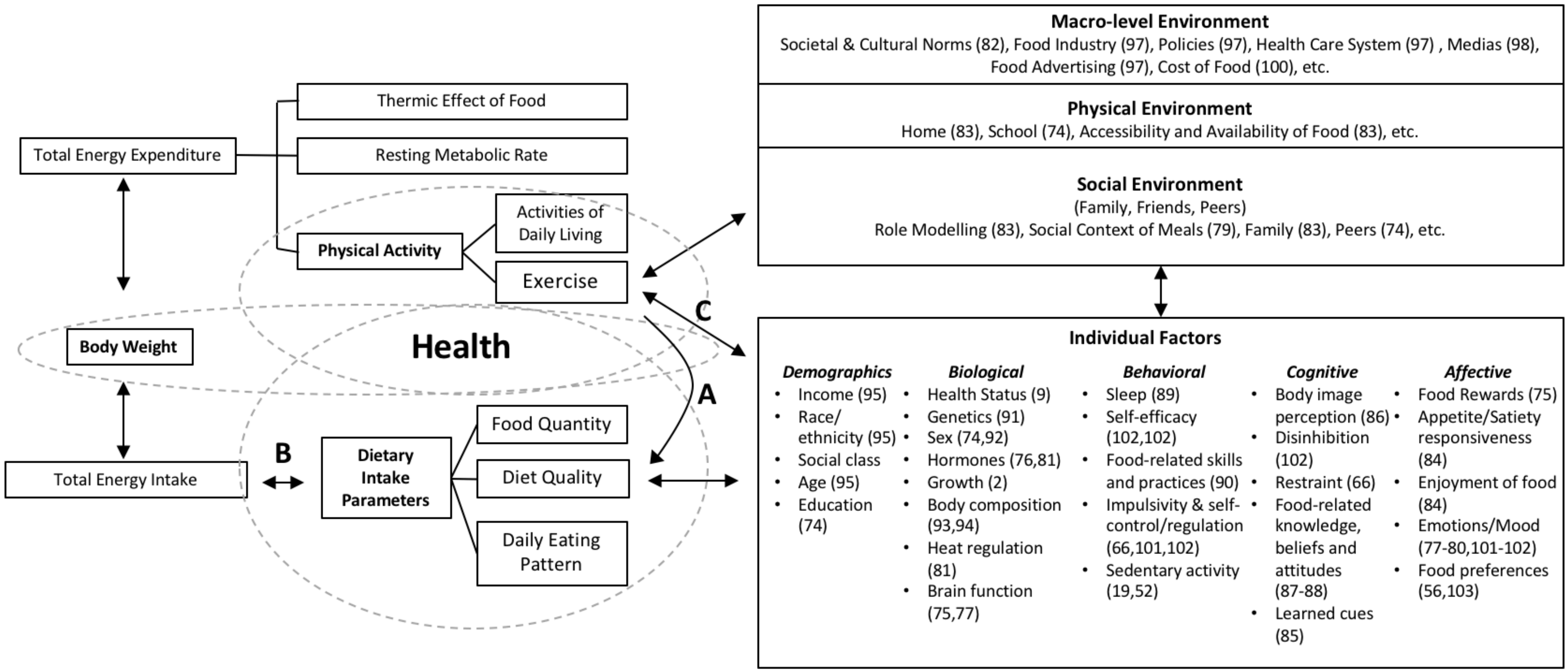

Figure 4. Theoretical Framework of Potential Factors Involved in Post-Exercise Dietary Energy Compensation After an Exercise Session or an Exercise Intervention [2,9,19,53,57,66,74–103]

A highlights the relationship assessed as part of the first thesis objective; **B** highlights the relationship assessed as part of the second thesis objective; **C** highlights the relationship assessed as part of the third thesis objective.

Adapted from Cameron & Doucet 2007, Shatenstein 2013, Story & Alton 1996, Story et al. 2008, Verstraeten 2014[85,97,104–106]

Inspired from Moreno et al. 2008, Story et al. 2002[73,74] choices to their students. Thus, the environment surrounding adolescents is filled with macro-level influences that may impact the diet indirectly. Adolescent's home food environment can also influence certain aspects of their diet. In fact, limiting unhealthy foods in the home environment was associated with greater diet quality in children[83]. This may also be the case in adolescents, as they remain dependent of their parents and family. This is categorized as the physical environment, referring to the community setting as well as the physical resources available to adolescents[74]. Finally, the social environment consists of individuals, networks or relationships in one's life. The latter can "affect eating behaviours through mechanisms such as modeling, reinforcement, social support and perceived norms"[74]. It has been suggested that mothers engaging in dietary restriction could negatively impact eating behaviors of their daughters[107]. Parenting styles and feeding practices may also have an impact on the children's future eating behaviors[107]. Therefore, social interactions with their family and friends occupy a significant role in dietary decisions related to the quantity of food consumed, diet quality and daily food intake patterns.

There are also individual factors that may influence the diet and total energy intake of adolescents. This could also justify inter-individual variability in the diet of Canadian adolescents. Puberty and associated hormones are thought to impact energy requirements and subsequent hunger[65]. These physiological characteristics, along with age and sex, may therefore influence the diet of adolescents. Indeed, energy and macronutrient intake, as well as food choices have been shown to differ depending on these individual characteristics[6,7].

Weight status may also influence overall energy intake of adolescents[108], through differences in food choices and diet quality. It has also been suggested that appetite and eating behaviours, which may help in controlling energy intake and maintaining energy balance, could be altered in individuals with excess weight as opposed to individuals with a normal body weight[45,72]. Similarly, it was proposed that coping mechanisms related to food consumption may differ based on weight status[80].

Psychological factors have also been studied amongst adolescents, where body image was identified as a driver for eating restriction and disinhibition[66]. Similarly, adolescents are susceptible to making food choices based on their mood and food preferences[78–80].

Furthermore, from a behavioural perspective, sleep was shown to impact weight through potential changes in energy intake[109]. As previously mentioned, physical activity and screen time can also influence the diet. These various influences certainly highlight the challenges that adolescents face on a daily basis, when it comes to food intake and choices and can help explain how energy intake may be modified following an exercise intervention.

PART 4: OBJECTIVES & HYPOTHESES

The present thesis aims to answer the following research question: What is the effect of an 8-week aerobic exercise program on the diet and eating behaviours of previously inactive adolescents with a normal weight and excess body weight.

4.1 Objectives

The specific objectives of this thesis are to:

1) Assess the effect of an aerobic exercise program and weight status on the following dietary parameters of adolescents: food quantity, diet quality and eating pattern.
2) Examine the relationship between each dietary parameter and the change in energy intake induced by the aerobic exercise program.
3) Assess the effect of an aerobic exercise program and weight status on the following eating behaviours of adolescents: cognitive restraint, uncontrolled eating and emotional eating.

4.2 Hypotheses

Based on the literature, it is hypothesized that:

1) The aerobic exercise program would lead to improved dietary intake parameters; a decrease in total quantity of food consumed, an increase in diet quality and an earlier shift in daily eating patterns. Paticipants with an excess body weight may have a greater dietary chronic response to the exercise intervention than participants with normal weight.
2) The decrease in energy intake would be associated with an improvement in diet quality of adolescents.
3) The aerobic exercise program would lead to an increase in cognitive restraint, but no change in uncontrolled eating or emotional eating. The change in eating behaviours would be greater for participants with excess body weight compared to those with normal weight.

PART 5: METHODOLOGY

This study is part of a larger research project that looked at the effect of an 8-week aerobic exercise program on daily energy expenditure and intake of adolescents (see Figure 5 for protocol timeline). The research protocol follows a pre-post quasi-experimental design, which involves an 8-week exercise intervention, with pre- and post-intervention dietary analysis. Data collection was performed between January and April 2016. This project was approved by the Hôpital Montfort and University of Ottawa Research Ethics Boards (see information sheet and consent form in Appendix II as well as certificates in Appendix III)

Refer to Methods sections in respective manuscripts for detailed methods (see Part 6). Copies of the questionnaires used in this study are found in Appendix IV.

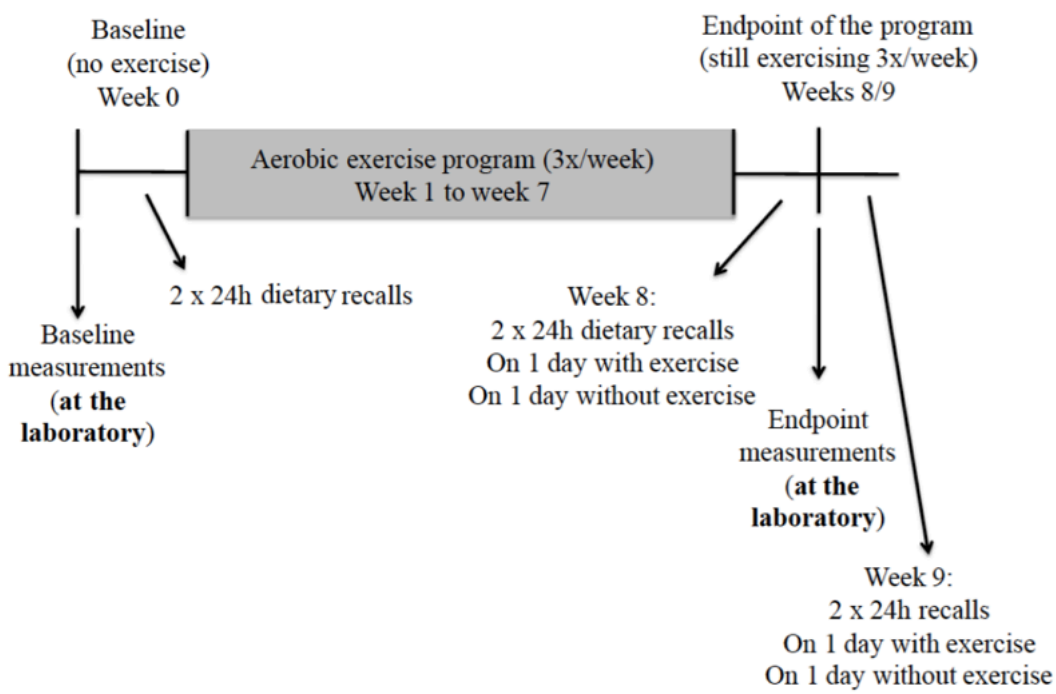

Figure 5: Research Protocol Timeline

Adapted from Biagé et al. (2016)

PART 6: RESULTS

6.1 Manuscript 1: Effects of an 8-Week Aerobic Exercise Program on Food Quantity, Diet Quality and Eating Patterns of Adolescents

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Abstract

Objective: To assess the effects of an 8-week exercise program on food quantity, diet quality and eating patterns of adolescents and determine how these parameters influenced energy intake.

Design: Quasi-experimental design with pre- and post-intervention measurements.

Setting: High-school in Quebec, Canada.

Participants: Twenty-six adolescents, aged 14-18 years.

Main Outcome Measure: Food quantity, diet quality and eating patterns. Food intake was measured via 24-hour diet recalls.

Analysis: Paired sample t-tests, repeated measures ANOVAs and Pearson correlations.

Results: A decrease in meal size at lunch (-110.1g, P=.02) and dinner (-143.7g, P=.03), food density at breakfast (-1.8kcal/g, P=.04), daily carbohydrate intake (-56.1g, P=.005), percentage of energy intake consumed at school (-5.1%, P=.04) and a tendency for the percentage of energy intake to increase after school (+4.8%, P=.05) were observed following the exercise program. No changes in Healthy Eating Index scores or percentage of energy from processed foods were observed. Correlations were found ($p<.05$) between all dietary intake parameters and change in energy intake.

Conclusions and Implications: Changes in food quantity but not diet quality were observed following the 8-week aerobic exercise program. All dietary parameters may have contributed to changes in energy intake. Nutrition interventions may be needed, in addition to participation in an exercise program, to target diet quality and help improve eating patterns of adolescents.

Keywords: exercise, energy intake, eating behavior; adolescent.

Introduction

Today's obesogenic environment is concerning as it impacts many health-related behaviors such as physical activity status, sedentary behaviors and the diet[1]. Children and adolescents are especially vulnerable to food advertisement, peer influence and the use of technology, which leads them to adopt unhealthy eating habits and inactive lifestyles[2]. Results from the 2004 Canadian Community Health Survey (CCHS 2004) highlight the suboptimal food choices of Canadian adolescents as well as their poor adherence to Canada's Food Guide (CFG) recommendations[3,4]. These dietary habits are alarming from a weight management and health standpoint[5,6]. Therefore, there is a need to develop interventions to address these problematic lifestyle behaviors amongst adolescents.

One of the strategies used for health promotion and obesity prevention is exercise. In addition to its benefits for overall health, exercise has been found to affect the diet of adolescents[7,8]. Evidence suggests there may be a decrease in energy intake following a single exercise session (acute effect) as well as in response to an exercise intervention[7,8] (chronic effect). However, this has only been studied from an energy balance perspective and the mechanisms driving this potential decrease in energy intake after exercising, in acute or chronic conditions, remain unclear.

Although energy balance is key for weight management, food choices and overall diet composition are of greater importance for health[9]. Energy balance and intake are influenced by the food-related decisions and subsequent eating habits[9]. Thus, it is pertinent to assess specific dietary intake indices of adolescents in response to an exercise intervention. Dietary intake indices, such as the quantity of food consumed, the quality of food choices and overall diet as well as eating patterns, are modifiable diet factors that could influence the total daily energy intake[9]. Documenting the effect of an exercise intervention on these dietary intake indices would contribute in determining if an exercise intervention alone is sufficient to elicit changes in eating habits. Furthermore, dietary intake indices can help understand how energy intake is modulated following an exercise intervention.

Most studies in the field of exercise and subsequent energy compensation were conducted over a short-term period[8]. Thivel and collaborators[10] were among the first to assess the chronic effect of exercise on energy and macronutrient intake of adolescents. They have found a significant decrease in fat intake and a trend for energy intake to decrease following a 10-week exercise intervention. However, it is unclear if these results were due to positive changes in food choices or overall diet quality. There is a need to investigate the effect of an exercise intervention, beyond energy and macronutrient intake, to better understand its impact on the diet and perhaps, if necessary, tailor nutritional recommendations to inactive adolescents participating in an exercise program. Thus, the present study addressed the following research questions: 1) What are the effects of a single exercise session and an 8-week aerobic exercise program on the dietary parameters (food quantity, diet quality and individual eating patterns) of previously inactive adolescents? and 2) Are changes in dietary indices associated with changes in energy intake following the exercise program? It is hypothesized that the exercise program will lead to positive changes in dietary indices, specifically in diet quality, which will contribute to partly explain the decrease in energy intake previously observed.

Methods

Study Design

The present study is a secondary analysis of data from an exercise intervention study regarding the effect of an 8-week aerobic exercise program on daily energy expenditure and intake in adolescents. The complete study design and methodology of the study is described in a previous publication[11]. The intervention consisted of an 8-week aerobic exercise program. Participants continued to exercise on week 9 for the purpose of data collection. Baseline and post-intervention testing sessions took place at the Hôpital Montfort on weekends prior to week 1 and at the end of week 8. Diet was assessed at school during lunch hours in pre-intervention (PRE) as well as weeks 8 and 9 (POST).

Participants

A total of 30 healthy inactive adolescents, aged 14 to 18 years old, were randomly selected for this study. Participants were recruited from a high school in Gatineau, Quebec, Canada. Power analysis revealed a minimum of 20 participants needed to reach significance (power=0.95, α=0.05). Exclusion criteria included: 1) saying yes to any of the questions on the Physical Activity Readiness Questionnaire (PAR-Q)[12], 2) exceeding 60 minutes of exercise bi-weekly in the past 4 months, 3) having type 1 or type 2 diabetes, asthma, severe premenstrual syndrome, allergies to milk and/or gluten, or having any physical activity restriction, 4) being pregnant, and 5) taking prescribed medication. This study was approved by the University of Ottawa Research Ethics Board, as well as the Hôpital Montfort Research Ethics Board. All participants provided informed consent and those under the age of 18 years were required to provide a co-signature from a parent or guardian. Participants were blinded to the true purpose and rationale of the study throughout the project.

Exercise Intervention

The exercise program consisted of three 30 minutes exercise sessions per week on cycle ergometers. The targeted exercise intensity ranged from moderate to vigorous, aiming for 75% of heart rate reserve. Exercise sessions were led by a kinesiologist and took place at the participants' high-school at lunch time. Heart rate monitors (Polar Electro Oy, Kempele, Finland) were worn on participants' left wrist, and monitored throughout the exercise sessions to ensure they remained in the exercise targeted heart rate zone.

