Effect of an Aerobic Exercise Program on Daily Energy Expenditure and Intake in Adolescents.

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ABSTRACT

Effect of an Aerobic Exercise Program on Daily Energy Expenditure and Intake in Adolescents.

Objectives: The purpose of this study was to investigate the effect of an 8-week aerobic exercise program on daily energy expenditure and intake in adolescents with normal-weight and with overweight or obesity.

Methods: Prospective intervention study. The study included twenty-six adolescents aged between 14-18 years: 17 adolescents (8 girls and 9 boys) with normal-weight (BMI <85th percentiles for age and sex), and 9 adolescents (5 girls and 4 boys) with overweight or obesity (BMI ≥85th percentile for age and sex). The aerobic exercise program included 30 minutes of cycling performed on a Monark cycle ergometer 3 times a week for 8 weeks at an exercise target heart rate at 75% of participants' heart rate reserve using the Karvonen formula. Total daily energy expenditure was measured with an indirect calorimeter wear for resting metabolic rate and a 7-day accelerometer for energy expenditure from physical activity. Energy intake was estimated with 24-hour recalls.

Results: The aerobic exercise program did not have any significant effect on body weight. Significant effects of aerobic exercise on total daily energy expenditure (p=.051), energy expenditure from physical activity (p=.031) and total daily energy intake (p=.008) were observed, which mainly revealed a reduction in daily physical activity and energy intake following the exercise program. However, there was no significant effect of weight status and no interaction effect between of aerobic exercise and weight status for those three variables.

Conclusions: Adolescents with normal weight, overweight or obesity not only reduced their daily total energy expenditure by reducing physical activity, but simultaneously decreased their total daily energy intake after an aerobic exercise program.

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CHAPTER 1 : INTRODUCTION

Obesity

Obesity among children, adolescents and adults, can be qualified as a pandemic (Cameron & Demerath, 2002; Flynn et al., 2006; Kaur, Hyder, & Poston, 2003; World Health Organization, 2000, 2009). Weight gain can be explained by the principle of energy imbalance, that can result from either an increase in daily energy intake exceeding daily energy expenditure or a reduction in energy expenditure compared to daily energy intake (Daniels et al., 2005; Lau et al., 2007). The excess energy is stored in adipose tissue. If the state of positive energy balance is maintained, an increase in body mass, specifically fat mass, will result which may lead to overweight or obesity. A positive average daily energy balance of 5% could result in weight gain between 6 and 7 kg after five years (Schutz, 1995).

Obesity is viewed as a worldwide health problem (Daniels et al., 2005; World Health Organization, 2009). It is a well-documented risk factor for many chronic diseases such as type 2 diabetes, dyslipidaemia, cardiovascular diseases, cancers and psychosocial abnormalities (Alberga, Sigal, Goldfield, Prud'homme, & Kenny, 2012; Carroll, Navaneelan, Bryan, & Ogden, 2015; Daniels et al., 2005; Flynn et al., 2006; Simmonds et al., 2015). Previously, obesity primarily afflicted middle age adults, but it is now widespread among adolescents. In fact, in 2013, 27.0% of Canadian children/adolescents were overweight or obese (Government of Canada, 2011; Rodd & Sharma, 2016). Over the past decades, the rate of adolescents with obesity has expanded in an alarming way, which increases the risk of obesity in adulthood (Carroll et al., 2015). It is estimated that 80% of adolescents with obesity transition to being obese adults (Daniels et al., 2005; Simmonds et al., 2015), thus increasing their risk of developing obesity-related health issues (Flynn et al., 2006; Raphael, 2013). It has been shown that men and women who were obese during their adolescence have higher rates of early mortality (Dietz, 1997; Flynn et al., 2006).

Adolescence: a critical period

Adolescence is a period that can be defined by the start of puberty and by a variety of psychological and physiological changes that occurs between the ages of 10 and 19 years (Canadian Paediatric Society, 2003; World Health Organization, 2000). There are changes in body composition and fat distribution in both sexes during this period. Both boys and girls present an increase in fat mass, although adolescent girls show a higher increase in subcutaneous and peripheral fat (especially in the breasts and the hips), while adolescent boys show an increase in subcutaneous and visceral abdominal fat (Alberga et al., 2012). The development and the expression of obesity-related comorbidities are the reasons why the adolescence is a critical period (Daniels et al., 2005). There are also behavioral changes that occur during adolescence which may contribute to the development of obesity in both sexes (Alberga et al., 2012): a decrease in the average quality of food and beverages ingested (Banfield, Liu, Davis, Chang, & Frazier-Wood, 2016; Holubcikova, Kolarcik, Madarasova Geckova, van Dijk, & Reijneveld, 2016), an increase in sedentary activities (Arundell, Fletcher, Salmon, Veitch, & Hinkley, 2016) and a decrease in physical activity and participation in sports (Brooke, Corder, Griffin, & van Sluijs, 2014; Lam & McHale, 2015).

According to past epidemiological research, here are three important transition periods during the human development, where individuals are more apt experience specific stimuli that can provoke changes and that may predict long-term negative outcomes (Cameron & Demerath, 2002). Specifically, a "critical period" of life has been defined by Daniels et al. (2005) as "a specific period of development when an insult has an enduring effect on the structure or function of organs, tissues, and body systems". The period of adolescence represents one of three specific critical periods for the development of subsequent negative health outcomes in adulthood, for instance obesity (Alberga et al., 2012; Cameron & Demerath, 2002; Daniels et al., 2005; Dietz, 1994, 1997; Sawyer et al., 2012). Due to physiological, hormonal and behavioral changes, adolescence is a sensitive stage in life during which excessive weight may be especially detrimental and associated with the earlier development of many chronic diseases (Alberga et al., 2012; Sawyer et al., 2012).

The problem

There is a public health urgency to find effective ways to reduce the incidence and the prevalence of overweight and obesity among adolescents, considering the health impacts of co-morbidities associated with excess weight and the fact that adolescence represents one of the critical periods associated with an increased risk for developing overweight or obesity (Alberga et al., 2012). Consequently, public health organizations worldwide have been promoting healthy lifestyles, including daily physical activity. Indeed, regular physical activity can serve several purposes, such as helping to maintain a healthy weight, given the health benefits of physical activity are independent of the amount of excess weight loss (Loprinzi et al., 2014) or helping to create a negative energy balance by increasing total daily energy expenditure for individuals who need to lose weight (Ross, Flynn, & Pate, 2016; World Health Organization, 2009). However, there is significant individual variability regarding the success rate of weight loss following an exercise program in adults (Blundell, Gibbons, Caudwell, Finlayson, & Hopkins, 2015) and in adolescents (Schwartz, King, Perreira, Blundell, & Thivel, 2016). Moreover, in adults with overweight or obesity, an aerobic exercise program was shown to be a less effective intervention in terms of weight loss and changes in body composition (fat mass loss and fat free mass retention) compared to interventions combining diet, aerobic and resistance exercise (Clark, 2015). Similarly, a recent systematic review of meta-analyses in children and adolescents with overweight or obesity concluded that there is insufficient evidence that exercise programs lead to improvements in body weight, body mass index (BMI) and central obesity (Kelley & Kelley, 2013). The main question that underlies those findings is: "Why is there such a low rate of weight loss success following an exercise program?" It is tenable that exercise might have an undesirable impact on daily energy balance, a notion that is brought to light by the energy compensation concept (Mayer & Thomas, 1967). Thus, the goal of this thesis is to investigate the energy compensation concept in a sample of adolescents who participated in an aerobic exercise program.

CHAPTER 2 : LITERATURE REVIEW

This section describes the factors affecting energy balance and explains the energy compensation concept. The results of studies related to the acute and chronic effect of aerobic exercise on energy compensation in adolescents are also presented.

Factors influencing energy balance

Weight management relies on the concept of energy balance. There are two components to consider when analyzing the equation of energy balance: energy expenditure and energy intake. A stable body weight is the result of the equilibrium between energy expenditure and energy intake (Schutz, 1995; World Health Organization, 2009).

Energy expenditure can be divided into three categories: resting energy expenditure (REE), the thermal effect of food and physical activity. REE represents 60-75% of total energy expenditure (Ravussin, Lillioja, Anderson, Christin, & Bogardus, 1986). It is defined as the energy spent by an individual in a resting state (supine position) and in a post-absorptive state (after 12 hours fasting) in a thermoneutral environment (Thrush, Dent, McPherson, & Harper, 2013). The impact of the thermal effect of food on energy expenditure is very modest (approximately 10% to 11%). It is usually not affected by minor exercise interventions (Melanson, Keadle, Donnelly, Braun, & King, 2013). Physical activity is the main component that can be manipulated. Conversely, physical activity is the main component of energy expenditure that can be manipulated and targeted in exercise interventions. Physical activity can be divided in four domains: occupational, transportation-related, household chores, and leisure time (Bassett, Troiano, McClain, &

Wolff, 2015). Increasing energy expenditure via physical activity is one angle to consider when trying to promote weight management (World Health Organization, 2009). The other is reducing energy intake (i.e., food intake).

Energy intake is the number of kilocalories consumed during a day. It can be altered and also partly regulated by hormones that promote either satiety (anorexigenic hormones), which is the absence of hunger (Bowen, Noakes, & Clifton, 2007; Hazell, Islam, Townsend, Schmale, & Copeland, 2016), or appetite (orexigenic hormones), which is the presence of hunger. The satiety hormones know to date are leptin, glucagon-like peptide-1, peptide tyrosine, pancreatic polypeptide and cholecystokinin, whereas ghrelin is the hormone associated with appetite (Blom et al., 2006; Jane Bowen, Noakes, Trenerry, & Clifton, 2006; Hazell et al., 2016).

It is also important to note that besides the two main components of energy balance, many other factors (that will not be addressed and measured in this research) affect body energy expenditure. On the one hand, the effectiveness of weight loss interventions may be influenced by individuals' energy efficiency (Thrush et al., 2014), and in particular, the efficiency of muscle mitochondria to produce adenosine triphosphate may be important. A person who is efficient in producing adenosine triphosphate (who could be characterized as a slow weight loser) will expend less energy than a person who is not efficient (who could be represented as a fast weight loser) for the same volume of physical activity. This difference in energy efficiency could be partly explained by a mitochondrial proton leak in the fast loser (Thrush et al., 2014, 2013). On the other hand, genetic variability between individuals also plays an important role in the response to weight loss intervention (Tremblay, Pérusse, & Bouchard, 2004). Although those factors might impact energy balance during an exercise intervention, the focus of the present thesis will be on the specific effect of exercise on daily total energy expenditure (TEE) and energy intake, which may be explained in part by the compensation theory. This theory is described next.

Concept of energy compensation

In 1998, Rowlands proposed a theory called the "activitystats hypothesis", based on the findings of Mayer and Thomas (1967). This theory contends that there is a biological control center, situated in the central nervous system, which unconsciously regulates energy expenditure and intake (Sjaan R. Gomersall, Rowlands, English, Maher, & Olds, 2013; Mayer & Thomas, 1967; Rowland, 1998). In other words, it was suggested that there is an intrinsic biological mechanism that manages the energy status of the human body to ensure that it has enough energy reserve to sustain physiological functions. This refers to the energy homeostasis concept; in a situation of energy disturbance (i.e. low food consumption or high energy expenditure), the human body responds by decreasing the resting energy expenditure and body movements and increasing appetite for survival reasons (Rowland, 1998). According to this theory, an increase in energy expenditure associated with an exercise session in the first part of the day could be compensated by less physical activity during the second part of the day (Thivel, Aucouturier, Doucet, Saunders, & Chaput, 2013). Likewise, exercise (i.e., an increase in energy expenditure) has also been suggested to impact energy intake. There is evidence that when exercising daily, there is an increase in hunger in the morning and also an increase of postprandial satiety following an exercise session (King et al., 2009). In addition, the effect of exercise on energy expenditure and energy intake varies between individuals, which might partly explain the individual variation that is seen in weight loss following an exercise program (Blundell et al., 2015).

