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Influence of Perceived Stressful Homework on Lifestyle Habits and Subsequently on Adiposity: a QUALITY Study

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Résumé

Contexte : Les devoirs perçus stressants semblent avoir un effet négatif sur l'adiposité des enfants entre 8-10 ans et l'activité physique d'intensité moyenne-élevée (APMV) et le temps-écran sont des médiateurs dans cette relation.

Objectifs : 1) Examiner si un facteur nutritionnel pourrait aussi être un médiateur, 2) Étudier les associations et médiateurs présents à l'âge de 10-12 ans, et 3) Prendre une approche longitudinale sur ces résultats pour étudier ces relations.

Méthodes : Les données suivantes de l'étude de QUALITY ont été extraites : durée des devoirs, niveau de stresse et temps-écran, durée de sommeil et APMV, facteurs nutritionnels, et profil d'adiposité. « Process Macro » a été utilisé pour faire les analyses statistiques.

Résultats principaux : Les devoirs perçus étant stressants étaient positivement associés avec l'adiposité seulement à 8-10 ans chez les enfants, particulièrement les filles. La consommation de breuvage sucré était un médiateur partiel entre les devoirs perçus étant stressants et le pourcentage de gras abdominal des enfants de 8-10 ans. À 10-12 ans, le temps-écran était le seul médiateur entre les devoirs et l'index de masse corporelle. Le changement dans la durée de sommeil était le seul médiateur entre les changements de devoirs perçus étant stressant et pourcentage de gras abdominal qui s'est produit depuis l'âge de 8-10 ans chez les enfants, particulièrement les filles.

Conclusions : Avec l'avancée de l'âge et augmentation des devoirs, les habitudes d'écran changent. Dans l'aspect préventif de l'obésité pédiatrique, le temps-écran et la durée de sommeil pourraient être surveillés de près.

Mots-clés: Devoir, écran, sommeil, activité physique, alimentation, breuvages sucrés, enfants, obésité

Abstract

Background: Perceived stressful homework was shown to be associated with poor adiposity profile in children aged 8-10 years old, and this was mediated by a decrease in moderate-to-vigorous physical activity (MVPA) and an increase in screen time.

Objectives: 1) Explore if any dietary factors could be potential mediator, 2) Observe the associations and mediators present at 10-12 years of age, and 3) Examine from a longitudinal perspective these associations (from 8-10 years old to 10-12 years old).

Methods: The following information on the QUALITY cohort children were extracted: homework duration, stress level and screen time, sleep and MVPA duration, dietary factors, and adiposity profile. Process Macro for SPSS was used for the statistical analyses.

Main Results: Perceived stressful homework was positively associated with adiposity at 8-10 years old only in all children, particularly in girls. High-sugar drink was a partial mediator between perceived stressful homework and trunk fat percentage in children at 8-10 years old. Screen time mediated the relationship between homework and body mass index of children at 10-12 years old. Sleep duration change mediated the association between perceived stressful homework duration and trunk fat percentage changes in children since ages 8-10 years old, especially in girls.

Discussion: As children grow and perform a lot of homework, screen habits changes. In prevention aspect of paediatric obesity, screen time and sleep duration are the two major habits to monitor.

Keywords: Homework, screen, sleep, physical activity, diet, high-sugar drink, children, obesity

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List of Acronyms and Abbreviations

BMI: Body mass index

DQI-I: Dietary Quality Index-International

KBW: Knowledge-Based Work

Kg: Kilograms

kJ: Kilojoules

LPA: Low-Intensity Physical Activity

m: meter

MVPA: Moderate-to-Vigorous Physical Activity

OECD: Organisation for Economic Cooperation and Development

QUALITY: QUebec Adiposity and Lifestyle InvesTigation in Youth

WC: Waist circumference

WHO: World Health Organisation

To my little brother who grows every day

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Introduction

Definition of obesity and its classification in adults

Obesity refers to a condition in which fat accumulates excessively or abnormally in adipose tissue, and impairs an individual's health (Ofei, 2005; World Health Organisation (WHO), 2016c). An individual could be classified as obese according to their body mass index (BMI), which is considered to be an indicator of overall adiposity (I. Janssen et al., 2005). A BMI of ≥ 25 kilograms (kg)/meter $(m)^2$ is classified as overweight whereas ≥ 30 kg/m^2 is classified as obese (WHO, 2016c). BMI category delineations vary based on the ethnicity of an individual (Deurenberg, Yap, & van Staveren, 1998; Misra, 2003). For example, an Asian Indian would be classified as obese with a BMI ≥ 25 rather than ≥ 30 kg/m^2 (Misra et al., 2009). BMI alone was observed to be a good predictor of mortality, with each increase of 5 kg/m^2 increasing risk of mortality by ~30%, neoplastic mortality by 10%, vascular mortality by 40%, and diabetic, renal, and hepatic mortality by 120% (Prospective Studies, 2009).

Another known indicator of adiposity is waist circumference (WC), which is used as a predictor of abdominal visceral adiposity (Rankinen, Kim, Perusse, Despres, & Bouchard, 1999). This measurement also provides obesity-related health risk assessment, for example, WC can be used to predict the risk of cardiovascular disease (S. Zhu et al., 2002), type 2 diabetes (Chan, Rimm, Colditz, Stampfer, & Willett, 1994) and mortality (Koster et al., 2008). This indicator is stronger than BMI in predicting health risk associated with obesity (Ian Janssen, Katzmarzyk, & Ross, 2004). Similar to BMI categories, the WC cut-offs and related health risks vary depending on an individual's ethnicity (Misra, Wasir, & Vikram, 2005). For example, an Asian individual will be at a much higher morbidity than a Caucasian individual for the same WC (Misra et al., 2005). One factor among others that explains these ethnic variations is the difference in abdominal adipose tissue and skeletal muscle composition.

It has been suggested to combine WC with BMI to better determine obesity-related health risk (Douketis, Paradis, Keller, & Martineau, 2005; Lau et al., 2007). Below is a table in which BMI and WC are combined and indicate the health risk that is associated with each category (Table 1).

Tableau 1. BMI combined with WC and their disease risk

	BMI	Obesity class	Disease risk (relative to normal weight and WC) Men <102 centimeters, women <88 centimeters	
			Yes	No
Underweight	<18.5			
Normal	18.5-24.9			
Overweight	25.0-29.9		Increased	High
Obesity	30.0-34.9	I	High	Very high
Obesity	35.0-39.9	II	Very high	Very high
Extreme obesity	>40	III	Extremely high	Extremely high

BMI: Body mass index; WC: Waist circumference;
Source: Adapted from (NIH, National Heart, & North American Association for the Study of Obesity, 2000)

Obesity classification in children

There exists a BMI classification for children based on a percentile graph. Since the weight and height of children change as they grow, this percentile chart is designed to compare children of same sex and age (Hammer, Kraemer, Wilson, Ritter, & Dornbusch, 1991). Currently, BMI-for-age growth charts are used internationally to classify children in different weight categories based on national data (i.e. data from children born in the United States, collected between 1963 and 1994) (Kuczmarski et al., 2000). However, to compare the trend in overweight and obesity internationally, Cole and colleagues suggested cut-offs for children between 2 and 18 years of age based on international surveys. The authors also provided BMI percentile charts for different countries and sex (Cole, Bellizzi, Flegal, & Dietz, 2000).

As was the case for adults, children's body fatness is not equivalent to BMI throughout the different race-genders (Daniels, Khoury, & Morrison, 1997), hence the exploration of other tools such as WC, which provides an effective measure of truncal adiposity in children and adolescents (Taylor, Jones, Williams, & Goulding, 2000), and can more accurately classify health risks associated with obesity. Fat distributed mostly around the abdominal area has a greater risk profile than fat distributed in the gluteal-femoral area (Zwiauer, Pakosta, Mueller, & Widhalm, 1992). WC assesses the adiposity profile of children and predicts overweight at puberty (Maffeis, Grezzani, Pietrobelli, Provera, & Tato, 2001).

In the clinical setting, BMI has been suggested to be combined with WC to best assess health risk (Bassali, Waller, Gower, Allison, & Davis, 2010; I. Janssen et al., 2005) and predict risk factors clustering (Katzmarzyk et al., 2004) in children and teenagers. For example, children in the overweight BMI category are two times more at risk of high triglycerides, elevated insulin levels, and the metabolic syndrome when also demonstrating a high WC (I. Janssen et al., 2005).

Another measurement called the waist-to-height ratio is a simple tool that is better than BMI and WC in predicting adiposity in children and adolescents (Brambilla, Bedogni, Heo, & Pietrobelli, 2013), and identifying cardiometabolic risk in adolescents (Rodea-Montero, Evia-Viscarra, & Apolinar-Jiménez, 2014). In children, this measurement does not alter with age or sex like BMI, which allows setting one single cut-off value for children (Arnaiz et al., 2014).

Obesity trends in adults

Worldwide

WHO states that since 1975 worldwide obesity has tripled (WHO, 2017b). In 2014 and 2016, 1.9 billion adults (≥ 18 years old) were identified as being overweight. However, in 2014, 600 million of those individuals actually fell into the obese category of BMI classification (WHO, 2016c), whereas in 2016, 650 million were considered overweight (WHO, 2017b). An upward trend in the prevalence of obesity from 1960 to 2025 has been observed in the United States, England, Mauritius, Australia and Brazil (Kopelman, 2000). Alarmingly, half of the world's population living with obesity reside in only ten countries, the highest prevalence observed in the United States (Komlos & Kelly, 2016).

In Canada

Among the approximately forty countries part of the Organisation for Economic Cooperation and Development (OECD), Canada ranked as having the sixth highest-adult-obesity-rate with 25.4% of its adult population living with obesity (OECD, 2014). Statistics

Canada reported that in 2014, 20.2% of the adult population, which is around 5.3 million people, were classified as obese (Statistics Canada, 2015). The obesity rate in men has increased to 21.8%, which is an increase of 1.7% compared to 2013, and the highest percentage reached since 2003. The same trends were seen in women where the prevalence of obesity was 18.7% in 2013, which was also the highest percentage reached since 2003 (Statistics Canada, 2015). Moreover, the percentage of males with overweight was 40.0%, and 27.5% for women. It is important to note that 70% of adults in the First Nations Communities are considered overweight or obese, which is substantially higher than the rest of the Canada (Standing Senate Committee on Social Affairs, 2016).

Obesity trends in children

Worldwide

Since 1990, the number of children with overweight and obesity has increased drastically worldwide (de Onis, Blössner, & Borghi, 2010). In 1990, 32 million children between 0 and 5 years old were considered above overweight. In 2016, this number had increased to approximately 41 million children (WHO, 2016b). Moreover, this number is expected to increase and reach around 60 million children in 2020 (de Onis et al., 2010). The worldwide prevalence of childhood overweight and obesity has increased by 47.1% between 1980 and 2013 (Ng et al., 2014). Childhood obesity has widespread in developed countries and considered to have reached an epidemic level (Dehghan, Akhtar-Danesh, & Merchant, 2005). In the United States, for example, 25% of children were considered overweight whereas 11% were considered obese (Dehghan et al., 2005). In 2004, the highest prevalence of childhood obesity was in the Middle East, Central and Eastern Europe, and North America (James, 2004).

In Canada

Since 1980, the number of Canadian children living with obesity has increased sevenfold (Standing Senate Committee on Social Affairs, 2016). In 2014, 13% of children between the ages of 5–17 years were classified as obese and 20% as overweight (Standing Senate Committee on Social Affairs, 2016). Currently one out of seven Canadian children are considered to be obese (Rao, Kropac, Do, Roberts, & Jayaraman, 2016). Compared to other countries surveyed, Canada ranked fifth on a list of forty countries with the highest childhood obesity prevalence (Standing Senate Committee on Social Affairs, 2016). As was the case for adults, in the First Nation Communities, there is a higher percentage of children below the age of 11 years who are considered either overweight or obese, and this percentage (62.5%) is considered to be high when compared to the rest of Canadian children (Standing Senate Committee on Social Affairs, 2016).

Consequence of obesity

Consequences on physical health

In adults

With increases in BMI demonstrated globally, we begin to see increased risk of developing type 2 diabetes, musculoskeletal diseases such as osteoarthritis, and certain types of cancers as well (endometrial, breast and colon) (Kopelman, 2000; WHO, 2017b). Obesity is associated with several other co-morbidities, such as cardiovascular diseases (WHO, 2016a, 2017b). In high-income countries, along with alcohol use and smoking, overweight and obesity are the main causes of cancer (Danaei, Vander Hoorn, Lopez, Murray, & Ezzati, 2005). The relative risk of cholelithiasis, hypertension, and coronary heart disease also increase with increases in BMI (Willett, Dietz, & Colditz, 1999). Moreover, obesity increases the risk of hospitalization and death due to cardiovascular diseases or type 2 diabetes (Smith, 2007). The Framingham Heart Study with approximately 40 years of follow-up (1948–1990) found an association between living with obesity and overweight, and having a shorter life expectancy/early death (Peeters et al., 2003). Obesity and overweight are associated with all-cause mortality (Flegal, Kit, Orpana, & Graubard, 2013).

In children

Children also suffer from numerous negative consequences of obesity. Obesity increases the risk of developing cardiovascular disease, insulin resistance, certain types of cancers, musculoskeletal disorders (WHO, 2016b), asthma (Gilliland et al., 2003), hypertension, and fracture (WHO, 2017b). Other health problems include cholelithiasis, glucose intolerance, hyperlipidemia and many more (Dietz, 1998). Some systemic health problems that can be observed in children as a consequence of obesity are obstructive sleep apnea, polycystic ovary syndrome, and renal hyperfiltration (Han, Lawlor, & Kimm, 2010).

Aside from this poor risk factors profile, diseases such as diabetes (Wiegand, Dannemann, Krude, & Gruters, 2005) and hypertension (Sorof, Lai, Turner, Poffenbarger, & Portman, 2004), which were until recently referred to as adult diseases, are being diagnosed in children with obesity (Bridger, 2009). Moreover, living with obesity during childhood can have repercussions in adolescence and even adulthood. In fact, a little less than half of the incidence of obesity between ages 5–14 years occurs in 15% of children who were overweight at 5 years old (Cunningham, Kramer , & Narayan 2014). Living with obesity during childhood is associated with premature death and disability in adulthood (WHO, 2016c).

Consequences on mental health/social life

The consequences of obesity are not restricted to physical aspects only, there are also psychosocial consequences (Dietz, 1998). Children with obesity were observed to have a negative self-esteem, especially in girls (Richard S. Strauss, 2000). Moreover, children living with obesity typically have greater amounts of depression and low Health-Related-Quality of Life score compared to their normal-weight peers (Morrison, Shin, Tarnopolsky, & Taylor; Schwimmer, Burwinkle, & Varni, 2003). Many other consequences, such as school problems, grade repetition and conduct disorder have also been noted (Halfon, Larson, & Slusser). It is important to note that children with obesity were observed to transition into adolescence with a poor self-perception (Franklin, Denyer, Steinbeck, Caterson, & Hill, 2006).

Consequences on the Canadian economy

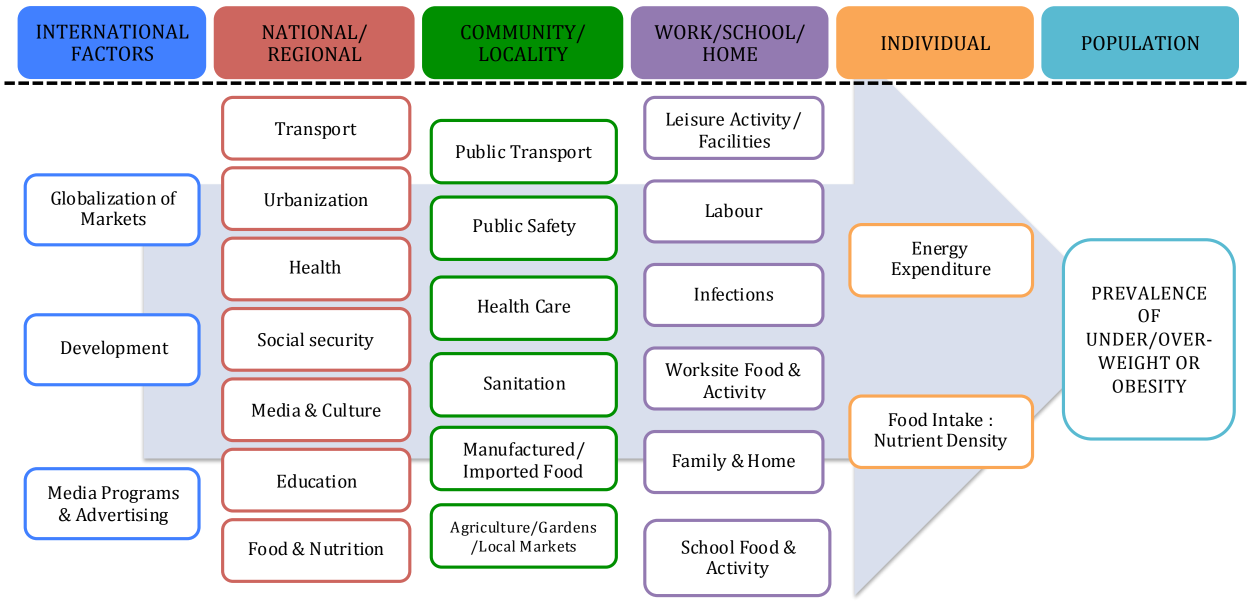
In 2006, total direct cost attributable to overweight and obesity in Canada was six billion dollars, and obesity accounted for 66% of this cost (Anis et al., 2010). This cost was calculated based on 18 comorbidities that were linked to obesity. Obesity also provokes indirect costs such as absenteeism and loss of productivity, which increase the burden on Canadian economy. In 2013, in Canada, compared to the economic burden of tobacco smoking and physical inactivity (18.7 billion and 10.8 billion dollars respectively), excess weight created a burden of 23.3 billion dollars (Krueger, 2015).