Duration of exercise, heart rate for the 5-minute warm-up and remaining 25 minutes of exercise, as well as rate of perceived exertion using the 14-point (6-20) BORG scale were measured at each session to ensure that the intervention was followed appropriately by participants.

Measurements

Questionnaires

The International Physical Activity Questionnaire (IPAQ)[13], the International Study of Childhood Obesity, Lifestyle and Environment (ISCOLE) questionnaire[14] and a nutrition questionnaire were completed by participants in pre- and post-intervention to assess participants' physical activity status, sleep, sedentary behaviors and involvement in food choices and preparation at home. Weekly Metabolic Equivalent of Task (MET) were computed from the IPAQ in pre- and post-intervention. Levels of physical activity were categorized as "low", "moderate" or "high", based on IPAQ guidelines[15]. Ethnic origin and puberty Tanner stage were self-reported at baseline.

Diet

A comprehensive dietary assessment was performed on two non-consecutive days in pre-intervention (PRE) and on four non-consecutve days in POST; two on exercise days (POST-Ex) and two on non-exercise days (POST-NEx). Twenty-four hour dietary recalls were completed by registered dietitians as well as trained 4th year dietetic interns from the University of Ottawa. The Multiple Pass Method was used to ensure standardization, accuracy and comprehensiveness of dietary recalls[16]. Information such as time and type of meals or snacks, portion sizes, types of food and product brands were collected. Food models were used to help participants estimate their portion sizes. Weekend intake was not included, as food choices of adolescents were shown to be highly variable on those days[3].

Data Analysis

Dietary Analysis

Dietary recalls were analyzed with ESHA Food Processor SQL version 11.0.137 (ESHA Research, Oregon, USA) using nutrient contents from the Canadian Nutrient File and other sources of information (e.g. the US Department of Agriculture database). New products were manually entered in the database with the information provided by manufacturers. Data from two dietary recalls were averaged for food quantity, diet quality and individual eating patterns of adolescents for each of the three exercise conditions (PRE, POST-NEx, POST-Ex). Food quantity was measured by assessing the number of daily eating occurrences, (total number of meals and snacks consumed daily), and the average daily portion sizes and energy density were calculated. Total portion sizes and energy density were also calculated for each meal and snack. Diet quality was measured based on macronutrient intakes, adherence to CFG's recommendations and level of food processing in participants' diet. Macronutrients intake and their daily distribution were extracted from the ESHA Food Processor software. Participants received a score from 0-100 based on the Canadian Healthy Eating Index (C-HEI 2009) criteria[17]. All foods were categorized as being part of group I (unprocessed and minimally processed foods), group II (processed culinary ingredients), group III (processed foods) or group IV (ultra-processed food and drink products) based on the NOVA Food Classification System criteria for food processing[4]. Results are presented as percentage of total energy intake from each group. Finally, participants' eating patterns were analyzed by calculating energy and percentage of total daily energy consumed before school (<9:00), at school (9:00-16:00) and after school (>16:00) for all conditions. POST-NEx and POST-Ex data were combined for each variable to reflect the diet of participants in the post-intervention condition (POST-AVG). Change scores (POST score – PRE score) were also computed for each diet variable to assess the relationship with change in energy intake and potential confounding variables. All data entries and analyses were performed and verified by a registered dietitian and/or trained nutrition assistant.

Statistical Analysis

Paired-sample t-tests were used to assess differences in pre- and post-intervention measurements (PRE/POST-AVG). Differences in POST-NEx and POST-Ex conditions were further assessed using repeated measures ANOVA. Data is not presented for POST-NEx and POST-Ex if no significant difference was found. Mixed method ANOVA was performed to evaluate if any significant differences existed between boys and girls. If no significant differences were found, the groups were combined for greater statistical power. Relationships between dietary indices and energy intake, as well as factors having potentially influenced results (age, sleep, percentage of adherence to exercise intervention and change in aerobic power) were assessed using Pearson correlations. Shapiro-Wilk was used to test for normality of distributions. If not normally distributed, log transformation or non-parametric test equivalents were conducted. Post-hoc analyses with Bonferonni adjustments were used for significant outcomes. Effect sizes are reported as Cohen's d coefficient for t-tests (negligible if $d<0.2$, small is $0.2< d< 0.5$, medium if $0.5< d<0.8$ and large if $d >0,8$) and partial eta-squared (η^2_p) for ANOVAs (negligible if $\eta^2_p<0.01$, small if $0.01< \eta^2_p<0.06$, medium if $0.06< \eta^2_p<0.14$ and large if $\eta^2_p>0.14$). Statistical analyses were performed using IBM SPSS Statistics (version 24). Data are presented as mean ± standard deviation (SD) or as median and interquartile range (IQR). Results were statistically significant when $p<0.05$.

Results

Participant Characteristics

A total of 26 participants (15.3 ± 1.0 years old), 13 girls and 13 boys, completed the 8-week aerobic exercise program (Table 1). Our sample self-reported as 58% White, 15% Arab, 8% Chinese, 8% Black, 8% other and 3% not specified. Based on the responses from the nutrition questionnaire, all participants reported being involved in family meal suggestions to some extent; 8% always, 38 % often, 42% occasionally and 12% rarely. For participation in food choices for grocery shopping, 11% reported being always involved, 35% often, 27% occasionally and 27% rarely or never. Only 34% of participating adolescents often or always prepared meals on their own, 35% occasionally and 31% rarely or never.

Characteristics of Exercise Sessions

Participants attended 82.1 ± 8.8% of all exercise sessions from week 1 through 9. Average length of exercise sessions was 29.6 ± 0.9 minutes. Throughout the exercise program, 9 participants' average heart rate was within target range while 17 participants exceeded 75% of their heart rate reserve. The median for rate of perceived exertion was 12.3 (IQR = 3.00) on the 14-point (6-20) BORG scale, which is classified as moderate intensity exercise[18].

Lifestyle Changes Following the Exercise Intervention

At baseline, daily physical activity was classified as "low" for 10 participants and "moderate" for the remaining 16 participants. Following the exercise program, physical activity status for all participants was moderately active, which included exercise sessions on cycle ergometers. There was a significant increase in total weekly METs from pre- (214.5 ± 227.1 MET/week) to post-intervention (281.2 ± 300.2 MET/week), estimated from the IPAQ. No significant change was observed in the number of hours spent sleeping (week days: 8.1 ± 0.8 vs 8.2 ± 0.9 hours/day, weekend days: 9.1 ± 1.2 vs 8.9 ± 1.3 hours/day), watching television (week days: 2.5 ± 1.3 vs 2.2 ±1.1 hours/day, weekend days: 3.8 ± 1.6 vs 3.5 ±1.6 hours/day) or playing video games (week days: 2.9 ± 1.3 vs 3.0 ± 1.6 hours/day, weekend days: 4.4 ± 1.7 vs 4.0 ± 1.7 hours/day) following the exercise program.

Food Quantity

Participants ate on average 5.2 ± 1.3 times/day in pre-intervention and 4.6 ± 1.0 times/day in post-intervention. However, this difference did not reach statistical significance (P = .06). Daily average portion sizes were greater in male than female participants (PRE: 113.1 ± 28.8 vs 98.6 ± 45.5 grams, POST: 115.3 ± 23.4 vs 87.2 ± 20.2 grams; P = .01, $\eta^2_p = 0.2$). No change in daily average portion sizes or energy intake density of participants was observed following the exercise intervention (data not shown).

When analyzing meals and snacks separately, the meal sizes at lunch and dinner decreased in post-intervention by 110.1g (*P* = .02, *d* = 0.5) and 143.7g (*P* = .03, *d* = 0.5), respectively (Figure 1). The change in meal size at lunch was negatively associated with age (*r* = -0.4, *P* = .047). Total energy density was greater in PRE (8.7 ± 5.3 kcal/g) compared to POST-AVG (6.9 ± 3.8 kcal/g; *P* = .04, *d* = 0.4) for breakfast and in POST-Ex (3.7 ± 4.0 kcal/g) compared to POST-NEx (2.2 ± 2.7 kcal/g; *P* = .04) for afternoon snacks (Table 2).

Diet Quality

Table 3 presents results for daily macronutrient intake and distribution. Carbohydrate intake (*P* = .003) and daily percentage of energy from carbohydrate intake decreased following the exercise program (*P* = .03, *d* = 0.5). Additionally, POST-NEx was significantly different from PRE and POST-Ex for protein intake (*P* = .02, η^2_p = 0.4). No difference was observed for fat intake between conditions.

No significant change was observed for the average HEI-C scores between pre- and post-intervention (59.6 ± 12.2 vs 57.6 ± 9.8%) (Table S1). Both pre- and post-intervention HEI-C scores qualified as “diet needing improvement”. No participants scored above 80%, which represents a “good quality diet”. Of the 11 participants who’s HEI-C score increased, 5 managed to improve their score from “poor” to “needing improvement”. The score of 2 participants decreased from “needing improvement” to “poor”. Consumption of “other foods” contributed to 28.7 ± 15.0% of the participants’ total energy intake in pre-intervention. Additionally, 77 % of participants did not meet CFG daily vegetables and fruit serving recommendation. The meat intake score (0-10) of males significantly decreased following the exercise program (7.2 ± 2.9 to 4.9 ± 1.5; *P* = .005, η^2_p = 0.3) compared to females. No other HEI-C score breakdown was influenced by the exercise program. The percentage of total daily energy intake consumed from each of the NOVA food processing groups was not different in post-intervention (Figure 2). No difference in HEI-C scores or NOVA food processing groups were found between Post-NEx and Post-Ex (data not shown).

Eating Pattern

A significant decrease in energy intake (995.6 ± 482.3 to 745.3 ± 212.3 kcal; *P* = .009, *d* = 0.6) and percentage of daily energy intake (40.6 ± 13.4 to 35.5 ± 8.0%; *P* = .04, *d* = 0.5) consumed at school was observed following the exercise program. In contrast, there was a tendency for the percentage of daily energy intake consumed after school to increase (42.1 ± 11.4 to 46.9 ± 8.4%; *P* = .05) (Figure 3). No difference in eating pattern was found between POST-NEx and POST-Ex (data not shown).

Dietary Indices and Energy Intake Change Scores

A positive relationship was observed between the change in energy intake and the change scores for meal size at breakfast (r = 0.5, P = .02), meal size at lunch (r = 0.5, P = .009) and energy density at breakfast (r = 0.6, P = .001). For the diet quality indices, the change in energy intake was positively associated with a change in carbohydrate (r = 0.9, P < .001), protein (r = 0.6, p = .002) and fat intake (r = 0.6, P = .002). The NOVA Group 4 (ultra-processed foods) change score was also positively correlated with the energy intake change score (r = 0.5, P =.02). For the eating pattern indices, changes in energy intake positively correlated with changes in energy intake consumed before school (r = 0.6, P = .002), at school (r = 0.4, P = .03) as well as after school (r = 0.4, P = .04).

Discussion

To our knowledge, this is the first study to examine the effect of an aerobic exercise program on dietary indices (food quantity, diet quality and individual eating patterns) of adolescents, highlighting the underlying eating habits driving changes in energy intake. The major finding of the present study suggests that the decrease in energy intake observed by Biagé et al.[11] following the exercise program was mainly driven by a decrease in meal size as well as in carbohydrate intake, rather than a change in food choices or overall diet quality. The absence of change in diet quality is not surprising following the participation in an 8-week aerobic exercise program as there was no nutritional education provided. As expected, the exercise program led to an increase in weekly MET, but did not affect the measured sedentary behavior or sleeping pattern, which are known to influence dietary behaviors of adolescents[19,20].

The present study found a moderate decrease in meal sizes at lunch and dinner following the exercise program, but did not find any significant changes in the number of eating occurrences. Although participants trained at lunch time, no difference was found between Post-Ex and Post-NEx, confirming that the study protocol did not influence the intake of participants at lunch. Additionally, our results align with Lopez and Johnson's findings, having found that restrained eaters manipulate their portion sizes rather than their meal frequency[21]. Consuming snacks and eating regularly may have a protective effects on obesity for adolescents[22]. Therefore, maintaining the constant number of eating occasions could be considered as a positive habit for participants. Moreover, the decrease in meal size at lunch, following the exercise program, was inversely associated with age. Although this result was significant, the weak correlation (r^2 = 0.15) suggests that other unknown factors may have impacted the change in lunch size following the exercise program, such as environmental and individual factors[2]. This includes peer influence, hunger, individual beliefs and nutrition-related knowledge, amongst many others, which could have influenced participants' response to exercise. Meal size reduction at lunch may have also particularly contributed to the decrease in total daily energy intake (Biagé et al.), as these two variables were found to be positively correlated with one another. These results highlight the importance of eating habits at lunch and at school for the regulation of total daily energy intake.

The meal size reduction at lunch may also help partly explain the decrease in energy intake during school, observed in post-intervention. Additionally, it may have led to a partial compensation in energy intake later in the afternoon and evening (-5.1% at school compared to +4.8% after school), similar to Mars and colleagues' findings[23]. This shift in eating pattern is not beneficial for health in the long run, as it has been linked with higher body mass index[24] and suboptimal diet quality[25]. In contrast, consuming similar proportion of energy throughout the day is associated with greater diet quality[26]. Thus, there may be a need to promote an even distribution of energy intake to avoid overeating. Furthermore, the present study found no change in energy consumed before school, despite the moderate decrease in total energy density at breakfast. To explain these results, we would expect to have found a decrease in meal size at breakfast or a change in morning snack habits. However, this was not the case for our participants. We suspect that the high individual variation in our sample, as shown by the large standard deviations for food quantity variables, may have masked significant changes in breakfast size or morning snack parameters (size or density). Future studies may benefit from looking at food choices to better understand changes in energy density.

The dietary analyses revealed that eating habits of our participants were suboptimal at baseline, in comparison with Canadian Food Guide recommendations, similar to the Canadian adolescent population[3]. Unfortunately, the exercise intervemtion did not lead to any changes in the percentage of energy intake from processed or ultra-processed foods, overall HEI-C scores or any of its components. However, improvements in diet quality could lead to healthier outcomes, compared to reduction in meal sizes observed at lunch and dinner.

The present study found a positive correlation between the change in consumption of ultra-processed foods and the change in energy intake of participants, highlighting the potential of reducing ultra-processed foods for energy intake regulation. Despite no change in overall diet quality, males were found to decrease their intake of meat and alternatives (based on the HEI-C score breakdown) in post-intervention, but not their daily protein intake. Sex differences are common when it comes to baseline eating habits[3]. However, the latter results suggest that males' response to exercise program may be different than females', which goes against previous findings[27]. A greater sample size may help further analyze sex differences in dietary intake parameters, in response to an exercise program. Moreover, the absence of significant change in the other diet quality indices may be related to the high variability in individual HEI-C scores and food processing data. This might have to do with the various levels of involvement of participants in food-related decisions at home and nutrition-related knowledge.

Additionally, environmental factors, such as home food environment greatly influences adolescents' food-related decisions and may have not made changes in food choices or diet quality possible for participants.

Participants' daily carbohydrate intake moderately decreased following the exercise program, which modified its daily distribution. Despite these results, the percentage of daily energy intake from carbohydrates remained within the recommended range (45-65% of total energy intake[28]). Our findings are consistent with the results reported by Schwartz and colleagues[7]. However, these researchers have also found a decrease in protein and fat intake in response to an exercise intervention, which was not the case in this study[7]. We identified a positive correlation between the change in carbohydrate intake and the change in energy intake, as carbohydrates provide an important source of energy to the body. Researchers have focused on physiological mechanisms to help explain these changes in energy and carbohydrate intake following exercise[7,8]. Yet, many have ignored how this may translate to eating habits of adolescents. Dietary sources of carbohydrates include dairy products, grains, fruits, "other foods" (such as cookies, spreads, sugar sweetened beverages, etc[29]), and processed or ultra-processed foods, which contain added fats and/or sugars[4]. Interestingly, the present study did not find any significant changes in the previously mentioned foods. Cumulative changes in various diet quality indices could have led to the overall reduction in carbohydrate intake with exercise intervention. Alternatively, the HEI-C score breakdowns for dairy, grain products, fruits and "other foods" may not have detected changes in total number of CFG servings. If participants were still meeting recommendations after having decreased their number of servings, they would have still been assigned the highest possible score for that category. Due to this tool's limitations, we cannot conclude that the decrease in carbohydrate intake was caused by a change in diet quality. More studies are warranted to understand the changes in daily carbohydrate intake, and especially fibre and sugar intake, following an exercise program.