This concept of energy compensation has been investigated in many populations using different experimental designs (Blundell et al., 2015). In the following section, the acute effects of an aerobic exercise session on energy expenditure and energy intake over a single day will be presented, followed by an overview of the results of studies examining the chronic effects of aerobic exercise training.

Effect of an acute bout of aerobic exercise on energy compensation in adolescents

There is evidence in the literature suggesting that adolescents with obesity present a decrease in energy expenditure following an aerobic exercise session as opposed to an increase in energy intake. The next section summarizes the finding of studies that investigated the acute effect of an exercise session on energy expenditure or energy intake.

Energy expenditure

For instance, after cycling for 30 minutes at 75% maximal oxygen consumption (VO_2 max) in the morning, adolescents have shown a decrease in their energy expenditure during the afternoon, which resulted in the same daily energy expenditure compared to the day they did not exercise (D. Thivel, Aucouturier, Metz, Morio, & Duché, 2014; David Thivel, Metz, Julien, Morio, & Duché, 2014). This compensation phenomenon thereby goes against the main purpose of exercising in the context of a weight loss intervention, which is to produce a daily energy deficit by increasing total energy expenditure. However, in the study by Thivel et al (2014), there was also a significantly higher average daily energy expenditure on exercise days compared to control days among lean adolescents, meaning that energy expenditure in the afternoons after the morning exercise was not significantly different than after the sedentary session (David Thivel et al., 2014).

Although previous studies have similarly reported energy expenditure compensation in adolescents with obesity but not in lean adolescents, inconstancy persists in the literature. Saunders and his colleagues (2014) found that there were no significant differences in energy expenditure in the 24 hours following either sedentary activity or exercise of light or moderate intensity (Saunders et al., 2014). These findings support those of two previous studies carried out with British children (8 to 13 years old) among whom an increase in physical activity at one point during the day did not result in a decrease in energy expenditure afterwards (Frémeaux et al., 2011; Goodman, Mackett, & Paskins, 2011). However, in a another Denmark study, children from sports schools presented a higher level of moderate and vigorous physical activity (MVPA) at school, and practiced more sedentary activities and less MVPA during their leisure time, compared to children from regular schools (Møller et al., 2014). Similar results were found in a study with Australian children whereby more minutes of MVPA accumulated in one day were significantly associated with less physical activity the next day (Ridgers, Timperio, Cerin, & Salmon, 2014). Therefore, there are still inconstancies on that subject in the literature

Energy intake

There are similar inconsistencies regarding the energy intake compensation phenomenon following an exercise session observed in some adult studies (Melanson et al. 2013), but the energy compensation phenomenon does not seem to apply to adolescents following a single-bout of an aerobic exercise session. The average daily energy intake was shown to decrease significantly in obese adolescents after an aerobic exercise session of 3 x 10 minutes of cycling at 75% maximal oxygen consumption (David Thivel et al., 2011; David Thivel, Saunders, & Chaput, 2013). Two other studies on this topic concluded also that acute aerobic exercise sessions did not significantly change daily energy intake in adolescents with overweight or obesity (Chaput et al., 2015; Dodd, Welsman, & Armstrong, 2008; Tamam, Bellissimo, Patel, Thomas, & Anderson, 2012). Similarly, an acute aerobic exercise session did not provoke significant difference in energy intake in lean adolescents (Dodd et al., 2008; Moore, Dodd, Welsman, & Armstrong, 2004; David Thivel et al., 2014). Moreover, in a study that examined the effect of the duration of aerobic exercise (15 vs. 45 minutes) on energy intake in (n = 14) and girls (n = 15) with normal weight aged between 9 and 14 years, no significant difference was found in energy intake between the two exercise conditions (Bozinovski et al., 2009).

Although the results of these studies suggested the absence of compensation in terms of energy intake after an aerobic exercise bout, it is important to highlight that energy intake was measured using an *ad libitum* buffet meal technique after the aerobic exercise session. However, this technique presents some limitations. The fact that participants know that they are being observed could influence their nutritional choices and food intake. In fact, the availability of large amounts of food in an *ad libitum* buffet meal might lead to an overconsumption (Rising et al., 1992). Finally, the buffet technique does not allow for determining the presence of a change in energy intake in a participant’s usual environment following an acute exercise bout. Accordingly, a food record or multiple 24-hours dietary recalls might be more representative of participants’ usual daily energy intake.

Effects of chronic exercise training on energy compensation

Although most studies to date with adolescents have investigated the effect of an acute exercise session on post-exercise energy compensation, there are a few exceptions. In one study performed by Thivel and al. (2014), they investigated the effect of a 10-week aerobic exercise program on daily energy intake in twenty-six adolescents with obesity between 12 and 17 years of age (14 girls and 12 boys). Energy intake was measured with a 3-day food diary. They found a trend towards a decrease in daily energy intake from before (7440 ± 1744 Kilojoule [KJ]) to after the exercise intervention (6740 ± 2124 KJ) ($p = .07$), although no weight loss was observed (D. Thivel, Chaput, Adamo, & Goldfield, 2014). The authors contend that, even though there was a decrease in mean energy intake following the aerobic exercise program, the absence of weight loss could be explained by a decrease in participants' total energy expenditure (TEE). Unfortunately, no measure of daily total energy expenditure was captured in this study.

Similarly, a recent systematic review and meta-analysis that included seven studies involving adolescents with obesity (n = 500) revealed a significant mean effect -1.003 ($p < 0.001$) of exercise interventions in reducing daily energy intake (Schwartz, King, Perreira, Blundell, & Thivel, 2016). However, the influence of the exercise interventions on body weight was inconclusive and to our knowledge none of the studies in this review measured daily energy expenditure.

Role of exercise on daily energy intake and physical activity compensation in adolescent with obesity

As previously described, many researchers have investigated the acute effects of a single aerobic exercise session on post-exercise energy expenditure and energy intake compensation in order to identify factors that could help explain the success (or failure) of exercise interventions on weight loss. Following an aerobic exercise weight loss program, the majority of participants with obesity do not lose the estimated weight that would be expected from the prescribed energy deficit based on exercise induced energy expenditure. Furthermore, there is significant individual variation in weight loss following a weight loss program (Donnelly & Smith, 2005; D. Thivel, Chaput, et al., 2014). Even if individual variation in weight loss could be partly explained by individual genotype (Tremblay et al., 2004), other factors still need to be identified to explain the discrepancy between the predicted vs. measured/actual weight loss. In this regard, the energy compensation concept needs further investigation, especially in adolescents. From a practical standpoint, health professionals need to know what to expect when exercise alone is used in adolescents with obesity.

The main objective of the present thesis is to generate knowledge to better understand the chronic effects of an aerobic exercise program in adolescents on their daily energy expenditure and energy intake over time. To our knowledge, documentation of the effect of an exercise program on energy expenditure and energy intake simultaneously has never been investigated in a prospective study with adolescents.

AIM OF THE THESIS

The aim of this thesis is to investigate the effect of an 8-week aerobic exercise program on daily total energy expenditure and energy intake in adolescents with normal-weight and in adolescents with overweight or obesity.

HYPOTHESIS

1) In adolescents with normal weight, there would be no daily energy expenditure and energy intake compensation after the aerobic exercise program;

2) In adolescent with overweight or obesity, there would be a decrease in daily energy expenditure and energy intake following an aerobic exercise program.

CHAPTER 3 : METHODOLOGY

A prospective intervention study was performed to verify the effect of an 8-week aerobic training intervention on daily energy expenditure and energy intake in adolescents with normal-weight (n=17) (8 girls and 9 boys) and with overweight or obesity (n=9) (5 girls and 4 boys).

A complete methodology is described in Chapter 4 on page 28

CHAPTER 4: Article

This chapter presented, in an article format, the major findings, the discussion of the results and the main conclusion of this thesis. This article is entitled: **Effect of an Aerobic Exercise Program on Daily Energy Intake and Expenditure in Adolescents.**

Effect of an Aerobic Exercise Program on Daily Energy Expenditure and Intake in Adolescents.

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Keywords: energy compensation, training, youth, 7-day accelerometer, 24-hour dietary recalls.

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Abstract

Objectives: The purpose of this study was to investigate the effect of an 8-week aerobic exercise program on daily energy expenditure and intake in adolescents with normal-weight and with overweight or obesity.

Methods: Prospective intervention study. The study included twenty-six adolescents aged between 14-18 years: 17 adolescents (8 girls and 9 boys) with normal-weight (BMI <85th percentiles for age and sex), and 9 adolescents (5 girls and 4 boys) with overweight or obesity (BMI ≥85th percentile for age and sex). The aerobic exercise program included 30 minutes of cycling performed on a Monark cycle ergometer 3 times a week for 8 weeks at an exercise target heart rate at 75% of participants' heart rate reserve using the Karvonen formula. Total daily energy expenditure was measured with an indirect calorimeter wear for resting metabolic rate and a 7-day accelerometer for energy expenditure from physical activity. Energy intake was estimated with 24-hour recalls.

Results: The aerobic exercise program did not have any significant effect on body weight. Significant effects of aerobic exercise on total daily energy expenditure (p=.051), energy expenditure from physical activity (p=.031) and total daily energy intake (p=.008) were observed, which mainly revealed a reduction in daily physical activity and energy intake following the exercise program. However, there was no significant effect of weight status and no interaction effect between of aerobic exercise and weight status for those three variables.

Conclusions: Adolescents with normal weight, overweight or obesity not only reduced their daily total energy expenditure by reducing physical activity, but simultaneously decreased their total daily energy intake after an aerobic exercise program.

Keywords: energy compensation, training, youth, 7-day accelerometer, 24-hour recalls

Introduction

Obesity is viewed as a worldwide health problem (Daniels et al., 2005; World Health Organization, 2009). In 2013, 27.0% of Canadian children and adolescents were overweight or obese (Government of Canada, 2011; Rodd & Sharma, 2016). For the past decades, the rate of obesity among adolescents has expanded in an alarming way, which drastically increases the risk of adulthood obesity. In fact, 80% of adolescents with obesity transition to being obese adults (Daniels et al., 2005; Simmonds et al., 2015), thus increasing their risk of developing obesity-associated health problems (Flynn et al., 2006; Raphael, 2013).

There is a public health urgency to find effective ways to reduce the incidence and the prevalence of overweight and obesity among adolescents, considering the health impacts of co-morbidities associated with excess weight and the fact that adolescence represents one of the critical periods associated with an increased risk for developing overweight or obesity (Alberga, Sigal, Goldfield, Prud'homme, & Kenny, 2012). Consequently, public health organizations worldwide have been promoting healthy lifestyles, including daily physical activity. Indeed, regular physical activity can serve several purposes, such as helping to maintain a healthy weight, given the health benefits of physical activity are independent of the amount of excess weight loss (Loprinzi et al., 2014) or helping to create a negative energy balance by increasing total daily energy expenditure for individuals who need to lose weight (Ross, Flynn, & Pate, 2016; World Health Organization, 2009). However, there is significant individual variability regarding the success rate of weight loss following an exercise program in adults (Blundell, Gibbons, Caudwell, Finlayson, & Hopkins, 2015) and in adolescents (C. Schwartz, King, Perreira, Blundell, & Thivel, 2016). Moreover, in adults with overweight or obesity, an aerobic exercise program was shown to be a less effective intervention in terms of weight loss and changes in body composition (fat mass loss and fat free mass retention) compared to interventions combining diet, aerobic and resistance exercise (Clark, 2015). Similarly, a recent systematic review of meta-analyses in children and adolescents with overweight or obesity concluded that there is insufficient evidence that exercise programs lead to improvements in body weight, body mass index (BMI) and central obesity (Kelley & Kelley, 2013). The main question that underlies those findings is: "Why is there such a low rate of weight loss success following an exercise program?" It is tenable that exercise might have an undesirable impact on daily energy balance, a notion that is brought to light by the energy compensation concept (Mayer & Thomas, 1967).