Causes of obesity

Figure 1 is a modified casual web of the International Obesity Task Force's that shows different factors that will end up influencing energy intake and energy expenditure (Huang, 2009; Kumanyika, Jeffery, Morabia, Ritenbaugh, & Antipatis, 2002) in children. In simple words, overweight or obesity is caused by a positive difference in energy balance that consists of energy intake, energy expenditure and energy storage (James O. Hill, Wyatt, & Peters, 2012). For example, factors such as high screen viewing time (low energy expenditure) with high consumption of energy-dense food with high fat content (high energy intake) will result in a state of positive energy balance (James O. Hill et al., 2012). This positive imbalance maintained over time will induce weight gain and in this context, 60–70% of the weight gain will be fat (J. O. Hill & Commerford, 1996). Moreover, physical inactivity is associated with obesity (M. S. Tremblay & Willms, 2003). In the past century, the daily amount of energy expended has decreased and this is, in part, due to sedentary occupations, modes of transportation and urbanization (James O. Hill et al., 2012). In children with obesity, a risk reduction of 23–43% and a reduction of 10–24% in children with overweight were observed when physical activity was performed regularly (M. S. Tremblay & Willms, 2003). In Figure 1, under the category "School/Work/Home", a subcategory called "School Food & Activity", which could regroup homework, a mental work that might have its share in affecting the energy balance.

On a larger scale, some key drivers of obesity are urbanization, economic growth, food availability and marketing (Huang, 2009). Even factors such as agriculture policies imposed on cultivation outcomes can have an influence on the eating habits of the population (Huang, 2009). For example, policies that support growth of certain types of food might impact farmers' decisions on what type of food to grow, for instance, corn taking priority over fruits and vegetables (Huang, 2009). Eating habits of the population depend on commercial messages including packaging and marketing, which are determined by the food industries (Huang, 2009). Biological factors such as birth weight, genes and appetite can also affect the energy balance (Huang, 2009).

Figure 1. Different levels and sectors of society that are related to obesity



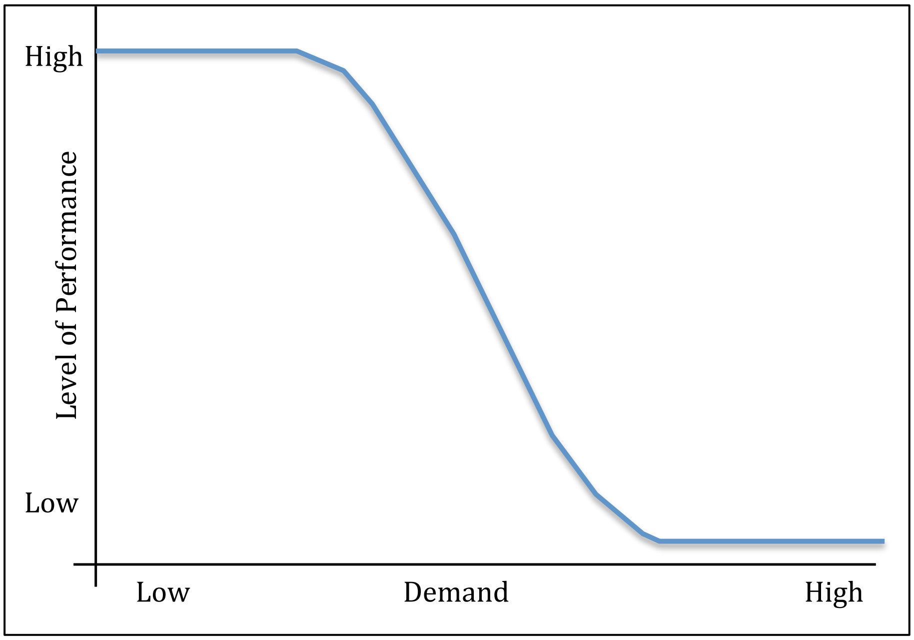
Source: Adapted from (Huang, 2009; Kumanyika et al., 2002)

Definition of mental work and workload

Mental work is defined as a mental task that demands a cognitive effort. In other words, a work to be considered, "mental work" must be cognitively demanding (Chaput & Tremblay, 2007; Lemay, Drapeau, Tremblay, & Mathieu, 2014).

In the 1980s, there was no consensus on the definition of mental workload and how it must be measured. Mental workload was thought to be tied to social pressure and expectations. An objectively easy task could appear harder under fatigue or lack of motivation thus making it more demanding (higher workload) (Moray, 1982). Workload can be defined as the portion of the total resource capacity allocated at a given time to perform a certain task (Pierce, 2009). Thus, if there is an increased mental demand, the person will increase the proportion of their resources to complete that task which would indicate that they are under increased mental workload. Subsequently, depending on the mental demand imposed on an individual, performance will vary which is described by a hypothetical graph between performance and mental workload proposed by Meister in 1976 shown in Figure 2 (De Waard, 1996). Briefly stated, as mental demand increases the performance decreases.

Figure 2. Relationship between performance and mental workload proposed by Mesiter



Source: Adapted from (De Waard, 1996)

Measure mental workload

Questionnaires are used to measure mental workload (subjective). In research a widely used questionnaire is the NASA Task Load Index, a multidimensional scale that estimates overall workload during or after a given task (Hart, 2006; Hoonakker et al., 2011). Participants are asked the following question: “How much mental and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?”. Workload score is calculated based on these answers and other factors such as participants’ weight (Hart, 2006). Other questionnaires have been used to assess mental workload (sample question: “How mentally straining do you consider your work?”) (Kivimäki et al., 2002). In children, homework and schoolwork would be considered mental work. The homework duration has been “measured” through questionnaires as well (M. K. Galloway & Pope, 2007; I. Michaud, Chaput, O'Loughlin, Tremblay, & Mathieu, 2015). For example, Galloway & Pope (2007) asked: "On a typical day, how many hours do you spend on homework (Do not include time spent taking breaks, instant messaging, etc.)?".

Objective measures have been used to measure mental workload in aircraft pilots and car drivers (Borghini, Astolfi, Vecchiato, Mattia, & Babiloni, 2014). Combination of heart rate and eye blink data could indicate the mental workload imposed on a pilot (Wilson & Fisher, 1991). For example, number and duration of blinks were associated with mental workload, with shorter and fewer blinks related to increased workload (Brookings, Wilson, & Swain, 1996). Performance-based measures, which are based on the assumption that a difficult task imposes higher demands, which will in turn decrease performance, can also objectively measure mental workload (Rubio, Díaz, Martín, & Puente, 2004).

Definition of stressful mental work

Dr Steptoe provided a widely accepted definition of stress in the 1991. It states that stress occurs when there is an imbalance between the resources that a person disposes to cope with various situations, which are the psychosocial resources, and the demands imposed by their environment (Steptoe, 1991; Wallis & Hetherington, 2004).

Mental work, an emerging factor

Adults

In males, sedentary work was noted to have increased (24.9% to 48.3%) and very physically demanding work decreased (31.5% to 10.2%) between 1972 and 2002 (Bockerman, Johansson, Jousilahti, & Uutela, 2008). In addition, workers were observed to suffer less of a physical burnout and more of a psychological exhaustion due to the advancement of technology that has transitioned the type of work from physical to mental (Angelo Tremblay & Therrien, 2006). It is therefore important to study the influence of mental work on the population.

Bockerman and colleagues conducted a study examining physical strenuousness at work and the BMI of workers between 1972 and 2002 (with data collection every 5 years) (Bockerman et al., 2008). In male workers, occupational structural changes were estimated to account for 7% of the BMI increase that occurred during this period. Compared to males who performed sedentary work, those who performed very physically demanding work were observed to have a 2.4% lower BMI. Likewise, females performing physically demanding work had 1.4% lower BMI than those performing sedentary work.

Lallukka and colleagues incorporated a mental aspect into their occupational analyses and adiposity (Lallukka et al., 2008). In a 28-year follow-up, they collected the type of work, mental or physical, BMI and weight changes between 1973 and 1983 (Lallukka et al., 2008). This longitudinal study also recorded changes that took place in participants' working conditions (i.e. increased, decreased or constant physical and mental strain) throughout those years. Male workers whose mental strain increased between these years gained 4.3 kg whereas those who had constant or decreased mental strain gained 2.4 kg (Lallukka et al., 2008).

Children

To our knowledge, the only study which has examined the relationship between mental work and adiposity in children is Michaud et al. (2015), from our own research team. In addition to analyzing the relationship between perceived stressful homework and adiposity indicators, they also examined which lifestyle habits (screen time, moderate-to-vigorous physical activity (MVPA) or sleep duration) mediated this relationship. Data of 511 Caucasian children from the QUALITY cohort between ages 8–10 years old was gathered. Boys who performed more than 30 minutes on homework while feeling stressed by schoolwork had a poor adiposity profile (I. Michaud et al., 2015). In teenagers, those who accumulated more than 3.5 hours/night of homework reported experiencing weight gain (M. K. Galloway & Pope, 2007). In addition, 72% of teenagers reported being stressed by school-related work and 56% reported homework as being the primary stressor in their life (M. K. Galloway & Pope, 2007).

Taking all these results into consideration, it is important to do a follow-up of Michaud and colleagues' study (2015) when QUALITY cohort children were 10–12 years old while taking into account their perceived stress. Moreover, with increasing age, children's homework load, number of hours spent doing homework on a weekday (M. K. Galloway & Pope, 2007), increases as well. Students nearly 13 years old performed more homework than children around 9 years of age (Snyder & Dillow, 2012). Compared to younger children, 11–

14 year old spent more time doing their homework (Canadian Fitness & Lifestyle Research Institute, 2014). Girls, generally, spend more time performing schoolwork than boys. High school students estimated to have a longer workday than most adults when hours spent doing homework were added to their regular school hours (M. K. Galloway & Pope, 2007). In addition to this increase in homework throughout academic years, the amount of homework given to students increased throughout the past decades i.e. percentage of high school students spending more than two hours of homework has increased from 7% to 37% from 1980 to 2002 (Statistics, 2007). These trends demonstrate the need to study the influence of homework on adiposity in older children.

Lifestyle habits relevant to mental work

Sedentary behaviors

Sedentary behaviors are activities characterized by low energy expenditure, ≤1.5 metabolic equivalents, such as sitting or being in a reclined position (Sedentary Behavior Research, 2012) while still awake. Canadian children spend on average 8.6 hours/day in sedentary behaviors, which is approximately 62% of the total time that they are awake (Colley et al., 2011). It is important to note that a child could be considered sedentary regardless of their daily physical activity level (Herman, Sabiston, Mathieu, Tremblay, & Paradis, 2014). Studies have demonstrated that 11-year-old children have a higher prevalence of sedentary behaviors than 6-year-old children (Fakhouri, Hughes, Brody, Kit, & Ogden, 2013). Furthermore, sedentary behaviors gradually increase from early teenage years towards adulthood (Brodersen, Steptoe, Boniface, & Wardle, 2007). Sedentary time has been linked to obesity during childhood and adolescence (Must & Tybor, 2005). Reducing these behaviors can be an effective strategy to decrease the incidence of obesity (M. S. Tremblay et al., 2011).

Screen time

Screen viewing (television, video games), reading or playing quietly are examples of sedentary behaviors (LeBlanc et al., 2015). In adults, television viewing was associated with negative health outcomes even though participants met physical activity recommendations (Healy et al., 2008). There was also a dose-response relationship between television viewing and WC, systolic blood pressure, and 2-hour plasma glucose levels. In women, there was a dose-response relationship linking television viewing with fasting plasma glucose, triglycerides and high-density lipoprotein cholesterol (Healy et al., 2008).

In school-aged children, television viewing is often used as a measure of sedentary behavior (M. S. Tremblay et al., 2011). Recommended leisure time screen time for children is not more than two hours per day (Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents, 2011; Mark S. Tremblay et al., 2011). Television viewing of > 2 hours/day had a dose-response relationship with the risk of overweight/obesity whereas less than 2 hours/day was associated with higher fitness results and bone health (M. S. Tremblay et al., 2011). Low self-esteem and behavioral problems were also noted with ≥ 2 hours of screen time per day. Moreover, screen viewing during childhood and adolescence also has repercussions into adulthood (Boone, Gordon-Larsen, Adair, & Popkin, 2007). In fact, watching ≥ 2 hours of television per day during childhood and adolescence contributes to adulthood overweightness (Hancox, Milne, & Poulton, 2004).

It is noteworthy that in children, screen time, especially watching television, increases as they move from childhood to early adolescence (Rideout, Foehr, & Roberts, 2010), and the peak television viewing occurs between 9 and 13 years old (Gorely, Marshall, & Biddle, 2004). In teenagers, the home environment was observed to influence screen time. In fact, two predictors of television viewing (≥ 2 hours/day) were watching television with parents and mother viewing ≥ 2 hours/day of television (Hardy et al., 2006).

To the best of our knowledge, in adults, no studies have examined the effect of mental work on screen time and subsequently on adiposity. However, in children, it was found that increased screen time was a partial mediator between perceived stressful homework sessions and adiposity (I. Michaud et al., 2015). With increasing perceived stressful homework duration, screen time was seen to increase which was consequently associated with an increase in BMI.

As mentioned above, sedentary behaviors are more prevalent in early adolescence, increases with age and the amount of homework increases with academic years. It is therefore important to reinvestigate this relationship in older children.

Physical activity

The recommended amount of physical activity for adults is at least 150 minutes of more than moderate intensity aerobic exercise per week (WHO, 2010). However, a large proportion of adults were observed not to accumulate enough amount of physical activity (Metzger et al., 2008). More importantly, as mentioned earlier, reductions in physical activity on a daily day basis has contributed to the obesity epidemic (Fox & Hillsdon, 2007). Failure to reach this recommendation (physical inactivity) increases the risk of overall mortality (Fox & Hillsdon, 2007). Being physically active reduces the risk of high blood pressure, stroke, type 2 diabetes and many other diseases (Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010).

The recommended daily amount of physical activity for children between 5 and 17 years old is around 60 minutes of MVPA per day (WHO, 2010). Overall physical activity levels for a given age group decreased throughout chronological years. For example, step counts of 11–12 year-old Japanese boys in 1999 was 20,832 whereas in boys of the same age in 2009 was 12,237 (Itoi, Yamada, Nakae, & Kimura, 2015). In addition, the step counts of young girls of the same age were lower than those of boys at both time points (16,087 and 10,748 respectively). It is important to note that the overall physical activity level of young girls is much lower than boys whether it is at the age of 8 or 12 years old, after-school or during recess time (Itoi et al., 2015; Ridgers, Saint-Maurice, Welk, Siahpush, & Huberty, 2011; Veitch et al., 2006). In children, physical activity is known to be beneficial for health; improved cardiovascular fitness, lower body fat, and better cardiometabolic profile (WHO, 2010).

The physical component in the occupational setting has been extensively investigated in adults. However, the relationship between overall daily physical activity levels and mental work is currently unknown. In children, physical activity duration in a non-school environment was observed to partly mediate the relationship between homework and adiposity at 8–10 years old (I. Michaud et al., 2015). Children who performed a lot of homework while feeling stressed by schoolwork accumulated less minutes of physical activity, more precisely MVPA, which was consequently related to a poorer adiposity profile. Interestingly, a study with a sample size of 496 reported that 56% of children reported dropping out of their favorite activity or hobby due to the high schoolwork load (M. K. Galloway & Pope, 2007), which could have been physical activity.

As children age, they become physically inactive and consequently do not reach the recommended physical activity levels each day (Dumith, Gigante, Domingues, & Kohl, 2011; Kimm et al., 2002; Troiano et al., 2008; Veitch et al., 2006). During the after-school period, the mean minutes/day of MVPA of children between 10–12 years old was lower than those between 5 and 6 years old in 2001, 2004 and 2006 (Veitch et al., 2006). For example, in 2001, 5–6 years old accumulated 277 minutes/day whereas 10–12 years old cumulated 150 minutes/day. Moreover, the physical activity levels of teenagers were observed to be low using various indicators of physical activity (Colley et al., 2011; Itoi et al., 2015; Verloigne et al., 2012). These trends describe the need for a longer-term follow-up on the relationship between mental strain and adiposity observed in young children becoming teenagers.

Sleep

In adults, a longitudinal study (*n*=6981) reported that individuals who had less than seven hours of sleep per night at the baseline had a higher BMI and increased risk of obesity than those with full seven hours of sleep per night (Gangwisch, Malaspina, Boden-Albala, & Heymsfield, 2005). In women, sleep duration and WC was noted to have a U-shape relationship (Theorell-Haglöw, Berglund, Janson, & Lindberg, 2012). However, after adjusting for poor habits such as physical inactivity and smoking, short sleepers were still at increased risk of central obesity, whereas in long sleepers this association disappeared (Theorell-Haglöw et al., 2012).