This study also aimed to understand the acute effects of exercise on food quantity, diet quality and eating patterns, by comparing POST-Ex to POST-NEx. Despite the high standard deviations, total energy density of afternoon snacks was found to be greater in POST-Ex compared to POST-NEx. This reflects a potential change in food choices following exercise sessions, which may be explained by an increase in appetite, previously observed in response to an acute bout of moderate intensity exercise[30]. Furthermore, rather than focusing on the adoption of healthier eating habits following an exercise session, participants may have focused on popular sports nutrition beliefs. Protein intake was found to be greater in POST-Ex compared to PRE and POST-NEx. Though this is not supported by evidence, participants may have thought additional protein was needed on days when they were more physically active. However, we did not assess nutrition beliefs of participants. Whether changes in the diet were intentional or not may be an important consideration for future studies in order to better target nutrition education and intervention amongst adolescents initiating an exercise program.

The present study has some limitations. First, the study did not include a control group, which limits the ability to infer that changes in diet were associated with changes in physical activity status. However, the quasi-experimental design allowed to control for some inter-individual differences (i.e. baseline eating behaviours, food related knowledge, body image, etc). Second, we were not able to interpret results based on sex and race due to our relatively small sample. Third, this study did not assess nutrition knowledge of participants prior to the study. This could have helped in interpreting results and better understanding changes made to the participants' diet. It could have also helped in identifying if changes were intentional or not. Although the sample was relatively small, recruiting from one school may be considered as a strength, as it allowed to control for socio-economic status, education and school environment, which are factors known to influence food access and intake[2]. Other strengths include the use of questionnaires to control for potential confounding variables, the participants' high level of engagement in the study as well as the dietary assessment performed in free-living conditions.

Implication for Research and Practice

The diet of participants was suboptimal at baseline based on HEI-C scores and intake from processed and ultra-processed foods. Participation in an exercise program did not trigger substantial changes to diet quality of adolescents. However, a decrease in meal sizes at lunch and dinner as well as a decrease in carbohydrate intake were observed following the exercise program. It is unclear whether these changes were attributed to the intervention, therefore results may be interpreted with caution. In addition to an exercise program, a nutrition education intervention addressing food choices, meal patterns and media messaging regarding nutrition and physical activity, may be beneficial to support adolescents in improving their diet quality. Involving parents in nutritional interventions may also provide additional support for changes in home food environment. Future research is warranted to confirm these findings in a larger sample and allow for generalizability of results to the adolescent population.

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Tables & Figures

Table 1. Descriptive characteristics of participants (n=26)

Variables	**Girls (n=13)**	**Boys (n=13)**
Age (years)	15.4 ± 1.0	15.2 ± 1.0
Height (m)	1.6 ± 0.1	1.7 ± 0.05*
Weight (kg)	62.4 ± 15.0	69.7 ±15.6
BMI (kg/m^2)	23.6 ± 5.5	23.5 ± 4.8
BMI for Age		
< 50th percentile	15% (4)	8% (2)
50th – 85th percentile	15% (4)	27% (7)
85th – 97th percentile	8% (2)	4% (1)
> 97th percentile	12% (3)	12% (3)
Tanner Stage		
External Genitalia	--	4.2 ± 0.7
Pubic hair	4.3 ± 1.1	4.3 ± 0.6
Breast Development	4.1 ± 1.0	--

*Significantly different from girls (p<0.001, paired sample t-test)

Values are presented as percentage (n) or means ± standard deviation

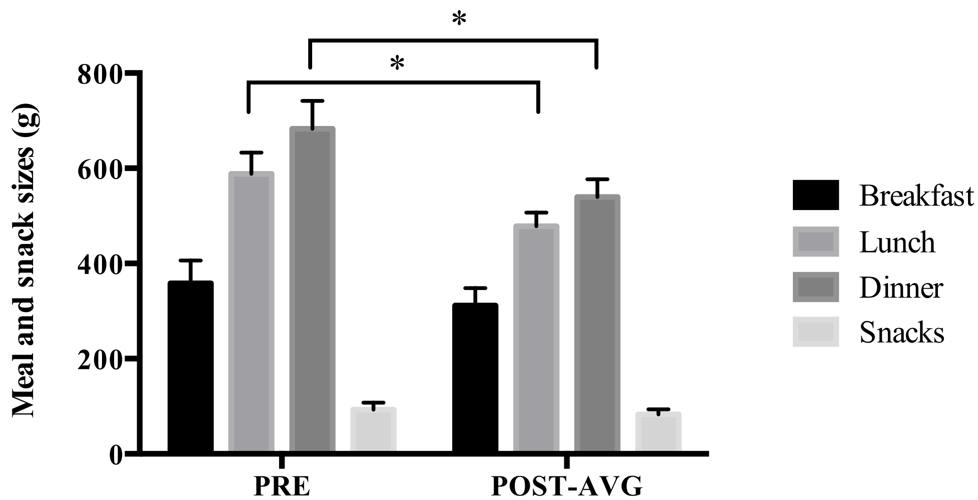

Figure 1. Average daily portion sizes at meals and snacks before and after an 8-week aerobic exercise program (n=26)

*p<0.05, Paired sample t-test

Values are presented as means ± standard error

PRE: pre-intervention, Post-AVG: post-intervention (average of Post-NEx and Post-Ex)

Table 2. Average daily energy density at meals and snacks before and after an 8-week aerobic exercise program (n=26)

	PRE	POST-NEx	POST-Ex	POST-AVG
Breakfast (kcal/g)	8.7 ± 5.3	7.0 ± 3.9	6.9 ± 4.4	6.9 ± 3.8*
Lunch (kcal/g)	11.6 ± 4.4	10.7 ± 4.4	11.3 ± 4.7	11.0 ± 3.8
Dinner (kcal/g)	11.6 ± 6.0	8.8 ± 5.0	10.3 ± 4.3	9.6 ± 3.8
Morning snacks (kcal/g)	2.1 ± 2.6	1.2 ± 2.2	1.3 ± 1.8	1.3 ± 1.9
Afternoon snacks (kcal/g)	3.8 ± 3.6	2.2 ± 2.7	3.7 ± 4.0†	3.0 ± 2.8
Evening Snacks (kcal/g)	2.3 ± 3.2	2.8 ± 3.1	2.0 ± 1.9	2.4 ± 2.1

*Significantly different from PRE (p<0.05, paired sample t-test)

†Significantly different from POST-NEx (p<0.05, Wilcoxon signed rank test)

Values are presented as means ± standard deviation

PRE: pre-intervention, POST-NEx: post-intervention on non-exercise days, POST-Ex: post-intervention on exercise days, Post-AVG: average of Post-NEx and Post-Ex

Table 3. Pre- and Post-Intervention Daily Macronutrient Intakes and Distribution (n= 26)

	PRE	POST-NEx	POST-Ex	POST-AVG
Carbohydrates (g)	337.9 ± 94.1	275.8 ± 64.8	287.6 ± 91.4	281.7 ± 72.9*
Protein (g)	93.9 ± 26.8	80.2 ± 23.0†	92.53 ± 26.1	86.3 ± 22.4
Fat (g)	80.0 ± 27.0	75.6 ± 21.5	75.4 ± 22.6	75.5 ± 19.0
Carbohydrate (%)	56.5 ± 7.0	53.4 ± 6.5	53.0 ± 5.8	53.2 ± 5.3
Protein (%)	15.6 ± 3.2	15.5 ± 2.7	17.2 ± 3.0	16.3 ± 2.2
Fats (%)	29.4 ± 6.8	32.3 ± 6.8	31.4 ± 5.7	31.9 ± 5.7

*Significantly different from PRE ($p<0.05$, paired sample t-test)

†Significantly different from POST-Ex and PRE ($p<0.05$, repeated measure ANOVA using Bonferroni adjustment)

Values are presented as means ± standard deviation

PRE: pre-intervention, POST-NEx: post-intervention on non-exercise days, POST-Ex: post-intervention on exercise days, Post-AVG: average of Post-NEx and Post-Ex

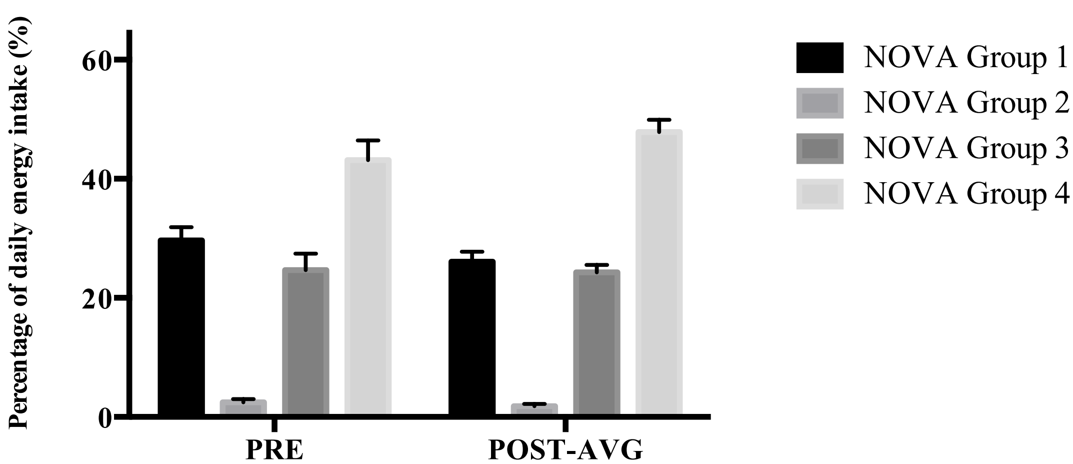

Figure 2. Distribution of daily energy intake based on NOVA Classification System for food processing (n=26)

P = NS

Values are presented as means ± standard error

PRE: pre-intervention, Post-AVG: post-intervention (average of Post-NEx and Post-Ex), NOVA Group 1: unprocessed or minimally processed foods, NOVA Group 2: processed culinary ingredients, NOVA Group 3: processed foods, NOVA Group 4: ultra-processed food and drink products

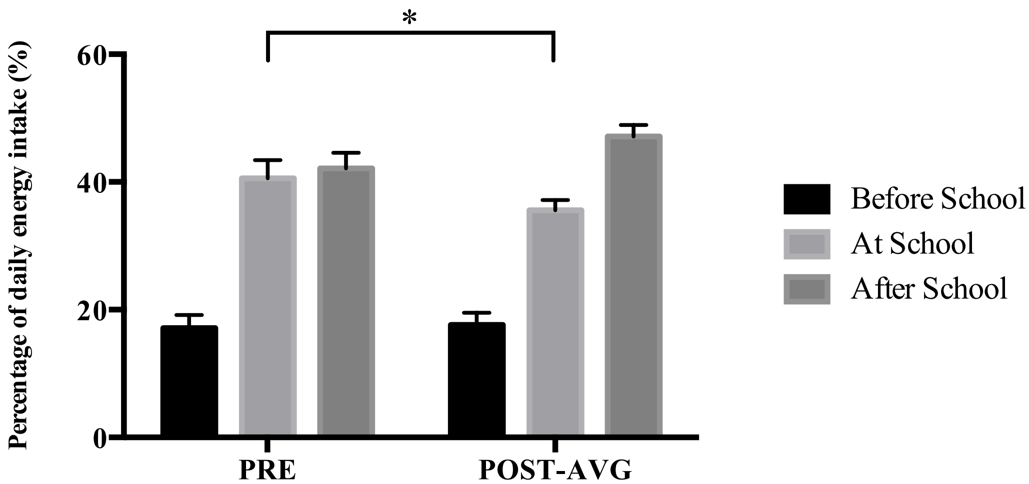

Figure 3. Distribution of energy intake in pre- and post-intervention in relation to school schedule (n=22)

*p<0.05, Paired sample t-test

Values are presented as means ± standard error

PRE: pre-intervention, Post-AVG: post-intervention (average of Post-NEx and Post-Ex)

Supplementary Materials

Table S1. Pre- and Post-Intervention HEI-C scores and breakdown (n=26)

	PRE	POST-AVG
Total HEI-C Score	59.6 ± 12.2	57.6 ± 9.8
Adequacy (0-60)		
Total vegetable & fruit consumption (0-10)	7.4 ± 2.6	6.9 ± 2.3
Whole fruit (0-5)	3.6 ± 1.6	3.1 ± 1.7
Dark green and orange vegetables (0-5)	2.6 ± 2.0	2.0 ± 1.2
Total grain product consumption (0-5)	4.1 ± 0.9	3.9 ± 0.9
Whole grains (0-5)	1.4 ± 1.7	1.4 ± 1.5
Milk and alternatives (0-10)	6.1 ± 2.7	5.5 ± 2.1
Meat and alternatives (0-10)	6.9 ± 2.8	6.3 ± 2.1
Unsaturated Fats (0-10)	8.3 ± 1.9	8.0 ± 1.3
Moderation (0-40)		
Saturated Fats (0-10)	6.6 ± 3.0	6.4 ± 2.1
Sodium (0-10)	4.5 ± 2.6	5.4 ± 2.1
"Other foods" (0-20)	8.2 ± 5.9	8.7 ± 4.5

Values are presented as means ± standard deviation

PRE: pre-intervention, Post-AVG: post-intervention (average of Post-NEx and Post-Ex)

6.2 Manuscript 2: Effects of weight status on the dietary response to an 8-week aerobic exercise program in previously inactive adolescents

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Abstract

Background: Exercise may lead to decreased energy intake in adolescents. This is mainly the case for adolescents with excess body weight. Moreover, it remains unclear whether these changes are driven by behavioral or physiological adaptations.

Objective: To assess the effect of weight status on dietary parameters and eating behaviors of adolescents in response to an exercise program.

Methods: Twenty-six adolescents (17 with normal weight, 9 with excess weight) engaged in an 8-week aerobic exercise program. Diet and eating behaviors were assessed in pre- and post-intervention, via 24-hour diet recalls and the three-factor eating questionnaire, respectively. Diet was further analyzed to assess food quantity, diet quality and eating patterns.

Results: At baseline, adolescents with excess weight ate more frequently ($p=0.02$), had greater portion sizes for their evening snack ($p=0.05$), consumed a smaller proportion of their total energy intake before school ($p=0.05$), and had less cognitive restraint ($p=0.008$) than those with normal weight. A decrease in the total number of eating occurrences was observed following the exercise program, only for participants with excess weight ($p=0.01$).

Conclusion: Weight status may affect dietary parameters and eating behaviors of adolescents as well as their dietary response to an exercise program. More studies are needed to support these findings.

Keywords: energy intake, feeding behavior, exercise, adolescents

Introduction

Our modern environment is known to promote sedentary lifestyles and unhealthy food choices. This may be one of the main drivers for obesity and its comorbidities. In Canada, less than 20% of children and adolescents are meeting the 24-hour Canadian Movement Guidelines[1], for their sedentary activities, physical activity levels and sleeping habits. Furthermore, sedentary behavior may be associated with poor diet quality[2]. This may explain why more than 50% of Canadian boys and girls, aged 14-18 years, are not meeting their fruit and vegetable intake recommendations[3]. Additionally, nearly a quarter of the daily energy consumed by adolescents comes from the consumption of "other foods"[3]. This category includes fats, oils, spreads, candy, soft drinks and any other food item that does not fit in any of the four Canada's Food Guide food groups.

There is a need to address these poor lifestyle behaviors at an early age to promote better health-related outcomes in adulthood[4]. This may be achieved by having adolescents engage in structured exercise programs. Benefits of exercise are known to go beyond its influence on cardiovascular health and strength. As such, studies have investigated the effect of aerobic exercise program on energy intake of adolescents. A recent systematic review has found that exercise program leads to a decrease in energy intake, particularly in adolescents with an excess body weight[5], suggesting that adolescents with excess body weight may respond differently than those with normal weight. However, experimental studies have only focused on energy and macronutrient intake of adolescents in response to exercise program.

Two hypotheses have been highlighted in the literature to explain the change in energy intake documented following an exercise program[6]. The first being that physiological changes induced by exercise program may influence subsequent energy intake[6]. Another interesting theory is that there may be a behavioral shift induced by an exercise program, promoting a change in eating behaviors[6]. There is the possibility that a positive change in physical activity (i.e. participation in an exercise program) would elicit a positive change in the diet of adolescents. Alternatively, adolescents may be tempted to reward themselves for their positive change in physical activity behaviors by consuming low quality food choices.

Lifestyle interventions, combining changes in diet and physical activity, may lead to an increase in cognitive restraint[7–9]. However, it is unclear if this was a result of the nutrition counselling provided to participants. Little evidence exists on potential changes in eating behaviors following an exercise program alone, especially in the adolescent population. This is pertinent as it could support the use of exercise to help address the problematic eating habits of adolescents. Chanoine and colleagues found that cognitive restraint was greater amongst adolescents with excess body weight, compared to those with normal weight[10]. This discrepancy in cognitive restraint depending on weight status may help explain why adolescents with excess weight respond differently than those with normal weight to an exercise intervention.

This study aims to assess the effect of weight status on dietary parameters (food quantity, diet quality and eating pattern) and eating behaviors of adolescents in response to an 8-week aerobic exercise program. This will help better understand how to tailor lifestyle interventions to adolescents with normal weight and excess weight.