In 1998, Rowlands proposed a theory called the "activitystats hypothesis", based on the findings of Mayer and Thomas (1967). This theory contends that there is a biological control center, situated in the central nervous system, which unconsciously regulates energy expenditure and intake (Sjaan R. Gomersall et al., 2013; Mayer & Thomas, 1967; Rowland, 1998). In other words, it was suggested that there is an intrinsic biological mechanism that manages the energy status of the human body to ensure that it has enough energy reserve to sustain physiological functions. This refers to the energy homeostasis concept; in a situation of energy disturbance (i.e. low food consumption or high energy expenditure), the human body responds by decreasing the resting energy expenditure and body movements and increasing appetite for survival reasons (Rowland, 1998). According to this theory, an increase in energy expenditure associated with an exercise session in the first part of the day could be compensated by less physical activity during the second part of the day (Thivel, Aucouturier, Doucet, Saunders, & Chaput, 2013). Likewise, exercise (i.e., an increase in energy expenditure) has also been suggested to impact energy intake. There is evidence that when exercising daily, there is an increase in hunger in the morning and also an increase of postprandial satiety following an exercise session (King et al., 2009). In addition, the effect of exercise on energy expenditure and energy intake varies between individuals, which might partly explain the individual variation that is seen in weight loss following an exercise program (Blundell et al., 2015).

This concept of energy compensation has been investigated in many populations using different experimental designs (Blundell et al., 2015). However, up to now, most studies performed in adolescents to date has investigated the effect of an acute exercise session on post-exercise energy compensation. Specifically, studies have shown that energy expenditure and intake were either decrease following an exercise session compared to a sedentary session (Møller et al., 2014; Ridgers, Timperio, Cerin, & Salmon, 2014; David Thivel et al., 2011, 2013; David Thivel, Metz, Julien, Morio, & Duché, 2014) or remain unchanged (Bozinovski et al., 2009; Chaput et al., 2015; Dodd, Welsman, & Armstrong, 2008; Frémeaux et al., 2011; Goodman, Mackett, & Paskins, 2011; Moore, Dodd, Welsman, & Armstrong, 2004; Saunders et al., 2014; Tamam, Bellissimo, Patel, Thomas, & Anderson, 2012; David Thivel et al., 2014).

Regarding the chronic effect of exercise on energy compensation, Thivel and al. (2014) investigated the effect of a 10-week aerobic exercise program on daily energy intake in twenty-six adolescents with obesity between 12 and 17 years of age (14 girls and 12 boys). Energy intake was measured with a 3-day food diary. They found a trend towards a decrease in daily energy intake from before (7440 ± 1744 Kilojoule [KJ]) to after the exercise intervention (6740 ± 2124 KJ) (p = .07), although no weight loss was observed (D. Thivel, Chaput, Adamo, & Goldfield, 2014). The authors contend that, even though there was a decrease in mean energy intake following the aerobic exercise program, the absence of weight loss could be explained by a decrease in participants' total energy expenditure (TEE). Unfortunately, no measure of daily total energy expenditure was captured in this study.

Similarly, a recent systematic review and meta-analysis that included seven studies involving adolescents with obesity (n = 500) revealed a significant mean effect -1.003 (p < 0.001) of exercise interventions in reducing daily energy intake (C. Schwartz et al., 2016). However, the influence of the exercise interventions on body weight was inconclusive and to our knowledge none of the studies in this review measured daily energy expenditure.

The aim of this study was to investigate the effect of an aerobic exercise program on daily TEE and energy intake in adolescents with normal-weight compared to those with overweight or obesity. The hypothesis had two folds: 1) In adolescents with normal weight, there would be no daily energy expenditure and energy intake compensation after the aerobic exercise program; 2) In adolescent with overweight or obesity, there would be a decrease in daily energy expenditure and energy intake following an aerobic exercise program. By simultaneously documenting daily energy expenditure and energy intake, the results of the present study will contribute to improving our knowledge of the effects of an aerobic exercise program on the concept of energy compensation in adolescents.

Methodology

PARTICIPANTS

Figure 1 presents the screening, enrolment and retention of participants in this study. Out of 171 adolescents, a total of twenty-six post-pubertal adolescents aged 14–18 years old, 17 (8 girls and 9 boys) with normal-weight (BMI < 85th percentiles for age and sex), and 9 (5 girls and 4 boys) with overweight or obese (BMI ≥ 85th percentiles for age and sex), were recruited to participate in this study. The exclusion criteria were: 1) answering 'yes' to at least one question on the Physical Activity Readiness Questionnaire (Adams, 1999), 2) participating in regular exercise or aerobic sports > twice a week for at least 60 minutes per session during the previous 4 months, 3) having type 1 or 2 diabetes, 4) presenting asthma at rest and/or during exercise, 5) experiencing significant weight change in the last 2 months (> 2kg), 6) presenting physical activity restrictions due to disease(s), 7) suffering from severe premenstrual syndrome, 8) being pregnant, 9) consuming prescribed medication or 10) having allergies to milk products or to gluten. The primary recruitment strategy was word of mouth at Collège Saint-Alexandre, a high school in Quebec, Canada. All participants provided informed consent and for those under the age of 18 years, a parent or guardian co-signed the consent form. During the entire project, the participants were blinded to the true purpose and rationale of the study. They were told that "*the purpose of the study is to document the participation of adolescents in an 8-week aerobic exercise program on a stationary bike supervised by an exercise specialist*" (AB-14-08-15, p. 1). This study received approval from the ethics committees of the Montfort Hospital and the University of Ottawa.

[INSERT FIGURE 1. HERE]

THE SAMPLE SIZE CALCULATION

Sample size was calculated on the results of Thivel and al. (2014) study regarding the effect of an aerobic exercise program on daily energy intake, because there was no available data on the effect of this type of exercise intervention on daily TEE in adolescents. Thivel and al. (2014) reported a reduction of 9.4% of daily energy intake following a 10-week aerobic exercise program. Sample size calculation was performed with the software *GPower* (Version 3: Faul, Erdfelder, Lang, & Buchner, 2007 http://www.gpower.hhu.de/), with a power = 0.95 and α = 0.05, which estimated a sample size of 20 participants. Considering an estimated drop-out rate of 20%, a minimum of 24 participants needed to be recruited.

MEASUREMENTS

Anthropometric assessment

Body weight and height were measured with a Health-O-meter digital scale (Pelstar LLC d.b.a., Health-o-meter® Professional Scale, McCook, Illinois) and a SECA stadiometer (SECA, Birmingham, United Kingdom) respectively. BMI was calculated using weight (kg) divided by height squared (m^2). For children and adolescents (from 5 to 19 years old), individuals with a BMI between the 85^{th} and 95^{th} percentiles for age and sex category can be characterized as “overweight”, whereas a BMI over the 95^{th} percentile suggests that the individual is obese (de Onis et al., 2007). Waist circumference (WC) was determined using a flexible measuring tape at the mid-distance between the lowest rib and the iliac crest (using the mean of three measures). Body composition was assessed by the hand-to-foot bioelectrical impedance analysis (Tanita BC-418, Corporation of America Inc., Arlington Heights, IL), which been validated using the dual energy X-ray absorptiometry in children with normal weight and with overweight (Meredith-Jones, Williams, & Taylor, 2015). The validation study showed no significant difference between the two methods in regards to fat mass, fat-free mass and percentage of body fat for children with normal weight and with overweight, with the exception of percentage of body fat for girls with normal weight.

Resting energy expenditure

Participants arrived at the laboratory between 7:00 am and 12:00 pm after a 12-hour fast. Before starting the resting energy expenditure (REE) measurement, the participant had to rest quietly in a supine position for 20 minutes. Afterwards, oxygen and carbon dioxide consumption was measured by indirect calorimetry using an automated metabolic system (Vmax Ve29n System, VIASYS Healthcare Inc, Yorba Linda, CA) for 30 minutes. Only the data between the 5th minute and 25th minute were analyzed (Duval et al., 2013).

Energy expenditure from physical activity

The biaxial accelerometry units (Actical; Mini Mitter Co., Inc., Bend, OR) were used to measure energy expenditure from physical activity. The accelerometer was worn for 7 days. This duration was chosen because it is estimated to result in 90% reliability for the measurement of physical activity in both males and females (Matthews, Ainsworth, Thompson, & Bassett, 2002). Participants put on the accelerometer upon waking up and take it off just before going to bed. The accelerometer was worn at the hip, because that placement was showed to be the best predictor of energy expenditure (Bouten, Sauren, Verduin, & Janssen, 1997). Although, the accelerometer is an accurate predictor of energy expenditure accurately in youth (de Graauw, de Groot, van Brussel, Streur, & Takken, 2010), the epoch time, especially in children, has to be set up as short as possible for greater precision (R. C. Colley, Harvey, Grattan, & Adamo, 2014). Therefore, it was set up at 15 seconds in this study. Accelerometry data were retained only if the participants presented four valid days of data, which meant 10 hours or more per day with the device and interruptions of less than 60 minutes (except at night for sleeping) (R. Colley, Connor Gorber, & Tremblay, 2010).

Sub-maximal exercise energy expenditure

Energy expenditure was measured by indirect calorimetry during a sub-maximal exercise at 50% and 75% of heart rate (HR) reserve using Karvonen's formula (exercise target HR = ([(220 - age) – resting HR] x exercise intensity (%)) + resting HR) (Karvonen, Kentala, & Mustala, 1957). Using a HR monitor (Polar Electro Oy, Kempele, Finland) worn on the left wrist, HR was measured at rest three times at one-minute intervals after the participants had been sitting down for 5 minutes, and at exercise every minute during exercise. The exercise included two stages. For the first stage, participants exercised on an ergocycle for 5 minutes at 50% of HR reserve, which was followed by the second stage, a 6-minute bout at 75% of HR reserve. Oxygen consumption and carbon dioxide production were measured by indirect calorimetry using an automated metabolic system (Vmax Ve29n System, VIASYS Healthcare Inc, Yorba Linda, CA). The average oxygen consumption (L/min) and carbon dioxide production (L/min) for the last 3 minutes of each stage were used in the Weir equation to calculate the exercise energy expenditure (kcal/min) (Weir, 1990).