In children, sleep duration and obesity are closely linked in a dose-response relationship (Sekine et al., 2002). Children who slept ~10 hours/night were more likely to be classified as obese and have a higher annual BMI gain compared to those who slept ~12 hours/night (Ruan, Xun, Cai, He, & Tang, 2015). In addition, every gain of an hour of sleep reduces the risk of obesity by 21% in children (Ruan et al., 2015).

To better understand the relationship between sleep and adiposity, the level of certain hormones have been analyzed. Short sleepers had an increased level of ghrelin, a hormone that increases appetite, and a decrease of leptin, a hormone that suppresses appetite (Taheri, Lin, Austin, Young, & Mignot, 2004). Other hormones such as cortisol, a hormone that increases food intake and accumulation of visceral fat (Yehuda & Mostofsky, 2007), and thyroid hormone, that regulates metabolism (Brent, 2012; Oetting & Yen, 2007), may also play a role in this relationship (Leproult, Copinschi, Buxton, & Van Cauter, 1997; Pereira & Andersen, 2014). Increased duration of wakefulness is associated with increased energy intake and sedentary behaviors such as screen viewing (Chaput, 2010; Magee, Caputi, & Iverson, 2014; Nedeltcheva et al., 2009). Another study described that an increase in energy intake or level of hormones was not affected, but a decrease in the daytime physical activity was observed (Schmid et al., 2009).

One of the factors that was observed to affect sleep is cognitive workload (Goel, Abe, Braun, & Dinges, 2014). Sixty-three healthy adults were randomly assigned to four different groups of varying cognitive workload and duration of wakefulness (sleep restricted vs. non-restricted) (Goel et al., 2014). To differentiate between different workload groups, the researchers kept the same battery of cognitive tests, but adjusted the time spent performing those tests such that the high workload group spent 120 minutes and the moderate group spent 60 minutes. This recent study showed that subjects who were under increased mental workload, regardless of the duration of wakefulness, had an increased rating of subjective fatigue and sleepiness (Goel et al., 2014). In addition, the high workload group had a delayed sleep onset and less wake after sleep onset compared to the moderate condition. Adults subjected to stressful mental work had increased anxiety and incorporation of prior-sleep-stressful-events into their dreams (Koulack, Prevost, & De Koninck, 1985).

To our knowledge there is a limited number of studies that have observed the effect of mental work on sleep and consequently on adiposity profiles in adults. However, in children (8–10 years old) this type of analyses was performed and sleep duration did not mediate the relationship between mental work and adiposity (I. Michaud et al., 2015). It is important to perform a follow-up on these three variables in older children since, as a child moves from one academic year to another, trends towards increased homework duration (Clemmitt, 2007) and sleep insufficiency are observed (Eaton et al., 2010). In fact, in young teenagers, longer homework duration was one of the factors that were associated with shorter sleep duration and later bedtimes (Jiang et al., 2015). In addition, girls were observed to have shorter sleep duration than boys and this difference was seen to accentuate with age. Homework duration was also noted to be associated with sleep quality (Jiang et al., 2015).

Dietary patterns

Eating habits, i.e. the other side of the energy balance equation, could have a negative impact on health. For example, dietary fat intake and added sugar seems to play a major role in obesity trends seen in adults (Popkin, 2006; Popkin, Adair, & Ng, 2012). In children, an unhealthy diet is linked to obesity (Collins, Watson, & Burrows, 2009; WHO, 2017a). For instance, consuming high amounts of added sugar (Maunder, Nel, Steyn, Kruger, & Labadarios, 2015) or low consumption of iron (Papandreou et al., 2016) are linked to obesity in children. Parents along with their children and teens were noted to consume high amounts of junk and sweet food (Rosen et al., 2014). Around 90% of children (7–12 years old; *n*=860) were noted to consume more than recommended amount of non-core foods such as soft drinks and snacks (Gevers, Kremers, de Vries, & van Assema, 2016).

Mental work has been documented to influence eating habits in adults. A case study reported that following a period during which an individual had to dictate a text for a grant application, the ratings of feeling of hunger and desire to eat were higher under the experimental condition (Angelo Tremblay & Therrien, 2006). While a case study can be limited, other studies suggest the same results. Chaput and colleagues (2007) had two experimental conditions: 1) 45 minutes of knowledge-based work (KBW), which consisted of reading then writing a 350-word summary on the computer, and 2) seated-resting period. Both of these conditions were followed by an *ad libitum* buffet. Energy intake was observed to be higher by 959 kilojoules (kJ) following KBW compared to control. This increase in energy intake was not compensated by a decrease in energy intake during the rest of the day, which consequently lead to a positive energy balance (Chaput & Tremblay, 2007). Another study, which used a similar design, reported that women had a higher energy intake after KBW than following resting conditions whereas male had a higher energy intake following resting condition (Perusse-Lachance et al., 2013).

McCann and colleagues observed employees of Grant and Contract Services under low and increased workload periods (McCann, Warnick, & Knopp, 1990). During high workload periods, during which perceived stress and workloads were high, plasma total cholesterol, calorie intake, total fat and percentage of calories from fat were elevated (McCann et al., 1990). Mental work can also increase sweet food consumption. Cognitively demanding tasks increased chocolate intake by 15% compared to control condition (Wallis & Hetherington, 2004).

During the KBW task, participants had reported feeling stressed compared to the control condition which might explain the increase in energy intake (Chaput & Tremblay, 2007). A mental arithmetic problem that could not be solved (stress condition) vs. could be solved (control condition) was given to participants (Rutters, Nieuwenhuizen, Lemmens, Born, & Westerterp-Plantenga, 2009). The energy intake and energy intake from sweet foods were found to be higher under stressful mental work compared to the control condition. Psychological stress was stated to be associated with increased food intake without the presence of hunger, and participants had a preference for certain macronutrients (Rutters et al., 2009).

In school-aged children, snacks during the after-school period were found to provide 13% of the total daily energy intake and were more often energy-dense and with poor nutrient content (Gilbert, Miller, Olson, & St-Pierre, 2012). This after-school eating habit coincides with the moment of the day during which homework is performed. In fact, doing a lot of reading/doing homework was associated lower consumption of sugar drinks and snacks, and with higher consumption of vegetables and fruits (Utter, Neumark-Sztainer, Jeffery, & Story, 2003). When stress is taken into consideration, different patterns emerge. Teenage girls during school examination period were noticed to increase their energy intake whereas boys were observed to increase the level of fat intake (C. Michaud et al., 1990).

To our knowledge no study has investigated the effect of mental work on adiposity mediated by nutritional factors neither in adults nor in children. Michaud and colleagues (2015) studied different lifestyle habits, but lacked the nutritional aspect necessary to more completely understand the relationship. It is important to identify if any of these nutritional factors that are associated with homework could mediate the relationship between mental and adiposity while taking stress into consideration.

Article 1

Information

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Author's contribution

Thiffya Arabi Kugathasan is the first author of this manuscript whose contribution is primary for each section of the manuscript and from the beginning (literature review) to end (submission).

Pr Mélanie Henderson is the principal researcher of the QUALITY cohort. She helped in reviewing the article and provided her professional expertise on each component of the manuscript.

Pr Angelo Tremblay who has already worked on this topic (mental work and adiposity) brought his knowledge to the article.

Pr Marie-Eve Mathieu is the project mentor who guided and followed each step closely. She is the head of the laboratory.

ABSTRACT

BACKGROUND: At 8–10 years of age, perceived stressful homework duration was observed to be associated with children's adiposity profiles. Moderate-to-vigorous physical activity (MVPA) and screen time partly mediated this relationship. The current study aims to track these associations in those children at 10–12 years of age.

METHODS: Accelerometer, DXA, and questionnaires provided all necessary data for the analyses. Using mediation models (PROCESS Macro), screen, sleep, and MVPA duration were investigated as potential mediators of the association between homework duration and adiposity in children (n = 361) at 10–12 years old, and over 2-year period.

RESULTS: At 10–12 years, only in girls not feeling stressed by schoolwork, homework was positively associated with total and trunk fat percentages. Screen time mediated the relationship between homework and body mass index percentile in children. Longitudinal analyses revealed that sleep duration mediated the relationship between homework and trunk fat percentage changes over 2 years in children and in girls who were stressed.

CONCLUSION: At 10–12 years, perceived stressful homework was rarely associated with adiposity and almost none of the mediating factors persisted in this relationship. Sleep with increasing homework duration should be further investigated in the prevention of pediatric obesity, especially in girls.

Keywords: Stress; Child & Adolescent Health; Physical Fitness & Sport

BACKGROUND

One of the emerging factors of obesity is principal occupation. In fact, males who have a sedentary occupation have a body mass index (BMI) that is 2.4% higher than males who perform strenuous physical occupations.[1] It is possible that in addition to a reduction in energy expenditure, a cognitive component affects the adiposity profile in adults. In fact, a prospective study found that male workers who were under increased mental strain in their employment gained two times more weight than those under decreased or constant mental strain over a period of ten years.[2] Stressful mental work was observed to affect dietary intake[3-6], which could lead to a positive energy balance and weight gain over time.

In children, our team is the only one to have noted that young boys (8–10 years) who performed long periods of stressful homework had higher adiposity than those who performed short-duration-homework, and this only when they reported feeling stressed by schoolwork.[7] Interestingly, this was not observed in young girls of the same age under the same conditions, supporting the sex specificity found in adults' study.[2] In young children, a decrease in moderate-to-vigorous physical activity (MVPA) was considered to partly mediate the relationship between stressful perceived stressful homework and adiposity.[7]

As children age, they opt for unhealthy behaviors such as becoming physically inactive.[8-10] At 10–12 years of age, their physical activity levels are below recommended levels, with girls' physical activity levels being much lower than boys[11] during recess[12] and in the after-school period.[10] Also, children aged 11 to 14 years spend more time doing their homework, a sedentary behavior requiring mental work, than younger ones.[13] How these changes influence the relationship between mental strain and childhood adiposity remains unknown.

Other lifestyle habits such as screen time and sleep duration also have an impact on the adiposity profile of children. Screen time was associated with increased risk of obesity[14,15], and short sleep duration with obesity.[16] Long homework duration has been shown to be one of the factors related to shorter sleep duration in children aged 8 to 17.[17] Only one study observed the effect of mental strain on screen time and sleep duration and subsequently on adiposity.[7] The authors reported that screen time, but not sleep duration mediated the relationship between mental work such as homework and adiposity profile. As children age, they increase their screen time[18] and decrease their sleep duration[19,20]. It is therefore important to reinvestigate the impact of mental workload on sleep and screen time, and consequently on the adiposity profile in older children.

There is very little data in the literature regarding mental strain and adiposity profiles of children over 10 years of age, and no study has addressed all lifestyle activities as potent mediators. As a result, the purposes of this study were to (1) examine the relationship between mental work and adiposity indicators in children at 8–10 and 10–12 years old while stress level is considered or ignored and (2) determine whether screen time, MVPA and/or sleep duration mediate these associations.

METHODS

Participants

Data was extracted from the first (V1) and second (V2) visits of the QUebec Adiposity and Lifestyle InvesTigation in Youth (QUALITY) cohort[21,22]: V1 when children were 8–10 years of age (July 2005 to December 2008), whom we will be referring to as young children, and V2, two years thereafter (July 2007 to March 2011), whom we will refer to as older children. This cohort is composed of Caucasian children with at least one obese biological parent at recruitment (parental obesity defined by: BMI ≥ 30 kg/m^2 or waist circumference ≥ 88 cm for women and ≥ 102 cm for men).[23]

Anthropometric measurements

Anthropometric measurements included height and weight obtained according to standardized methods[24], and BMI in percentile interpreted according to the U.S. Centers for Disease Control and Prevention growth charts.[25] Dual-energy X-ray Absorptiometry (DXA) (Prodigy Bone Densitometer System, DF114664, GE Lunar Corporation, Madison, WI, USA)[26] was used to determine total and truncal body fat percentages.

Lifestyle activities profile

Average daily MVPA duration was calculated using accelerometry (Actigraph LS 7164 and CAL71 calibrator, Actigraph LLC, Pensacola, FL, USA). It had to be worn for seven consecutive days from the time children were awake to the time they went to bed. They had to remove the accelerometer when doing a water-based activity such as showering, swimming and bathing. Periods of non-wear were excluded from the analyses defined as 60 consecutive minutes during which the activity intensity count was equal to zero; children were allowed 1–2 minutes of 0–100 counts.[8] Children who failed to wear the accelerometer more than 4 days for at least 10 hrs/day[27,28] were excluded from the analyses, both for MVPA and sleep levels. Based on self-reported television time (including video movies) on weekends and weekdays, a mean score over seven days was calculated and used as an indicator of average daily screen time. Average daily sleep duration was obtained by calculating the mean difference between the time at which the accelerometer was removed at bedtime and the time at which it was reattached to the child the following morning.

Homework profile

Children filled out a questionnaire with a research assistant's help, and answered the following questions to obtain daily homework duration and concerns about schoolwork[7]: 1) "How many hours do you usually spend on homework in a single day (including homework on the computer)?". From this data, average time spent doing homework per day was calculated, and was kept on a continuous scale. 2) "During the past 3 months, have you been worried or stressed by schoolwork?". Depending on their answer, homework was considered as either "perceived non-stressful" if answered, "not at all", or "perceived stressful" if reported a little bit, quite a bit or a whole lot.

Data Analysis

All analyses were performed using SPSS Statistics software (IBM, Armonk Corp., NY, USA) version 24.0. The characteristics of the cohort were analyzed as follows: Independent sample t-test to evaluate whether there were significant sex differences in children at V1 only and an ANOVA for repeated measures to analyze any significant changes between V1 and V2, and boys vs. girls in all variables (visit x sex). In addition, Chi-square was used to analyze sex differences and McNemar test for longitudinal changes in stress-related schoolwork data since it is a dichotomous variable. After applying the log-transformation on homework, sleep, and screen duration data, regression and mediation analyses (PROCESS macro for SPSS, v2.16)[29] was used to examine if any lifestyle habit was a mediator between homework duration and adiposity at V1, V2, and from V1 to V2 (difference between both visits (V2-V1)). The direct effect (c'), which is the remaining effect of the total effect after taking into consideration a mediating factor, is reported in the figures. Potential mediators were considered individually, one at a time, and the bootstrapped confidence intervals (CI) for indirect effects were used to determine which of those habits was a mediator (CI must be exempt of 0 to be considered significant). Unstandardized beta coefficients (β) between two variables and their *P* values are reported.

Statistical significance was set to a *p*-value of < 0.05. Not all children from V1 were present at V2 (loss to the follow-up), thus children who were not present at V2 were excluded from the 10–12 years old and longitudinal analyses. Independent sample t-test was used to examine the differences between children, who were included vs. excluded from V1 for the subsequent analyses.

RESULTS

Outliers [homework = 5.86 hrs/day (*n* = 1 in V2) and sleep = 3.18 hrs/night (*n* = 1 in V1)] were excluded, and there was no significant difference in all the variables between the included vs. excluded children from V1 (*p* > 0.05).

Participants' characteristics

At V1 (*n* = 432), total fat and truncal fat percentages were significantly greater in girls than in boys [*t*(430) = -5.078 and *t*(430) = -4.803 respectively, both *p* < 0.001] (Table 1). MVPA was significantly lower in girls than in boys [*t*(430) = 7.687; *p* < 0.001]. From V1 to V2 (*n* = 361), all parameters except BMI percentile changed significantly (Table 2), and most shifted towards poor habits (all *p* < 0.05). Significantly higher total and trunk fat percentages in girls than in boys independently of the visit were observed [*F*(1, 359) = 9.891, *p* = 0.002 and *F*(1, 359) = 9.011, *p* = 0.003 respectively]. Homework duration increased by 42.9% in girls and 50.0% in boys between both visits. Significantly more children were stressed at V2 than at V1 (*p* = 0.025), but no sex differences were found at V1 (*p* = 0.104) or V2 (p = 0.069). Boys accumulated significantly more minutes of MVPA than girls independently of the visit [*F*(1, 359) = 54.740, *p* < 0.001].

Mediation analyses at V1 (at 8–10 years old)

At V1, using a continuous scale for homework duration showed that when a child's stress status was not considered, from the mediation models, homework duration was positively associated with total fat and trunk fat percentages (total effect) (β: 10.983, *p* = 0.019; β: 13.380, *p* = 0.011 respectively). In addition, the relationship between homework duration and all three adiposity indices (total fat percentage, trunk fat percentage, BMI) in those children was mediated (indirect effect) by MVPA (CI: [0.760, 6.697], [0.768, 7.017] and [0.623, 9.403], respectively) and screen time (CI: [0.025, 3.377], [0.024, 3.749] and [0.262, 9.621], respectively). As homework duration increased, children decreased their MVPA duration, which was associated with increased adiposity indicators (BMI shown, Figure 1). As for screen time, it increased with increased homework duration and was associated with increased adiposity indicators (BMI shown, Figure 1). In girls only, homework duration was positively associated with trunk fat percentages (β: 15.577, $p = 0.027$). Also, screen time was a mediator. It increased with increasing homework duration and was positively associated with all adiposity indicators (CI: [1.084, 8.951], [1.125, 10.380], and [1.739, 23.024], respectively). In boys, no association between homework duration and adiposity was observed (all $p > 0.05$), and none of the lifestyle habits mediated this relationship.