Methods

Participants

A total of thirty participants aged between 14-18 years old, including adolescents with normal weight (BMI<85th percentile for age and sex) and excess weight (BMI≥85th percentile for age and sex), were recruited from a High-School in Quebec, Canada. Participants engaged in less than 60 minutes of physical activity twice per week and did not have any medical conditions affecting their metabolism or response to the exercise program prior to the study. This study was approved by the University of Ottawa and Montfort Hospital Research Ethics Board.

Exercise Intervention

Participants engaged in an 8-week aerobic exercise program on cycle ergometers (Monark, Sweeden), aiming for 75% of their heart rate reserve. Exercise sessions were 30 minutes in length and conducted at the participants' school. Heart rate was measured throughout the exercise sessions using heart rate monitors (Polar Electro Oy, Kempele, Finland). Rate of perceived exertion (RPE) was also collected at each session using the 20-point Borg scale. Individual exercise target heart rates were calculated using the Karvonen equation[11].

Anthropometric Measurements

Participant's body weight and height were measured using Health-O-meter digital scale (Pelstar LLC d.b.a., Health-o-meter® Professional Scale, McCook, Illinois) and SECA stadiometer (SECA, Birmingham, United Kingdom). Body composition and waist circumference were also assessed using hand-to-food bioelectric impendence analysis (Tanita BC-418, Corporation of America Inc., Arlington Heights, IL) and a flexible measuring tape (mean of 3 measures at the mid-distance between the lowest rib and the iliac crest). Body mass index (BMI) was calculated using the following equation: BMI (kg/m^2) = body weight (kg) /[heigth(m)]^2. Normal weight was considered as BMI for age between -2 and +1SD z-score, overweight between +1 and +2SD and obese greater than +2SD[12]. NW group includes participants with normal weight and EW group includes participants with overweight or obesity.

Participant Characteristics and Lifestyle

Tanner stage, sedentary behaviours, sleep, weight perception and involvement in food preparation and choices at home were assessed using the Tanner Stage Questionnaire, International Study of Childhood Obesity, Lifestyle and Environment (ISCOLE) questionnaire[13] as well as a weight and nutrition-related questionnaire developed by our research team to assess adolescents' involvement in food-related tasks at home.

Eating Behaviours

The 18-item Three-Factor Eating Questionnaire (TFEQ-18) was used to assess cognitive restraint (CR), uncontrolled eating (UE) and emotional eating (EE) of participants in pre- and post-intervention. This questionnaire consists of three parts, each assigned to one of the eating behaviour listed above. Responses to each question are scaled (definitely true, mostly true, mostly false and definitely false) and assigned a score ranging from 1-4. Raw scores for each question were transformed to percentages using the following equation[14]: Transformed score (%) = [((raw score - lowest possible raw score)/possible raw score range) x 100]. Transformed scores were then averaged for each eating behavior.

Dietary Assessment

Diet was assessed using 24-hour dietary recalls. Two recalls were collected on non-consecutive weekdays in pre-intervention and four in post-intervention. Participants continued to exercise on some days following the 8-week mark until post-tests was completed. Dietary recalls were performed by dietitians and trained dietetic interns, using the Multiple Pass Method[15] as well as food models. Diets were entered in ESHA Food Processor SQL to calculate energy and nutrient intakes. Data was extracted from the diet analysis software to evaluate portion sizes (g) and energy density of foods (kcal/g). Further dietary analyses were conducted by the research team using the Healthy Eating Index adapted to Canadians (HEI-C)[16] and the NOVA classification system[17]. Meal patterns were assessed based on percentage of energy intake consumed before school (<9:00), at school (9:00-16:00) and after school (>16:00).

Statistical Analysis

Participant characteristics and lifestyle factors were compared based on weight status using independent samples t-test. The concurrent effects of the exercise program and weight status on diet parameters and eating behaviors were assessed using mixed method ANOVA. Shapiro-Wilk test was used to assess normality of distributions. If normality assumptions were not met, log transformation or non-parametric tests were conducted (Wilcoxon signed rank test for within-subject and Mann-Whitney U for between subject). Effect sizes were reported as Cohen's d coefficient (d) for independent t-tests and partial eta square (η^2_p) values for mixed ANOVA (negligible if $d < 0.2/\eta^2_p < 0.01$, small if $0.2 < d < 0.5/0.01 < \eta^2_p < 0.06$, medium if $0.5 < d < 0.8/0.06 < \eta^2_p < 0.14$ and large if $d > 0.8/\eta^2_p > 0.14$). Statistical analyses were performed using IBM SPSS Statistics, version 24.

Results

Participant Characteristics

Twenty-six healthy adolescents (17 with NW, 9 with EW) participated in this study (see **Table 1**). Of the nine adolescents with EW, three were classified as overweight and six as obese based on their BMI for age z-scores. When asked about their weight, 17% (1NW, 3EW) of participants reported making active efforts to lose weight, 22% (3NW, 2EW) reported trying to maintain their weight and 16% (3NW, 1EW) reported making attempts to gain weight at baseline. The remaining 55% of participants felt indifferent about their weight prior to the intervention.

Participants spent an average of 2.54±1.27 and 2.92±1.29 hours watching TV and playing video games on weekdays as well as 3.77±1.61 and 4.38±1.70 hours on the weekend days, respectively. EW group reported sleeping longer on weekends than NW group (9.78±1.15 vs 8.79±1.14 hours, p=0.05, d=2.10). Participants slept on average 8.14±0.83 hours on week days. Average RPE throughout the exercise program was similar between the NW and EW group.

The EW group seemed to be more involved when it came to food preparation compared to NW group (p=0.04). The perspective of participants on their dietary habits, involvement in family meal suggestions, involvement in food choices while grocery shopping, frequency of cooking independently and consuming meals with family were not statistically different between groups (data not shown). Responses to self-reported nutrition questionnaire revealed that 11.5% perceived their diet as very good, 53.8% as good, 23.1% as not good nor bad and 11.5% as bad.

Dietary Parameters

Table 2 presents the dietary parameters of participants in pre- and post-intervention based on weight status. At baseline, EW group ate more frequently than NW group (p=0.02, η^2_p=0.23). A significant interaction was found between exercise program and weight, where the EW group decreased their total number of eating occurrences (p=0.01, η^2_p=0.69), whereas the NW group did not. No effect of weight status or interaction was found for average daily portion sizes or for total portion sizes at each meal. Portion sizes of evening snacks were also found to be greater in the EW group compared to the NW group at baseline (Mann Whitney U, EW: 239.31±202.03 vs NW: 91.39±126.05 grams; p=0.05). This was not influenced by the exercise program. As for eating patterns, participants with NW group consumed greater percentage of their daily energy intake before school (p=0.05, η^2_p=0.18). No effect of weight status or interaction between exercise program and weight was observed for diet quality parameters.

Eating Behaviors

There was no statistically significant interaction between exercise program and weight status for any of the three eating behaviors assessed by the TFEQ-18. Weight status had a significant effect on cognitive restraint of participants ($p=0.008$, $\eta^2_p=0.27$), but not on uncontrolled eating ($p=0.27$) or emotional eating scores ($p=0.62$). Precisely, NW group had greater cognitive restraint scores (pre: 56.5% ± 1.5 vs post: 58.5% ± 2.2) than EW group (pre: 51.2% ± 2.0, post: 51.9% ± 3.0) in both pre- and post-intervention conditions (see **Table 3**).

Discussion

A recent systematic review highlighted the potential difference between adolescents with NW and EW in their dietary response to a single exercise session[5]. The present study, involving an exercise program, attempted to dig deeper in the dietary parameters of adolescents to determine if and how weight status affects their dietary response to an 8-week aerobic exercise program.

Behavioral factors, such as sleep, TV viewing and video gaming were measured at baseline as these variables are known to influence the diet and overall health of adolescents[18,19]. No differences were observed based on weight status, except for sleeping time on weekends. Both groups met the 24-hour Movement Guidelines[20] for sleep on weekdays and weekends. However, the average was situated in the lower range of the recommendations. In contrast, participants did not meet the sedentary behavior guidelines[20], as both groups exceeded 2 hours of screen time per day. Sedentary behaviors was found to be associated to poor diet quality[2]. In fact, our participants consumed between 66.9-71.2% of their total energy intake as processed and ultra-processed foods, with an average HEI-C classifying as “diet needing improvement”, comparable to the Canadian adolescent population[3,21]. Diet quality was not significantly different between NW and EW. Pediatric obesity clinical practice guidelines may need to be reinforced to emphasize the importance of diet quality for all the adolescent, independently of their weight status[22]. The difference in weight status between NW and EW may then be explained by a difference in physical activity status or sedentary behaviors. This may be another aspect that should be emphasized in public health interventions and obesity guidelines.

The present study found a large effect of weight status on the total number of eating occasions, where participants with EW ate more frequently than those with a NW. The association between eating frequency and weight remains unclear in the literature. Some studies have found a negative association between eating frequency and BMI[23]. However, a greater eating frequency could be associated with increased snacking. Given that the diet quality of participants is suboptimal at baseline and that snacking foods are usually pre-packaged, dense in energy and high in added sugars and/or fats, a greater eating frequency in adolescent may not be beneficial to their health. Yet, the EW group decreased the number of eating occurrences following the exercise program, which can be perceived as a positive change. This supports the hypothesis that response to exercise in adolescent with EW may be different than adolescent with NW.

The EW group was also found to consume greater portion sizes at evening snacks compared to NW group. Eating closer to the onset of bedtime was found to lead to greater energy intake and to be associated with a greater BMI[24,25]. This may also have to do with the daily energy distribution of participants. Compared to NW group, the EW group consumed a smaller percentage of their total energy intake before school. Omitting breakfast or engaging in eating restriction early on in the day has been associated with greater energy intake later in the day and evening[26]. This concept, related to eating patterns, is also reinforced in pediatric obesity guidelines[22]. There may be a need to provide education, particularly to adolescents with EW, regarding the importance of consuming breakfast and having an even energy intake distribution throughout the day.

Eating behaviors are thought to impact dietary parameters and may play a role in the dietary response to an exercise program[14,27]. In the present study, no effect of the exercise program was observed on either of the measured eating behaviors. This is surprising as previous studies have found an increase in cognitive restraint following a lifestyle intervention, including dietary counselling and an exercise program[7,8]. Thus, physical activity alone may not elicit changes in eating behaviours. However, adolescents with NW were found to have greater cognitive restraint than those with EW. This goes against previous findings by Chanoine and colleagues[10]. These researchers suggest that their group of overweight boys may have been more aware of their BMI, therefore engaging in greater cognitive restraint. In our sample, only 3 (12%) participants with EW reported making active efforts to lose weight. The EW group may not have attempted to limit their food intake, potentially due to their lack of awareness of their weight status, motivation or education to act on it.

The present study has some limitations when it comes to its sample size and external validity. Both groups were not of equal size and may not have been large enough to detect significant change. However, all significant differences observed had a large effect size. Additionally, participants were recruited within one high-school to limit the variable effect of socioeconomic status and environmental factors and to make the intervention possible. This influences the external validity of our results, which may not be generalizable to the adolescent population. Future studies with a greater sample size and randomized sampling are warranted to confirm our findings. Additionally, the 8-week aerobic exercise program may not have been long enough to detect changes in eating behaviors and dietary parameters. A longer, potentially higher intensity exercise program and or different type of exercise may be needed to trigger changes in eating behaviors.

However, inactive adolescents could be less motivated to participate in a higher intensity exercise program. The strengths of this study include the thorough dietary assessment and analyses conducted by dietitians and 4th year trained dietetic interns, as well as the high retention and adherence of participants to the exercise program.

Conclusions

Differences were observed in the dietary intake parameters of adolescents with normal weight and excess weight, at baseline as well as in response to the exercise program. However, there were also similarities in terms of their poor diet quality and food choices. This highlights the need to address the diet quality of adolescents and to tailor nutrition interventions to adolescents' weight status, as adolescents with excess weight may respond differently to an exercise program than those with a normal body weight. Future studies should involve a more thorough assessment of participants' weight perception, as this may impact their food intake and dietary parameters.

Conflict of Interest

No conflict of interest to declare.

Acknowledgments

CP, AB, DP and IG participated in the study design, data interpretation and writing of the manuscript. CP and AB were actively involved in data collection and analyses. CP conducted the literature search and generated the figures. Final approval was received from all authors before submission of the manuscript.

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Tables and Figures

Table 1. Participant characteristics based on weight status

	Normal Weight (n=17)	Overweight (n=9)
Age (years)	15.17±0.92	15.4±0.97
Weight (kg)	56.85±7.49	81.50±12.05**
Height (m)	1.67±0.07	1.67±0.07
Waist Circumference (cm)	70.26±6.23	89.49±12.55**
BMI (kg/m^2)	20.38±1.86	29.02±3.63**
Body Fat (%)	20.15±6.11	33.11±6.13**
Fat-Free Mass (kg)	45.04±6.78	54.24±8.95*
Tanner Stage	4.21±0.80	4.00±1.07

*$p<0.01$

**$p<0.001$

Data presented as mean ± SD.

Table 2. Diet parameters of participants with normal weight (NW) and excess weight (EW) before and after the 8-week aerobic exercise program§

	Pre-Intervention		Post-Intervention	
	NW	EW	NW	EW
Food Quantity (n=26, 17NW, 9 EW)				
Number of daily eating occurrences	4.77±1.13*	6.07±1.21	4.69±1.02	4.64±0.76†
Average daily portion size (g)	100.69±43.59	115.66±23.52	96.53±23.20	110.16±29.44
Average daily food density (kcal/g)	2.14±0.30	2.14±0.47	2.09±0.24	2.15±0.47
Diet Quality (n=26, 17NW, 9EW)				
Carbohydrate intake (g/day)	323.16±81.91	365.44±113.68	288.16±79.77	269.47±60.28
Protein intake (g/day)	92.53±28.04	96.55±25.71	85.69±25.08	87.57±17.37
Fat intake (g/day)	79.29±28.77	81.33±25.05	74.69±20.71	77.07±16.41
HEI-C Score (%)	59.84±10.33	59.22±15.95	56.87±10.86	59.00±7.88
NOVA - Class I (%)	31.18±10.26	26.71±13.25	25.96±8.72	26.23±9.26
NOVA - Class II (%)	2.69±3.04	2.04±2.46	2.05±2.30	1.32±1.79
NOVA - Class III (%)	24.60±16.56	24.73±8.67	26.10±6.39	20.83±5.07
NOVA - Class IV (%)	41.39±16.81	46.52±16.91	45.89±10.89	51.62±8.86
Timing (n=22, 15NW, 7OW)				
Before school (%)	20.22±8.89*	10.54±7.74	19.31±8.43	14.51±9.31
At school (%)	37.90±12.59	46.37±14.06	33.91±8.27	38.73±4.19
After school (%)	39.50±12.74	46.68±7.30	47.49±7.81	46.49±9.96

*p<0.05, difference between group

†p<0.05, difference with pre-intervention

§Based on 24-hour dietary recalls

Data presented as mean ± SD.

Table 3. TFEQ-18 scores of participants with normal weight (NW) and excess weight (EW) before and after the 8-week aerobic exercise program (n=26)

	Pre-Intervention		Post-Intervention	
	NW (n=17)	EW (n=9)	NW (n=17)	EW (n=9)
Cognitive restraint (CR)	56.54 ±5.97*	51.23 ±6.07	58.50 ±9.24	51.85 ±8.33
Uncontrolled eating (UE)	60.78 ±11.78	54.32 ±14.46	61.87 ±16.60	56.38 ±12.93
Emotional eating (EE)	75.16 ±31.06	65.43 ±29.63	73.86 ±30.67	67.90 ±36.19

*p=0.008, difference between group

Data presented as mean ± SD.

PART 7: GENERAL DISCUSSION & CONCLUSIONS

7.1 Thesis Discussion

The main purpose of this thesis was to better understand the chronic effect of an 8-week aerobic exercise program on the diet and eating behaviours of previously inactive adolescents with normal weight and excess body weight. Previous studies have only assessed post-exercise energy compensation from an energy balance and macronutrient intake standpoint[15,37]. Gillman et al. looked at the association between exercise and dietary intake adequacy but were not able to assess the cause-effect relationship between these two variables[61]. Additionally, most studies involved adults, and did not comprehensively assess the diet[61–63]. Therefore, dietary parameters, such as food quantity, diet quality and daily eating patterns, have yet to be assessed in the adolescent population in response to an exercise program. This is of utmost importance for health promotion purposes as well as prevention of obesity and its comorbidities.

