### UNIVERSITY OF QUEBEC IN MONTREAL

### THE RELATION BETWEEN METABOLIC COMPLICATIONS AND COGNITIVE FUNCTIONS IN OBESE POST-MENOPAUSAL WOMEN: THE EFFECT OF HIGH INTENSITY INTERVAL TRAINING

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# RELATION ENTRE LES COMPLICATIONS MÉTABOLIQUES ET LES FONCTIONS COGNITIVES CHEZ LES FEMMES OBÈSES POST-MÉNOPAUSÉES: L'EFFET D'UN ENTRAÎNEMENT PAR INTERVALLES

ESSAI DOCTORAL PRÉSENTÉ COMME EXIGENCE PARTIELLE DU DOCTORAT EN PSYCHOLOGIE

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# LIST OF ABBREVIATIONS

ApoB	Apolipoprotein
AD	Alzheimer's Disease
ADL	Activities of daily living
BDNF	Brain-derived neurotrophic factor
BFM	Body fat mass
BFP	Body fat percentage
BMI	Body mass index
BP	Blood pressure
CHD	Coronary heart disease
CME	Continuous moderate intensity exercise
CRUNCH	Compensation-Related utilization of neural circuits hypotheses
CVD	Cardiovascular disease
CWIT	Color-Word Interference Test
D-KEFS	Delis-Kaplan Executive Functions Systems
DP	Diastolic blood pressure
DXA	Dual energy X-ray absorptiometry
ES	Effect size
GDS	Geriatric depression scale
GMA	Gross motor activities
HAROLD	Hemispheric asymmetry reduction in old adults
HbAlc	Glycated hemoglobin
HDL	High-density lipoprotein
HIIT	High intensity interval training
HOMA	Homeostasis model assessment
HOMA-IR	Homeostasis model assessment-estimated insulin resistance
HS	High-sensitivity
hsCRP	High-sensitivity c-reactive protein
IADL	Instrumental activities of daily living
IGF-1	Insulin-like growth factor 1
LBS-A	Lower body strength + aerobic training
LDL	Low-density lipoprotein
LPC	Lateral prefrontal cortex
MAO	Metabolically abnormal but obese
MAP	Maximal aerobic capacity
MAP	Mean arterial blood pressure
MCI	Mild cognitive impairment
MCT	Moderate continuous aerobic training
MHO	Metabolically healthy but obese

MHR	Maximal heart rate
MMSE	Mini mental state examination
MoCA	Montreal cognitive assessment
PASA	Posterior-Anterior shift in aging
RAVLT	Rey auditory-verbal learning test
Rt	Reaction-time
RT	Resistance Training
SB	Systolic blood pressure
SD	Standard deviation
TMT	Trail Making Test
TUG	Timed-up-and Go
UBS-A	Upper body strength + aerobic training
VEGF	Vascular endothelial growth factor
W	Watts
WHR	Waist-hip-ratio
10MWT	10-minute walk test

# RÉSUMÉ

Il se dégage de la littérature, une tendance marquée vers la prolongation de l'espérance de vie des personnes âgées. Par conséquent, le besoin de recherches portant sur le progrès de la qualité de vie des personnes âgées est plus criant qu'il ne l'a jamais été. Autre que le vieillissement physique, il convient également de mentionner qu'il existe un risque accru de déclin cognitif associé à l'âge. Ceci ne signifie pas que toutes les personnes âgées connaîtront un déclin de la fonction cognitive, ni que ce déclin, s'accentuera à la même cadence ou intensité. Cependant, un déclin de la fonction cognitive peut conduire à une perte d'autonomie, entrainant ainsi les facteurs de risque tels que des chutes pendant la marche, une réduction de la mobilité, un déclin de la qualité de vie et un déclin dans l'altération des fonctions cognitives.

Les personnes âgées sont plus à risque de développer des maladies cardiovasculaires, l'obésité et des complications métaboliques. De plus, l'obésité est désormais une épidémie mondiale et si la tendance se maintient dans les cent prochaines années, sera la cause principale de décès. En ce qui concerne le fonctionnement cognitif et l'obésité, une grande partie de la littérature pertinente porte sur les facteurs de composition de la masse corporelle et les complications métaboliques. En générale, les études ont montré une relation négative entre l'obésité (p. ex., indice de masse corporelle et masse grasse) et la cognition ainsi que les complications métaboliques (hypertension et résistance à l'insuline) et la cognition.