At V1, when stress status was considered and only when present, the following were observed from the mediation models: In children, perceived stressful homework duration was positively associated with all three indicators (β: 18.680, 21.882 and 44.768 respectively; all $p < 0.05$), and screen time was a mediator with total trunk fat percentage and BMI only (CI: [0.025, 6.831] and [1.728, 21.195], respectively). As perceived stressful homework duration increased, screen time increased which excludes time spent in front of a screen for homework purpose, and was associated with increased adiposity indicators. In girls, perceived stressful homework duration was positively associated with all three adiposity indicators (β: 19.130, 24.250 and 52.473 respectively; all $p < 0.05$), and screen time was the mediator (CI: [2.194, 16.458], [1.496, 18.189] and [5.770, 51.846], respectively). As perceived stressful homework duration increased, screen time increased and was subsequently associated with increased adiposity indicators (trunk fat percentage shown, Figure 2). In boys, regardless of stress status, none of the mediating factors were significant.

Mediation analyses at V2 (10–12 years old)

In children, when stress status was not considered in the mediation model, although homework duration was not directly associated with BMI ($p > 0.05$), screen time mediated the relationship between homework duration and BMI (CI: [-8.713, -0.031]). As homework duration increased, screen time decreased, which was associated with decreased BMI (Figure 1). This was the only exception since the other mediating factors observed at V1 did not persist. In girls, in those who reported not feeling stressed, homework duration was positively associated with total and trunk fat percentages (β: 25.459, $p = 0.009$; β: 30.233, $p = 0.006$ respectively).

Mediation analyses from V1 to V2

In the longitudinal analyses, in children who claimed to be stressed by their homework at both visits, sleep duration changes mediated the relationship between homework duration and trunk fat percentage changes (CI: [-2.914, -0.443]). As children increased their perceived stressful homework duration between both visits, they decreased their sleep duration, which was associated with decreased trunk fat percentage (Figure 3). In those who reported not feeling stressed at both visits, homework duration changes was negatively associated with screen time (β: -0.476; p = 0.009). In girls who reported feeling stressed at both time points, sleep time changes was also a mediator (CI: [-3.800, -0.217]), i.e. with increase in homework duration, sleep duration decreased (β: -0. 070) which was associated with a decreased trunk fat percentage over time (β: 24.619). In boys who initially reported feeling stressed, but did not feel stressed at V2, an increase in homework duration was positively association with the trunk fat percentage (β: 18.787; p = 0.024). In those who reported not feeling stressed at both visits, homework duration changes were negatively associated with screen time changes (β: -0.538; p = 0.008).

DISCUSSION

Few studies have examined mental work as a potential obesogenic factor in the pediatric population. The current study adds to the current literature by examining mental work, lifestyle habits, and adiposity profiles in older children. Our results show that in 10-12-year-old girls who did not feel stressed by schoolwork, adiposity indicators (total and trunk fat percentage) worsened with increasing homework duration. Contrary to what was hypothesized, almost no lifestyle habits (MVPA and sleep duration) mediated the relationship between homework duration and adiposity profile in older children. The only exception was screen time. When stress status was not considered, it mediated the relationship between homework duration and BMI. The longitudinal analyses revealed that children who were stressed by schoolwork since ages 8–10 and increased their homework duration decreased their sleep duration, which was associated with an improved trunk fat percentage. Sex analyses revealed that this result was also true in girls who were stressed at both time points.

The relationship between mental work and adiposity profile has been studied in adults. As mentioned earlier, males under increased mental strain over a period of 10 years had doubled the body weight gain observed in those under decreased or constant mental strain.[2] A nutritional analyses revealed that the energy intake was significantly superior following a mental work period than a seated rest period, and was not compensated by a decreased caloric intake in the following meals of the day, thus favoring weight gain.[3] In children, only Michaud and colleagues' study (2015), a study by our team, has examined homework, which is considered a cognitive task, and adiposity profile. This current analyses of the relationship between homework duration and adiposity profile in children aged 8–10 years, with homework duration as a continuous variable and not dichotomous, showed that an increase in screen time mediated the relationship between perceived stressful homework duration and all three adiposity indicators, not just with BMI as reported by the previous explanatory study.[7] Our results also showed that low levels of MVPA did not mediate the relationship between perceived stressful homework duration and total or trunk fat percentages in boys only. Moreover, girls seemed to be more susceptible to homework duration than boys. As a result, when the current study is compared to Michaud and colleagues' (2015) study, a few similarities stand out such as the effect of perceived stressful vs. perceived non-stressful homework duration on adiposity profile; however, our analyses showed that girls were more prone to have a poor adiposity profile when performing a lot of homework than boys.

In adults, the relationship between stressful mental work and adiposity profile was observed to have a sex difference. Men's body weight was seen to be more vulnerable to mental work than women.[1,2] In children, our team's previous work that boys were more susceptible to weight gain under perceived stressful homework.[7] The current results support the fact that there is a sex difference in this relationship. In fact, depending on the sex of the child, there were different associations observed in young and older children. However, according to our results, girls seemed to be more vulnerable to mental work, more specifically to homework duration, than boys of the same age group. In fact, increased homework duration was associated with a poor adiposity profile in young and older girls but not in boys of the same age groups. Our study is in concordance with a recent randomized crossover study that reported that energy intake following mental work was different between young adult males and females[30]: the energy intake of females was much greater after mental work than a seated rest period.

A previous study has reported that, in children between the ages 5–12, stress was associated with poor adiposity profile, and that cortisol levels and lifestyle habits moderated this association.[31] The present study adds to the existing literature, with stress playing a significant role in the relationship between homework duration and the adiposity profiles of young and older children. In fact, in young girls who felt stressed about schoolwork, screen time mediated the relationship between homework duration and adiposity, which was not observed in young girls who claimed not feeling stressed. In the current longitudinal analyses, only when children were stressed since ages 8–10 did sleep duration changes mediate the relationship between changes in homework duration and trunk fat percentage which is known to be detrimental to health since it does not only cause obesity but is associated with many other diseases such as cardiovascular disease and Type 2 diabetes.[32]

One of the important mediating factors was screen time. Screen time was the only factor to continue to mediate the relationship between homework duration and BMI in older children. In young children, an increase in homework duration was associated with an increase in screen time, which was consequently associated with an increase in BMI. Whereas in older children, an increase in homework duration was associated with a lower screen time, which was in turn associated with improved BMI. Thus, homework duration does not have a detrimental effect on BMI by means of decreased screen time. Screen time with homework duration and adiposity might be further analyzed in future studies since it is the only mediator to persist since young age. Another important finding is that homework duration did not seem to have a negative impact on MVPA duration in older children. Galloway and Pope reported that 56% of children who participated in their study decreased the time devoted to favorite activities and hobbies due to the high amount of homework each night.[33] In the current study, older children seemed to be able to balance their homework routine with physical activity duration. Even the longitudinal analyses did not reveal that an increase in homework duration decreased MVPA duration of children, regardless of stress status.

In the longitudinal analyses, sleep duration changes appeared as a mediating factor in all children and girls who were stressed since ages 8–10. In fact, increases in homework duration, since the ages 8–10, decreased sleep duration, which was consequently associated with a decrease in the trunk fat percentage. The association between homework duration and sleep duration observed in the current study does agree with a previous study[17] which had mentioned that homework was one of the reasons why children had shorter sleep duration and later bedtimes. The mediation model in the current study also showed that as sleep duration decreased, trunk fat percentage decreased, which seems to contradict general knowledge.[34] However, it is important to note that in the current study, even though sleep duration decreased in children who had increased their perceived stressful homework duration, sleep duration was on average about 13 hrs/night, which is not below duration observed in previous studies (7-10 hrs/night)[34,35], and might explain why the adiposity indicators did not deteriorate. Moreover, homework duration might not have affected sleep quality, perhaps explaining why trunk fat percentage was not affected, since poor sleep quality has been previously shown to be associated with higher BMI in children.[36]

Strength and limitations

The strength of the current study is the utilization of objective measurements such as accelerometer and DXA values. Moreover, the present study was conducted in a real-life setting, which allowed us to obtain a significant understanding of the impact of mental work during after-school hours. The longitudinal analyses of this cohort enabled us to compare this evolution in the same individuals (only 11% of participants were lost at a follow-up). One of the limitations of this study is that screen and homework questionnaires contained self-reported-recall answers by children rather than on-the-spot recorded data. It is noteworthy that sleep data was not optimally collected since the removal of the accelerometer at night-time does not necessarily indicate that children fell asleep.

Conclusion

The role of homework duration and related stress should be further studied as potential targets in the prevention of pediatric obesity, especially in young children, since they seem to be more susceptible to the effects of mental work. Our findings suggest that this is particularly relevant for girls, since they seem to be the most affected by mental work.

IMPLICATIONS FOR SCHOOL HEALTH

Based on the current study results, the school system could be cautious when giving homework to their young students since they are readily affected by homework duration, especially if it is stressful and/or performed by girls. Strategies should be tested in the future to reduce this burden. Moreover, as the children age from 8–10 to 10–12 and increase perceived stressful homework duration, sleep duration gets affected. However, on average, remaining around 13 hrs/night does not seem to increase the abdominal fat percentage. These challenges can be reduced or at least acknowledged in future studies conducted in line with school settings.

Furthermore, parents should take note when their young children spend a considerable amount of hours performing homework. Particular attention could be given to their daughters since ages 8–10 because an increase in stressful homework duration could decrease their sleep duration.

Finally, health care professionals should recognize homework duration as a potential obesogenic factor and share this knowledge with the family. They should also refer such children to an appropriate specialist; for example, a young child who decreases their physical activity level with increasing homework duration could be referred to an exercise physiologist.

Human Subjects Approval Statement

The Ethics Comity of the Sainte-Justine University Hospital Center and Laval University approved this study. Parents were required to approve the use of their children's information by signing a consent form.

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Table 1. **Descriptive Characteristics of the Children at 8-10 Years Old (Cross-Sectional Analysis)**

	V1 (n =432)		
	Girls (n=194)	**Boys (n=238)**	**Sex difference, P-value**
Age (years)	9.6 ± 1.0	9.6 ± 0.9	0.927
BMI (percentile)	66.3 ± 29.1	68.6 ± 27.7	0.396
Total fat mass (%)	28.7 ± 10.0	23.6 ± 10.9	**<0.001**
Trunk fat mass (%)	27.3 ± 11.5	21.8 ± 12.1	**<0.001**
Homework (hrs/day)	0.7 ± 0.5[a]	0.6 ± 0.5[b]	0.114
MVPA (min/day)	40.9 ± 18.9	58.1 ± 26.0	**<0.001**
Sleep duration (hrs/night)	13.3 ± 1.1	13.4 ± 1.0	<0.252
Screen time (hrs/day)	1.7 ± 1.4	2.0 ± 1.6[c]	0.050

Values are mean ± standard deviation; Significant results are in boldface; [a] n=193; [b] n=235; [c] n=237; BMI: Body mass index; MVPA: Moderate-to-vigorous physical activity

Table 2. **Descriptive Characteristics of Children Present at Both Visits (Longitudinal Analysis)**

	V1 (n=361)		**V2 (n=361)**		**Visit**		**Sex**		**Visit x sex**	
	Girls (n=160)	**Boys (n=201)**	**Girls (n=160)**	**Boys (n=201)**	**F**	**p**	**F**	**P**	**F**	**p**
Age (years)	9.5 ± 0.9	9.6 ± 0.9	11.6 ± 1.0	11.6 ± 0.9	55982.3	**<0.001**	0.2	0.659	0.4	0.548
BMI (percentile)	63.8 ± 29.5	69.5 ± 27.3	64.3 ± 28.7	68.9 ± 28.2	0.0	0.904	3.1	0.081	0.6	0.424
Total fat mass (%)	27.7 ± 9.9	24.0 ± 10.8	29.4 ± 9.9	26.4 ± 11.0	65.7	**<0.001**	9.9	**0.002**	1.9	0.173
Trunk fat mass (%)	26.1 ± 11.4	22.2 ± 12.1	28.4 ± 11.3	25.0 ± 12.1	84.1	**<0.001**	9.0	**0.003**	1.0	0.313
Homework (hrs/day)	0.7 ± 0.5[a]	0.6 ± 0.5[b]	1.0 ± 0.7[a]	0.9 ± 0.6[b]	53.7†	**<0.001**	2.4†	0.126	0.0†	0.884
MVPA (min/day)	41.3 ± 19.3	56.5 ± 25.3	34.6 ± 18.2	50.2 ± 24.4	32.9	**<0.001**	54.7	**<0.001**	0.0	0.843
Sleep duration (hrs/night)	13.3 ± 1.1[c]	13.4 ± 1.0[d]	13.7 ± 1.3[c]	13.6 ± 1.5[d]	12.3†	**0.001**	0.0†	0.976	1.4†	0.239
Screen time (hrs/day)	1.7 ± 1.4	2.0 ± 1.5	2.1 ± 1.5	2.2 ± 1.6	12.6	**<0.001**	2.2	0.139	1.2	0.284

Values are mean ± standard deviation; Degrees of freedom of all F values are (1, 359) except for † = (1, 356); Significant results are in boldface; [a] n=159; [b] n=199; [c] n=158; [d] n=200; BMI: Body mass index; MVPA: Moderate-to-vigorous physical activity

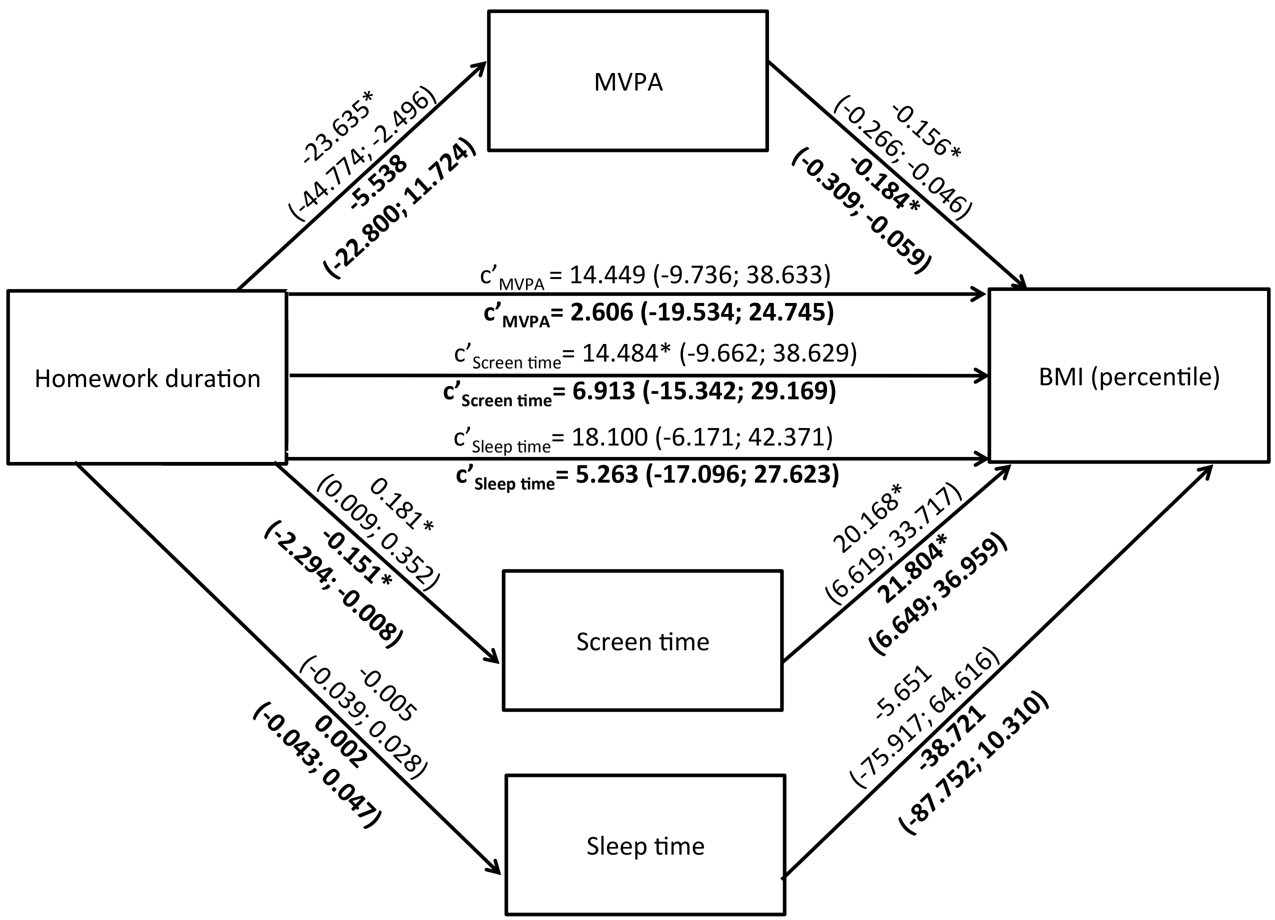

Figure 1. **Lifestyle Habits as Mediators in the Relationship Between Homework Duration and BMI in Children at 8–10 and 10–12 Years Old.** Data at V2 (10–12 years) are in boldface. Unstandardized β coefficients (95% Confidence intervals) are given for path value a (association between homework duration and lifestyle habit mediator), path value b (association between lifestyle habits mediator and an adiposity indicator) and path value c′ (the remaining effect of homework duration on adiposity when mediator is present in the model); Example of an interpretation for mediator MVPA at V1: with an increase in homework duration, MVPA duration decreases since unstandardized β coefficient of path a for that particular mediator is negative. Then, MVPA duration is negatively associated with BMI (path b) therefore it could be interpreted as with increase in MVPA duration BMI decreases. Since bootstrap confidence interval for the indirect effect of this mediator was significant (not shown), MVPA duration is considered a significant mediator; Significant association*: $P<0.05$; BMI: Body mass index; MVPA: Moderate-to-vigorous physical activity