The most recent Canadian Community Health Survey conducted in 2004 highlights the suboptimal diet quality of adolescents aged 14-18 years old. Baseline dietary parameters of our sample were comparable to the Canadian adolescent population, when it came to their HEI-C score (59.6 vs. 54.3-55.6), percentage of daily energy intake from snacks (21.5% vs. 28-30%), "other foods" (28.7% vs. 25% and ultra-processed foods (43.2% vs. 55%). A recent study by Janssen et al.[110] reported that health outcomes of children and youth improved as more recommendations from the 24-Hour Movement Behaviour Guidelines were achieved. As such, we would have expected our sample to improve their dietary intake parameters, specifically diet quality, after having participated in the 8-week aerobic exercise program. However, many factors, such as the ones listed in the theoretical framework (Part 3, Figure 4), may help explain the observed responses within our sample of adolescents, including environmental (i.e. family influences, food availability, etc.) as well as individual factors (appetite response, eating behaviours, etc.).

The first objective, addressed in manuscripts 1 and 2, was to assess the chronic effects of the exercise program and weight status on food quantity, diet quality and eating pattern (relationship A illustrated in Part 3, Figure 4). Our findings suggest that the aerobic exercise program led to a decrease in participants' carbohydrate intake, meal size at lunch and dinner, a decrease in energy density at breakfast and a slight shift in daily energy intake distribution of participants. Contrary to our hypothesis, we found that an 8-week moderate intensity aerobic exercise program was not sufficient to trigger changes in adolescents' diet quality, which was suboptimal at baseline. This is not overly surprising as adolescents' food choices are known to be highly influenced by their family and home food environment[74]. Therefore, changes in food choices and subsequent diet quality may not have been possible despite participants' intentions. Our findings are also aligned with results from previous randomized control trials, having looked at the effect of an exercise program on dietary habits of adults[62,63]. Although some small improvements were observed in the exercise compared to the control group (decrease in fat intake and increase in vegetable intake), most dietary intake variables remained unchanged following the exercise program[62]. Similarly, Wilcox et al. found no association between changes in dietary habits following exercise and changes in physical activity. An exercise program alone may not be sufficient to trigger changes in diet quality of participants. Thus, participants may require nutrition education and/or motivational counselling to promote behaviour change for improvements in their adherence to nutrition recommendations.

This first thesis objective also aimed to assess the effect of weight status on the dietary response of adolescents to an aerobic exercise program. Some differences in dietary intake parameters were observed at baseline between adolescents with normal weight and those with excess weight. This was true for the total number of daily eating occurrences, portion sizes at evening snacks and percentage of daily energy intake consumed before school. Moreover, as hypothesized, the group with excess weight had a greater response to the exercise program, compared to the group with normal weight, when it came to their total number of eating occurrences. A review by French et al. highlighted the association between excess weight and key eating behaviours, such as eating in absence of hunger, disinhibition, response to immediate food reward as well as loss of self-control. These undesired eating behaviours, which are prominent amongst adolescents with excess weight, may predispose them to eating more frequently, engaging in evening snacking and potentially overeating, compared to adolescents with a normal body weight[111]. Alternatively, the difference in response between adolescents with normal weight and excess weight may be partly explained by the altered gut-brain axis previously observed amongst individuals with an excess weight or obesity. Alteration in gut hormones and appetite signaling could therefore influence feelings of hunger and satiety[112]. Very few studies have compared the dietary response of adolescents with normal weight to those with excess weight, in response to an exercise session or intervention[1,43]. Many studies have only focused on adolescents with obesity[38,39,53]. However, suboptimal eating habits should be addressed regardless of adolescents' weight status. Conducting research amongst both groups (adolescents with normal weight and those with excess weight) is paramount and could help adapt health promotion strategies to increase effectiveness of exercise and lifestyle interventions.

Differences in baseline and chronic effects of an exercise intervention on dietary intake parameters should also be considered between male and female adolescents. Results from this thesis suggest that average daily portion sizes of males were greater than females and that only males reduced their meat intake score in response to the aerobic exercise program. Differences in appetite hormone regulation, between male and females[113] might help explain these results. However, this is highly contradicted in the literature and needs to be explored further, especially in response and exercise intervention[113].

In addition to assessing the chronic effect of the aerobic exercise program, this project looked at the dietary response to a single exercise session in post-intervention. This was also part of the first thesis objective, as an exploratory component. We found greater total daily protein intake and energy density of afternoon snacks on post-exercise exercise days compared to non-exercise days. Evidence exists related to the acute and chronic effect of exercise on energy and macronutrient intake[15,37]. However, the difference between the acute and chronic effect of exercise on the diet remains unclear. Both acute and chronic effects of exercise should be considered when participating in an exercise program, as this could have an impact on long-term weight and health outcomes. Additionally, more research is needed to better understand the drivers for acute and chronic dietary compensation, after an exercise session or exercise intervention respectively.

The second thesis objective, addressed in manuscript 1, was to examine the relationship between each dietary parameter and the change in post-exercise energy intake of adolescents following the aerobic exercise program (relationship B illustrated in Part 3, Figure 4). Changes in meal sizes at breakfast and lunch, energy density at breakfast, daily carbohydrate, protein and fat intake as well as percentage of energy ultra-processed foods were positively associated with changes in energy intake following the aerobic exercise program. As hypothesized, improvements in diet quality parameters were associated with a decrease in post-exercise energy intake. Thus, it is possible that improving food choices and overall adherence to Canadian nutrition recommendations, could help regulate energy intake and weight of adolescents, which in the long run could have a positive effect on their health. This type of approach is supported by Obesity Practice Guidelines[30,31]. Although all dietary intake parameters contribute to energy intake regulation[73], there is a need to identify the ones that are most important when it comes to post-exercise energy intake compensation. Cluster analyses may help identify these factors and may also be helpful in addressing the high inter-individual variability observed in our sample as well as in previous work[32]. Despite our attempts to control for inter-individual variability, it can be very challenging to do so, as there are various factors influencing food choices and eating habits of adolescents. Therefore, future studies should involve larger sample size to allow for clustering analyses and identification of various types of acute and chronic post-exercise dietary responses.

The third thesis objective, addressed in manuscript 2, was to assess the effect of the aerobic exercise program and weight status on eating behaviours of participants (relationship C illustrated in Part 3, Figure 4). The 8-week aerobic exercise program did not have any effect on cognitive restraint, uncontrolled eating or emotional eating. These results lead to the rejection of the third hypothesis. Surprisingly, participants with normal weight were found to have greater cognitive restraint than those with excess body weight, which challenges Chanoine and colleagues' findings[72]. More research is needed to understand the eating behaviour responses of adolescents to an exercise intervention.

Evidence suggests that eating behaviours may help explain changes in dietary intake parameters as well as differences in responses between weight status groups[67–71].

This thesis contributes to a unique body of knowledge as it focused on the chronic effects of an exercise program on various diet indices as well as explored the acute effects of exercise in post-intervention condition. Additionally, it is the first study to comprehensively assess the effect of exercise on dietary intake parameters of adolescents to help explain changes observed in post-exercise energy intake. Thus, it contributed to better understanding relationships A, B and C illustrated in the conceptual framework presented previously (see Part 3, Figure 4). The comparison between sex and weight status, as well as analysis of eating behaviours generates new findings that will help further our knowledge in the field of post-exercise energy compensation following an exercise intervention. Eventually, the goal is to develop a thorough understanding of the individual characteristics that predispose adolescents to responding to exercise in a particular way, given the high inter-individual variability previously observed[32]. Such evidenced-based knowledge would help in adapting recommendations to subpopulations of adolescents to promote healthy behaviours and contribute to obesity prevention and health promotion strategies.

7.2 Practice Implications

The findings from this thesis suggest that an 8-week moderate intensity aerobic exercise program alone may not be sufficient to elicit substantial chronic changes in diet quality of adolescents. A nutrition intervention may be needed, in addition to the exercise program, to encourage the adherence to the CFG recommendations and consumption of healthier food choices in previously inactive adolescents. Previous findings suggest that combining an exercise intervention and nutrition counselling leads to an increase in cognitive restraint and a decrease in disinhibition and susceptibility to hunger in men[69]. Such a combined intervention may also be effective to help improve diet quality and food choices of adolescents. Differences in sex and weight status of adolescents should also be considered when counselling adolescents, as their acute and chronic responses to exercise and eating behaviours may be different. Additionally, a motivational counselling approach may be needed to trigger behavioural changes amongst adolescents and encourage them to adopt healthier eating habits along with a more active lifestyle[31]. This study provides insight on how to tailor future lifestyle interventions that target health behaviours of previously inactive adolescents while contributing to obesity prevention.

7.3 Limitations and Strengths

The quasi-experimental design did not allow for randomization of participants to an intervention or control group, which could have affected the validity of our inferences in relation to the effect of the 8-week exercise program. Therefore, results may be interpreted with caution. However, the experimental design, involving a control group, would not have taken into account inter-individual differences in factors affecting food choices and overall intake of participating adolescents (outlined in Part 3, Figure 4), justifying the use of a pre-post quasi-experimental design for this study.

Despite the power calculation conducted as part of the study conceptualization (suggesting a minimum of 20 participants for statistical power), our sample size may be considered a limitation, as it did not allow for analysis of covariates or factors predicting changes in energy intake using ANCOVAs and multiple regressions. The sample size may have also affected the statistical power for our group comparison (i.e. weight and sex) analyses. Additionally, there was also a high inter-individual variability observed amongst the sample, which may have made it difficult to detect individual as well as group differences amongst participants. However, the study had a high retention of participants (93%), with only 2 participants having dropped-out of the study for lack of interest/time. Those who completed the exercise program had a high adherence to the aerobic exercise program, with 82% attendance to prescribed exercise sessions. Additionally, all participants were meeting or exceeding targeted exercise intensity during exercise sessions.

There may also be an increased risk of type 1 errors to consider, related to the multiple statistical analyses and multiple comparisons conducted as part of this study. Corrections were used when appropriate. However, Bonferroni adjustments for multiple comparisons were not performed, as we intended to test the null hypothesis for each diet-related variable independently[114]. The universal null hypothesis was not of interest in this study. Furthermore, the Bonferroni adjustments could have led to an increased risk of type 2 errors[114].

Another study limitation includes the missing data from four participants for the eating pattern analysis. The timing of food intake for these four participants were not recorded for all three conditions (PRE, POST-Ex and POST-NEx), which led to data exclusion. This contributed to a smaller sample size for eating pattern analysis. However, significant changes, with small to medium effect size, were still observed despite the small sample size. A larger data set would help confirm these findings.

The use of self-reported food intake assessment via 24-hour dietary recalls for the dietary assessment may also be considered as a limitation, as this tool may be subject to misreporting, particularly under-reporting of total energy intake[115]. Other methods such as weighing food intake from *ad libitum* buffets may be more accurate, rather than relying on memory. However, the latter method would not have taken into account free-living conditions of adolescents. Ideally, participants would have been asked to complete weighed food journals. Yet, this would have increased participants' burden and may have affected participants' food choices or food-related decisions, as they would have been conscious their intake was being weighed daily. Additionally, the main objective of this thesis was to assess the dietary intake parameters of adolescents, rather than focusing on total daily energy intake. Despite the numerous critiques on self-reported dietary assessment measurements, the latter remain a useful tool for collection of valuable dietary intake data on the consumption of food and beverages[116]. As recommended by Subar et al.[116], additional measures were taken to limit measurement errors or misreporting. For instance, recalls were performed on two non-consecutive days, as well as analyzed and verified by dietitians and 4th year dietetic interns[50]. The validated Multiple Pass Method for performing 24-hour dietary recalls as well as food models were also used for a more thorough assessment and more accurate report of portion sizes.

The interdisciplinary team is considered a strength for this research project as it allowed for thorough dietary assessments and analyses, as well as for appropriate implementation of the aerobic exercise program and standardization of the exercise protocol. Moreover, the study was conducted in free-living conditions which helps reflect participants daily choices and habits in response to the aerobic exercise program. This is extremely important, as we know adolescents are subject to many environmental and social influences. Despite these influences, we were able to control for some cofounding factors by recruiting participants from one high-school. Finally, our research team was able to give back to participants at the end of the study by providing them with reports on their physical activity and dietary status in comparison with Canadian recommendations. We plan on returning to the participants' high-school to share our research findings in hopes of making a positive impact on the community's health and lifestyle.

7.4 Future Directions

More research is needed to confirm the thesis' findings. Future studies should involve a longer duration of the aerobic exercise program with a longer follow-up period. This would allow more time for participants to modify their lifestyle behaviour and assess sustainability of dietary changes adopted by participants in response to an exercise intervention. Additionally, researchers should consider different intensities and/or frequencies of exercise sessions to match 24-hour Movement Guideline recommendations for daily physical activity. This type of exercise intervention should be feasible, as our participants were able to reach 75% of heart rate reserve with expected RPE values, despite low levels of physical activity at baseline. Studies should also aim for a thorough dietary assessment, taking into account the three main dietary intake parameters considered in this study (i.e. food quantity, diet quality and eating patterns). Furthermore, there is a need to analyze the daily carbohydrate intake of adolescents more thoroughly, with regards to sugar and fibre intake, as well as analyze specific food choices of participants to better understand and interpret changes in dietary intake parameters following an exercise program. A mixed method approach involving a qualitative component would also be pertinent as it would help in understanding nutrition-related knowledge of participants and intentionality of post-exercise dietary changes. This approach would also help explore the behavioural response to an exercise program, which has not been considered in previous studies. Finally, in order to confirm our findings and improve external validity, it is recommended for future studies to have a greater sample size, that would allow for comparison of sub-groups (sex and weight status), covariate analyses, multiple regression analyses with an overall greater statistical power. A larger sample size may also be useful in order to conduct cluster analyses, to identify individual responses to an exercise intervention. Adolescents, their parents and families, teachers, school administration and health professionals may benefit from these findings.

7.5 Conclusions

A decrease in meal size at lunch and dinner, as well as a decrease in total daily carbohydrate intake and shift in eating patterns of participants were observed following the 8-week aerobic exercise program. The exercise program alone was not sufficient to trigger substantial changes in diet quality or eating behaviours. Additionally, changes in meal sizes at breakfast and lunch, energy density at breakfast, daily carbohydrate, protein and fat intake as well as percentage of energy from ultra-processed foods (NOVA group IV) may have especially contributed to the decrease in post-exercise energy intake following the exercise intervention. Some differences in dietary intake parameters were also found at baseline and in response to the aerobic exercise program based on sex and weight status, as well as on post-intervention on exercise days compared to non-exercise days. It is important to note that due to the many factors involved in the relationship between exercise and the diet (i.e. environmental, physiological, behavioural, etc.) as well as due to the study's research design, it is difficult to determine if changes observed in the diet were attributed to the exercise intervention. Therefore, caution may be used when interpreting results observed. Nonetheless, these results contribute to the scientific literature and may help tailor interventions to promote a healthy lifestyle as well as prevent development of obesity and its comorbidities amongst adolescents. More research is needed to confirm these findings and to better understand the mechanisms driving the acute and chronic post-exercise dietary changes.

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APPENDIX I

EUROPEAN CONGRES ON OBESITY 2018 (EUROPEAN ASSOCIATION FOR THE STUDY OF OBESITY), VIENNA, AUSTRIA
MAY 22ND – MAY 26TH, 2018

Average Diet Quality Scores of Inactive Adolescents Was Not Altered by an 8-Week Aerobic Exercise Program

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Intro: Exercise is known to have many health benefits. Studies suggest it may lead to a decrease in energy intake of adolescents, thus playing a role in obesity prevention and management. This may be in part due to changes in macronutrient intake, which was especially observed in adolescents with excess body weight. However, studies remain unclear as to how adolescents modify their diet following the initiation of an exercise program. This study examined the effect of both exercise and weight status on diet quality of previously inactive adolescents.

Methods: A total of twenty-six adolescents, 17 with normal weight (BMI: 20.4±1.9kg/m^2) and 9 with excess body weight (BMI: 29.0±3.6 kg/m^2), participated in an 8-week moderate intensity aerobic exercise program on cycle ergometers. Two 24-hour dietary recalls were completed in pre-intervention and four in post-intervention. Dietary assessments were conducted by dietitians and trained nutrition interns using the Multiple Pass Method and food models. Data were analyzed with ESHA Food Processor software. The Healthy Eating Index adapted to Canadians (HEI-C) was used to assess diet quality of participants. Daily scores were averaged for pre- and post-intervention conditions. Scores were categorized as "good quality diet" (>80%), "diet needing improvement" (50-80%) or "poor quality diet" (<50%). A mixed-method ANOVA was conducted to compare pre- and post-intervention HEI-C scores between adolescents with normal and excess body weight. Friedman's test was also used for data that did not meet normality assumptions.