Une méthode d'intervention contre les complications métaboliques et l'obésité est l'activité physique. Les entrainements d'endurance, de résistance et par intervalles de haute intensité (HIIT) peuvent aider à réduire les complications métaboliques. Cependant, à ce jour, le HIIT à lui seul semble avoir de plus grandes améliorations sur les complications métaboliques et l'obésité chez des populations saines et à risque. Présentement, très peu d'études ont examiné l'effet de HIIT sur le profil métabolique et cognitif. Par conséquent, l'objectif principal de la présente étude est d'analyser les effets d'un entrainement HIIT en utilisant l'ergocycle sur les complications métaboliques et la fonction cognitive chez les femmes obèses postménopausées qui sont à risque de complications métaboliques. Nous avons émis l'hypothèse que HIIT améliorerait à la fois le profil métabolique et cognitif. Après l'intervention, nous avons observé une amélioration significative de la circonférence de la cuisse, de la santé cardiorespiratoire (VO2 pic), et la pression diastolique au repos. En outre, nous avons noté une tendance plus faible pour l'indice de masse corporelle après l'intervention. La présente étude indique que l'entrainement HIIT sur ergocycle semble améliorer en partie les complications métaboliques et la composition corporelle chez les femmes obèses post-ménopausées. Par contre, aucune amélioration n'a été observée pour les fonctions cognitives. Cette étude indique que HIIT pourrait avoir un effet positif sur le profil métabolique. Les professionnels de la santé pourront considérés le HIIT dans la préparation de leurs programmes d'interventions. Cette étude préliminaire pourrait stimuler la recherche dans le domaine des maladies métaboliques et neurocognitives dans différentes populations.

Mots clés : Complications métaboliques, fonction cognitive, HIIT, obésité, personnes âgées

#### RESUME

Worldwide there appears to be a demographic shift that the lifespan expectancy of older adults has increased. Therefore, research on advancements for the quality of life of older adults is crucial for the well-being of this growing population. It can not go without mention that there is an increased risk of cognitive decline associated with age, but it does not mean that all older adults will experience a decline in cognitive function nor will it progress at the same speed or intensity. However, a decline in cognitive function can lead to a loss in autonomy increasing risk factors for falls during gait, a reduction in mobility, a decline in quality of life and a decline in performing altering cognitive functions.

In addition, older adults are more at risk to develop conditions and diseases affecting cardiovascular and metabolic functionality. The disease of obesity has become a world epidemic and in the next 100 years is believed to become the primary cause of death. In relation to cognitive function, much of the research is in relation to body mass composition factors and metabolic risk factors. The relationships between obesity and cognition and metabolic risk factors and cognition and the contribution they each have on cognition have been studied. However, there is opportunity to better understand the contribution of both obesity and metabolic risk factors in terms of predicting cognition as they both can be dissociated from each other.

A method of intervention against metabolic risk factors and obesity is physical activity. There appears to be benefits of endurance training, resistance and combined training (HIIT). However, as of lately HIIT appears to have greater benefits on both healthy and at-risk populations. To present, very few studies have looked at the effect of HIIT on both the metabolic and cognitive profile. Therefore, the main objective of the current study was to investigate the effect of HIIT on metabolic risk factors and cognitive function in obese postmenopausal women who are at risk for metabolic complications. We hypothesized that HIIT would improve both the metabolic and cognitive profile.

After the intervention, we observed a significant improvement for thigh circumference,  $VO_{2 peak}$ , and diastolic resting blood pressure. In addition, we noted a lower tendency for body mass index after the intervention. The present study indicates that ergocycle HIIT seems to improve metabolic risk factors and body composition in obese post-menopausal women. However, there was no change in cognitive functions. Health care professionals could potentially recommended HIIT to patients when planning intervention programs. This preliminary study could stimulate

research in the fields of metabolic and neurocognitive diseases in different populations.

Key words: Metabolic complications, cognitive function, HIIT, obesity, older adults.

#### **GENERAL INTRODUCTION**

Unprecedented changes are occurring as the world's population is aging and life expectancy is increasing. These rapid changes have left societies with cultural, economical, political and societal challenges. Statistics Canada predicts that 20% of the Canadian population will be aged 65 years and older by 2026 and by 2056 it is expected that more than one quarter of the Canadian population will be aged over 65 years old. As it stood in 2001, older adults represented 13% of the population, however 43% of the government's expenditures were for health-related matters that concerned older individuals (ICIS, 2014). Therefore, it is important to implement changes in the lifestyle (e.g., promoting physical activity) of older adults in order to decrease the burden on the health care system.