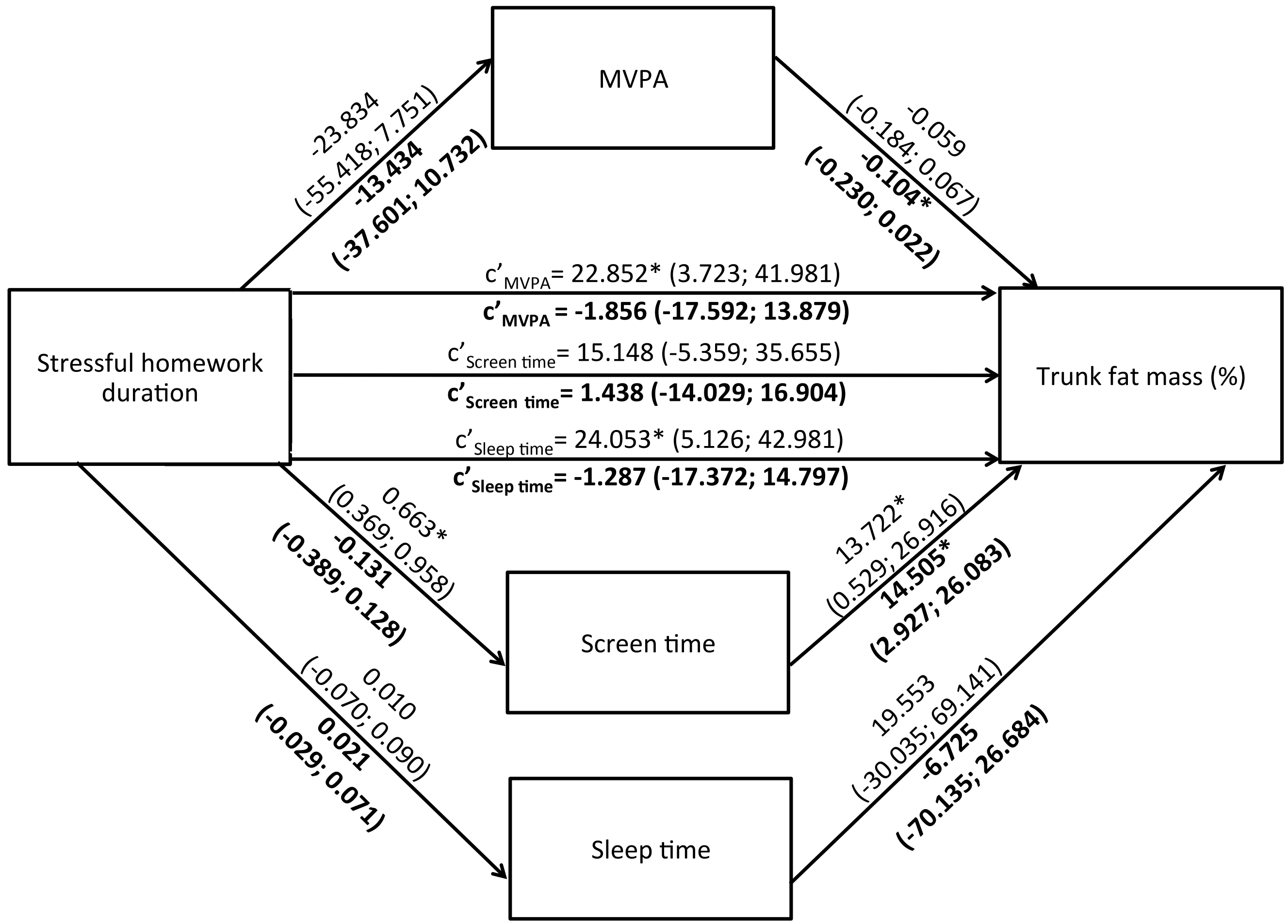

Figure 2. **Lifestyle Habits as Mediators in the Relationship between Homework Duration and Trunk Fat Percentage in Girls Stressed by Schoolwork at 8–10 and 10–12 Years Old.** Data at V2 (10–12 years) are in boldface. Path value and c′ are unstandardized β coefficient (95% Confidence intervals); *P<0.05; BMI: Body mass index; MVPA: Moderate-to-vigorous physical activity

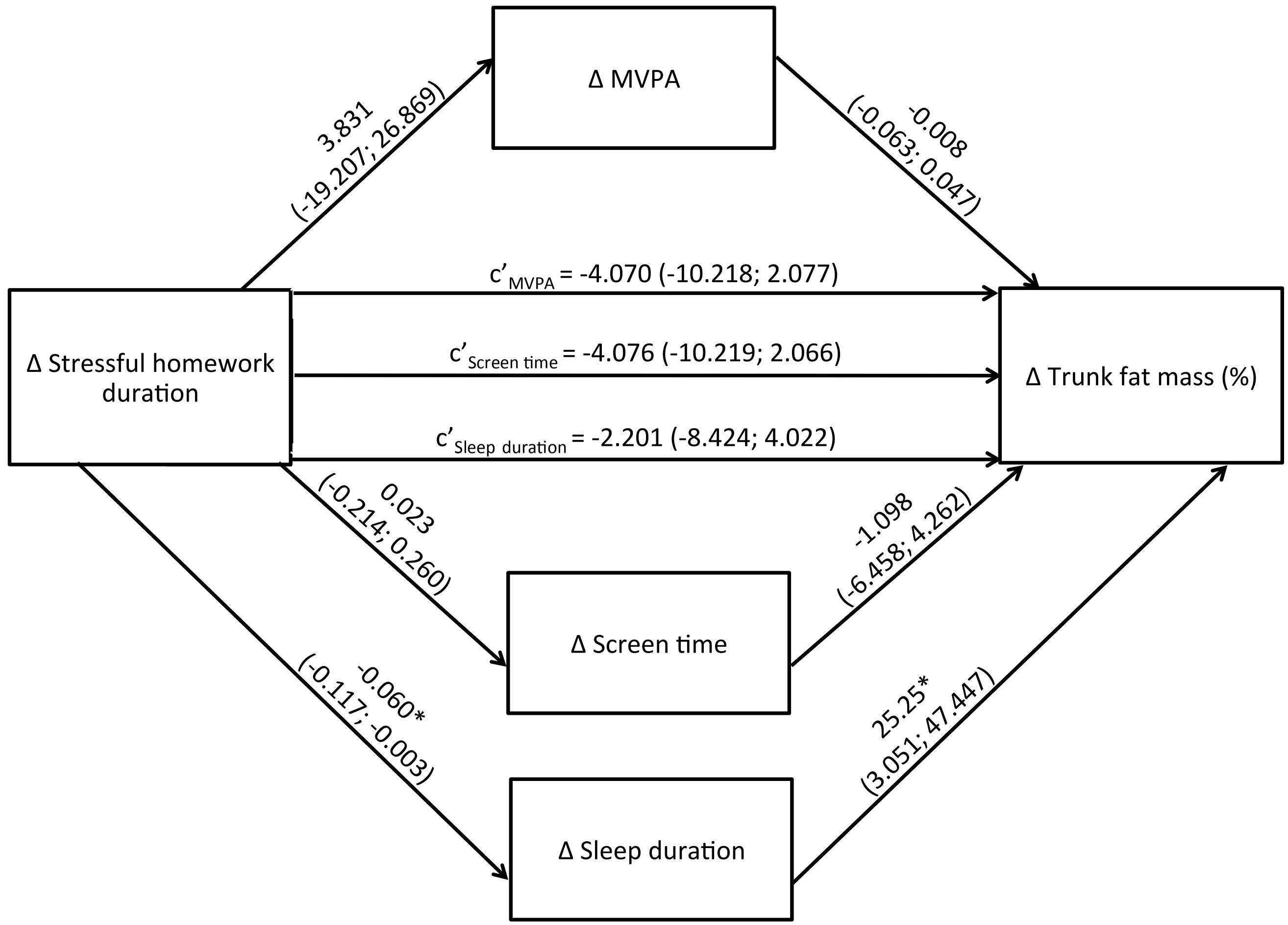

Figure 3. **Lifestyle Habits as Mediators in the Longitudinal Relationship between Homework Duration and Trunk Fat Percentage in Children Stressed by Schoolwork from 8–10 to 10–12 Years old.** Δ: Changes between V1 (8–10 years old) and V2 (10–12 years old) are presented. Path value and c' are unstandardized β coefficient (95% Confidence intervals; *P<0.05; BMI: Body mass index; MVPA: Moderate-to-vigorous physical activity

Article 2

Information

Title of the manuscript: Influence of Perceived Stressful Homework on Dietary Intake and Adiposity in Children: a QUALITY Cohort Study

To be submitted to the Journal of Nutrition Education and Behavior

No conflict of interest to declare and co-authors authorized inclusion of this manuscript in this dissertation

Author's contribution

Thiffya Arabi Kugathasan is the first author of this manuscript whose contribution is primary for each section of the manuscript and from the beginning (literature review) to end (submission).

Pr Vicky Drapeau conceived the idea of exploring the DQI-I as a mediator. She also gave her professional opinion on the manuscript and commented on each section of the manuscript.

Pr Katerina Maximova provided the Dietary Quality Index-International (DQI-I) that she has calculated for the QUALITY cohort. She also commented on each section of the manuscript.

Pr Mélanie Henderson is the principal researcher of the QUALITY cohort. She helped in reviewing the article and provided her professional opinion on each component of the manuscript.

Pr Angelo Tremblay who has already worked on this topic (mental work and adiposity) brought his knowledge to the article.

Pr Marie-Eve Mathieu is the project mentor who guided and followed each step closely. She is the head of the laboratory.

ABSTRACT

Objective: To examine nutritional factors as potential mediators in the relationship between perceived stressful homework duration and adiposity.

Methods: Cross-sectional design; 24-hour dietary recalls, questionnaires and DXA data of 544 children aged 8–10 years old of the QUALITY cohort study were used.

Results: Perceived stressful homework and total and trunk fat percentages were positively associated. In boys, perceived stressful homework was positively associated with total fat percentage. In boys, perceived stressful homework was positively associated with a number of snacks whereas non-stressful homework was negatively associated with saturated fat. Only high sugar beverages consumption was found to be a partial mediator between perceived stressful homework and trunk fat percentage.

Conclusions and Implications: The relationship between perceived stressful homework and adiposity is partly attributable to high-sugar beverages. Regarding pediatric obesity prevention, number of snacks and saturated fat intake in boys who perform a lot of homework while feeling stressed should be closely followed.

Key Words: Sugar-sweetened beverage, snacks, saturated fatty acids

INTRODUCTION

Children, especially boys, doing more homework while feeling stressed by schoolwork, have been recently observed to have increased adiposity.[1] A decrease in moderate-to-vigorous physical activity (MVPA) and an increase in screen time were mediators in this relationship. However, the aforementioned study did not examine nutritional habits.

In adults, energy and fat intake following a 45-minute mental work period was higher than after a seated rest period (~ 24 and 26% higher, respectively).[2] Acutely, women subjected to high mental work seem to be more prone to weight gain than males[3,4], whereas chronically, men were noted to gain more weight[5]. Moreover, young adults under stressful conditions were observed to change their food selection and opted for unhealthy choices.[6]

The effect of mental work such as schoolwork on eating behavior in children is understudied. To the best of our knowledge, only one study has examined after school behaviors. That study reported that girls who were supervised by an adult during an after-school period did more homework and ate more.[7] It is therefore possible that there is a relationship between the amount of homework and eating habits. Moreover, stress has been shown to influence eating habits in teenagers. In fact, girls increase their energy intake whereas boys increase their intake of fat under stressful events such as school examinations.[8] It is thus possible that the perception of homework as being stressful versus non-stressful could influence eating habits. Thus, the main purpose of this study was to explore whether there were any nutritional habits that could serve as mediators between homework duration and adiposity in children while giving a particular attention to the role of perceived stress related to schoolwork.

METHODS

Participants

Data were collected between 2005 and 2008 from the QUebec Adiposity and Lifestyle InvesTigation in Youth (QUALITY) cohort.[9,10] This cohort is composed of Caucasian children at high risk of obesity due to having at least one obese biological parent (Body Mass Index (BMI) ≥ 30 kg/m^2 or waist circumference ≥ 88 cm for women and ≥ 102 cm for men).[11] Only children who had their homework duration and schoolwork stress level data were included in the analyses. The Ethics Comity of the Sainte-Justine University Hospital Center and Institut

Universitaire de Cardiologie et de Pneumologie de Québec approved this study. Parents were required to sign a study consent form and children signed assent.

Anthropometric Measurements

Anthropometric measurements included height and weight, and were measured according to standardized methods.[12,13] Dual-energy X-ray absorptiometry (Prodigy Bone Densitometer System, DF114664, GE Lunar Corporation, Madison, WI)[14] was used to determine the total and truck body fat percentages.

Nutritional Habits

Nutritional data was collected from three 24-hour dietary recalls. Over the phone using a disposable food portion models tool kit, children indicated their food intake to a dietician.[9] Based on existing literature on mental work, eating habits and adiposity, the following indicators were considered potential mediators (daily mean value): energy intake[2,4], intake of saturated fat[15], volume of high sugar drinks[16], number of snacks[17], and Diet Quality Index-International (DQI-I)[18].

Homework Profile

Using questionnaires: 1) homework duration was obtained asking, "How many hours do you usually spend on homework in a single day (including homework on the computer)?".[1] Children were then categorized according to homework duration: < 30 minutes and ≥ 30 minutes.[1,19] 2) Perceived stress related to schoolwork by asking, "During the past 3 months, have you been worried or stressed by schoolwork?". Homework was categorized as perceived non-stressful or stressful (a little bit, quite a bit or a whole lot).

Data Analysis

Independent samples t-tests with Bonferroni adjustments were used to compare significant differences between girls and boys' characteristics (statistical significance was set to $P < .005$). Chi-square test of independence was used to analyze sex difference in perceived stress-related schoolwork (categorical data, $P < 0.05$). The Shapiro-Wilk test was used to test normality, followed by Log-transformation for all non-normal mediators. Thenceforth, regression and mediation analyses using one potential mediator at a time were considered using Preacher and Hayes mediation test (PROCESS macro, v2.16)[20]. From this model, unstandardized beta (β) coefficients between two variables and their *P* values were obtained (*P* value < .05). Bootstrapped confidence intervals at 95% (CI) were used to examine significance of indirect pathways, i.e. mediator (CI should not contain zero value). Different combinations of groupings (girls, boys and children) with/without perceived stress (stressful vs. non-stressful) were analyzed. Analysis was performed using SPSS Statistics (IBM, Armonk Corp., NY) version 24.0. Statistical significance was set to *P* value $< .05$.

RESULTS

Characteristics of Participants

A total of 544 children's data were analyzed. The total and trunk fat percentage as well as snacks were significantly higher in girls than in boys, while energy intake and grams of saturated fat were significantly higher in boys than in girls (Table 1).

Homework and Adiposity Profile Association

When perceived stress was not considered, homework duration was positively associated with the trunk fat percentage (β: 2.2356, $P = .03$). There was also a positive association between perceived stressful homework duration with total and trunk fat percentages in children (β: 3.1204, $P = .03$; β: 3.6457, $P = .03$ respectively). In boys only, perceived stressful homework duration was positively associated with total fat percentage (β: 4.2558; $P = .04$). No significant association was seen between perceived non-stressful homework duration and adiposity indicators ($P > .05$). No significant association was seen in girls only ($P > .05$).

Homework and Eating Habits Association

In children, perceived stressful homework duration was negatively associated with high-sugar drinks consumption (β: -0.3019; $P = .04$; Figure 1). In boys only, perceived stressful homework duration was positively associated with a number of snacks (β: 0.0808; $P = .04$). In boys only, perceived non-stressful homework duration was negatively associated with saturated fat intake (β: -0.0483; $P < .05$). In girls only, there were no significant associations ($P > .05$).

Eating habits as Mediators

In children, high-sugar drinks consumption was the only significant partial mediator between perceived stressful homework duration and trunk fat percentages (CI: [-1.4280, -0.0107]). Children who performed ≥ 30 minutes of perceived stressful homework had a lower consumption of high-sugar drinks (i.e. 107.7 vs. 124.2 ml for <30 min), which was associated with a lower trunk fat percentage (Figure 1).

DISCUSSION

The current study suggests that the association between perceived stressful homework and trunk fat percentage is partly mediated by high-sugar drinks without sex differences. The current study adds that monitoring the number of snacks consumed and total saturated fat intake might be beneficial in boys who have high homework duration and perceived stress related to schoolwork.

In adults, the energy intake following a cognitive task was greater than that following a seated-rest period[2], potentially due to imbalanced glucose homeostasis.[21] In the current study, children who performed longer homework while feeling stressed were not seen to have an increased energy intake. This discrepancy might be due to the fact that in adult studies[2-4,21], an *ad libitum* buffet is often provided post task. The QUALITY study considers children's real-life environment, therefore, children may have limited control over what and when they eat. They were likely supervised by their parents[7] whom were seen to have an impact on the total caloric, saturated fatty acids and added sugar intake, thus limiting unhealthy eating habits of their child.[22] In addition, as children age, they respond more to environmental than internal stimuli.[23] In the current study, while performing perceived stressful homework, children might not have been exposed to energy-dense food, which might explain why they did not increase their energy intake.