Results: Average HEI-C scores of adolescents was 59.62 ±12.24% at baseline, which qualifies as "diet needing improvement". There was no significant difference in baseline scores based on weight status or sex. Our analyses also revealed no significant interaction or independent effect of exercise or weight status on HEI-C scores of adolescents ($p>0.05$). When analyzing each components of the HEI-C, scores were not statistically different between pre- and post-intervention conditions ($p>0.05$). However, we observed individual variation in diet quality scores in response to the exercise program (Figure 1). Twenty-seven percent of participants changed diet quality categories following the exercise program. Five of those participants made improvements to their diet ("poor quality diet" to "diet needing improvement") while the other two decreased their adherence to Canadian Food Guide recommendations ("diet needing improvement" to "poor quality diet").

Conclusion: Participation in the 8-week exercise program did not significantly influence the total HEI-C scores of adolescents or any of its components. Our results highlight the need to provide nutrition education to adolescents initiating an exercise program. Future studies should aim for a larger sample size and examine the effect of exercise on other dietary assessment parameters.

HUMAN KINETICS GRADUATE STUDENT ASSOCIATION CONFERENCE,
UNIVERSITY OF OTTAWA, CANADA
APRIL 12, 2018

Can an aerobic exercise program play a role in modidying eating patterns of previously inactive adolescents?

Catherine Pouliot[1,2], Alyssa Biagé[2], Denis Prud'homme[1,2], Isabelle Giroux[3]

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Introduction: Adopting healthy eating habits and an active lifestyle early on in life was found to have preventative effects on obesity. Engaging in exercise may lead to a decrease in energy intake. However, it remains unclear how exercise affects the eating pattern of adolescents with normal and excess weight. This study aimed to evaluate the effect of an aerobic exercise program and weight status on eating frequency, snacking pattern and daily energy distribution of adolescents.

Methods: Twenty-six adolescents (15.28±0.96yrs), 17 normal weight and 9 with excess weight, participated in three 30-minute sessions/week on cycle ergometer for 8 weeks. Diets were assessed using 24-hour recalls, in pre- and post-intervention. Baseline differences in frequency of eating occurrences, snacking and daily energy intake distribution were assessed using independent sample t-tests. Mixed method ANOVA was conducted to assess the effect of the exercise program and weight status on the previously listed variables.

Results: The exercise program lead to a decrease in eating frequency of participants with excess weight ($p=0.01$). All participants significantly decreased the percentage of energy intake consumed as snacks following the intervention ($p=0.002$). Additionally, participants decreased the percentage of energy intake consumed at school ($p=0.04$) and increased the percentage of energy consumed after school ($p=0.05$).

Discussion and Conclusions: Participation in an aerobic exercise program may lead to changes in eating patterns of adolescents. The decrease in energy intake observed in previous studies may be driven by the decrease in daily eating frequency and energy consumed as snacks. More research is needed to support these findings.

OBESITY WEEK 2017 CONFERENCE (THE OBESITY SOCIETY), WASHINGTON DC, USA
OCTOBER 30TH – NOVEMBER 2ND, 2017

The Effect of Exercise on Eating Behaviors of Adolescents with Normal and Excess Body Weight

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Background: Evidence suggests that exercise may lead to changes in eating behaviors, which could help explain subsequent changes in energy intake. Moreover, dietary responses to exercise are thought to differ based on weight status. While these variables have been examined in adults, it remains unclear as to how a long-term exercise intervention elicits a change in eating behaviors of adolescents. This study examined the concomitant effects of an aerobic exercise program and weight status on eating behaviors of inactive adolescents with normal and excess body weight.

Methods: This quasi-experimental study involved seventeen adolescents with normal body weight (BMI: 20.4±1.9kg/m^2) and nine with excess body weight (BMI: 29.0±3.6 kg/m^2) having taken part in an 8-week aerobic exercise program on cycle ergometers. Participants completed the 18-item Three-Factor Eating Behavior Questionnaire (TFEQ-18) to assess cognitive restraint, uncontrolled eating, and emotional eating. A mixed-method ANOVA was used to compare pre- and post-intervention TFEQ-18 scores between adolescents with normal and excess body weight. Statistical analyses were adjusted for sex.

Results: No statistically significant interaction was found between exercise and weight status for cognitive restraint ($p=0.95$), uncontrolled eating ($p=0.88$) or emotional eating ($p=0.52$). There was also no effect of the exercise intervention on any of the previously mentioned eating behaviors ($p>0.05$). Weight status did not statistically influence uncontrolled eating ($p=0.27$) or emotional eating ($p=0.62$). However, we observed that adolescents with normal body weight had greater cognitive restraint than those with excess body weight ($p=0.008$, $\eta^2=0.27$).

Conclusion: An 8-week aerobic exercise program did not elicit changes in eating behaviors of adolescents. However, weight status was found to affect cognitive restraint. Studies with a greater sample size are needed to further investigate the effect of exercise on eating behaviors of adolescents.

APPENDIX II

Université d'Ottawa · University of Ottawa
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Faculty of Health Sciences · School of Human Kinetics

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Hôpital Montfort

Un hôpital d'enseignement affilié à l'Université d'Ottawa
A teaching hospital affiliated with the University of Ottawa

Information Sheet and Consent Form

AN AEROBIC EXERCISE PROGRAM IN ADOLESCENTS

1. GENERAL INFORMATION

Student:
Alyssa Biagé (M.Sc. candidate)
School of Human Kinetics, Faculty of Health Sciences, University of Ottawa
Institut de Recherche de l'Hôpital Montfort (IRHM), Institut du savoir Montfort.
Supervisor:
Denis Prud'homme (M.D., M.Sc.)
School of Human Kinetics, Faculty of Health Sciences, University of Ottawa
Institut de Recherche de l'Hôpital Montfort (IRHM), Institut du savoir Montfort.
Co-supervisor:
Isabelle Giroux (PhD, RD, BÉd, ÉFI)
School of Nutrition Sciences, Faculty of Health Sciences, University of Ottawa
Institut de Recherche de l'Hôpital Montfort (IRHM), Institut du savoir Montfort.

Emergency Contact: Dr. Denis Prud'homme.

Funding Sources: Institut de recherche de l'Hôpital Montfort

Conflicts of Interest: There are no apparent or potential conflicts of interest in this project and no disclosure of the likelihood of marketing the results.

2. INTRODUCTION

Before agreeing to participate in this research project, please take the time to read and carefully consider the following information. This document explains the goal of the research project, its procedures, benefits, risks and drawbacks. Please ask any questions you consider relevant to Alyssa Biagé, master candidate in Human Kinetics and principal researcher of this research project.

3. INVITATION TO PARTICIPATE

You are being asked to participate in the above-named research project conducted by Alyssa Biagé (M.Sc. canditate) of the University of Ottawa (School of Human Kinetics, Faculty of Health Sciences) and of the IRHM, Institut du savoir Montfort under the supervision of Denis Prud'homme (M.D., M.Sc.) and the co-supervision of Isabelle Giroux (*PhD, RD, BÉd, ÉFI*) of the University of Ottawa (Faculty of Health Sciences) and the IRHM, Institut du savoir Montfort.

You are free to participate in this study or not. Your decision to participate or withdraw from the study will not affect the quality of service now being provided to you now, or that which may be provided to you in the future in any way at the Collège Saint-Alexandre and at the Hôpital Montfort.

It is possible that this letter includes words and expressions that you do not understand or that might raise questions. If it is the case, do not hesitate to tell us. Take all the time you need to take your decision.

4. PURPOSE

The purpose of the study is to document the participation of adolescents in an 9-week aerobic exercise program on a stationary bike supervised by an exercise specialist.

5. INCLUSION/EXCLUSION CRITERIA

To be a participant in the study you must be: an adolescent boy and girl aged 14–18 years.

You will not be able to participate in this study if you:

- Answer yes at one of the questions of the Physical Activity Readiness Questionnaire,
- participated in a regular program of exercise or sports more than 2 times per week for at least 60 minutes per session during the previous 4 months,
- have diabetes mellitus, asthma at rest and/or during exercise,
- went through a significant weight change (+/- 2 kg) in the last 2 months, or
- have physical activity restrictions due to a disease, severe premenstrual syndromes, or being pregnant,
- daily medication consumption prescribed by a doctor,
- Have allergies to milk product or to gluten.

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6. PARTICIPATION

Your participation will essentially consist of participating in an aerobic exercise program on stationary bike, that will take place at the Collège Saint-Alexandre, for 9 weeks (30 minutes, 3 times per week), during which your attendance will be documented. You will also be asked to attend two sessions of testing (measuring your resting heart rate, your body composition, your energy expenditure at rest and during sub-maximal exercise) of 3 hours at the Hôpital Montfort (before and after the exercise program). Moreover, a measure of your daily energy expenditure (at rest, during physical activities and exercise) and your energy intake (food and drink consumption), twice before and four times after the exercise program, will be done. A total of 3 months will be needed to complete the study. The procedure is clearly detailed on page 3. In addition, a summary table and a figure of the measurements can be found below.

Table. Summary table of the measurements and an estimation of the duration needed for each meeting during the study

Measurements	Meetings at school	Two meetings at Montfort (Pre- and Post-exercise program)	Full week of data collection (Pre- and Post-exercise program)
Duration	30 min for each measurements x 7 meetings = 3 hours and 30 minutes total	3 hours per meeting x 2 meetings = 6 hours total	7 days x 2 weeks = 14 days total By wearing an accelerometer daily
Informed consent and Physical Activity Readiness Questionnaire	X (Initial meeting)		
Resting heart rate		X	
Body composition		X	
Resting energy expenditure		X	
Energy expenditure during sub-maximal exercise		X	
Daily energy expenditure (wearing the accelerometer)			X
Daily energy intake (24-h dietary recalls)	X (Pre-exercise program = 2 x 30 min Post-exercise program = 4 x 30 min)		

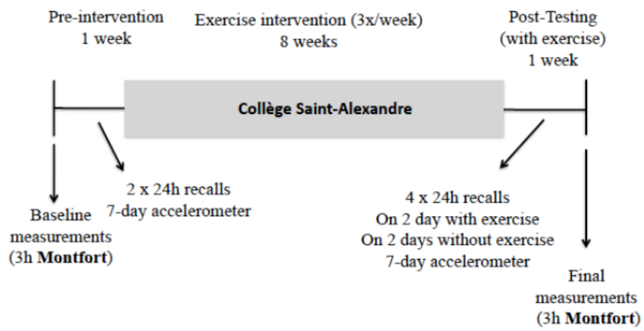


Figure. Evaluation and intervention activities' sequence during the study

Pre-testing sessions

Session at Montfort: Resting heart rate, body composition, energy expenditure at rest and during sub-maximal exercise

Your resting heart rate (number of beats per minute of your heart), body composition (amount of fat mass and muscle mass, % body fat), resting energy expenditure (the energy expend lying on your back on a bed) and the energy you expend during a sub-maximal exercise will be measured at the Nutrition and Metabolism Laboratory (1E109) at IRHM. The sub-maximal test will be preceded by a standardized breakfast (detailed on page 4). The testing sessions at the laboratory will be performed during weekends.

Following week: Energy expenditure and energy intake

After that session at the IRHM, you will have to wear an accelerometer, a small device worn on your belt on your right hip, for 7 consecutive days to measure your physical activity.

During that same week, your daily energy intake (consumption of food and drinks) will also be measured using 24-hour dietary recalls. Alyssa Biagé, Alexandra Maria Bodnaruc, Catherine Pouliot or another nutritionist will ask you twice what you have eating and drank in the last 24 hours. The dietary recalls will be performed at your high school (Collège Saint-Alexandre). You will have to return the accelerometer to Alyssa Biagé the following week at your first training session at school.

The aerobic exercise program

After the Pre-testing sessions, you will start an 9-week aerobic exercise program. In the presence of an exercise specialist (Alyssa Biagé), you will perform 30 minutes of exercise on a stationary bike three times per week between 50% and 75% of your estimated maximal heart rate. The exercise specialist will guarantee proper technique and safety. Your heart rate will be recorded with a heart rate monitor (Polar Electro Oy, Kempele, Finland) worn on your left wrist during each exercise session to make sure you exercise at the prescribe intensity. The exercise sessions will be held at your school, either at lunch or after school (at 4:00 PM).

Post-testing sessions

The tests taken during the Pre-testing sessions will be redone at the end of the aerobic exercise program. You will return at the Hôpital Montfort to measure your resting heart rate, body composition and resting energy and sub-maximal exercise energy expenditure. A week will also be needed to measure your daily physical activity and your daily food consumption (four 24-hour dietary recalls) before the evaluation session at Hôpital Montfort. You will continue the exercise program during that week until all the post-tests are completed.

The Pre- and Post- testing program session at Hôpital Montfort - Protocol

You will need to fast for 12 hours prior to your scheduled visit (no food, but water will be allowed), to not perform moderate or vigorous exercise or sport for at least 36 hours and to not take any medication (like Advil or Tylenol) 12 hours before your visit at the Laboratory. You will be asked to arrive in physical education apparel with exercise shoes.

1. **Arrival at the IRHM -** Alyssa Biagé and her research assistant (Émilie Mallet, Thamid Ahmed or Catherine Pouliot) will greet you at the Nutrition and Metabolism Laboratory.

2. **Body composition (10 min)** – Your body composition will be measured by bioimpedance (measurement of fat mass and muscle mass with a non-evasive courant). Bioimpedance is a very safe procedure. You will be asked to remove all metal and electronic devices from your clothing and body before the exam (such as watch, jewellery, cellular phone, etc). After, you will be asked to step on the platform (without shoes and socks) and stand on it for one minute without moving.

3. **Resting energy expenditure (1h)** - You will be required to lie down on your back on a bed for 20 minutes. Afterwards, you will stay in this position for 30 minutes during which time a measurement of your resting energy expenditure will be performed. You will breathe normally under a bubble connected to a computer. The computer will measure the amount of certain gases in the air you breathe in and out. You will be asked to stay awake and to move as little as possible during the test.

4. **Resting heart rate measurements (5 min)** – Your heart rate (number of heart beats per minute of your heart) at rest will be measured three times after sitting down for 5 minutes with a heart rate monitor (Polar Electro Oy, Kempele, Finland) on your left wrist.

5. **Standardized Breakfast (20 min)** - A standardized breakfast will be served (575 kcal (2400 kJ) (57% carbohydrates, 13% proteins, 30% lipids)). The breakfast will consist of two slices of whole wheat bread (80 g), raspberry jam (20 g), cheddar cheese 27% milk fat (20 g) and orange juice (225 ml). The breakfast will need to be eaten within 10 minutes.

6. **Questionnaires (15 min)** - You will have to fill out three questionnaires: the "International Physical Activity Questionnaire", the Tanner stage questionnaire (only in the pre-testing) and the Lifestyle Questionnaire.

7. **Energy expenditure during a sub-maximal exercise test (20 min)** – Following a 5-minute warm-up at 50% of your maximal heart rate on a stationary bike, you will be invited to exercise between 4 to 6 minutes at 75% of your maximal heart rate. The target exercise heart rate (exercise intensity) will be calculated by Alyssa Biagé. Your heart rate will be measured every minute with the Polar watch. You will breathe through a mouthpiece (disinfected) connected to a computer. The computer will measure the amount of certain gases in the air you breathe in and out. You will wear a nose clip so that no air escapes through your nose.

8. **Accelerometer (10 min) (Only in the pre-testing)** - All instructions relating to the use the accelerometer will be explained in detail before you leave the laboratory.

7. BENEFITS

Your participation in this research will give you:

- The chance to exercise on the stationary bike under the supervision of an exercise specialist;
- The chance to receive a Polar watch at the end of the study if you participate to more than 80% of the study;
- The possibility to improve your level of cardiorespiratory fitness and even your health status,

- The opportunity to receive personal information, at the end of the study, related to the different measurements performed and recommendations on your future exercise practices;
- Access to reliable resources on physical activity (Canadian physical activity recommendations for youth) and nutrition (Eating well with Canada's Food Guide); and
- The opportunity to contribute by your participation to advance knowledge in the field of exercise.

8. RISKS

You understand that since your participation in this research requires to do a small amount of exercise during the testing sessions and the aerobic exercise program (3 times a week for 9 weeks), there is some possibility that it could result in some discomfort. The methods used in this protocol have been designed to minimize the risks. In addition, these methods are widely used in exercise research studies and generally recognized to be safe. Furthermore, the testing procedures will be explained to you in detail by Alyssa Biagé in the presence of a research assistant. In fact, the low risk associated to this project are the same as those associated with the practice of physical activity.

The sub-maximal exercise test is a common procedure in physical exercise laboratory and it is associated with minimal risks, considering the intensity (low to moderate) and the duration of exercise (10 minutes). The test will be monitored by an exercise specialist (Alyssa Biagé) and a research assistants and will be stopped in case of problems. The discomfort you may experience could include symptoms and/or signs such as shortness of breath, fatigue, local muscle discomfort, fainting, dizziness or chest pain.