Senescence is associated with an increased risk of chronic diseases such as dementia, heart disease, obesity, type 2 diabetes, hypertension and cancer, which in turn decrease the quality of life and the loss of independence. (Ryan, 2010). In 2003, 81% of older adults living at home were diagnosed with at least 1 chronic disease problem (Statistics Canada, 2009). Therefore, health promotion and disease prevention programs are important in maintaining the autonomy of older adults.

Chronological aging has been associated with a decline in cognition. More specifically, the cognitive functions of short-term memory, attention and processing speed have been reported to decline with aging and in turn this increases the risk of falls during gait, reduces mobility and decreases the quality of life (Taylor, Delbaere, Lord, Mikolaizak, & Close, 2013; Yogev-Seligmann, Hausdorff, & Giladi, 2008).

Moreover, recent studies have identified a relationship between the decline in attention and walking speed, suggesting that cognition may play a significant role in functional capacity. Similarly, it has been shown that older adults who are more at risk of falling during gait will stop walking to pursue the course of conversation (Lundin-Olsson, Nyberg, & Gustafson, 1997). The dual task paradigm is further evidence of attentional limitations (Beauchet et al., 2009). This suggests that when dual tasks are performed there is a decline in performance for one or both tasks as a compensation strategy (Yogev-Seligmann et al., 2008).

Aging has also been associated with a higher increase of metabolic complications such as dyslipidemia, insulin resistance and hypertension. These metabolic complications may lead to a higher risk for cardiovascular disease and type 2 diabetes (Jagust, Harvey, Mungas, & Haan, 2005). Obesity along with metabolic complications is also associated with a decline in cognitive function. There has been evidence of a decline in the cognitive performance of global cognition, attention, processing speed, learning and memory as well as verbal abilities related to obesity and metabolic complications (van den Berg, Kloppenborg, Kessels, Kappelle, & Biessels, 2009).

There is evidence that physical activity protects against the deleterious effects of age on cognition. There is an extensive amount of intervention (Dustman et al., 1984; Kramer, Hahn, Cohen, et al., 1999; Langlois et al., 2013; Predovan, Fraser, Renaud, & Bherer, 2012; Renaud, Maquestiaux, Joncas, Kergoat, & Bherer, 2010), crosssectional (Berryman et al., 2013; Clarkson-Smith & Hartley, 1989; Renaud, Bherer, & Maquestiaux, 2010) and longitudinal studies (Barnes, Yaffe, Satariano, & Tager, 2003; Boyle, Buchman, Wilson, Leurgans, & Bennett, 2009; Larson et al., 2006; Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001) supporting the idea that higher physical activity levels are beneficial for cognition. Different interventions such as aerobic, strength and gross motor training programs have led to improvements in cognitive functions (Bherer, Erickson, & Liu-Ambrose, 2013). Physical activity has also been shown to improve body composition and metabolic complications (e.g. blood pressure, insulin resistance, inflammation) in at-risk populations (Drigny et al., 2014). More specifically, there is evidence to suggest that high-intensity interval training (HIIT) is an effective method to improve cardiorespiratory fitness and metabolic complications compared to traditional methods of intervention (Kessler, Sisson, & Short, 2012).

Postmenopausal women have been associated with an increased risk for chronic conditions such as obesity, metabolic complications and cardiovascular disease. As mentioned above, all of these conditions may influence cognitive function. Therefore, obese postmenopausal women become an ideal population to study the relationship between obesity and metabolic complications with cognition and to examine the effects of exercise on all of these factors. Accordingly, the objective of the present study was to investigate the effect of HIIT on metabolic complications and cognition in obese postmenopausal women. In the following sub-sections of this chapter a review of the literature regarding cognitive aging, obesity, metabolic complications and physical activity of older adults will be summarized. Within the obesity section, prevalence and cognitive impairment (body composition and metabolic complications) will be discussed in greater detail. The section on physical activity will look at the relation between cognition and the different methods of interventions more specifically HIIT. Followed by the problem, model, objective and hypothesis of the present study. In Chapter II, an overview of the methodology will be given: participants, protocols and procedures, measurements (anthropometric measures, physical capacities and body composition, blood analyses, blood pressure, medical evaluation and cognitive screening, neuropsychological assessment and aerobic capacity) as well as statistical analysis. Followed by Chapter III, the results section,

which discusses characteristics of participants: physical and anthropometric characteristics, neuropsychological characteristics, and metabolic profiles. Ending with Chapter IV, the discussion section, putting forth the scientific and clinical implications and limitations of this study as well as the conclusion.