The macronutrient analysis in adults has shown that higher energy intake from fats was observed during[15] and following[2] a mental work period, which was not the case in this study. Also, mental work was not observed to favor more energy intake from sugary foods.[2] Along these lines, our results showed that an increase in perceived stressful homework duration was associated with a lower consumption of high-sugar beverages, which was subsequently associated with a lower trunk fat percentage. This might be due the fact that those children were too preoccupied by their homework to turn to food.

It was only when children perceived schoolwork as being stressful that homework was associated with poor total and trunk fat percentages. In teenagers, school examinations that induced stress were seen to increase energy intake in girls and levels of fat intake in boys.[8] This is potentially because a stressor can activate the hypothalamic-pituitary-adrenal axis[24], which causes the release of cortisol in circulation, a hormone known to stimulate appetite.[25] In adults, a 45-minute knowledge-based task was associated with increased energy intake and elevated blood cortisol levels.[21] Taking these findings into consideration, it was expected that perceived stressful homework would be at least associated with increased energy intake and/or saturated fat, but this was not the case in our study. Along these lines, in boys who reported not feeling stressed by schoolwork, a decrease in saturated fat consumption was noted.

Previous studies involving adults[26,27] report that, under stressful conditions, eating habits change; similarly, our findings suggest that only when children feel stressed by schoolwork that they have a low consumption of high-sugar beverages. However, in adults, participants who underwent a stressful mental task, such as unsolvable mental arithmetic, increased their energy intake from sweet food in the absence of hunger.[28] Cognitive tasks increased chocolate intake by 15% compared to control tasks that consisted of neutral words.[29] We might have found a different association due to the type of sugar we have studied. The aforementioned adult studies examined mental work and *solid* sources of sugar intake, whereas sugar beverages were considered in the current study. In 2003, a study examined stress levels and eating habits of children, and found that children ate more snacks when they were stressed.[30] The current study adds that high amounts of homework with perceived stress are associated with more snacking in boys.

In adults, women were observed to have a higher energy intake following mental work compared to a seated rest period, which was also associated with increased intake of carbohydrates, whereas, in men, decreases in energy intake and dessert consumption were noticed.[3] According to the adult findings and knowing that girls spend more time on homework than boys[31] a sex difference in energy intake and eating habits was expected. However, it was not the case in our study. In teenagers, the effect of stress alone on eating habits has revealed that girls and boys change their eating habits differently in response to stress.[8] Along these lines, the current study observed that young boys who did not feel stressed by schoolwork and performed less homework consumed less saturated fat.

The strength of the current study is the examination of these associations in a real-life setting compared to adult studies of a similar nature, which were conducted mostly in a laboratory.[2,3] One limitation of this study is the auto-reported amount of homework and perceived stress by children. It is also noteworthy that dietary habits are difficult to measure with accuracy. Moreover, the parental control and educational levels, as well as family socioeconomic status were not taken into account, but might have had an influence on the child's food intake.

IMPLICATIONS FOR RESEARCH AND PRACTICE

High sugar drinks consumption seems to explain part of the association between perceived stressful homework duration and adiposity of children aged 8–10 years old. Boys seem to adopt poor eating habits in the presence of stress, such as an increase in the number of snacks consumed when feeling stressed and performing a lot of homework. Randomized control trials are potentially needed to further study these associations between homework duration, stress, adiposity, number of snacks and saturated fat intake in more detail.

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Table 1. Age, Anthropometric, Homework, Stress and Dietary Intake Data of the QUALITY Cohort Children (n=544)

	Girls (n=244)	Boys (n=300)
Age (years)	9.5±1.0	9.6±0.9
Body Mass Index (percentile)	67.5±29.2	68.9±27.7
Total fat mass (%)[ab]	29.0±10.2	23.8±10.8*
Trunk fat mass (%)[ab]	27.5±11.7	22.1±12.0*
Homework (h/d)	0.7±0.5	0.6±0.5
Stress, %[†]	49.0	40.0*
Energy intake (kcal/d)[cd]	1597.6±351.7	1782.6±405.6*
High sugar drinks (mL/d)[cd]	101.5±128.9	134.6±149.2
Number of snacks (#/d)[cd]	5.2±2.0	4.5±2.1*
Saturated fat (g/d)[cd]	20.7±7.1	23.0±7.9*
Diet Quality Index-International[cd]	57.5±7.0	58.2±7.5

Significantly different from girls (**P*: [†]Chi-square: < .05; Independent samples t-test: < .005); Values are mean±standard deviation; Differing sample size: Girls ([a] n= 243; [c] n= 238) and Boys ([b] n= 295; [d] n= 294)

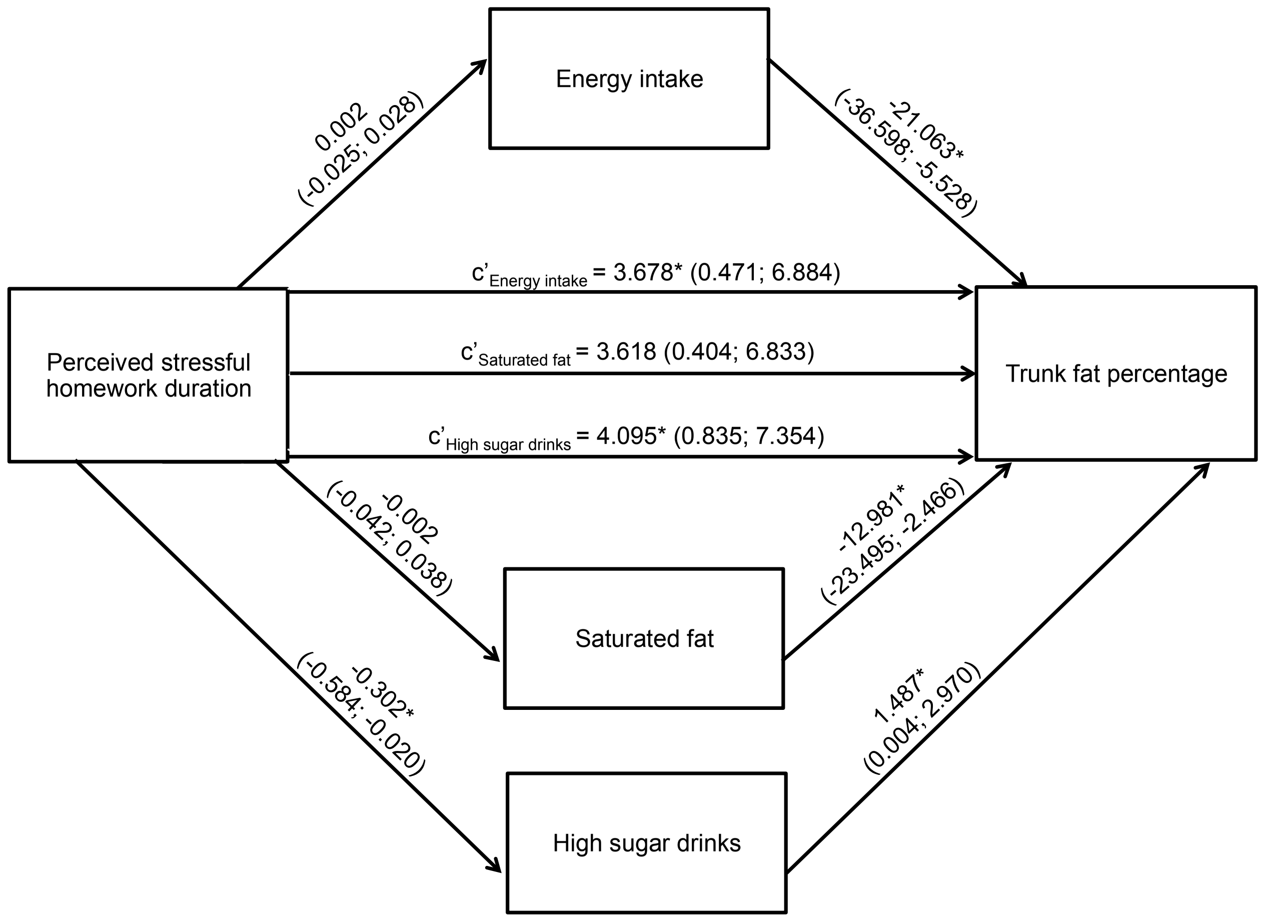

Figure 1. In all children, relationship between perceived stressful homework duration (X) and trunk fat percentage (Y) mediated by dietary intake factors (M) excluding number of snacks and Dietary Quality Index-International, which were not significant mediators. Path a refers to relationship between X and M whereas path b indicates association between M and Y. With a mediator in the model, left over association between X and Y is called c'. There are three c' for each M. From mediation models (PROCESS macro) unstandardized beta coefficients along with their 95% confidence interval and *P* value for path a, b and c' are represented; intervals with zero value not considered as significant association, and " * '' complements by indicating that $P < .05$. Based on significance of path a, b, and c', high sugar drink is a partial mediator

Discussion

Purpose of this project

In an era during which work modality is transitioning from physical work to mental work, the effect of the latter on health is of major concern. Recently, studies regarding the effect of stressful mental work on dietary intakes are emerging in the adult population. However, this association has not been extensively studied in children. Fortunately, the QUALITY cohort study exists as it allowed for the exploration of this effect in children longitudinally. Since this cohort follows the children throughout the years with respect to the same variables, it allowed this project to explore the longitudinal component of the relationship between homework duration and adiposity with lifestyle habits as mediators. Thus, the aim of this master's thesis was to do a follow-up and to complete the study that was published in 2015 by Michaud and colleagues. Following are the goals of the current master's thesis:

1. Observe whether the associations and mediating factors seen at ages 8–10 years old persist when the same children are 10–12 years old.
2. Do a longitudinal follow-up on the relationship between homework duration and adiposity indicators considering lifestyle habits (excluding dietary intakes) as mediators.
3. Find which nutritional habits could be a potential mediator in this relationship at 8–10 years old since the data for at 10–12 years old is not available.

Summary of the major results

To facilitate the comprehension of these results, a simple figure illustrating the basic framework of associations between the independent, dependent and mediator variables could be found in Appendix 1. The reanalyses of children at 8–10 years old with homework duration as a continuous and not dichotomous variable showed that homework duration, without even considering the stress status of the child, was associated with poor total and trunk fat percentages, and was mediated by a decrease in MVPA and increase in screen time as seen in Michaud and colleagues. One of the key observations is that contrary to what was found in this earlier observational study by our team, girls were seen to be more susceptible to weight gain when doing perceived stressful homework on a chronic basis. In fact, homework duration was associated with adiposity, and screen time was a mediator only in young girls, who claimed to be stressed by schoolwork. Contrary to what was hypothesized namely most of the associations and mediating factors seen at 8–10 years old did not persist when the children were 10–12 years old. The longitudinal analyses revealed that as perceived stressful homework duration increased since 8–10 years old; sleep duration decreased and was consequently associated with an improved trunk fat percentage. This was true when all the children were analyzed all together and when the girls were isolated. Finally, a decrease consumption of high-sugar drinks was seen to partly mediate the relationship between perceived stressful homework and trunk fat percentage in young children.

In the following sections, brief summary of existing literature on each subtopic is followed by important points that our results add, and are discussed in context.

Adiposity

1.0 Adiposity and mental work

In adults, physical strenuousness at work explained small but significant 7% of BMI increase in male workers (Bockerman et al., 2008). This type of analyses was also done in the United States with the goal of exploring the cause of increased obesity prevalence in the population (Helmchen, 2001). In that study, the shift in working modality accounted for 10% of the total increase in obesity prevalence. Thus, indicating that another component such as mental work might have a role on body weight gain, and this was the main focus in Lallukka and colleagues' study (2008). Increased mental strain doubled the weight gain of male participants compared to those who had reported a decreased or constant mental strain over a 10-year period. This longitudinal study also found that males' body weight was negatively impacted by mental work compared to women (Lallukka et al., 2008).

Others studies examining at mental work have been published, but they have not studied body weight per se, rather energy intake (Chaput & Tremblay, 2007; Perusse-Lachance et al., 2013; Salama, Drapeau, Tremblay, & Perusse-Lachance, 2016). Following the mental work period, the energy intake was 959 kJ higher than the energy intake following resting condition, which is a difference of ~20% (Chaput & Tremblay, 2007). There were other follow-up studies on this association, and they all shared this common finding (Chaput, Drapeau, Poirier, Teasdale, & Tremblay, 2008; Chaput & Tremblay, 2009). These studies focused on the acute effect of mental work, this increase in energy intake might eventually lead to a weight gain in the long run. Acutely, women were seen to increase their energy intake following KBW (Perusse-Lachance et al., 2013; Salama et al., 2016), which longitudinally could favor weight gain in women.

Stress along with mental work seems to have an important effect on energy intake (McCann et al., 1990). In 2008, participants who performed KBW were observed to have elevated mean blood cortisol levels over 45-minute compared to a seated-rest period (Chaput et al., 2008). Thereby insinuating the presence of stress during KBW, and somewhat explaining the increase in energy intake that has been observed. However, some of their team's preliminary results suggested that mental work itself could lead to positive energy balance (Chaput & Tremblay, 2007). Therefore, the actual mechanism relating mental work and energy intake in adults needs to be further documented.

In children, the only study that has examined mental work with adiposity is Michaud and colleagues (2015). This study is from the same laboratory as the current study and has performed the same analyses, but with dichotomous homework duration. In that study, perceived stressful homework was found to be associated with poor adiposity profile especially in boys aged 8–10 years old (I. Michaud et al., 2015).

2.0 Adiposity as outcome

2.1 At 8–10 years old

Perceived stress not considered

This is one of the first studies to examine the effect of homework duration on children's adiposity profiles, and more importantly explore the dose-response influence of homework on adiposity. The results of the current study add that there is a clear association between homework duration and adiposity in children between 8–10 years old. It is also in agreement with the aforementioned adults' studies that have examined the effect of mental work on body weight. It is important to notice that perceived stress was not considered in this part of the analyses, but in the adults' studies stress was omnipresent (Lallukka et al., 2008). Therefore, this comparison should be taken with a reservation.

Based on our results, girls who performed high amount of homework seemed to be prone to have a poor adiposity profile than boys of the same age category. This result disagrees with Michaud and colleagues (2015).

Perceived stress considered and present

Our study agrees with Lallukka et al (2008) and adds to the existing literature that performing a lot of homework is associated with all three adiposity indicators in children. However, in the current study, perceived stressful homework was not seen to affect daily energy intake, which in the long run could have an effect on adiposity and/or weight status of children. This finding does not agree with the previously mentioned adults study. This disagreement could be due to the way the stress data was assessed. In fact, in the current study a questionnaire, a subjective tool, was used whereas in the adults' study, blood samples were drawn which is an objective measure. This might also be due to the fact that adults' study an *ad libitum* buffet was given whereas in the present study, children were exposed to what was in their house and under parental control, which has an effect on the intake.

Our study observed a sex difference between mental work and adiposity since when girls were isolated alone; the association between perceived stressful homework duration and adiposity still persisted, whereas it was absent in boys alone. However, the daily energy intake in girls was not associated with mental work as seen in the adults' studies. Previous studies explain that this sex difference exists due to the response to stress each sex has (Torres & Nowson, 2007).

Perceived stress considered and absent

This part of the analyses served to further demonstrate the effect of stress in the relationship between homework duration and adiposity because in children who claimed not to be stressed by schoolwork, none of the association between homework duration and adiposity indicators was seen. This is in agreement with all the adults' studies, which have seen that only stressful mental work increases body weight (Lallukka et al., 2008) and energy intake (Chaput et al., 2008; Chaput & Tremblay, 2007; McCann et al., 1990; Perusse-Lachance et al., 2013; Salama et al., 2016). It might be that children who do not stress over their schoolwork do not opt for poor lifestyle habits thereby not having any negative influence on their body composition.

There was no sex difference that was seen at this age, thus homework duration is not associated with a poor adiposity profile when children are not stressed by schoolwork.

2.2 At 10–12 years old

Perceived stress not considered

The association between mental work and adiposity disappeared when children were 10–12 years old, and when girls were isolated. It was expected that homework duration would still be associated with adiposity since as children age; since they do a lot more homework (Canadian Fitness & Lifestyle Research Institute, 2014). This association was at least expected when girls were analyzed alone since girls perform more homework than boys (Devís-Devís et al., 2017; Lazarou & Soteriades, 2010). Also, since homework is a sedentary task, a stronger link with children's body composition indicators was expected. A study examined the association between various sedentary behaviors such as homework and playing video games in teenagers (mean age of 15 years old), and physical activity level (Feldman, Barnett, Shrier, Rossignol, & Abenhaim, 2003). Teens who had productive sedentary behavior such as doing homework performed a lot more physical activity. So, the authors concluded that children who were productive in their learning and academic work were more likely to make time for physical activity thus seeming to have better time management skills. Taking this finding into account, children in our cohort might also have been more efficient at managing their time hence why at 8–10 years old, homework was related to most of the adiposity indicators, but at 10–12 years old, it disappeared. However, although, the aforementioned study stated that their students were being time-efficient, the teenager's sleeping habits were not explored. Their participants might have had short sleep duration in order to maintain their busy schedule. The authors just mentioned that those time-efficient teens are less likely to sleep late, but no sleep data was collected in the study to confirm this statement.