Daily total energy expenditure

Daily TEE was calculated using the following equation:

TEE (kcal/day) = [(physical activity energy expenditure + REE) x thermic effect of food (11%)]. The energy expenditure from physical activity used to calculate the TEE in post-intervention was modified. Considering that participants were still exercising during the testing week, the energy expenditure from their exercise session (measured by indirect calorimetry) was subtracted from the energy expenditure measured with the accelerometer, on each day of exercise, using the following equation: *modified physical activity energy expenditure = initial physical activity energy expenditure – [EE at 75% of HR reserve (kcal/min) x time of exercise (min)].*

Daily energy intake

The 24-hour dietary intake recall with the multiple pass method was used to measure energy intake. The multiple pass method is composed of 5 steps; 1) fast list, 2) forgotten food items, 3) time and eating occasions, 4) detailed explanations, and 5) final revision (Health Canada, 2006). In addition, food models were used to help participants determine the portion size of food and beverages consumed. The 24-hour dietary recall was performed for two days at baseline (during weekdays), and for two days with- and two days without- exercise at the endpoint of the exercise program. The dietary recalls were performed at the participants' high school by registered dietitians and trained dietetic interns. Participants were asked to maintain their usual daily lifestyle in term of activities and food intake during that the testing week. The ESHA Food Processor SQL (version 10.15.41, 2015) program with the Canadian Nutrient File (Health Canada, 2012) was used to analyze the 24-hour dietary intake recall data. Analyses were carried out by research assistants who were trained under the supervision of the co-author I.G.

Questionnaires

Participants' ethnic origin (at baseline), date of last menstruation period (for girls) and weight perception (at baseline) were documented. Body weight perception was assessed by asking participants if they were currently taking any measures to manage their weight, which might have influenced their daily energy expenditure and/or energy intake. The pubertal stage self-assessment questionnaire (Tanner, 1981) was used at baseline to determine the pubertal stage of participant. This questionnaire has demonstrated validity in determining the onset and progression of puberty in adolescents (Faria, Franceschini, Peluzio, Sant'Ana, & Priore, 2013).

[INSERT FIGURE 2. HERE]

BASELINE AND ENDPOINT TESTING SESSIONS AT THE LABORATORY

Participants were required to fast (water was allowed) and not take any medication (like Tylenol or Advil) for 12 hours prior to their scheduled visits to the laboratory. Participants were not to perform moderate or vigorous exercise or sport for at least 36 hours before the visits. Participants were asked to arrive in physical activity apparel with exercise shoes. The tests were performed in the following sequence: 1) anthropometry and body composition, 2) resting energy expenditure, 3) resting HR, 4) standardized breakfast consisted of two slice of whole wheat bread (70 g), raspberry jam (20 g), cheddar cheese of 27% milk fat (20 g) and orange juice (225 ml) for a total of 575 kcal (2400 kJ) (57% carbohydrates, 13% proteins, 30% lipids), 5) questionnaires, 6) sub-maximal exercise test. Finally, detailed instructions relating to the accelerometer were provided before each participant left the laboratory.

EXERCISE INTERVENTION

After baseline measurements, participants started an 8-week aerobic exercise program, which did not include a nutritional intervention or any dietary advices. They were asked to perform 30 minutes of aerobic exercise on a Monark cycle ergometer three times per week under the supervision of a personal trainer to ensure proper participant technique and safety. After a 5-minute warm-up at an intensity of 50% HR reserve, the last 25 minutes of the exercise session was performed at an intensity of 75% of HR reserve. Participants recorded their HR with a monitor (Polar Electro Oy, Kempele, Finland) worn on their left wrist during each exercise session to assure they exercised at the prescribed exercise target HR. The exercise sessions were held at the Collège Saint-Alexandre High School, either in the morning (8:00 AM), at lunch (12:35 PM) or after school (4:00 PM). To increase adherence and retention, participants could keep the HR monitor at the end of the project if they attended more than 75% of prescribe exercise sessions. Only the data from the participants who attended at least 75% of prescribe exercise sessions or more were included in the analyses.

DATA ANALYSIS

The SPSS software (version 23; SPSS Inc, Chicago, IL) was used for statistical analyses. A series of 2x2 mixed-factorial ANOVAS were performed to investigate the effect of the 8-week aerobic exercise program (within-subject; pre-post) in adolescents with normal weight compared to adolescents with overweight or obesity (between-subject; 2 groups) on the outcome variables: daily TEE, daily total energy intake (taking the average caloric intake of the two and the four dietary recalls at baseline and endpoint of the exercise program respectively), REE, energy expenditure from physical activity. A 2x3 mixed-factorial ANOVA was conducted for daily energy intake given three time points were compared (baseline, endpoint without exercise, endpoint with exercise). A post-hoc Bonferroni correction test was performed.

Results

At baseline, there was no significant difference between the ages of participants with normal weight (15.18±0.95 years) and participants with overweight or obesity (15.44±1.01 years). The sample included a culturally diverse group of participants: 7.7% Black, 7.7% Asian, 11.5% Mixed race, 15.4% Arabic and 57.7% white Canadian. The median Tanner's Stage score was 4 for pubic hair (girls = 3.93 (range = 2 to 5); boys = 4.2 (range= 3 to 5) and 5 for organ size (girls = 4.36 (range 2 to 5); boys = 4.33 (range 4 to 5). According to the self-reported body perception information, 53.57% of the participants reported no weight goal whereas 11.5%, 19.2% and 15.4% of the participants wanted to lose weight, maintain weight or gain weight respectively. However, fewer girls (with normal weight = 0%; with overweight/obesity = 7.69% [of total]) than boys (with normal weight = 23.07%; with overweight or obesity = 15.38%) intended to take specific actions to achieve their weight goal.

Only one boy with normal weight and one girl with overweight dropped-out from the aerobic exercise program for lack of interest and time respectively. The data from 20 participants were analysed for energy expenditure from physical activity and daily TEE, because 2 accelerometry data sets did not meet the requirements of 4 valid days and 4 participants were assigned an accelerometer that was not initially calibrated. Participants attended on average 86.69 ±10.48 % of their mandatory sessions during the 8-week aerobic exercise program and 23 participants (14/17 normal weight vs 9/9 overweight/obese) attended more than 75% of prescribe exercise sessions. The first 5 minutes of the each session, that is the warm-up period, was performed at a mean HR of 130±19.14 bpm, representing an intensity of 45% of participants' HR reserve. The remaining 25 minutes of exercise were done at an average HR of 175±13.34 bpm representing an intensity of 75% of participants' HR reserve.

[INSERT TABLE 1. HERE]

Participants' body composition characteristics at baseline and at the endpoint of the aerobic exercise program are shown in Table 1. As expected, at both baseline and at endpoint, participants who were classified as overweight or obese at baseline presented by design significantly higher weight, BMI, WC, body fat mass (in kg and percentage) (all *p*-values <.001) and fat free mass (*p*=.004) than participants with a normal weight. There were no significant effects of exercise on body composition variables. Significant interaction effects of aerobic exercise by weight status were observed for WC (*p*=.045) and percentage of body fat (*p*=.048). Participants with normal weight increased their WC, albeit not significantly (*p*=.085), and their percentage of body fat (*p*=.002) from baseline to the endpoint, while participants with overweight or obesity maintained their WC and their percentage of body fat (from baseline to endpoint).

[INSERT TABLE 2. HERE]

Based on the mixed-factorial ANOVA analyses presented in Table 2, there was no significant difference at baseline and at the endpoint of the program for REE between participants with normal weight and those with overweight or obesity, either presented in absolute values (kcal/day) (*p*=.087) or relative to fat-free mass (kcal/kg of fat-free mass) (*p*=.18). No significant effect of aerobic exercise or interaction between aerobic exercise and weight status (i.e., normal versus overweight/obese) on absolute REE was detected, but a significant effect of weight status (*p*=.022) was observed for REE relative to fat-free mass. A marginally significant effect of aerobic exercise on daily TEE (p=.051) (Table 3) and a significant effect on daily energy intake (p=.008) was found, but no significant effect of weight status or interaction of aerobic exercise and weight status was observed for those two variables. Follow-up analysis revealed a significant reduction in daily energy intake from baseline to endpoint only on days without an exercise session (p=.004) (Figure 4). A significant reduction in energy expenditure from physical activity (p=.031) was also observed from baseline to the endpoint of the exercise program (Figure 3), however the effect of aerobic exercise on energy expenditure from physical activity was not affected by participants' weight status. There was no significant interaction between aerobic exercise and weight status on energy expenditure from physical activity. Overall, participants with normal weight and with overweight or obesity reduced daily TEE (by reducing their physical activity) and daily energy intake (by reducing their daily total energy intake on days without an exercise session) at the endpoint of the aerobic exercise program. The effect of the aerobic exercise program in participants who reported to take specific actions to achieve their weight goal was not significantly different compared to the participants who did not intended to take action about their weight status (data not shown).

[INSERT FIGURE 3. AND FIGURE 4. HERE]

Discussion

The major findings of the present study suggest that after an 8-week aerobic exercise program, adolescents with normal weight, overweight or obesity not only reduced their daily total energy expenditure by reducing physical activity, but simultaneously decreased their daily energy intake, especially during days without an exercise session. The results of the present study are consistent with and supplement those reported by Thivel and colleagues (2014) concerning the effect of a 10-week aerobic exercise program in 26 adolescents. Although they found a slight decrease in daily energy intake (p = .07), this reduction was not associated with a significant weight loss following the exercise intervention (D. Thivel et al., 2014). Considering that energy expenditure was not measured in this study, the authors suggested that the energy expenditure component of the energy balance equation, in particular a reduction in daily physical activity, might explain why the exercise intervention and the decrease in energy intake was not associated with a significant weight loss. Therefore, the results of the present study add to those by Thivel and collaborators by providing evidence of the effect of an aerobic exercise program on both daily TEE and energy intake in adolescents with normal weight and overweight or obesity. With further replications, these findings could have clinical implications in that it might be important to recommend to adolescents that they maintain their usual daily physical activity habits even if they start an exercise program. However, more studies are needed to confirm those results in adolescents, because the energy expenditure compensation hypothesis has been recently refuted based on the results of a 6-week aerobic and resistance exercise program in 129 inactive adults (S. R. Gomersall et al., 2016).

Nonetheless, a difference between adolescents and adults exists and it might rely on the higher autonomy that the latter have on their own lifestyle behaviors.

Our hypotheses that participants' weight status would generate different effects of the aerobic exercise program on daily TEE energy expenditure and energy intake is were not supported by our findings. In fact, no significant interactions between aerobic exercise and weight status on those variables were found. However, there was a significant interaction effect between aerobic exercise and weight status for WC and percentage of body fat. Participants with normal weight increased their percentage of body fat (p=.002) whereas no significant change was observed in participants with overweight or obesity. Interestingly, a recent systematic review of meta-analyses that investigated the effect of exercise (aerobic, resistance and both) on body composition parameters in children and adolescents with overweight or obesity concluded that percentage of body fat was the only parameter that significantly decreased with exercise (Kelley & Kelley, 2013). Conversely, the evidence is insufficient concerning the efficacy of exercise to reduce body weight, BMI or central obesity. Moreover, many other systematic reviews in overweight or obese adolescents reported a decrease, not only in percentage of body fat, but also in BMI, BMI z-score, WC or weight after an exercise program (Ho et al., 2012; Kelley, Kelley, & Pate, 2014; Stoner et al., 2016). In this regards, the absence of reduction in body composition indices in participants of the current study could be partly explained by the fact that the duration of the aerobic exercise program (e.g., 8 weeks compared to up to 36 weeks) and the volume of exercise (e.g., frequency: 3 compared to up to 4 times/week; 30 compared to up to 43 min/session) were lower in comparison to the exercise intervention studies included in those systematic reviews. Surprisingly, the adolescents with normal weight in the present study increased, on average, their percentage of body fat, even if the effect of the aerobic exercise program on weight, daily TEE and energy intake was similar among the two groups. It is possible that the body composition measurement technique, that was the hand-to-foot bioelectrical impedance, is not as valid to measure the percentage of body fat in girls with normal weight (Meredith-Jones et al., 2015). It is important to keep in mind that, even though body composition did not changed in these adolescents following the exercise program, the exercise itself might have had a positive impact on their cardio-metabolic health, but no direct measurement was done on these parameters. There is a common thought in society that weight loss is necessary for a better health, which is not true (Loprinzi et al., 2014).