#### CHAPTER I

#### THEORETICAL CONTEXT

### 1.1. Cognitive Aging

Cognitive functioning is a determining factor in healthy living and autonomy in older adults (Wilson et al., 2013). Cognitive function refers to all processes of which a person becomes aware of his/her situations, needs, goals, and required actions. Moreover, it uses this information to implement problem-solving strategies for optimal living. Normal aging generally is associated with neuroanatomical and neurophysiological changes that effect cognitive functioning as well as the general health and autonomy of older adults.

Structurally, brain volume decreases as a natural phenomenon of aging. At age 14, the brain has reached its maximum capacity and decreases at a rate of approximately 2% every decade. There is a daily loss of tens of thousands of neurons resulting in the reduction of brain volume and atrophy. Brain atrophy typically effects all areas in the brain specifically the temporal and frontal lobes (Tortora & Grabowski, 2001). However, brain imaging studies have put forth evidence that if younger adults challenge their cognitive capacities from a younger age, cognitive decline generally

tends to decrease. By contrast, lower education and less stimulation of cognitive capacities results in greater risk of cognitive decline and can lead to dementia (Couillard-Despres, Iglseder, & Aigner, 2011). Even in the later stages of life, an older adult can improve their brain's plasticity by performing challenging learning tasks, which could lead to neural improvements. These observations suggest that cognitive deficits could be the result of an imbalance between acquired/integrated experiences and the levels of neurogenesis (Couillard-Despres et al., 2011).

There have been several neuroimaging studies that have investigated the neural basis of different aging patterns in cognitive aging such as: 1) The Hemispheric Asymmetry Reduction in Old Adults (HAROLD) model, 2) The Posterior Anterior Shift in Aging (PASA) model, 3) Dedifferentiation and finally 4) The Compensation-Related Utilization of Neural Circuits Hypotheses (CRUNCH). The HAROLD model reports that during episodic memory retrieval, episodic encoding/ semantic retrieval, working memory, perception and inhibitory control older adults engaged cerebral regions bilaterally as compared to younger adults whom isolated a hemisphere(Cabeza, Anderson, Locantore, & McIntosh, 2002). The PASA model describes a transfer of occipital activation towards more frontal activation (e.g., attention, visual perception, visuospatial processing, working memory, episodic memory encoding and retrieval) in some cognitive functions during aging (Davis, Dennis, Daselaar, Fleck, & Cabeza, 2008). Both the above models are compensatory strategies older adults use to maintain cognitive performance. Dedifferentiation is characterized by the number of brain sites recruited to perform a task increases with age or is different from the sites used by young adults (Park, Polk, Mikels, Taylor, & Marshuetz, 2001). There are three forms of dedifferentiation: contralateral recruitment, unique recruitment and substitution. The first form of dedifferentiation is contralateral recruitment in which younger adults perform a cognitive task in one hemisphere as compared to older adults that recruit the homologous site in the other

hemisphere. The second form of dedifferentiation is unique recruitment whereas older adults recruit additional brain areas that are not homologous to the sites activated by younger adults. The third form of dedifferentiation is substitution, in which a site that is used to perform a cognitive operation in younger adults is not activated by older adults, but different structures show activation. The CRUNCH model takes into account the changes in cerebral activation and behavior seen in cognitive aging (Reuter-Lorenz & Park, 2010). The CRUNCH model suggests that declining neural efficiency leads older adults to engage more neural circuits than younger adults to meet task demands. Therefore, older adults are more likely to show overactivation, including frontal or bilateral recruitment, at lower level of cognitive demand whereas younger adults show more focal activation (Reuter-Lorenz & Park, 2010). When load is increased, older adults may have already reached their maximal cognitive capacity at a less demanding task, showing under-activation or poorer performance. In comparison to younger adults, whom may shift to an overactive or bilateral pattern to reach task demands.