Unfortunately, in the literature the association between homework and weight change in children has not been examined thereby making it hard to compare our results to other research articles.

A reason as to why homework was not associated with adiposity at this age might be due to the lack of adherence of 8–10 years old children to subsequent visits. There were initially around 600 children in the cohort, and depending on the eligibility criteria nearly 410–500 children were selected for the first set of analyses. Then, at the second visit, with the dropouts and the eligibility criteria, nearly 400 children were considered. Thenceforth depending on the grouping and the analyses of interest, this number decreased and might have caused the strength of the association to disappear. This limitation was even more important in the longitudinal aspect of this study (n = ~350).

Perceived stress considered and present

When children were 8–10 years old, they seem to be more susceptible to having a poor adiposity compared to when they were 10–12 years old since no association was present in all children together, and in girls or boys alone. We hypothesized a similar explanation as Feldman and colleagues (2003) for this disappearance; it might be that young children might be less capable of coping with stress than older children thereby having a negative effect on their adiposity.

Michaud and colleagues (1990) studied at the food intake during examination days vs. those without any stress (control days) in teenagers (15–19 years old). They saw that girls consumed 135 kJ more energy during stressful examination days compared to control days (C. Michaud et al., 1990). Unfortunately, the nutritional data was not collected when the children were 10–12 years old, thus it is not possible to compare our results to this aforementioned study. Also, the age category is different between both studies.

Perceived stress considered and absent

The only significant result at 10–12 years old was that with increasing perceived not stressful homework duration, adiposity indicators worsened in girls only. With the existing literature, this sex difference at 10–12 years old cannot be demystified. It is also surprising that this relationship did not exist when stress was present.

2.3 Longitudinal analyses

In the longitudinal analyses, in boys who claimed to be stressed at 8–10 years old, but were not stressed at 10–12 years old, the increase in homework duration was associated with higher trunk fat percentage. This longitudinal aspect should be examined in future studies since it would allow identifying at which age stress can be problematic.

Physical activity

1.0 Physical activity and mental work

In adults, to our knowledge, the association between mental work and overall daily physical activity has not been studied.

In school-aged children, overall physical activity and homework routine have been examined. One of the main barriers for not doing physical activity was observed to be performing homework (O'Dea, 2003). Dales and colleagues (2013) wanted to know whether or not children (mean: 9.3 years old) compensated for the induced sedentary time at school during the after-school period. Children were not observed to increase their physical activity level after school to counterbalance their sedentary time at school (Dale, Corbin, & Dale, 2000). The authors did not measure any homework variables, which could have been interesting to have since it might have been the reason as to why compensation during the after-school period was not present. Due to the overloading schoolwork, high school students eliminated the time spent in another activity or hobby (M. K. Galloway & Pope, 2007). These dropout activities could have been playing outside or participating in an organized and structured physical activity. School-aged children (10–16 years old) spend more than two thirds of their day inactive, and homework was one of the three major contributing factors (R. S. Strauss, Rodzilsky, Burack, & Colin, 2001). In addition, as teenagers (12–18 years old) were involved in sedentary behaviors, less time was spent doing moderate intensity physical activity. Regardless of socioeconomic status, homework was one of the common barriers for physical activity participation in teenagers (Humbert et al., 2006).

Girls (11–16 years old) whose sedentary activity consisted of doing academic activities, such as homework, spent less time doing MVPA (Devís-Devís et al., 2017). Another study with teenage girls focused on influence of parental supervision on after-school behavior (Rushovich et al., 2006). They found that girls who were left unsupervised by their parents performed less homework, but were physically more active (Rushovich et al., 2006). At least in teenage girls there seems to exist an opposite relationship between homework duration and physical activity habits.

2.0 Physical activity and adiposity

The association between physical activity and adiposity is well known in children and adults. Adults who chronically performed vigorous intensity physical activity had better skinfold measurements and waist-to-hip ratio compared to those who do not perform this intensity (A. Tremblay et al., 1990). Moreover, exercise is used as a tool to decrease adiposity and lose weight (Swift, Johannsen, Lavie, Earnest, & Church, 2014). Once weight loss has been achieved, physical activity is also used to decrease weight regain (Fogelholm & Kukkonen-Harjula, 2000; Swift et al., 2014). In adults who previously had obesity and lost weight, around 45–60 minutes per day of MVPA is recommended to prevent weight (W. H. M. Saris et al., 2003).

In children, a close association between physical activity and adiposity has been observed. In fact, children who perform less physical activity were seen to have a worse adiposity profile (Jiménez-Pavón, Kelly, & Reilly, 2010). Moderate or vigorous physical activity was observed to positively affect body composition (Wittmeier, Mollard, & Kriellaars, 2007). The higher the amount of total physical activity, the lower the children's BMI, fat mass and trunk fat (Ness et al., 2007).

3.0 MVPA as a mediator

3.1 At 8–10 years old

Perceived stress not considered

The current study adds that children who performed a lot of homework were seen to decrease their MVPA duration, which was subsequently associated with a poor adiposity. In the literature, this type of mediation model has not been studied in children, therefore making this current study difficult to compare. But the link between homework and physical activity have been studied thus, making it possible to discuss to a certain extent; Our study agrees with the latter observations concerning the increase in homework duration with a decrease in MVPA duration. Future studies focusing on these variables are needed to confirm these relations. This would be the case for most of the lifestyle habits explored in this study.

Girls usually spend less time performing physical activity (Ridgers et al., 2011; Veitch et al., 2006), so with increasing homework duration, a decrease was expected, but it was not the case. It is also possible that the number of girls in this category was not high enough (n = 190) to observe this lifestyle habit as a mediator since when all the children were grouped together this link was present.

Perceived stress considered and present

MVPA was not a mediator between homework duration and MVPA when children claimed to be stressed by schoolwork.

3.2 At 10–12 years old

Perceived stress not considered

MVPA was expected to decrease with increasing homework duration, and consequently be associated with poor adiposity when those QUALITY cohort children were 10–12 years old, but was not the case. In the literature, the association between homework and MVPA is not clear. Participants (mean age: 15 years old) were observed to perform more leisure time physical activity with more time spent doing homework (Utter et al., 2003), which does not agree with the aforementioned studies (M. K. Galloway & Pope, 2007; R. S. Strauss et al., 2001). However, Strauss and colleagues (2001) used a more reliable tool to measure physical activity level, i.e. bi-axial accelerometer, compared to Utter and team (2003) who used a questionnaire to indicate the number and the intensity of physical activity. Therefore, we are more inclined towards Strauss and colleagues' (2001) findings indicating that more homework does not favor more physical activity. Based on the results of this study, what could be concluded from the absence of MVPA, as a mediator, is that homework does not at least have any negative effect on MVPA levels in older children.

Our study did not observe any sex difference regarding the relationship between homework duration and MVPA. This dissimilarity could be due to the age difference since our cohort was composed of early teenagers. For example, Devis-Devis and team's (2017) participants were between 11 and 16 years old, and Rushovich and colleagues (2006) had teenage girls. Maybe subsequent visits of the QUALITY cohort study, when participants are 15–17 years old, would allow to compare more adequately to the aforementioned studies. Another reason could be that Devis-Devis et al. (2017) used a recall of physical activity over seven days whereas the current study used an objective tool (accelerometer). Moreover, teenage girls were seen to perform physical activity of lower intensities than boys (Feldman et al., 2003). Thus, maybe if we had included low-intensity physical activity (LPA) as a mediator, in the relationship between homework duration and adiposity, different results might have been seen. The reason as to why LPA was not examined in the current study is because we wanted to stay close to the current recommendation of physical activity. Furthermore,

3.3 Longitudinal analyses

In the longitudinal aspect, MVPA duration was not an important mediator with increasing homework duration.

Screen time

1.0 Screen time and mental work

To our knowledge, in adults, mental work along with after-work screen time has not been documented.

In children, it is well known that those who watch a lot of television, do less homework (M. S. Tremblay et al., 2011), but is the opposite true, i.e. does performing a lot of homework has an impact on screen time? Teenage girls who were not supervised by their parents were seen to perform less homework and watch more television (Rushovich et al., 2006). No studies have examined the effect of homework on screen time.

2.0 Screen time and adiposity

In adults, screen time, a sedentary behavior, was positively associated with WC, in a dose-response relationship (Healy et al., 2008).

In elementary-school children, spending more than an hour in front of the television was associated with an increase in BMI later in life (Jackson & Cunningham, 2017). Children aged 9–10 years old who watched > 3 hours/day of screen time were seen to have a higher fat mass index and skinfold thickness than those who watched ≥ 1 hour/day (Nightingale et al., 2017). There also seems to be a sex difference in this association. Sedentary behavior rather than lack of physical activity was an important determinant in the overweight status in girls of 11 years old (te Velde et al., 2007). In addition, television viewing, in girls, increased the risk of being overweight. A more recent study also reported that girls (9–13 years old) who watched more than four hours per day of television and digital video disks (i.e. DVDs) had higher risk of being overweight or obese, while this was not statistically significant in boys (Lazarou & Soteriades, 2010).

3.0 Screen time as a mediator

3.1 At 8–10 years old

Perceived stress not considered

Children who performed a lot of homework were seen to have higher screen time, i.e. television/video movies, than those who performed less. Moreover, this behavior was subsequently associated with a poor adiposity profile as seen in the literature (Lazarou & Soteriades, 2010). The findings of the current study add to existing literature on homework and screen behaviors in children. The mean screen time in the current study was around 2 hours/day, which is close to guidelines (Physiology, 2012), yet this habit was still a significant mediator in the relationship between homework and poor adiposity. Considering that technology usage is increasing, these relationships are expected to become stronger; the longitudinal progression of screen time, homework habits, and adiposity is of interest in future studies.

Furthermore, our study also adds that that there is a sex difference with respect to this mediator. In fact, girls who accumulated a longer homework duration watched more screen time, which was subsequently associated with adiposity. Therefore, screen time should be one of the main targets in weight management programs of young girls.

Perceived stress considered and present

Our study took stress into consideration, which has not been done when examining the relationship between homework and screen time. Children, who are stressed by schoolwork, spend a lot of time in front of a screen. Although a cause-effect relationship cannot be concluded between perceived stressful homework duration and screen time, our study brings this new association to existing literature. Due to the lack of studies on these two variables, it is difficult to discuss this association further.

At 8–10 years old, screen time mediated the relationship between perceived stressful homework duration and screen time in girls. This was not the case in boys of the same age group and stress level. Maybe girls watch television as a way to relieve stress whereas boys put their concentration on other activities. It is rather intriguing the fact that girls did not decrease screen time in order to manage their time more efficiently. They could also use this time for exercises such as Yoga to relieve stress and improve their body composition.

3.2 At 10–12 years old

Perceived stress not considered

Screen time was not associated with total or trunk fat percentage, whereas it was with BMI. Screen time was a significant mediator between homework duration and BMI at this age. This study adds that increases in homework duration was associated with a decrease in screen time, which was then associated with a decreased BMI. However, our results should be taken with a grain of salt since the association was only noted with BMI. Future studies should explore these associations in detail since it would allow to tailor intervention programs aimed to decrease body weight issues in children at 10–12 years old. Moreover, there was no sex difference in this association.

Sleep time

1.0 Sleep time and mental work

In adults, increased mental workload was associated with higher ratings of subjective fatigue and sleepiness as well as delayed sleep onset (Goel et al., 2014). Moreover, when subjected to stressful mental work, adults were observed to be more anxious in their dreams and had nightmares of their stressful experience (Koulack et al., 1985).

Sixty-eight percent of adolescents reported that they, often or always, do not have enough hours of sleep each night due to their schoolwork (M. Galloway, Conner, & Pope, 2013). Homework was one of the top reasons for going to bed after 11:00 pm (Gau & Soong, 1995). This homework and sleep duration pattern seems to be present in all teenagers around the world. Moreover, in teenagers who perform a lot of homework while maintaining extracurricular activities were observed to decrease their sleep duration to compensate (M. Galloway et al., 2013).

Moreover, there might exist a sex difference in the association between homework duration and sleep duration. Chinese urban girls were seen to sleep less during weekdays compared to boys and that this association was stronger in older children (Jiang et al., 2015). Homework duration was also inversely associated with sleep duration in all the students who participated in their study.

2.0 Sleep time and adiposity

In adults, short sleep duration was associated with poor BMI and the risk of obesity (Gangwisch et al., 2005). Moreover, in females, a positive association between sleep duration and WC was noted (Theorell-Haglöw et al., 2012). In children, short sleep duration was associated with obesity (Sekine et al., 2002). The risk of obesity increased with every decrease of an hour in sleep duration (Ruan et al., 2015). In addition, children who slept around 10 hours/night were more likely to be obese compared to those who slept around 12 hours/night.

3.0 Sleep time as a mediator

3.1 At 8–10 years old

At 8–10 years old, regardless of the stress status, children's sleep habits were not associated with increased homework duration, which is rather positive since it means that perceived stressful homework duration did not have a negative influence on sleep duration.

3.2 At 10–12 years old

At 10–12 years old, increasing homework duration was not associated with sleep duration, regardless of the stress status and sex of the children. This a positive result since at least homework does not have a negative impact on the child sleep duration and subsequently on their adiposity profile between 10 and 12 years old. A follow-up on this association should be performed based on the aforementioned teenagers studies that have reported that with increasing homework duration, sleep duration decreases.

3.3 Longitudinal analyses

Children who were stressed since ages 8–10 years old and had increased their homework duration were seen to have decreased their sleep duration, which was subsequently associated with a decreased trunk fat percentage. In our study, the decrease in sleep duration was seen to be associated with improved trunk fat percentage, which seems to contradict existing literature. In our study, sleep duration decreased since ages 8–10 years, but did not go below the level seen in the aforementioned studies, i.e. the mean sleep duration in this cohort at 10–12 years old was around 13 hours/night, thereby explaining why the trunk fat percentage was not affected.

On the other hand, this duration (13 hours/night) is somewhat questionable since it seems to be high for 10–12 years old. This duration might be an overestimation since it was computed from accelerometer data. The time elapsed between the removal and attachment of the device back onto the children served as the sleep duration variable. However, this calculation does not take into account the time between the removal and the time at which the child actually fell asleep. Children might have removed the accelerometer before taking their shower and went to bed afterward, in which case extra and unnecessary non-wear time has been taken into the sleep duration calculation.

The current study adds that there is a sex difference between perceived homework duration, sleep duration and adiposity in the long run. Sleep duration was a mediator in this relationship in girls. In fact, girls who were stressed since 8–10 years old, increasing homework duration was associated with a reduction in sleep duration, which was associated with lower trunk fat percentage. This may be explained by the fact that girls are known to perform a lot more homework than boys (Canadian Fitness & Lifestyle Research Institute, 2014).

High sugar drinks

1.0 High sugar drinks and mental work

In adults, after KBW, carbohydrate intake was higher than after the control condition. However, the percentage of energy intake from carbohydrate intake was not significantly higher (Chaput et al., 2008; Chaput & Tremblay, 2007). Stressful mental tasks were observed to increase energy intake from sweet foods (Rutters et al., 2009; Wallis & Hetherington, 2004).

In adults, under stressful mental work, females were seen to consume more sweet food compared to men who decreased their consumption of dessert and carbohydrate intake following a KBW (Salama et al., 2016). Undergoing mental work, the presence of stress seems to affect the food preference of males differently compared to females. Torres and Nowson (2007) explained that female go towards sugary foods to relieve their mental stress whereas men prefer alcohol and tobacco.

In children and teenagers, a lot of reading/homework was associated with lower consumption of soft drink, and this was observed in both girls and boys (Utter et al., 2003).

Around 55–70% of all sugar-sweetened beverages' calories were consumed in a home environment and this during weekdays (Wang, Bleich, & Gortmaker, 2008).

2.0 High sugar drinks and adiposity

It is well known that high-sugar drinks are related to obesity in adults and children (Vasanti S. Malik, Popkin, Bray, Després, & Hu, 2010; Vasanti S Malik, Schulze, & Hu, 2006). Children who drank additional servings of high-sugar drinks were observed to have an increase in BMI (Ludwig, Peterson, & Gortmaker, 2001). High sugar drinks were reported to be positively associated with obesity in children.

3.0 High sugar drinks as a mediator

3.1 At 8–10 years old

Perceived stress considered and present

High sugar drinks consumption was a partial mediator in the relationship between perceived homework and trunk fat percentage in all the children. Interestingly, with increasing homework duration, this variable was seen to decrease. Due to the presence of stress, it was expected that this consumption would increase since in adults during stressful conditions participants seemed to prefer sweet foods (Epel, Lapidus, McEwen, & Brownell, 2001; Oliver, Wardle, & Gibson, 2000). Our results do not agree with the aforementioned adult's studies. However, it should be noted that not all sugar sources were included in our analyses, only high-sugar drinks consumption was measured therefore a direct comparison with these adult's studies cannot be done. Moreover, the state of sugar sources might have an influence on their intake (Pan & Hu, 2011; W. H. Saris, 2003); this association needs to be further assessed. The discrepancy between adults and the current findings might also be due to the fact that adults have more control over what they eat compared to children who are restricted by their parents. Another possible explanation is that children in this cohort were so stressed by their homework, that they did not have time or the thought to walk to the pantry and ingest a sugary drink. On a side note, Torres and colleagues wrote a review in which they studied at the eating behaviors in animals under stressful conditions. They reported that six studies reported that rats drank less sweet fluid/food intake, which is in line with these current results (Torres &

Nowson, 2007). Maybe the presence of stress is the answer to this decrease in consumption of sugary drinks.