Moreover, there are some risks of discomfort with the instrumentation that will be used (i.e. the mask and the bubble used to measure oxygen consumption and carbon dioxide production, the nose-clip), which are frequently used in exercise physiology research studies and are normally well tolerated by the majority of the participants.

A first aid kit will be readily available if needed at the Nutrition and Metabolism Laboratory and at the High School for each session (and an automatic external defribrillator (AED) device is available at the Laboratory only) and the emergency procedure will be follow if needed. Alyssa Biagé, is an exercise specialist trained in cardiopulmonary resuscitation (CPR) and exercise testing. She will be assisted at all time by a research assistant during the testing and aerobic exercise session.

During the aerobic exercise program, you might experience fatigue, muscular cramps, tendon or ligament pain or inflammation, dizziness, or chest pain. Again, the risks of occurrence of these signs/symptoms are relatively low, considering the exercise intensity (low to moderate). All the exercise session will be under the supervision of Alyssa Biagé, an exercise specialist and research assistants.

9. DATA CONSERVATION

During the course of this study, Alyssa Biagé and the research assistants will collect and record in a research paper file your information. The data include your results to the different tests, your lifestyles habits (physical activity, nutritional and sleep habits) and your participation (attendance at the exercise sessions) to the aerobic exercise program.

The data gathered will be kept in a secure manner. Data gathered on paper will be kept in the Nutrition and Metabolism Research Laboratory in locked file cabinets and the electronic version will be saved on the REDcap database housed on the secure server of Hôpital Montfort. Only the researchers mentioned above and the research assistant will have access to your data. The data collected in this study will be submitted for publication in scientific journals and conferences. It will be impossible to identify you in those articles and data presentation. The data will be kept for a period of 10 years post-publication and will subsequently be destroyed according to the secure protocol of documents' destruction in effect at Montfort (paper files) or deleted (electronic file).

10. CONFIDENTIALITY AND ANONYMITY

You have the researcher's assurance that any information you share with the research team members will be kept strictly confidential, except if the law force them to. You have the assurances that no record identifying you, by name or initials, for example, will be permitted to leave the Nutrition and Metabolism Laboratory. Only the researchers mentioned above and the research assistant will have access to your data. You are encouraged to request and discuss your test results with Alyssa Biagé at the end of the study.

We will protect the confidentiality of your personnel information and the research data by attributing you a numeric code (serial number). Every document that contains your information and your preliminary data will be identified with this numeric code. The list that links your name to your participant's code will be stored, in a lock area, separately from the data collected. As such, no one will be able to identify you as your name will not appear on these files.

11. VOLUNTARY PARTICIPATION

Your participation in the study is voluntary. You can decide to not participate in this study. If you decide to participate, you are free to withdraw at any time or to refuse to answer certain questions or to refuse to perform a test, without exposing yourself to any negative consequences. If you decide to withdraw from the study, you need to make sure that you inform Alyssa Biagé about your withdrawal, but you are not required to provide any explanation. She will ask you and your guardian if we can use your data gathered up to that time for analysis. If this request is denied, your data will be destroyed or deleted.

You understand that you can not participate in that study if you don't have your parent/guardian's approval.

12. REIMBURSEMENT/COMPENSATION

The parking at the Hôpital Montfort will be free for the participants. A parking pass will be provided to cover the parking fee. The heart rate monitor (Polar watch, about 70$) that you will used during the aerobic exercise sessions will be handed to you if you have attended 80 % and more of the prescribe aerobic exercise sessions and the post-testing session.

13. NOTIFICATION OF RESULTS

You will receive a report including your personal data on the following measurement: resting heart rate, body composition, resting energy expenditure, sub-maximal exercise energy expenditure, daily energy expenditure and intake with a simple and comprehensible description. After the end of the project, you will be able and invited to ask question or discuss your results with Alyssa Biagé. You will also be able to contact the research team to obtain information about the progress of the research.

14. CIVIL LIABILITY

Your consent to participate in this study does not affect your right to seek legal recourse in any manner whatsoever. If your participation in this study causes you any prejudice, you reserve the right to take any available legal recourse against the various research partners.

15. CONTACT PERSON

Alyssa Biagé (B.Sc. M.Sc. candidate)
Denis Prud'homme (M.D., M.Sc.)
Isabelle Giroux (PhD, RD, BÉd, ÉFI)

For information concerning ethical aspects of this research, you may contact the Hôpital Montfort Research Ethics Board, 745-A Montreal Road, Ottawa, Ontario by telephone at 613-746-4621, extension 2221, or by email at ethique@montfort.on.ca, or the University of Ottawa Office of Research Ethics and Integrity, 550 Cumberland (Tabaret Hall), room 154, Ottawa, Ontario, by telephone at 613-562-5387, or by email at ethics@uottawa.ca.

Hôpital **Montfort**

Institut de recherche

Université d'Ottawa · University of Ottawa

16. CONSENT

Acceptance:

I, ______________________________, agree to participate in this research project conducted by *Alyssa Biagé (B.Sc., M.Sc. candidate)* under the supervision of *Denis Prud'homme (M.D., M.Sc.) and Isabelle Giroux (PhD, DtP, BÉd, ÉFI)*. For any further information concerning this study, please contact the researcher or the researcher's supervisors.

We will give you the consent form and the information sheet, the researcher will keep the last page with the signatures in his files.

Participant's Signature: ______________________________ Date: ______________

Researcher's Signature: ______________________________ Date: ______________

For parent/guardian:
I understand the nature and the progression of study. I have read this consent form and I have a copy to keep. I had the occasion to ask questions from which I got clear answers. After reflection, I, ______________________________, accept that my child take part of this project.

Parent's Signature: ______________________________ Date: ______________

Researcher's Signature: ______________________________ Date: ______________

APPENDIX III

713, chemin Montréal Road, Ottawa, ON K1K 0T2
Tél./Tel. : 613-746-4621 Téléc./Fax : 613-748-4914
hopitalmontfort.com

Hôpital Montfort

Un hôpital d'enseignement affilié à l'Université d'Ottawa
A teaching hospital affiliated with the University of Ottawa

Avis d'approbation éthique
Comité d'éthique de la recherche de l'Hôpital Montfort

Le 21 septembre 2015

Chercheuse principale :

Alyssa Biagé
École des Sciences de l'activité physique,
Université d'Ottawa
Institut de Recherche de l'Hôpital Montfort (IRHM)
Institut du savoir Montfort.

Superviseur :

Dr Denis Prud'Homme
École des Sciences de l'activité physique
Université d'Ottawa
Institut de Recherche de l'Hôpital Montfort (IRHM),
denisprudhomme@montfort.on.ca

Co-superviseur

Isabelle Giroux
École des sciences de la nutrition
Faculté des sciences de la santé
Université d'Ottawa
igiroux@uottawa.ca

Titre du projet : « La participation d'adolescents dans un programme d'exercice aérobie de 8 semaines sur vélo stationnaire supervisé par un spécialiste de l'exercice »

Numéro du dossier : AB-14-08-15

Date de début : 21 septembre 2015

Date de fin : 20 septembre 2016

En conformité avec l'Énoncé de politique des trois conseils — Éthique de la recherche avec des êtres humains (ÉPTC 2), décembre 2014, le Conseil canadien des normes, les bonnes pratiques cliniques : directives consolidées, Conférence internationale sur l'harmonisation des exigences techniques relatives à l'homologation des produits pharmaceutiques à usage humain (ICH-GCP E6), la Loi de 2004 sur la protection des renseignements personnels sur la santé, les lois et règlements applicables en Ontario, je confirme que le Comité d'éthique de la recherche (CÉR) de l'Hôpital Montfort a étudié et approuvé votre demande d'approbation éthique pour une période d'un an pour les documents suivants :

- Message de recrutement (verbal)
- Script téléphonique et formulaire d'inclusion et d'exclusion / Initial screener form (FR et EN)
- Formulaire de renseignement et de consentement (FR et EN), version datée du 16 septembre 2015
- Questionnaire sur l'aptitude à l'activité physique_Q-AAP / PAR-Q (FR et EN)
- Visite à l'Hôpital Montfort (Pré et post) :
- Documents de mesures, questionnaires et fiches d'information suivants :
  - Anthropométrie et composition corporelle
  - Dépense énergétique au repos
  - Fréquence cardiaque au repos

- Déjeuner standard
    - Questionnaires :
        - Questionnaire international d'activité physique
        - Stades de Tanner (Taylor & al, 2001)
        - Habitudes de vie (Katzmarzyk & al, 2013).
    - Dépense énergétique à l'effort sous-maximal
    - Fiche d'information pour l'accéléromètre
- Formulaire de la dépense énergétique quotidienne par accéléromètre (pré et post) et formulaire de l'apport énergétique quotidien à l'aide du rappel de 24h (pré et post)
    - Fiche d'information pour les rappels de 24 heures (Blanchard, 2015)
- Fiche de présence lors des séances d'entraînement

Le CÉR de l'Hôpital Montfort est constitué et exerce ses activités d'une manière conforme à la Loi sur les aliments et les drogues et aux règlements applicables, à l'ÉPTC2, les bonnes pratiques cliniques, la Loi de 2004 sur la protection des renseignements personnels sur la santé ainsi qu'aux Code of Federal Regulations des États-Unis.

Le protocole de l'étude ne peut être modifié sans une approbation préalable du CÉR sauf s'il est question de la sécurité immédiate des participants ou de logistique administrative comme un changement de numéro de téléphone. Vous devez aviser le CÉR immédiatement de tout changement, événement indésirable ou nouvelle information pouvant augmenter le risque de l'étude, modifier le cours de l'étude ou atteindre la sécurité des participants. Les modifications au projet et aux outils de recrutement doivent être soumises au CÉR.

Veuillez nous acheminer **quatre semaines avant la date d'échéance de cet avis d'approbation**, un rapport final afin de fermer le dossier ou de faire une demande de renouvellement du certificat d'approbation éthique de l'étude.

Si vous avez des questions, vous pouvez communiquer avec le bureau du CÉR de l'Hôpital Montfort au 613-746-4621, poste 2221 ou par courriel au ethique@montfort.on.ca.

Lynn Casimiro, Pht., Ph. D.
Présidente du Comité d'éthique de la recherche — Hôpital Montfort

Université d'Ottawa University of Ottawa
Bureau d'éthique et d'intégrité de la recherche Office of Research Ethics and Integrity

October 29, 2015

Alyssa Biagé
School of Human Kinetics
Faculty of Health Sciences

Supervisors: Denis Prud'Homme, University of Ottawa and the Institut de Recherche de l'Hôpital Montfort.
Isabelle Giroux, University of Ottawa and the Institut de Recherche de l'Hôpital Montfort.

Re: U of O Ethics file no. A09-15-04 – "Effects of an 8-week aerobic exercise program on daily energy expenditure and energy intake in adolescents"

Dear Ms. Biagé, Dr. Prud'Homme and Professor Giroux,

Thank you for the protocol documents and Certificate of Approval from the Montfort Hospital's REB (file # AB-14-08-15) for your project named above.

This is to confirm that, in accordance with the agreement between the University of Ottawa and the Montfort Hospital's REB, the University of Ottawa has authorized this board to act as Board of Record for the review and oversight of research involving human subjects conducted at or through the hospital.

We remind you of your obligation to:

- Follow all procedures of the Montfort Hospital's REB including reporting and renewal procedures;
- Submit to the authority of the Montfort Hospital's REB and that you are subject to the Montfort Hospital's REB requirements, including, without limitation, the requirement to modify or stop the research on demand of the Montfort Hospital's REB.

If you have any questions, please contact our ethics office at 562-5387.

Sincerely yours,

Catherine Paquet
Director
Office of Research Ethics and Integrity

550, rue Cumberland 550 Cumberland Street
Ottawa (Ontario) K1N 6N5 Canada Ottawa, Ontario K1N 6N5 Canada

(613) 562-5387 • Téléc./Fax (613) 562-5338
http://www.recherche.uottawa.ca/deontologie/
http://www.research.uottawa.ca/ethics/

APPENDIX IV

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

Nous nous intéressons aux différents types d'activités physiques que vous faites dans votre vie quotidienne. Les questions suivantes portent sur le temps que vous avez passé à être actif physiquement au cours des **7 derniers jours**. Répondez à chacune de ces questions même si vous ne vous considérez pas comme une personne active. Les questions concernent les activités physiques que vous faites au lycée, lorsque vous êtes chez vous, pour vos déplacements, et pendant votre temps libre.

Bloc 1 : Activités intenses des 7 derniers jours

1. Pensez à toutes les **activités intenses** que vous avez faites au cours des **7 derniers jours**.
Les activités physiques intenses font référence aux activités qui vous demandent un effort physique important et vous font respirer beaucoup plus difficilement que normalement. Pensez seulement aux activités que vous avez effectuées pendant **au moins 10 minutes d'affilée.**

1-a. Au cours des **7 derniers jours**, **combien y a-t-il eu de jours** au cours desquels vous avez fait des **activités physiques intenses** comme porter des charges lourdes, bêcher, faire du VTT ou jouer au football ?

|__|__| **jour(s)**

❒ Je n'ai pas eu d'activité physique intense ➲ ***Passez au bloc 2***

1-b. Au total, combien de **temps** avez-vous passé à faire des **activités intenses au cours des 7 derniers jours ?**

|__|__| **heure(s)** |__|__| **minutes**

❒ Je ne sais pas

Bloc 2 : Activités modérées des 7 derniers jours

2. Pensez à toutes les **activités modérées** que vous avez faites au cours des **7 derniers jours**.
Les activités physiques modérées font référence aux activités qui vous demandent un effort physique modéré et vous font respirer un peu plus difficilement que normalement. Pensez seulement aux activités que vous avez effectuées pendant **au moins 10 minutes d'affilée.**

2-a. Au cours des **7 derniers jours**, **combien y a-t-il eu de jours** au cours desquels vous avez fait des **activités physiques modérées** comme porter des charges légères, passer l'aspirateur, faire du vélo tranquillement ou jouer au volley-ball ? Ne pas inclure la marche.

|__|__| **jour(s)**

❒ Je n'ai pas eu d'activité physique modérée ➲ ***Passez au bloc 3***

2-b. Au total, combien de **temps** avez-vous passé à faire des **activités modérées au cours des 7 derniers jours ?**

|__|__| **heure(s)** |__|__| **minutes**

❒ Je ne sais pas

Bloc 3 : La marche des 7 derniers jours

3. Pensez au temps que vous avez passé à **marcher au moins 10 minutes d'affilée** au cours des **7 derniers jours**.
Cela comprend la marche au lycée et à la maison, la marche pour vous rendre d'un lieu à un autre, et tout autre type de marche que vous auriez pu faire pendant votre temps libre pour la détente, le sport ou les loisirs.

3-a. Au cours des **7 derniers jours**, **combien y a-t-il eu de jours** au cours desquels vous avez marché pendant **au moins 10 minutes d'affilée.**

└─┴─┘ **jour(s)**

❒ Je n'ai pas fait de marche ➲ ***Passez au bloc 4***

3.b. Au total, combien d'épisodes de marche d'au **moins 10 minutes d'affilée**, avez-vous effectué au cours des **7 derniers jours** ?

└─┴─┴─┴─┘ **nombre d'épisodes de 10 minutes d'affilée**

Exemples :

Lundi :	1 marche de 60 minutes		6 épisodes
Mardi :	1 marche de 20 minutes et 3 marches de 5 minutes		2 épisodes
Mercredi :	1 marche de 35 minutes		3 épisodes
Jeudi :	1 marche de 8 minutes		0 épisode
Vendredi :	1 marche de 6 minutes puis 3 marches de 4 minutes	→	0 épisode
Samedi :	1 marche de 18 minutes		1 épisode
Dimanche :	1 marche de 10 minutes et 3 marches de 5 minutes		1 épisode
		Total	13 épisodes

❒ Je ne sais pas

Bloc 4 : Temps passé assis au cours des 7 derniers jours

4. La dernière question porte sur **le temps que vous avez passé assis** pendant les jours de semaine, au cours des **7 derniers jours**. Cela comprend le temps passé assis au lycée, à la maison, lorsque vous étudiez et pendant votre temps libre. Il peut s'agir par exemple du temps passé assis à un bureau, chez des amis, à lire, à être assis ou allongé pour regarder la télévision, devant un écran.