As for cognitive aging there is often a parallel drawn with cognitive decline. It is to be noted that changes in cognitive function related to aging do not affect all functions uniformly. The first cognitive function that we will target is that of semantic memory. Semantic memory includes all knowledge about the world that we have acquired and is the basis of human activity for example being able to recognize that a fork is used for transferring food. Retrieval from semantic memory can be assessed for example with the Information subtest of the WAIS-IV (Wechsler, 2008). Participants are asked to answer a series of general knowledge questions. Aging has been found to have little to no effect on semantic memory (Ronnlund, Nyberg, Backman, & Nilsson, 2005). In the Ronnlund et al. (2005) study, minor increments in semantic memory were observed until age 55, with small decrements in old age. Likewise, language abilities (e.g., word knowledge- vocabulary) appear preserved and at times improved

(Park et al., 2001).

A cognitive function more sensitive to the effect of age is working memory. It is the capacity to hold several pieces of information in mind for short periods and use or manipulate the information in thinking and problem-solving tasks. For example, working memory can be assessed using the digit-span subtest of the WAIS-IV requiring reversal or re-sequencing of digits (Wechsler, 2008). Specifically, the agesensitiveness of working memory tends to be greater if executive control processes such as inhibition, updating, and manipulation are required, and even greater if the memory load is high (Mattay et al., 2006). Mattay et al. (2006) reported that older adults performed just as well as younger adults at a 1-Back memory task and they showed greater prefrontal activity. However, at 2-Back and 3-Back older adults performed worse than younger adults. At higher memory loads older adults had reduced activity in the prefrontal regions. As cognitive demand increases older adults are pushed past a threshold beyond compensation and therefore a decline in performance occurs. In addition, episodic memory, which enables human beings to remember past experiences, has shown to be affected with normal aging along with Alzheimer's disease (AD) and dementia syndromes (frontotemporal dementia) (Bherer, Belleville, & Hudon, 2004). For example, episodic memory can be assessed by administering the Rey Auditory-Verbal Learning Test (RAVLT). RAVLT is a recall of a presentation of a list of 15 unrelated words in five repeated trials. Afterwards, a subsequent recall of a second a list of 15 words is given and participants are asked to recall the words from the first word list immediately after the second list and then again after longer, 30-minute delay. There is evidence that episodic memory tends to decline because of poor strategies and difficulty binding new information during the process of encoding. In addition, one's environmental surroundings are used less as a support structure.

Studies suggest that executive functions are one of the functions with the earliest onset of cognitive decline. Anatomically, executive functions have shown to be associated with the prefrontal cortex (Bherer et al., 2004; Stuss & Alexander, 2000; West, 1996). These functions typically include the cognitive processes of planning, organizing and synchronising of complex actions and groups together inhibition, processing speed and task-switching (Bherer et al., 2004). Inhibition, the ability to inhibit an automatic response or dominant response that can also be dictated by the context, is the strongly effected by cognitive aging. An example of a neuropsychological test most widely used with older adults to evaluate inhibition and cognitive control is the inhibition condition in the Stroop Test. The interference condition requires participants to read the name of the color rather than say the color in which the word is written. With age, interference effects older adults more as their performance scores are slower (Cohn, Dustman, & Bradford, 1984; Comalli, Wapner, & Werner, 1962). The Cohn et al. (1984) administered the Stroop Test to 81 healthy males aged 21-90 years old. There were no age differences on the reading task; however, significant age effects were observed for the color naming and interference task which appeared to be concomitant of normal aging. The two older age groups (61-70 and 71-90 years old) performed more slowly than older adults. Processing speed is the speed in which a person can understand and react to the information they receive, whether it be visual, auditory or movement. It has been shown that older adults strategies are less efficient when the occurrence of an event is less probable (Bherer et al., 2004). Moreover, task switching is the ability to rapidly switch between two different tasks or stimulus. It has been reported that task switching is effected by age (Bherer et al., 2004; Wecker, Kramer, Wisniewski, Delis, & Kaplan, 2000). Older adults are usually slower than younger adults when performing tasks that require switching attention on different stimulus or tasks. Kramer et al. (1999) presented younger and older adults with rows of digits and asked them to indicate whether the number of digits (element number task) or the values of the digits (digit value task) were greater than or less than five. The study found there to be an agerelated difference in switch costs in early practice. However, the switch cost was equivalent for older and younger adults after sufficient practice. Older adults showed a larger practice effect on switch trials (Kramer, Hahn, & Gopher, 1999).