Interestingly, at the end of the aerobic exercise program, a significant reduction in daily energy intake was observed, which was based on the mean energy intake estimate using two dietary recalls at baseline and four dietary recalls (including two days with and two days without an exercise session) at the endpoint of the program. This observation is not in agreement with the ActivityStat theory, but is in line with the results reported by Prado and colleagues (2015) in which they investigated the effect of a 12-week aerobic exercise program on food intake and appetite-regulating hormones in adolescents with obesity. They found a decrease in ghrelin, and an increase in peptide tyrosine following the exercise intervention, which explained the reduction in food intake as measured using the 24-hour food diary (Prado et al., 2015). However, a significant decrease in leptin was also observed following the exercise intervention. Leptin being an anorexigenic hormone, the same exercise response pattern than the peptide tyrosine was expected. Thus, the effect of the exercise intervention on food intake mediated by the decrease of ghrelin and increase of peptide tyrosine might be lessened by the decrease of leptin. It is also possible that the decrease in daily energy intake following the 8-week aerobic exercise program might have been partly due to a shift by participants toward a healthier lifestyle in general. The fact that they started exercising three times per week might have made them more conscious about their eating behaviors in relation to their exercise and sedentary habits. Specifically, the participants may have voluntarily maintained their food intake during the days with exercise and decreased their foods intake during the days without an exercise session. Access to appetite-regulating hormone measurements, combined with a qualitative assessment approach, would have been helpful to better understand the underlying mechanisms explaining why a significant decrease in daily energy intake was only found on days without an exercise session.

Participants' REE (expressed either in absolute value or relative to fat free mass) was not significantly affected by the aerobic exercise program, which is in agreement with evidence in the literature if exercise is not accompanied by weight loss (A. Schwartz & Doucet, 2010; Thrush, Dent, McPherson, & Harper, 2013). Interestingly, participants with normal weight presented a significantly higher REE in regards to fat-free mass than participants with overweight or obesity. On the other hand, in a large sample of children and adolescents (n=116), Rodriguez and colleagues (2002) reported that REE relative to fat-free mass was not significantly different between children/adolescents with normal weight and with obesity. Considering that fat-free mass is the main determinant of REE (Rodríguez et al., 2002), results of the present study run contrary to existing evidence.

The significant decrease in daily TEE presented in this study might partly explain why many exercise intervention studies in adolescents found mostly no change in body weight even in the presence of a daily decrease in energy intake (C. Schwartz et al., 2016; D. Thivel et al., 2014). This observation, in the current study, is also in agreement with the ActivityStat theory, which implies that an increase in physical activity at a point during the day is followed by a decrease in physical activity later that day. The reduction in daily TEE observed in the present study could be attributed to a significant reduction in energy expenditure from physical activity. This reduction might be partly explained by a modulation of leptin by exercise. Indeed, a 12-week aerobic exercise program in obese adolescents induced a significant decrease in leptin levels (Prado et al., 2015). Lower leptin levels has been associated with a significant decrease in energy expenditure from physical activity (Jéquier, 2002; Salbe, Nicolson, & Ravussin, 1997). Therefore, it is possible that a compensation phenomenon, observed in the energy expenditure component in the current sample, might have been caused by a decrease in leptin levels concentration induced by the aerobic exercise program.

The present study has some limitations. Even though small correlations between hormones and food intake have been reported, the lack of measured of appetite-regulating hormones limits our capacity to identify potential underlying mechanisms to explain the impact of an aerobic exercise program on energy expenditure and energy intake. Furthermore, the energy intake was measured with 24-hour dietary recalls on two weekdays for practical reasons. To assess the usual dietary intake, the average of three 24-hour dietary recalls is preferable, with the inclusion of two weekdays and one weekend day (Ollberding, Couch, Woo, & Kalkwarf, 2014). Moreover, the dietary recall, with most dietary assessment technique, presents some limitations (ESCC, 2004; Academy of Nutrition and Dietetics, 2015; Lee and Nieman, 2013). Moreover, we use accelerometers, because of financial limitations, instead of Doubly-labelled water, which is the gold standard to measure energy expenditure from physical activity. There are also limitations regarding self-reporting of 24-hour dietary recalls and the self-awareness of being evaluated while wearing an accelerometer.

Nonetheless, the current study is the first to investigate the effect of an aerobic exercise program on both daily TEE and energy intake in adolescents with normal weight as well as those with overweight or obesity, helping to fill the gaps of other studies in the literature. Specifically, to our knowledge the different effect of an aerobic exercise program on adolescents with normal weight and with overweight or obesity has never been compared. Finally, another major strength of this study is the high retention rate of participants (86.67%) as well as a high adherence (86,70%) to the aerobic exercise program.

Conclusion

The results of the current study suggest that adolescents with normal weight, overweight or obesity not only reduced their daily total energy expenditure, but simultaneously decreased their daily energy intake after an aerobic exercise program. Further studies in adolescents are needed to confirm those results and to help elucidate the reasons for the changes in energy expenditure and intake following the initiation of an aerobic exercise program which could partially explain the lack of weight loss following an exercise intervention in adolescents with overweight or obesity.

Authors' contribution

Alyssa Biagé, Drs Denis Prud'homme and Isabelle Giroux created the design of this study. Alyssa Biagé was in charge of collecting data, analysing data, interpreting the results and writing the draft of the manuscript. Drs Denis Prud'homme and Isabelle Giroux reviewed the manuscript.

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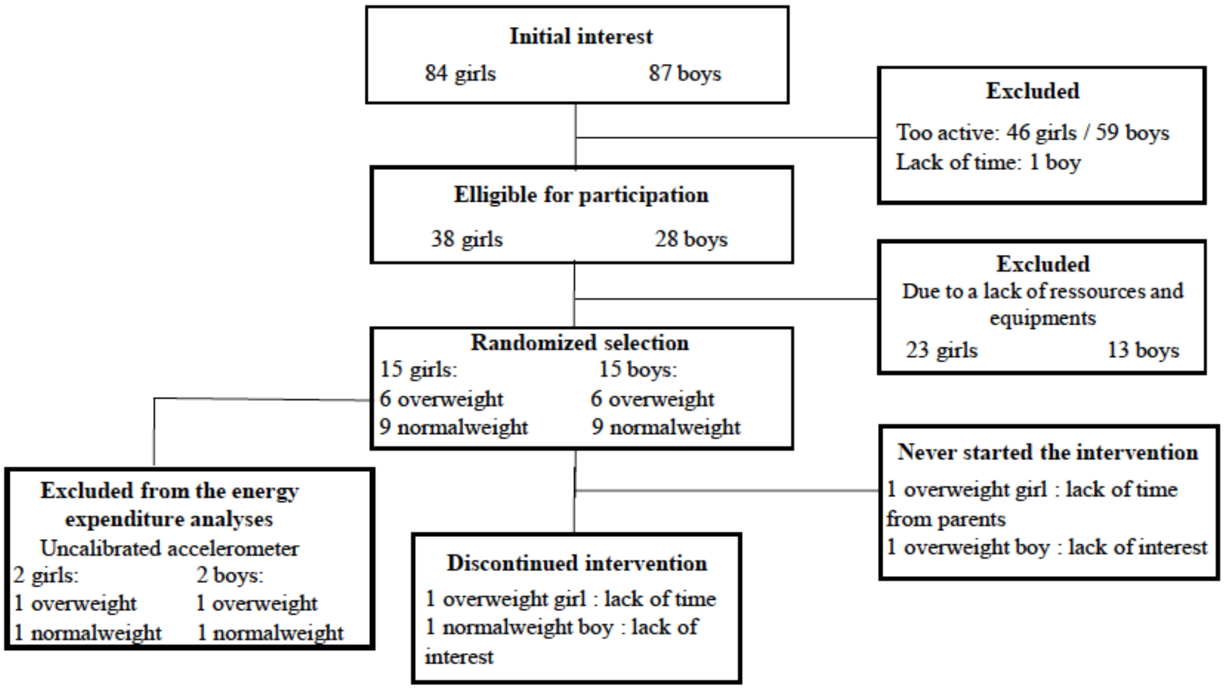

Figure 1. Screening, enrolment and follow-up of the study

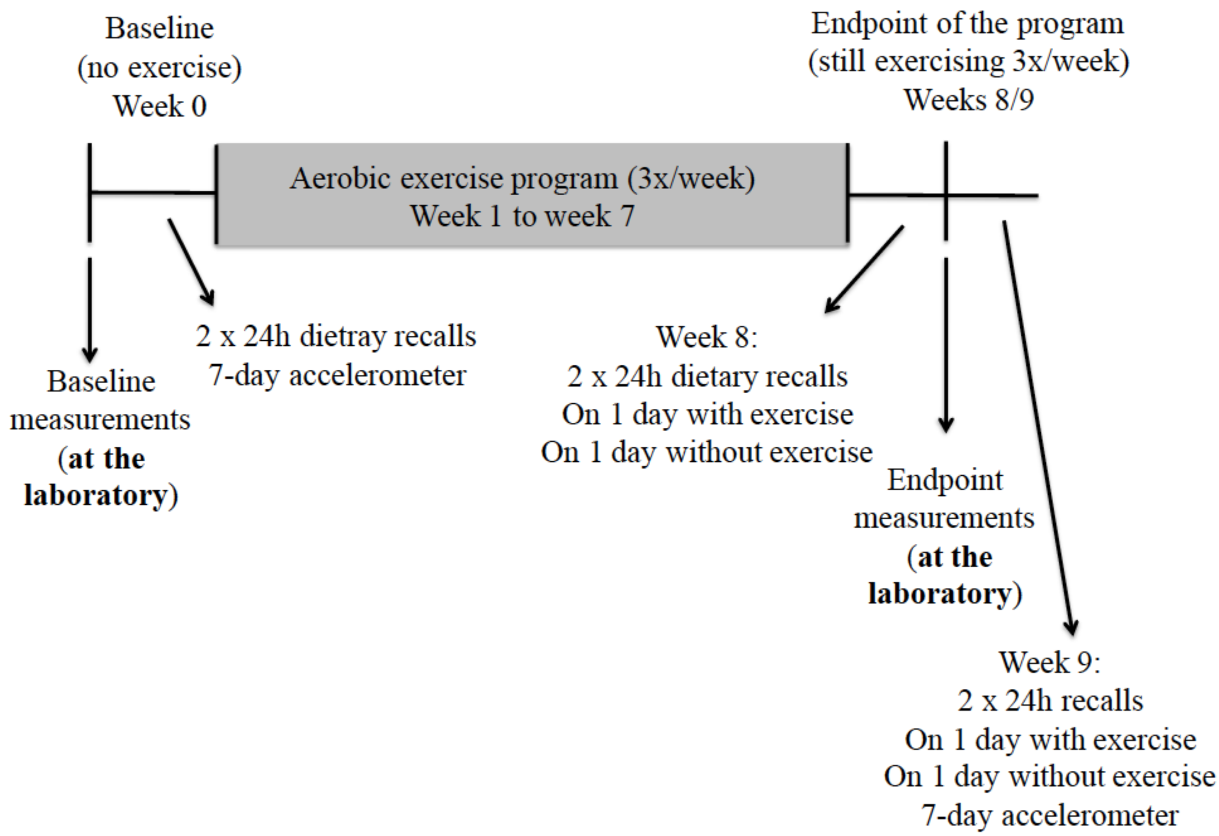

Figure 2. Timeline for each measurement

Table 1. *Main effects of aerobic exercise (i.e., baseline, endpoint) and weight status (i.e., normal weight, overweight or obese) and interaction effects on body composition characteristics.*