In our study, the between sex analyses did not reveal any significant difference. Based on the adult's study on this topic, it is possible that sugar beverages consumption was not a significant mediator in boys. However, it was expected that when girls were isolated alone this nutritional factor would have mediated the relationship perceived stressful mental work and adiposity. The reduction of our sample size could be a reason as to why high-sugar drinks consumption was not a mediator in girls since this association was true when children were put together, when sample size was bigger. Or it could be because the current study only considered sugar drink consumption rather than all sweet food such as dessert.

3.2 At 10–12 years old

Since the nutritional data is missing of the children at 10–12 years of age, the progression of this association cannot be explored.

Combined mediators interpretation

Throughout the analyses, in a given subgroup, two mediators were present simultaneously; this section would briefly relate our findings to the existing literature concerning those two particular mediators, homework and adiposity.

1.0 Screen time and high-sugar drinks

1.1 At 8–10 years old

The fact that children who performed a lot of perceived stressful homework were seen to watch more television and simultaneously drink less high-sugar drinks seems to contradict existing literature concerning screen viewing and sugar-sweetened beverages habits. In fact, as children watch more television, they were observed to drink more soft drinks (Gebremariam et al., 2017). A fairly recent study based on previous literature on habit formations has explained that when children are used to consuming high-sugar drinks while watching a screen, screen will become an environmental cue that would automatically trigger these drink consumptions

(Aarts, Paulussen, & Schaalma, 1997; Kremers, van der Horst, & Brug, 2007). However, the children in our cohort who performed perceived stressful homework were seen to increase their screen time, but decrease their consumption of high-sugar drinks. This might be explained by the parental control over what the children eat. A recent study has pointed out that screen time is independently associated with sugar-sweetened beverages, but parental education was a moderator in this relationship (Gebremariam et al., 2017). Also, it is possible that our young children watched more video movies on television, which does not contain advertisements encouraging to consume unhealthy snacks/drinks thereby explaining why our cohort consumption of this type of drink decreased. Finally, high-sugar drinks consumption was a mediator only with one of the three adiposity indicators. Therefore, future studies are needed to clearly see the association of these variables with perceived stressful homework duration.

1.2 At 10–12 years old

Since the nutritional data is missing at 10–12 years old, a longitudinal follow-up on this pattern cannot be further discussed. However, Utter and colleagues (2003) noticed that teenage boys who watched ≥ 4 hours/day of television/video use consumed more soft drinks compared to those who watched less. In girls, those who watched ≥ 4 hours/day consumed more than those who watched between 1 and 4 hours/day, who consumed more than those who watched ≤ 1 hours/day (Utter et al., 2003). It is difficult to estimate what would have happened in the current cohort at 10–12 years old because: 1) participants from the latter study were older, and 2) homework was not considered in the association between screen time and high-sugar drinks consumption.

2.0 Screen time and MVPA

2.1 At 8–10 years old

In all children, when perceived stress status was not considered in the analyses, doing a lot of homework was simultaneously associated with watching a high amount of screen and doing less MVPA, and thereby having a negative effect on all three adiposity indicators. In the literature, reductions in physical activity level have been associated with increasing screen duration (Alghadir, Gabr, & Iqbal, 2015). Our study not only agrees with this body of literature, but also adds that homework influences children into such poor habits. It is noteworthy that children who engage in very little screen time do not necessarily practice more physical activity (Fakhouri et al., 2013). Therefore, in the current study, it cannot be assumed that children who reported lower screen time adopted a healthier lifestyle.

The between sex analyses did not reveal a similar pattern, i.e. decreasing MVPA and increasing screen time with increasing homework duration, in girls or boys. Although, screen time was seen to be a mediator between homework and adiposity in girls, a decrease in MVPA was not accompanied. Hager (2006) reported that this type of pattern, i.e. decrease in MVPA with increasing screen time, was seen in boys and girls during weekends and weekdays' evening. Interestingly, they also observed a sex difference in certain slots of after-school period. In fact, boys who did not spend their time watching television were more active during the after-school compared to those who watched during weekdays between 3 and 9 pm (Hager, 2006). In the current study, the lifestyle habits were not separated into weekdays and weekends thus limiting the comparison with the aforementioned study. Also, no pattern between homework, screen time and MVPA was observed when each sex was analyzed separately.

2.2 At 10–12 years old

Melkevik and colleagues (2010) were interested in the association between physical activity duration and intensity, and different types of screen-based sedentary behaviors in children aged 11, 13 and 15 years old. They found that when the recommended 2 hours/day of television viewing was exceeded, children, regardless of sex, performed less MVPA, and vigorous physical activity in girls only (Melkevik, Torsheim, Iannotti, & Wold, 2010). Another study reported a completely different finding compared to the aforementioned studies (Hohepa, Scragg, Schofield, Kolt, & Schaaf, 2009). This study stated that students between 12 and 18 years old who watched more than four hours per day of television were much more likely to be active after school than those who watched less than an hour per day. Their screen and physical activity data were collected through surveys consequently this association needs to be reassessed with more objective methods in order to reach a consensus on this topic.

Based on the fact that MVPA and screen time were mediators in 8–10 years old children simultaneously and that these aforementioned studies included older children, this pattern between MVPA and screen time was expected to exist when QUALITY children were 10–12 years old. However, this was not the case based on our findings and regardless of the stress status. Maybe taking homework into account altered this pattern.

Moreover, no sex difference was seen in this pattern, which does not agree with existing literature. Boys who spent time in front of a screen decreased MVPA, which was not seen in girls of the same age group (Devís-Devís et al., 2017). The latter study included all the screens that is to say computer and video consoles, whereas in the present study, only television and video movies were used, thereby explaining why this pattern was not seen at 10–12 years old of QUALITY cohort. An old study has examined the fitness level of different types of screen viewers (< 2 hours, 2–4 hours and > 4 hours of daily screen time). High school boys who were heavy viewers, scored much more poorly on fitness tests such as long jump and jog-walk than light viewers (Tucker, 1986).

Clinical implications

From these results, parents could monitor certain lifestyle habits and bring some changes to their children's habits. One of the concerns is the television viewing in children 8–10 years old while performing perceived stressful homework. Parents could question their child concerning their perception of their homework load, and the level of stress they feel every day. If the child is considerably stressed and/or performs long periods of homework every day, then parents could advise their child to decrease the time they spend watching television and playing outside particularly young girls. This might be an attempt to decrease sedentary time and increase active time. An exercise physiologist could be contacted in order to increase the MVPA in children who seem to have trouble balancing homework, stress and physical activity. Fortunately, these screen viewers do not seem to increase their energy intake and unhealthy snacks. Screen time does not seem to be a problem in all the children at 10–12 years old; it even decreases as the homework duration increases.

Sleep is another concern in children performing perceived stressful homework since the ages of 8–10 years old. If parents notice that their child, especially a girl, is stressed by school work, and performs a lot homework since the age of 8–10 years old, then parents might want to monitor the sleep duration of the child. In our cohort, the sleep duration did not reach below 10 hours/night, explaining why negative effect on the weight was not observed. But it is a lifestyle habit that should not be unnoticed because United States teenagers were seen to cut down on sleep duration in order to finish their homework, or felt anxious about sleeping without finishing their homework (M. Galloway et al., 2013). The following is a comment written by one of their participants who reported homework as being a primary stressor: "*There's never a time to rest. There's always something more you should be doing. If I go to bed before 1:30 I feel like I'm slacking off, or just screwing myself over for an even later night later in the week… There's never a break. Never.*" Parents who hear this type of comment could consider time-management strategies or consultation with a psychologist as a potential solution.

Strength and limitations

One of the main strengths of our study is the use of objective measures such as an accelerometer, and Dual-energy X-ray absorptiometry, which is a gold standard method for body composition measures (Branski et al., 2010). In the QUALITY cohort study, the time gaps between the visits are relatively small, which makes it more sensitive to small changes. Having nutritional factors as well as the activity profile of the same child, helps to either clarify some associations that have been observed in literature, or to show what happens to those associations when mental work is present in children.

Some other methodological limitations are present in this study. Homework duration, screen time, and stress levels were all auto-reported by children. Moreover, children were asked to rank their stress level on a scale of 1 to 4, where 1 was no stress at all due to schoolwork. Although the same types of questions were asked in another study (M. Galloway et al., 2013), it might not be the optimal method to measure stress. However, Galloway and colleagues (2013) asked more questions regarding schoolwork, and those questions were slightly more elaborated. For example, "If you have felt stressed, what is the most stressful part of your schoolwork or academic experience?" (M. Galloway et al., 2013). It is also important to notice that this is a perceived/subjective stress rating, and not an objective one such as cortisol levels in blood. Also, although the period at which both visits were schedule was controlled, the weeks at which the data were collected were not controlled. For example, at one of the visits, children might have not been in a stressful week at school with less schoolwork like at the beginning of an academic year, in which case they would have given a low rating. The longitudinal analyses were based on data collected at two different time points without a more vigorous follow-up of each variable in between.

Furthermore, studies showed that children under-, over-, or misreport their consumption when the 24-hour recall method is used (Livingstone & Robson, 2000). An early study has examined the effect of a 45-minute portion-size training using portion-size instruments, similar to the ones used in this study, on the accuracy of the children's estimation in laboratory settings, and concluded that more training sessions would be beneficial since children still had estimation errors (Weber et al., 1999). Moreover, the chronological order of each lifestyle habit was not inquired in our study and might have played an important role. For example, children were not asked when they were in front of the screen. Did they watch television before doing their perceived stressful homework? In which case this perceived stressful mental work might not have had an effect on this mediator and subsequently on adiposity. Another limitation of the study is the ethnicity of the children; they were all Caucasian children. Our results can be generalized to a certain extent only. In certain countries, children perform more homework than American children (Chen & Stevenson, 1989). The level of educational and socioeconomic status was not analyzed in this study and might have played a role in the relationship between homework duration and lifestyle habits, since families with low socioeconomic status were observed to watch more television, and engaged less in physical activity (Tandon et al., 2012). Another limitation is the eligibility criteria; all the children had at least one of the parents in the obese category, which already gives a certain characteristic to the whole study population.

Future directions

If this study had to be repeated, several changes based on the limitations provided above could be made. Firstly, future studies should consider measuring homework duration and stress while the child is performing the homework. To analyze the food intake following mental work, the children could be given an *ad libitum* buffet while they are performing homework, as was the case in the adult population. This would enable to clearly see the link between homework and the eating pattern. However, *ad libitum* buffet might not represent the real-life setting. Some parents might restrict the food access to their child, and this can cause these children to over-consume the food provided. Girls whose mother restrained the access to snacks were seen to over-consume in an unrestricted setting (Fisher & Birch, 1995). Instead, a research assistant could note when the child gets up and picks a snack from what is available in the household in order to replicate real-life setting. If the 24-hour recall method is to be used, a shorter delay from the meal-to-be-questioned and the interview would decrease the error and provide a more accurate reporting of the energy and macronutrient (Baxter et al., 2010). In 2010, an article explaining a new approach using technology to capture food and quantify consumption was published (F. Zhu et al., 2010), so other methods could be used to assess the dietary intake. Furthermore, for more precise sleep duration, children should be asked to fill a logbook. By doing it this way, even if the accelerometer was removed at 9:00 pm, the sleep duration could be calculated based on the reported time at which the child actually went to bed.

My implication in this study

When I arrived, the data collection for this master's project was already completed, so I was involved in the writing of my articles and thesis. While being directed by my supervisor, I had to do the literature review and write my articles and this thesis. I also had to perform the statistical analyses and interpret the results. Since I did not participate in the data collection, thanks to my supervisor, I had the opportunity to work with the QUALITY cohort team to help in the data collection for the third visit. I was involved in testing some physical capacities of the children such as cardiorespiratory fitness (indirect maximal oxygen consumption test), and enter these data into the database of this cohort.

Conclusion

From the analyses of this cohort, homework duration seems to have an influence on the child's adiposity profile at 8–10 years old, especially in girls. As they grow (10–12 years old) this association disappears. At 8–10 years old, screen time and physical activity are the main concerns since with high homework duration, children allocate their time for the wrong habit i.e. decrease physical activity level and increase screen time. At 10–12 years old, homework does not have a negative impact on BMI, since children seem to choose to watch less television with high amounts of homework.

When stress is considered and present, screen time persists in young children who perform a lot of homework thus reinforcing the importance of monitoring screen time; this was especially true in girls. It is also in this situation that children were seen to lower their consumption of high-sugar drinks. When these children were stressed until 10–12 years old, their sleep duration decreased, which might be another habit to focus in the prevention aspect of pediatric obesity, especially in girls.

When children report not being stressed, at 8–10 years old, none of the associations or mediators is present. At 10–12 years old, only girls who perform a lot of homework have a poor adiposity profile, but another lifestyle habit that was not considered in the current study might mediate this relationship since the ones considered in this study did not explain this association.

In all these analyses, a common observation is that boys' adiposity seems to be less affected by homework duration compared to girls. Further studies are necessary to examine the extent to which perceived stressful homework duration has an impact on adiposity.

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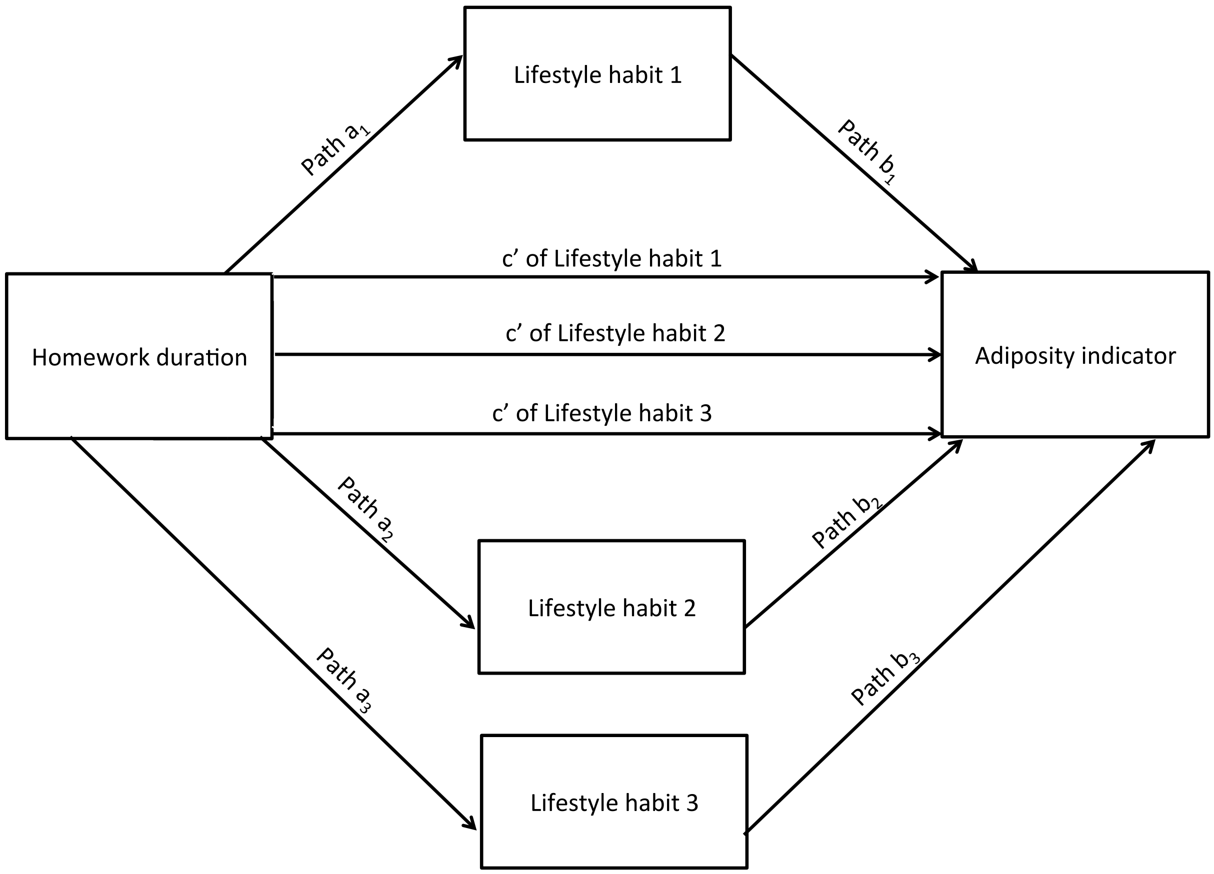
Annex 1: General mediation figure



Independent variable: homework duration

Dependent variable (outcome): adiposity indicator (i.e. BMI, total and trunk fat percentages)

Mediators: Lifestyle habits (MVPA duration, screen time or sleep duration) or nutritional factor (energy intake (kcal), saturated fat intake, number of snacks, high-sugar drinks or DQI)

Path a_1: association between independent variable and **first** mediator; Path b_1: association between **first** mediator and outcome; c' of Lifestyle habit 1: The remaining effect of the independent variable on the outcome when ONLY the **first** mediator is in the model;

Significant association*: $P < 0.05$; BMI: Body mass index; MVPA: moderate-to-vigorous physical activity; DQI: Dietary Quality Index-International;