Furthermore, the study of executive functions is also attributable to maintaining autonomy and medical prevention. Cognitive aging has lead to a greater risk of falls as older adults call upon several cognitive functions when walking. A study found that when older adults were asked to divide their attention between walking and a memory task they neglected the cognitive task (memory). Neglecting the cognitive task is an adaptive strategy to lessen or avoid the risk of falling (K. Z. Li, Lindenberger, Freund, & Baltes, 2001). Certain studies have also looked at older adult's quality of daily living and the relation it has with the performance of executive function. In several studies, the measurement of instrumental activities of daily living (IADL) has been used to observe the performance of older adults. Studies have identified executive functions as being both a mediating variable between age and cognitive function and a predicting factor of the decline of daily activities independent of age, education and medical factors (Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Royall, Palmer, Chiodo, & Polk, 2004).

### 1.2 Obesity, Metabolic Complications and Cognitive Dysfunction

#### 1.2.1 Prevalence of obesity

Obesity is defined with a body mas index (BMI) of  $\ge 30 \text{ kg/m}^2$ . The prevalence of obesity over the past 20 years has continued to rise at an alarming rate. In the United States, prevalence of obesity is 36.9% for men and 38.0% for women. In Canada, the

2004 Canadian Community Health Survey, estimated that 59% of the Canadian adult population was overweight (BMI between 25-29.9 kg/m<sup>2</sup>) and 23% was obese. The lowest prevalence of obesity was found in British Columbia and Quebec. By contrast, obesity was most prevalent in Newfoundland.

Obesity has been associated with several metabolic complications such as dyslipidemia, hypertension and insulin resistance, which could increase the risk for type 2 diabetes and cardiovascular disease (Jagust et al., 2005). Furthermore, obesity is a leading cause of death and claims as much as 400 000 lives/per year. In the next 100 years, it is believed that obesity will become the primary cause of death among adults (Gunstad, Lhotsky, Wendell, Ferrucci, & Zonderman, 2010).

#### 1.2.2 Obesity and cognitive impairment

The research of obese individuals uses the following measurements to assess obesity in cognitive aging studies: BMI, waist circumference (WC), waist-hip-ratio (WHR), and visceral fat. It appears that cognitive function in obesity is particularly impaired in the domains of global cognitive function, executive functioning, language and memory (Gunstad et al., 2010; Stillman, Weinstein, Marsland, Gianaros, & Erickson, 2017). For example, the Baltimore Longitudinal Study is a volunteer based study of 1703 individuals aged 19-93 years old. The cognitive functions that were evaluated were global cognitive function, attention and executive function, memory, language and visuospatial. Results indicated that individuals with a higher body composition showed a poorer performance in global cognitive function, memory and language (Gunstad et al., 2010). A review, which consisted of 15 cross-sectional and 4 prospective studies, also showed that obesity was associated with poorer (Smith, Hay,

Campbell, & Trollor, 2011) cognitive performance such as global cognitive functions, semantic and episodic memory, motor/processing speed and executive functions. In a recent meta-analysis, executive performance in obese and overweight individuals was compared to normal weight controls. The executive functions that were studied were that of inhibition, cognitive flexibility, working memory, decision-making, verbal fluency and planning (Yang, Shields, Guo, & Liu, 2018). Results indicated that obese individuals showed a poorer executive function performance in all areas. Cognitive functions that showed poorer performance with higher BMI, WHR and WC were global cognitive function, memory and language (Gunstad et al., 2010). As for BMI, higher BMI levels seems to have an effect on executive functions more precisely working memory, inhibition as well as attention and mental flexibility (Alarcon, Ray, & Nagel, 2016; Gameiro, Perea, Ladera, Rosa, & Garcia, 2017; Gunstad et al., 2007; Yau, Kang, Javier, & Convit, 2014). For example, a study showed that poor spatial and verbal working memory was correlated to a higher level of BMI in obese adolescents (Alarcon et al., 2016). In a cross-sectional study of healthy and overweight/obese adults (BMI  $< 25 \text{ kg/m}^2$ ), the authors reported poorer performance in executive function in the overweight/obese adults compared to normal individuals (Gunstad et al., 2007). It has been reported, however without consensus, that greater BMI levels are correlated with a poor cognitive outcome, which in turn could increase the risk of the reduction in brain volume, Alzheimer's disease and dementia (Naderali, Ratcliffe, & Dale, 2009; Raji et al., 2010; Ward, Carlsson, Trivedi, Sager, & Johnson, 2005). Moreover, 112 individuals 60 years and older were recruited for a neuroimaging study which set out to examine if greater WHR was associated with structural brain changes leading to cognitive impairment (Jagust et al., 2005). The results showed that greater WHR is associated with changes in brain structure and it supports previous hypotheses that greater WHR relates to neurodegenerative, metabolic and vascular processes thereby affecting cognitive functions (Jagust et al., 2005). Furthermore, higher visceral adiposity has been associated with lower cognitive performance in older adults. However, this was shown only in a group of