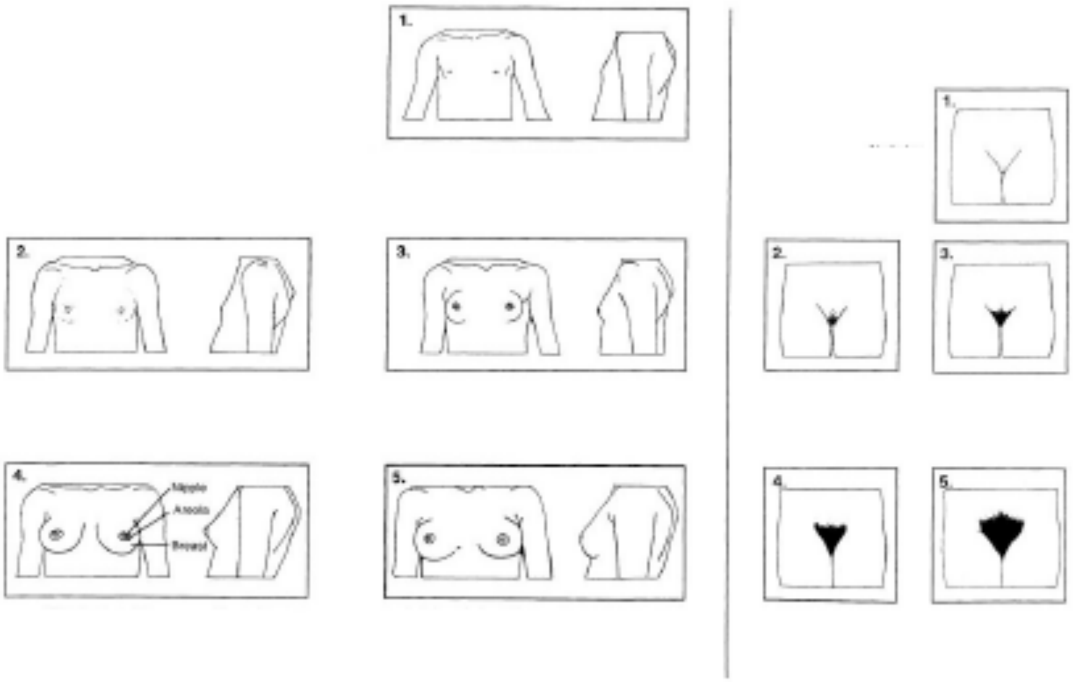
4-a. Au cours des **7 derniers jours**, pendant les jours de semaine, **combien de temps**, en moyenne, avez vous passé **assis** ?

└─┴─┘ **heure(s)** └─┴─┘ **minutes**

❒ Je ne sais pas

TANNER STAGES

Mettre un X sur l'image qui vous représente le plus présentement.



Date de la dernière menstruation : Du _______________ au __________________

WEIGHT PERCEPTION

Réponds à ces questions sincèrement.

Entreprends-tu des démarches spécifiques présentement pour…

1. … Perdre du poids? ☐ Oui ☐ Non
2. … Maintenir ton poids? ☐ Oui ☐ Non
3. … Prendre du poids (ex. masse musculaire)? ☐ Oui ☐ Non

Si oui, précise le type de moyen(s)? ____

ETHNIC ORIGIN

Êtes-vous: 1 : Blanc / **2** : Sud-Asiatique (p. ex., Indien de l'Inde, Pakistanais, Sri-Lankais, etc.) /

3 : Chinois / **4** : Noir / **5** : Philippin / **6** : Latino-Américain / **7** : Arabe / **8** : Asiatique du Sud-Est (p. ex., Vietnamien, Cambodgien, Malaisien, Laotien, etc.) / **9** : Asiatique occidental (p. ex., Iranien, Afghan, etc.) / **10** : Coréen / **11** : Japonais

12 : Autre – Précisez : ____

ISCOLE QUESTIONNAIRE

Pour les questions 1 à 4, dites-nous ce que vous avez fait la semaine passée?

1. Pendant une journée d'école (de semaine), combien d'heures de télévision avez-vous visionnées?

☐ Aucun ☐ < 1 heure ☐ 1 heure ☐ 2 heures ☐ 3 heures ☐ 4 heures ☐ 5 heures ou plus

de télévision lors de journées d'école

2. Pendant une journée d'école (de semaine), combien d'heures avez-vous passé à jouer un jeux vidéo ou un jeu d'ordinateur ou utiliser l'ordinateur pour une raison autre que vos travaux d'école?

☐ Aucun ☐ < 1 heure ☐ 1 heure ☐ 2 heures ☐ 3 heures ☐ 4 heures ☐ 5 heures ou plus

à jouer un jeux vidéo ou un jeu d'ordinateur ou à utilisé l'ordinateur pour une raison autre que vos travaux d'école?

3. Pendant une journée de fin de semaine, combien d'heures de télévision avez-vous visionnées?

☐ Aucun ☐ < 1 heure ☐ 1 heure ☐ 2 heures ☐ 3 heures ☐ 4 heures ☐ 5 heures ou plus

de télévision lors de journées de fin de semaine

4. Pendant une journée de fin de semaine, combien d'heures avez-vous passé à jouer un jeux vidéo ou un jeu d'ordinateur ou utiliser l'ordinateur pour une raison autre que vos travaux d'école?

☐ Aucun ☐ < 1 heure ☐ 1 heure ☐ 2 heures ☐ 3 heures ☐ 4 heures ☐ 5 heures ou plus

à jouer un jeux vidéo ou un jeu d'ordinateur ou à utilisé l'ordinateur pour une raison autre que vos travaux d'école?

5. Lors de la dernière semaine, à quelle heure avez-vous, en moyenne, fermer les lumières pour aller vous coucher et dormir lors des journées d'école (durant la semaine)?

☐☐:☐☐ AM / PM (encerclez AM or PM)

6. Lors de la dernière semaine, à quelle heure vous êtes-vous, en moyenne, réveillez le matin lors des journées d'école (durant la semaine)?

☐☐:☐☐ AM / PM (encerclez AM or PM)

7. Lors de la dernière semaine, à quelle heure avez-vous, en moyenne, fermer les lumières pour aller vous coucher et dormir lors des journées de fin de semaine?

☐☐:☐☐ AM / PM (encerclez AM or PM)

8. Lors de la dernière semaine, à quelle heure vous êtes-vous, en moyenne, réveillez le matin lors des journées de fin de semaine?

☐☐:☐☐ AM / PM (encerclez AM or PM)

9. Lors de la semaine passée, comment qualifierais-tu la **qualité** de ton sommeil en somme? (Comment dors-tu?)

☐ Très bien ☐ Bien ☐ Mauvais ☐ Très mauvais

10. Lors de la semaine passée, comment qualifierais-tu la **quantité** de ton sommeil en somme?

☐ Très bien ☐ Bien ☐ Mauvais ☐ Très mauvais

11. Avez-vous une télévision dans votre chambre?

☐ Oui ☐ Non

12. À quelle fréquence, en moyenne, regardez-vous cette télévision par semaine (combien de fois par semaine regardez-vous cette télévision) ?

____________ fois par semaine

18-ITEM THREE FACTOR EATING BEHAVIOUR QUESTIONNAIRE

Partie 1

1. Je choisis volontairement de manger des petites portions d'aliments afin de contrôler mon poids.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

2. Je m'abstiens volontairement de manger aux repas afin d'éviter de prendre du poids.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

3. Je ne mange pas certains aliments, car ils me font prendre du poids.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

4. À quelle fréquence évitez-vous de manger des aliments qui vous semblent tentants ?

□ Presque jamais □ Parfois □ La plupart du temps □ Presque toujours

5. À quel point avez-vous tendance à consciemment manger moins que vous le désiriez ?

□ Presque jamais □ Parfois □ La plupart du temps □ Presque toujours

6. Sur une échelle de 1 à 8, où 1 signifie aucune restriction alimentaire (manger ce que vous voulez, lorsque vous voulez), et 8 signifie une restriction importante (vous limitez constamment votre apport alimentaire et refusez de succomber aux tentations), quel numéro vous donnerez-vous ?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8

Partie 2

1. Lorsque je sens l'odeur d'un steak en train de cuire ou lorsque je vois un beau morceau de viande, il m'est très difficile de ne pas manger même si je sors de table.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

2. Parfois, lorsque je commence à manger, je n'arrive pas à m'arrêter.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

3. Être avec quelqu'un qui mange me donne souvent envie de manger aussi.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

4. Lorsque je vois un délice, je commence souvent à avoir tellement faim que je dois manger tout de suite.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

5. J'ai souvent si faim que mon estomac semble être un puits sans fond.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

6. J'ai toujours faim donc il est difficile pour moi d'arrêter de manger avant d'avoir fini mon assiette.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

7. J'ai toujours assez faim pour manger à n'importe quel moment.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

8. À quelle fréquence avez-vous faim?

□ Seulement aux moments des repas □ Parfois entre les repas □ Souvent entre les repas □ Presque en tout temps

9. Est-ce qu'il vous arrive de manger de grandes quantités d'aliments même si vous n'avez pas faim?

□ Jamais □ Rarement □ Parfois □ Au moins une fois par semaine

Partie 3

1. Lorsque je suis anxieux, il m'arrive souvent de manger.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

2. Lorsque je me sens déprimé, je mange souvent trop.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

3. Lorsque je me sens seul, je me console en mangeant.

□ Définitivement vrai □ Souvent vrai □ Souvent faux □ Définitivement faux

GENERAL NUTRITION QUESTIONNAIRE

1. **1.** Souffrez-vous d'allergie à certains aliments (ex. allergie aux arachides, aux fruits de mer, etc.)?

□ Oui □ Non

Si oui, quels aliments?

2. Souffrez-vous d'intolérance à certains aliments (ex. intolérance au lactose, aux produits laitiers, au gluten, etc.)?

□ Oui □ Non

Si oui, quels aliments?

3. Souffrez-vous de maladie(s) qui affectent votre digestion (ex. maladie cœliaque, maladie intestinale comme la maladie de Crohn, etc.)?

□ Oui □ Non

Si oui, laquelle ou lesquelles?

4. Suivez-vous une diète particulière à cause de votre état de santé (ex. sans gluten, sans lactose, etc.) de façon régulière?

Oui □ Non □

Si oui, quel type de diète?____

5. Suivez-vous une diète particulière à cause de votre religion ou vos croyances (ex. végétarienne, sans porc, etc.) de façon régulière?

Oui □ Non □

Si oui, quel type de diète?____

6. Suivez-vous une diète particulière à cause de vos préférences alimentaires (ex. sans poisson, sans sel, sans produits animaux, etc.) de façon régulière?

Oui □ Non □

Si oui, quel type de diète?____

7. Modifiez-vous votre alimentation à cause de traitement dentaire (ex. appareil d'orthodontie, etc.)?

Oui □ Non □

Si oui, comment modifiez-vous votre alimentation?_

8. Prenez-vous des suppléments nutritionnels (ex. multivitamine, fer, protéines, etc.) de façon régulière chaque jour?

Oui □ Non □

Si oui, quel est le nom du (des) supplément(s) ?____

9. Prenez-vous des médicaments de façon régulière ?

Oui □ Non □

Si oui, quel est le nom du (des) médicament(s) : ____

EATING HABIT AND FOOD FREQUENCY QUESTIONNAIRE

1. En général, diriez-vous que vos habitudes alimentaires sont…?
    a. Excellentes
    b. Très bonnes
    c. Bonnes
    d. Ni bonnes, ni mauvaises
    e. Mauvaises
    f. Très mauvaises
    g. Je ne sais pas

2. Questions en lien avec les choix et la préparation des repas. Cochez la case qui vous représente le plus.

		Toujours	Souvent	Des fois	Rarement	Jamais
2a	Faites-vous des suggestions pour les repas familiaux?					
2b	Participez-vous aux choix faits lors de l'achat des aliments à l'épicerie?					
2c	Aidez-vous lors de la préparation des repas ou de la cuisson des aliments (exemple couper, brasser, peler, laver)?					
2d	Préparez-vous des repas pour vous-même?					

3. À quelle fréquence, habituellement, mangez-vous le repas PRINCIPAL avec votre famille assise à la table ensemble? *Le repas principal représente le repas dans la journée qui requière le plus de préparation. Ce n'est pas tous les membres de la famille qui doivent être présents.*

a. Chaque jour
b. Presque chaque jour
c. Environ 2 à 3 fois/semaine
d. Environ une fois/semaine
e. Jamais
f. Je ne sais pas

4. Combien de jours par semaine consommez-vous…?

		Nombre de jours par semaine (entre 0 et 7 jours)
4a	Déjeuner	
4b	Diner	
4c	Souper	
4d	Collation le matin	
4e	Collation en après-midi	
4f	Collation en soirée	

5. À quelle fréquence mangez-vous les aliments suivants? Combien de fois (écrire un chiffre sous la case qui convient le mieux à votre consommation) par jour, par semaine, par mois ou par année? *Si vous ne mangez jamais d'un certain aliment, écrivez 0 dans chacune des cases associées à cette aliment.*

Les questions qui suivent se rapportent aux aliments que vous avez l'habitude de manger ou de boire. Pensez à <u>tous</u> les aliments que vous mangez, comme repas ou comme collation, tant à la maison qu'à l'extérieur.

	À quelle fréquence mangez-vous les aliments suivants?	Par jour	Par semaine	Par mois	Par année
	Consommation de céréales, de fruits et de légumes				
5a	Céréales chaudes ou froides				

5b	Pain à grains entiers				
5c	Pain blanc (y compris bagel, pita, tortillas)				
5d	Pâtes alimentaires				
5e	Riz instantané				
5f	Muffins				
5g	Agrumes (comme les oranges et les pamplemousses)				
5h	Fruits orangés (comme les pêches, abricots, mangues, nectarines, papayes, cantaloups)				
5i	Fraises, framboises, bleuets				
5j	D'autres types de fruits (bananes, pommes, poires, etc.)				
5k	Légumes verts foncés (comme la laitue et les épinards)				
5l	Légumes orangés (comme les carottes et les courges)				
5m	Pommes de terre				
5n	D'autres types de légumes (comme les tomates, champignons, etc.)				
	Consommation de viande et subsituts				
5o	Viande rouge (bœuf, hamburger, porc, agneau)				
5p	Du foie (foie de bœuf, de veau, de volaille)				
5q	Hot-dog de bœuf ou de porc				
5r	Saucisse ou bacon				

5s	Viande à sandwich				
5t	Œuf				
5u	Poisson et fruits de mer				
5v	Légumineuses				
5w	Noix ou beurre d'arachides				
	Consommation de produits laitiers				
5x	Substitut de lait (boissons enrichies à base de soya, de riz ou d'amandes**)**				
5y	Lait ou boissons à base de lait aromatisées				
5z	Fromage cottage				
5aa	Fromage fondu (Cheez Whiz)				
5bb	Fromage (cheddar, suisse, mozzarella)				
5cc	Yogourt				
5dd	Crème glacée				
	Breuvages				
5ee	Boissons gazeuses diètes				
5ff	Boissons gazeuses ordinaires				
5gg	Boissons sportives (gatorade, powerade)				
5hh	Boisson alcoolisée (comme de la bière, du cooler ou du vin)				
5ii	Jus d'orange ou pamplemousse pur à 100%				
5jj	D'autres jus de fruits purs à 100% (pomme, raisins, etc.)				

5kk	Boissons à saveur artificielle de fruits				
5ll	Jus de légumes				
5mm	Café, thé				
5nn	Eau du robinet ou de la fontaine				
5oo	Eau embouteillée				
	Types de repas				
5pp	Aliments faits maison (repas préparés à la maison)				
5qq	Aliments pré-préparés de type repas congelés (ex. pizza congelée)				
5rr	Aliments pré-préparés de type en conserve (ex. soupe)				
5ss	Aliments pré-préparés de type amenés déjà faits (ex. sous-marin frais)				
	Autres aliments (cochez la case qui convient le mieux à vos habitudes alimentaires)	Quelques fois par jour	Une fois par jour	Quelques fois par semaine	Jamais
5tt	Nourriture frite (comme patates frites)				
5uu	Desserts sucrés (comme du gâteau et des tartelettes)				
5vv	Chips et croustilles salées				
5ww	Maïs soufflé				
5xx	Craquelins				
5yy	Sucreries (comme du chocolat, des friandises et				

	des bonbons)				
5zz	Biscuits				
5aaa	Beignes, pâtisseries				

6. Dans le dernier mois, à quelle fréquence avez-vous mangé ou commandé à un restaurant…?
    a. Jamais
    b. 1 à 3 fois par mois
    c. Une fois par semaine (dans le dernier mois)
    d. Plus qu'une fois par semaine (dans le dernier mois)
    e. Chaque jour (dans le dernier mois)
    f. Je ne sais pas

7. Dans le dernier mois, à quelle fréquence avez-vous mangé à la cafétéria…?
    a. Jamais
    b. 1 à 3 fois par mois
    c. Une fois par semaine (dans le dernier mois)
    d. Plus qu'une fois par semaine (dans le dernier mois)
    e. Chaque jour (dans le dernier mois)
    f. Je ne sais pas