	Baseline	Endpoint	Exercise Effect	Weight status Effect	Interaction Effects
Body composition (n=26)					
Body weight (kg)					
Normal weight	57.10±7.64	57.08±7.75	NS	**< .001**	NS
Overweight/Obese	82.94±11.83	82.37±12.21			
BMI (kg/m^2)					
Normal weight	20.43±1.91	20.29±1.79	NS	**< .001**	NS
Overweight/Obese	29.38±3.67	29.48±3.92			
WC (cm)					
Normal weight	70.19±6.43	71.29±6.73	NS	**< .001**	**.045**
Overweight	90.43±12.93	89.12±10.44			
Fat mass (kg)					
Normal weight	11.81±4.02	12.21±3.70	NS	**< .001**	NS
Overweight/Obese	27.59±6.84	27.48±7.08			
Fat mass (%)					
Normal weight	20.57±6.03	21.56±5.72	.063	**< .001**	**.048**
Overweight/Obese	33.27±6.48	33.23±6.37			
Fat-free mass (kg)					
Normal weight	45.01±6.99	44.66±7.25	NS	**.004**	NS
Overweight/Obese	55.09±9.05	54.71±8.67			

Values are mean ± SD
Note: BMI, body mass index; WC, waist circumference; NS, non-significant.
Endpoint refers to week 8 for body composition variables.

Table 2. *Main effects of aerobic exercise (i.e., baseline, endpoint) and weight status (i.e., normal weight, overweight or obese) and interaction effects on total daily, energy expenditure and energy intake.*

	Baseline	Endpoint	Exercise Effect	Weight status Effect	Interaction Effects
Energy Intake (n=26)					
Total energy intake (kcal/day)					
Normal weight	2322.34± 579.46	2151.22± 507.44	**.008**	NS	NS
Overweight/Obese	2541.02± 576.61	2095.21± 335.88			
Energy Expenditure					
REE - absolute value (kcal/day) (n=26)					
Normal weight	1472.50± 213.69	1488.16± 256.14	NS	NS	NS
Overweight/Obese	1619.97± 197.18	1660.62± 235.44			
REE - relative value (kcal/kg of fat-free mass) (n=26)					
Normal weight	32.90±3.31	33.51±4.18	NS	**.022**	NS
Overweight/Obese	29.72±1.71	30.52±2.43			
TEE (kcal/day) (n=20)					
Normal weight	2309.10± 511.48	2106.51± 92.94	**.051**	NS	NS
Overweight/Obese	2497.56± 290.15	2414.98± 128.78			

Values are mean ± SD
Note: REE, resting energy expenditure; TEE, total energy expenditure; NS, non-significant.
Endpoint refers to week 9 for Energy Expenditure and to week 8 and week 9 for Energy Intake.

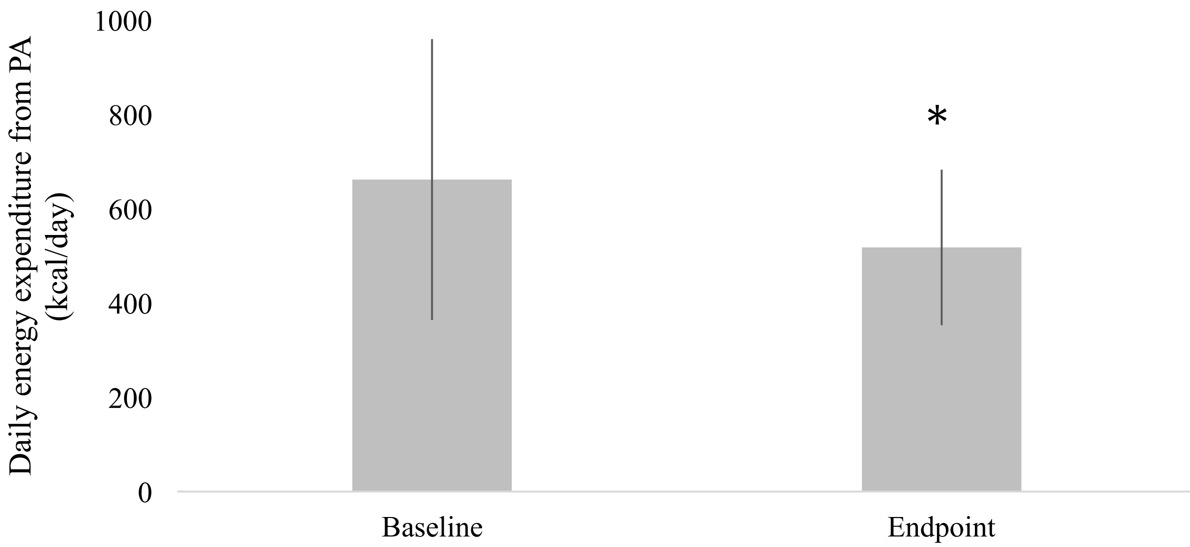

Figure 3. Effect of 8-week aerobic exercise program on daily energy expenditure from physical activity. *Significantly different from baseline (p = .031), n = 20.

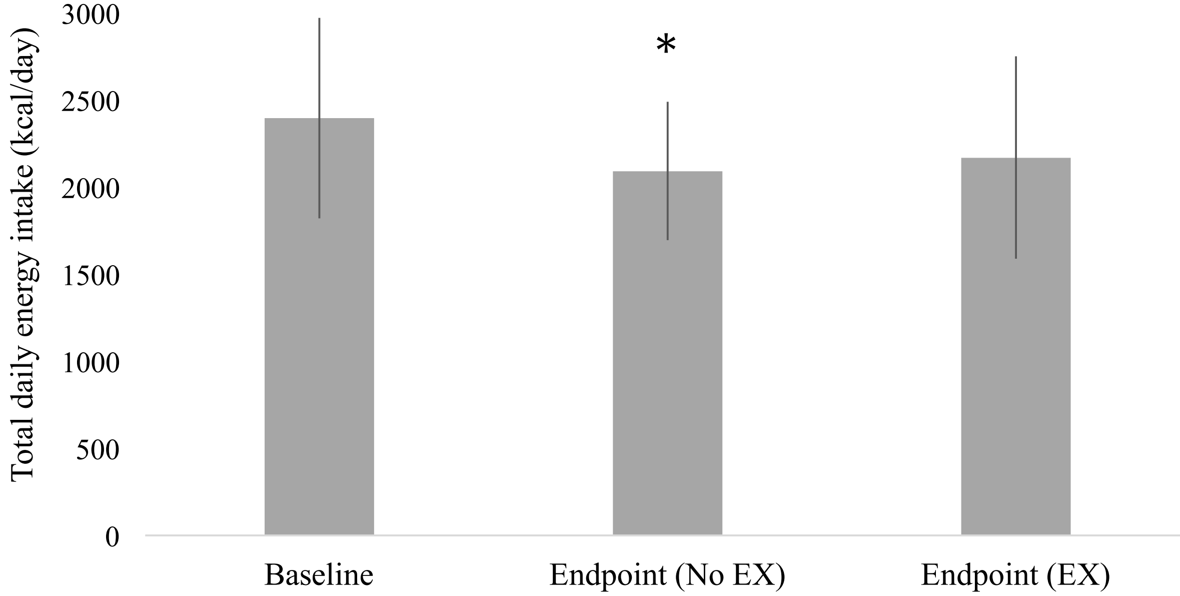

Figure 4. Effect of 8-week aerobic exercise program on daily energy intake. *Significantly different from baseline (p = .004), n = 26.

No EX: Days without an exercise session

EX: Days with an exercise session

CHAPTER 5: Summary and conclusion

To our knowledge, the present research is the first to investigate the effect of an 8-week aerobic exercise program on both daily energy expenditure and energy intake in both adolescents with normal weight, and overweight or obesity.

Previous studies, like those led by Thivel and collaborators (2014) and the studies included in the review from Schwartz et al (2016), have investigated the effect of an aerobic exercise program (between 8 to 12 weeks) on energy intake only in adolescents with obesity. A significant reduction in daily energy intake following the exercise program was the take home message from those manuscripts. The effect of exercise program on body weight was not significant. It was assumed that, following an aerobic exercise program, adolescents with obesity might compensate by reducing their daily energy expenditure, which lead to the hypothesis of this thesis.

The major findings in this study were a significant reduction in daily TEE from physical activity and energy intake, specifically during days without an exercise session following an 8-week aerobic exercise program. Moreover, the exercise program did not induce a change in the average body weight from baseline to the endpoint of the exercise program, which is consistent with the evidences in the literature and support by our findings demonstrating a reduction in both daily energy expenditure and energy intake following the aerobic exercise program. These results confirmed our hypothesis concerning the chronic effect of exercise training in our participants with overweight or obesity, but did not validated our hypothesis among our participants with normal weight; in fact, weight status did not influence the effects of the aerobic exercise program on the variables of interest.

The findings of the present study need to be confirmed in randomized controlled trials that will use at least three dietary recalls to measure daily energy intake, and ideally, doubly-labelled water to measure daily energy expenditure. The energy intake at baseline and the endpoint of the exercise program was determined, for practical and financial reasons, with the average of two 24-hours dietary recalls measure on weekdays. To assess the usual energy intake, the average of three 24-hour dietary recalls is preferable, with the inclusion of two weekdays and one weekend day (Ollberding, Couch, Woo, & Kalkwarf, 2014). Moreover, doubly-labelled water is the gold standard for the measurement of daily energy expenditure, especially in children and adolescents (Black & Cole, 2000). Again, because of practical and financial reasons, we relied on accelerometer to measure energy expenditure from physical activity. It is of note to mention that accelerometers predict energy expenditure accurately in youth (de Graauw, de Groot, van Brussel, Streur, & Takken, 2010).

The effects of exercise on energy expenditure and energy intake need to be further investigated in adolescents with normal weight, overweight and obesity, as well as the influence of the sex and weight status on the response to the exercise training. Due to a small amount of participants with overweight or obesity, as well as boys and girls, we were not able to performed statistical analysis with enough statistical power to detect a significant difference between sub-groups based on weight status and sex. Lastly, to be able to identify potential underlying mechanisms of the energy compensation concept, a mixed methods approach needs to be use in further investigations, which should include, per example, the measurement of appetite-regulating hormones, used of buffet tests and qualitative interviews.

Nonetheless, the current study is the first to investigate the effects of an exercise program on both daily energy expenditure and energy intake in both adolescents with normal weight and with overweight or obese, which fill the gap left by Thivel and colleagues (2014) in the literature. Furthermore, the retention rate (86.67%) of participants and the exercise adherence (86.70%) in the present study is excellent. Therefore, this study will be a stepping stone for many future studies, which might help elucidate the reasons for the individual variation in responses following an aerobic exercise program and contribute to enhance the prevention of excess weight gain and the improvement of cardio-metabolic health factors in adolescents with overweight or obesity.

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APPENDIX A : *Consent form*

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Information Sheet and Consent Form

AN AEROBIC EXERCISE PROGRAM IN ADOLESCENTS

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1. GENERAL INFORMATION

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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.

Version dated November 10th, 2015

Page **1** of 7

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)		

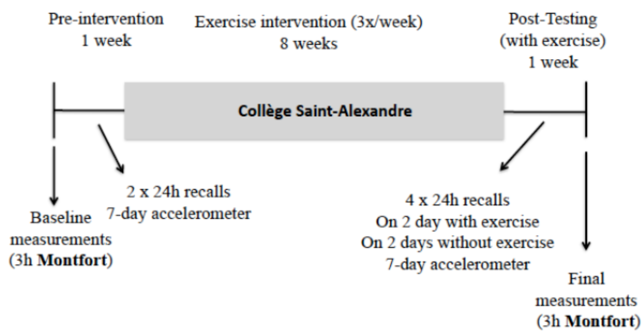

Figure. Evaluation and intervention activities' sequence during the study

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 Biagè (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 B : *Ethic's certificates of approval*

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),

Co-superviseur

Isabelle Giroux
École des sciences de la nutrition
Faculté des sciences de la santé
Université d'Ottawa

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 C : *Laboratory data sheets*

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

VERIFICATION LIST OF TESTS

TESTS	Done	Computerized (dd/mm/yyyy)	Initials	Verified (dd/mm/yyyy)	Initials
Flow sensor calibration	☐	________		________	___
Anthropometric test	☐	___/___/___		___/___/___	
Body composition	☐	___/___/___		___/___/___	
Automatic MCU calibration	☐	________		________	___
Resting energy expenditure	☐	___/___/___		___/___/___	
Resting heart rate	☐	___/___/___		___/___/___	
Standard breakfast	☐	___/___/___		___/___/___	
Questionnaires (8)	☐	___/___/___		___/___/___	
Automatic MCU calibration	☐	________		________	___
Sub-max exercise test	☐	___/___/___		___/___/___	
Accelerometer	☐	___/___/___		___/___/___	

Notes :

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

FLOW SENSOR CALIBRATION

Before the participant's arrival, the flow sensor calibration needs to be done.

Start-up

1. Turn on the computer
    a. The Vmax must always be ON; never shut it down (e.g. blue light must remain on)
2. Double click on the Vmax Icon

Calibration

1. Click on Flow sensor calibration
    a. F1 for calibration
    b. Connect the calibration syringe to the Vmax; follow the instructions:
        i. Do 2 strokes with the syringe
        ii. Spacebar
        iii. A screen will appear with a graph containing yellow horizontal sections. You need to do strokes (with the syringe) at different speed. When a proper line is produced within a yellow area, the corresponding section of the vertical bar on the right side of the screen will turn green. There is no particular order of the yellow areas to target.
        iv. Once all the areas on the vertical bar on the right side of the screen have turned green, the screen presents a verification of the calibration. The small graph on the right side of the screen has similar areas within a flow must be produced by doing strokes at different speeds with the syringe.
        v. If calibration procedures are successful, you will be brought back to the main options screen. If calibration is unsuccessful, a message prompt will appear indicating that one or more calibration strokes were out of range; the calibration must them be repeated.
        vi. F3 to save.
2. Notes :

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

ANTHROPOMETRIC AND BODY COMPOSITION

Anthropometric Measures :

Weight: _______.____ kg; _______.____ kg; _______.____ kg = _______.____ kg

_______.____ lbs; _______.____ lbs; _______.____ lbs = _______.____ lbs

Height: _______.____ cm; _______.____ cm; _______.____ cm = _______.____ cm

BMI: _______.____ kg/m^2

*Waist circumference: _______.____ cm; _______.____ cm; _______.____ cm = _______.____ cm

*To measure waist circumference, locate the upper hip bone and the top of the right iliac crest. Place a measuring tape in a horizontal plane around the abdomen at the mid way between iliac crest and last rib. Before reading the tape measure, ensure that the tape is snug, but does not compress the skin. The measurement is made at the end of a normal expiration to the nearest 0.5 cm. The average of 2 measures will be used provided each measure is within 0.5 cm.

Questions to ask before doing an impedance:

- Are you pregnant or think you might be pregnant (girl)? Yes ☐No ☐
- Did you eat in the last 12 hours? Yes ☐No ☐
- Did you empty your bladder? Yes ☐No ☐
- Did you exercise in the last 36 hours? Yes ☐No ☐
- When was the last time you drink water? _________________

* Remove all possible metal and electronic devices.
* Ensure that the arms are not touching the side of the body, and that the inner thighs are not touching each other during measurements; if necessary, place a dry towel between the arm and side and/or between the thighs.

Bioimpédance :

Body Composition			
Percent body fat: _______.____ %			
Fat Free Mass (FFM)		**Fat Mass (FM)**	
Arm L: _____._____ kg Leg L: _____._____ kg	Arm R: _____._____ kg Leg R: _____._____ kg	Arm L: _____._____ kg Leg L: _____._____ kg	Arm R: _____._____ kg Leg R: _____._____ kg
Trunk : _____._____ kg		Trunk : _____._____ kg	
Total FFM : _____._____ kg		**Total FM :** _____._____ kg	

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

AUTOMATIC CARDIOMETABOLIC UNIT CALIBRATION

On the computer, with the Vmax program

1. For subject information, press new study (enter the subject's information)
   a. ID, date of birth, etc…
   b. F3 to save

2. Exercise metabolic test
   a. Open the 2 gas canister at the back of the unit by using the Allen key (to open the canister, you turn the key in the counter clockwise side) ***Make sure to hold on to the canister with one hand while using the Allen key with the other hand***
   b. Choose Canopy study
   c. F1 start test; this process is automatic
   d. F1 for calibration
   e. If calibration fail, a message appears prompting you to repeat the calibration F1 again. (If required, keep pressing F1 until there is a successful calibration)
   f. Do F2 to verify the calibration
   g. Do F3 to save
   h. Do not close the canister during the test

3. Notes :

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

RESTING ENERGY EXPENDITURE

Time of the day : Hour : ______, Min : _______ A.M.☐ P.M ☐

1.	Have you fasted for 12 hours?	YES	☐	NO	☐
	Since when? (Last food intake time)	________________________________			
2.	What time did you go to sleep?	________________________________			
3.	How many hours did you sleep?	________________________________			
4.	Did you have a good night sleep?	YES	☐	NO	☐
5.	Did you practice any exercise in the last 36 hours before testing?	YES	☐	NO	☐
6.	Did you take any medications in the last 12 hours?	YES	☐	NO	☐
	If yes, which ones?	________________________________			
7.	Did you smoke or drink coffee in the last 2 hours?	YES	☐	NO	☐

**Bladder must be empty before doing the resting metabolic rate.

***The participant have to rest, in a supine position in the dark without sleeping, for 20 min before measuring the resting energy expenditure under the bubble.* ☐ check when it is done**

After the 20 min rest,

1. Put the participant under the bubble
2. Turn the fan pump ON and spacebar to continue
3. Adjust the FeCo2 : Adjust the pump flow (bottom right corner of the computer screen) to keep FECO2 between O.7 and 1.00 during the test. Ideally, try to stabilize between 0.75 and 0.85.
    a. If the FECO2 goes above 1.0, increase the pump flow by 2 or 3 units. If the FECO2 goes below 0.70, decrease the pump by 2 or 3 units.
    b. If the FECO2 is between 0.70 and 1.00 during the test, don't adjust the pump.
4. F8 to start the test
5. End of test: Y (yes) end study: Spacebar to continue, F3 to save, F3 again!!

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

Measurements of resting energy expenditure (under the bubble) / Temp: ______°C

	VO2 (ml/min)	VCO2 (ml/min)	RER
Minute 6			
Minute 7			
Minute 8			
Minute 9			
Minute 10			
Minute 11			
Minute 12			
Minute 13			
Minute 14			
Minute 15			
Minute 16			
Minute 17			
Minute 18			
Minute 19			
Minute 20			
Minute 21			
Minute 22			
Minute 23			
Minute 24			
Minute 25			

Mean results of REE, "under the bubble" (from minute 6 to minute 25)

VO2 (ml/min)	VCO2 (ml/min)	
_____ _____ _____ . _____	_____ _____ _____ . _____	
kcal/day	**RER**	**EE (kcal/min)**
_____ _____ _____ _____	_____ . ______ ______	_____._____ _____

DO NOT FORGET TO CLOSE THE CANISTERS AT THE END (CLOCKWISE)

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

RESTING MEASUREMENTS

Resting Heart Rate

- Sitting confortably on a chair with arms support
- Feet flat on the ground
- Resting for 5 minutes
- Take the heart rate with the Polar heart rate monitor

	1st measure 5 min (sitting)	2d measure 6 min (sitting)	3rd measure 7 min (sitting)	Mean
Heart rate (bpm)				

Karvonen equation:

Target heart rate = ((220 – age - resting heart rate) x exercise intensity (%)) + resting heart rate.

Age: _____________________

Target heart rate (50%) = _________________________

Target heart rate (75%) = _________________________

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

STANDARDIZED BREAKFAST

Standard breakfast contains:

Ingredients	Weight (g)
2 whole wheat toasts	
2 raspberry jam	
1 piece of cheese	
2 small orange juice	

= 575 kcal

1. Did the participant eat the breakfast completely within 15 minutes?	YES	☐	NO	☐

If not, what was left ?

Ingredients	Weight left (g)	Weight eaten (g)
2 whole wheat toasts		
2 raspberry jam		
1 piece of cheese		
2 small orange juice		

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INDICATIONS POUR LES QUESTIONNAIRES

Vous serez tenus, pour la prochaine heure, de répondre aux questionnaires ou aux questions suivants.

- International Physical Activity Questionnaire
- Tanner Stage Questionnaire
- Date de la dernière menstruation (fille)
- Question sur la perception de votre poids
- Questionnaire ISCOLE
- Question sur l'origine ethnique
- Questionnaire sur les comportements alimentaires
- Questionnaire général sur la nutrition
- Questionnaire de fréquence alimentaire

Je vous rappelle que vous n'êtes pas évalués sur ces questionnaires; ce n'est pas un examen. Il n'y a pas de bonnes ou mauvaises réponses. Vous répondez aux questions avec le meilleur de vos connaissances et de votre mémoire. Toutes les réponses que vous nous fournirez resteront confidentielles; personne ne pourra associer vos réponses avec votre nom.

Soyez le plus juste possible dans vos réponses. Vous ne serez en aucun cas juger ou critiquer sur la base de vos réponses.

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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

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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

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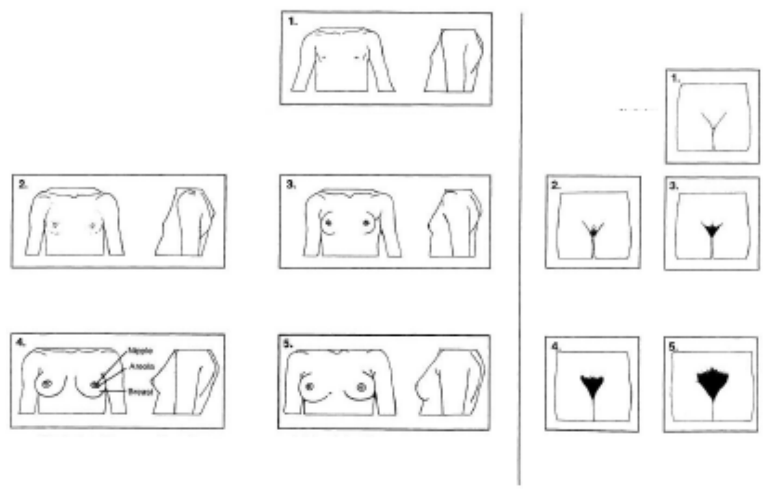
STAGES DE TANNER

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



Date de la dernière menstruation : Du _______________ au __________________

PERCEPTION DU POIDS

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)? ______________________________________

The participation of adolescents in an 8-week aerobic exercise program on a stationary bike supervised by an exercise specialist

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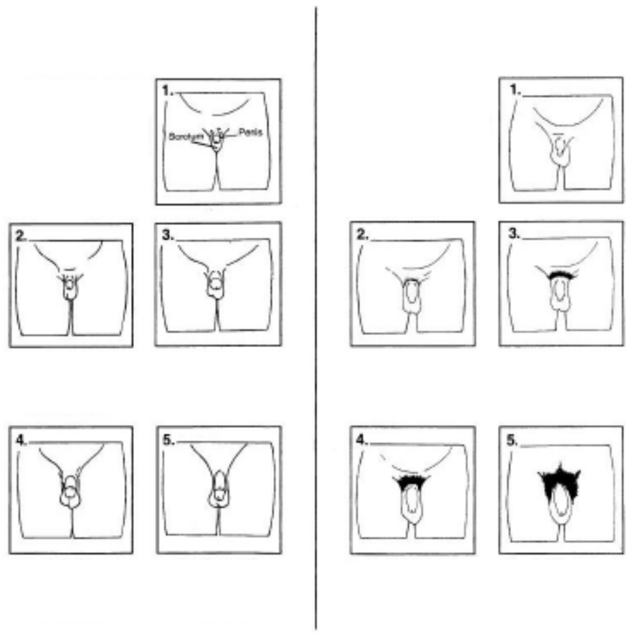
STAGES DE TANNER

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



PERCEPTION DU POIDS

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

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QUESTIONNAIRE ISCOLE

SVP lire les questions attentivement. Quelle réponse vous vient à l'esprit en premier? Choisissez la boîte qui correspond le mieux à votre réponse et remplissez-la.

Il n'y a AUCUNE mauvaise réponse.

Vous n'avez pas besoin de montrer vos réponses à personne. De plus, personne qui vous connaît ne va regarder ce questionnaire une fois rempli.

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)

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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

Origine ethnique

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 : ____

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   ☐☐:☐☐ AM / PM (encerclez AM or PM)

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____________ fois par semaine

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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

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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

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QUESTIONNAIRE GÉNÉRAL SUR LA NUTRITION

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?___

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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) : _________________________

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QUESTIONNAIRE DE FRÉQUENCE ALIMENTAIRE

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

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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 tous 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)				

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5m	Pommes de terre				
5n	D'autres types de légumes (comme les tomates, champignons, etc.)				
5bbb	Autres, spécifiez : ________________________				
	Consommation de viande et substituts				
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				
5ccc	Autres, spécifiez : ________________________				
	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				
5ddd	Autres, spécifiez : ________________________				
	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				

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5mm	Café, thé				
5nn	Eau du robinet ou de la fontaine				
5oo	Eau embouteillée				
5eee	Autres, spécifiez : ________________________				
	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)				
5fff	Autres, spécifiez : ________________________				
	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

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

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

Fin des questionnaires. Nous vous remercions pour votre temps !

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	**Date (dd/mm/yyyy)**			**Subject's code**		
Pre-						

AUTOMATIC CARDIOMETABOLIC UNIT CALIBRATION

On the computer, with the Vmax program

1. For subject information, press new study (enter the subject's information)
    a. ID, date of birth, etc…
    b. F3 to save

2. Exercise metabolic test
    a. Open the 2 gas canister at the back of the unit by using the Allen key (to open the canister, you turn the key in the counter clockwise side) ***Make sure to hold on to the canister with one hand while using the Allen key with the other hand***
    b. Choose Ergometer study
    c. F1 start test; this process is automatic
    d. F1 for calibration
    e. If calibration fail, a message appears prompting you to repeat the calibration F1 again. (If required, keep pressing F1 until there is a successful calibration)
    f. Do F2 to verify the calibration
    g. Do F3 to save
    h. Do not close the canister during the test

3. Notes :

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
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SUB-MAXIMAL EXERCISE TEST

From the Karvonen's equation:

Target heart rate (50%) = ________________________

Target heart rate (75%) = ________________________

Measurements during the test / Temp: _____°C

Warm-up at 50%	Heart rate (bpm)	VO2 (ml/min)	VCO2 (ml/min)	RER
Minute 1				
Minute 2				
Minute 3				
Minute 4				
Minute 5				
Test at 75%				
Minute 1				
Minute 2	☐			
Minute 3	☐			
Minute 4	☐			
Minute 5	☐			
Minute 6	☐			

→Steady state = 3 min at +/- 5 BPM

Mean results at steady state (target heart rate (75%))

VO2 (ml/min)	VCO2 (ml/min)	
_____ _____ _____ . _____	_____ _____ _____ . _____	
EE (kcal/min)	**RER**	**HR at 75% (BPM)**
_____._____ _____	_____ . ______ ______	_____ _____ _____

THE PARTICIPATION OF ADOLESCENTS IN AN 8-WEEK AEROBIC EXERCISE PROGRAM ON A STATIONARY BIKE SUPERVISED BY AN EXERCISE SPECIALIST

Visit	Date (dd/mm/yyyy)			Subject's code		
Pre-						

Moniteur portatif pour la mesure l'activité physique « Actical »

Comment utiliser votre moniteur :

L'Actical est porté sur la hanche droite (crête iliaque antérieure), fixé avec une ceinture élastique avec la flèche pointant vers le haut.

Le moniteur doit être porté pendant **7 jours à partir du moment vous vous réveillez jusqu'au moment où vous dormez.**

Enlever le moniteur lorsque vous prenez votre douche ou nagé. ***Il n'est pas résistant à l'eau!***

Dans le cas où vous ne portez pas le moniteur, vous devez inscrire sur le formulaire de la page suivante la raison et l'heure à laquelle vous avez enlevé et remis le moniteur.

Information

Vous trouverez ci-joint une trousse comprenant un moniteur portatif. Ces mesures sont très importantes en regard des objectifs de l'étude. Nous vous demandons donc d'être très vigilants avec l'instrument

N'oubliez pas de rapporter les instruments et les documents dans les plus brefs délais suivant la période de collecte de données.

Si vous avez des questions, n'hésitez pas à me contacter.

APPENDIX D : *24-h dietary recalls data sheets*

LA PARTICIPATION D'ADOLESCENTS DANS UN PROGRAMME D'EXERCICE AÉROBIE DE 8 SEMAINES SUR VÉLO STATIONNAIRE SUPERVISÉ PAR UN SPÉCIALISTE DE L'EXERCICE

Visite	Date (jj/mm/aaaa)			Code du sujet		
Pré						

Rappel de 24 heures

Liste des aliments et boissons consommés hier :

Heures et **emplacements** (repas/collation?)	**Nom** des aliments ou boissons	**Description détaillée** des aliments ou boissons (ex. type, saveur, frais/congelé/en conserve, fait maison ou marque/restaurant, régulier ou bas en gras/sucre/sel, cru/préparé, mode de cuisson, %MG des produits laitiers, etc.)	**Quantités** consommées

LA PARTICIPATION D'ADOLESCENTS DANS UN PROGRAMME D'EXERCICE AÉROBIE DE 8 SEMAINES SUR VÉLO STATIONNAIRE SUPERVISÉ PAR UN SPÉCIALISTE DE L'EXERCICE

Visite	Date (jj/mm/aaaa)			Code du sujet		
Pré						

Heures et **emplacements** (repas/collation?)	**Nom** des aliments ou boissons	**Description détaillée** des aliments ou boissons (ex. type, saveur, frais/congelé/en conserve, fait maison ou marque/restaurant, régulier ou bas en gras/sucre/sel, cru/préparé, mode de cuisson, %MG des produits laitiers, etc.)	**Quantités** consommées

LA PARTICIPATION D'ADOLESCENTS DANS UN PROGRAMME D'EXERCICE AÉROBIE DE 8 SEMAINES SUR VÉLO STATIONNAIRE SUPERVISÉ PAR UN SPÉCIALISTE DE L'EXERCICE

Visite	Date (jj/mm/aaaa)			Code du sujet		
Pré						

- Est-ce que c'était une journée de consommation **typique?** ___ Si non, s.v.p. expliquer pourquoi/comment : ________________
  ____
- Avez-vous pris des **suppléments et/ou médicaments** hier? ___ Si oui, s.v.p. décrire: _________________________________
  ____
- Avez-vous ajouté du **sel** à la table et/ou dans la préparation des aliments hier? ___ Si oui, s.v.p. clarifier : _________________
- Avez-vous **bu d'autre chose** hier (eau, café/thé, boissons sportives, etc.)? ___ Si oui, s.v.p. décrire : _____________________
  ____

Signature: _________________________________ Titre: __________________________

APPENDIX E : *Accelerometer data sheets*

LA PARTICIPATION D'ADOLESCENTS DANS UN PROGRAMME D'EXERCICE AÉROBIE DE 8 SEMAINES SUR VÉLO STATIONNAIRE SUPERVISÉ PAR UN SPÉCIALISTE DE L'EXERCICE

Visite	Date (jj/mm/aaaa)			Code du sujet		
Pré						

ACCÉLÉROMÈTRE
7 jours consécutifs avant la première visite

 # Actical: ______

Weight: ________ kg **Height:** ________ cm **BMI**: ________ kg/m^2

Worn on right hip : ☐ yes ☐ no

Date		Énergie Dépensée (kcal/jour)	Activity count	Minutes d'activité physique par catégorie d'intensité			
				Sédentaire	Légère	Modéréee	Vigoureuse
	L						
	Ma						
	Me						
	J						
	V						
	S						
	D						
Total		0.00	0.00	0.00	0.00	0.00	0.00
Moyenne		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
# jours		0					
Moyenne							
jour de semaine		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
fin de semaine		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Initiales de l'évaluateur: __

Visite	Date (jj/mm/aaaa)			Code du sujet		
Pré						

<u>Critères d'inclusion des données de l'accéléromètre dans la base de données</u>:

La personne doit avoir :

- Au moins 4 jours valides
- Ce qui comprends:
    - 10 heures ou plus par jour de temps avec le port de l'accélèromètre
    - des périodes d'interruption de moins de 60 minutes.

Source: 2007 to 2009 Canadian Health Measures Survey

Initiales de l'évaluateur: __

APPENDIX E : <u>*Exercise attendance data sheets*</u>

LA PARTICIPATION D'ADOLESCENTS DANS UN PROGRAMME D'EXERCICE AÉROBIE DE 8 SEMAINES SUR VÉLO STATIONNAIRE SUPERVISÉ PAR UN SPÉCIALISTE DE L'EXERCICE

Visite	Date (jj/mm/aaaa)			Code du sujet		
-	-	-	-			

Fiche de participation

	Heure du début	Date	Jour de la semaine	Fréquence cardiaque			Durée totale	Initiale (AB)	Borg	
				0-5 min	5-30 min moy.	5-30 min interval			5-15 min	15-25 min
Semaine 1										
Semaine 2										
Semaine 3										
Semaine 4										
Semaine 5										
Semaine 6										

Visite	Date (jj/mm/aaaa)			Code du sujet		
-	-	-	-			

	Heure	Date	Jour de la semaine	Fréquence cardiaque			Durée totale	Initiale (AB)	Borg	
				0-5 min	5-30 min moy.	5-30 min interval			5-15 min	15-25 min
Semaine 7										
Semaine 8										
Semaine 9										