younger older adults who were below 70 but older than 60 years old (Yoon et al., 2012). Cognitive function was also affected in a study involving healthy older adults in which it was found that visceral fat may be negatively associated with verbal memory and attention (Isaac et al., 2011). Interestingly, elevated visceral adiposity could also be associated with lower executive functions as early as adolescence (Schwartz et al., 2013).

#### 1.3 Metabolic Complications and Cognitive Dysfunction

Many studies have reported that metabolic complications could negatively impact cognition function (van den Berg et al., 2009). Although there are many metabolic complications the following ones have been selected and will be discussed in detail: insulin resistance, hypertension, and dyslipidemia.

Several studies have found that higher levels of insulin resistance could be associated with cognitive impairment (Craft & Watson, 2004; Kim & Feldman, 2015). (Hishikawa et al., 2015). In a review on insulin and neurogenerative disease, it was speculated that insulin resistance may have a negative influence on both verbal and visual memory as well as learning (Craft & Watson, 2004). In addition, a study showed that insulin resistance, measured by HOMA-IR, was found to decrease attention, working memory in older adults (Hishikawa et al., 2015). Moreover, in a study of middle-aged adults, insulin resistance as measured by high levels of fasting insulin and HOMA, was associated with slower processing, worse learning and memory (delayed recall) as well as phonemic fluency at baseline (Young, Mainous, & Carnemolla, 2006). In the same study, a greater decline was noticed 6 years later in learning and memory (delayed recall) as well as phonemic fluency (Young, Mainous, Mainous

& Carnemolla, 2006). Tan et al. (2011) also found an association with elevated HOMA and fasting insulin with poorer executive functions and visuospatial memory (Tan et al., 2011). Elevated levels of glucose have also been associated with a poorer performance in processing speed and fluid intelligence both including perceptual speed (Dik et al., 2007; Sanz et al., 2013). Furthermore, insulin resistance seems to play a role in the regulation of ageing related processes. That is, insulin resistance has been linked with an increase in neurodegeneration (Morley, 2004). For example, patients suffering from insulin resistance have a greater risk of developing Alzheimer's and dementia (vascular dementia). In addition, there is a higher prevalence of insulin resistance in patients with Parkinson's Disease and Huntington's Disease (Craft & Watson, 2004).

Evidence has also suggested a negative association between hypertension and an array of cognitive functions (Harrington, Saxby, McKeith, Wesnes, & Ford, 2000). In a meta-analysis of 12 studies with older adults with no indication of stroke or dementia, hypertension was associated with a decrease in episodic memory and global cognition. However, when controlled for vascular covariates there was also an association with attention and language (Gifford et al., 2013). Moreover, there is evidence that central abdominal obesity and hypertension are related to a poorer performance in executive functions and visuomotor skills (Wolf et al., 2007). Even when comparing hypertensive and normotensive older adults, hypertensive older adults had cognitive impairment in areas of attention, short and long-term memory as well as a decrease of approximately 10% in psychomotor tests. By contrast, there is also evidence showing that normotensive subjects may perform worse than hypertensive patients on certain cognitive functions. That is, in a study of 495 community living older adults compared normotensives, normalized hypertensives, untreated hypertensives, untreated hypertensives and treated but uncontrolled hypertensives normotensives (Paran, Anson, & Reuveni, 2003). Normotensives

performed worse than hypertensives (treated but uncontrolled) in terms of tasks for global cognitive functioning, memory and visual retention. In another study of 485 male participants, the authors showed that participants with a systolic blood pressure between 117-129 mm Hg had a greater risk (OR: 2.14) of cognitive decline compared to males with a systolic blood pressure of <117.6 mm Hg. This increase in risk was even greater (OR: 2.67) in males with a systolic blood pressure of >129.5 mm Hg (Matsumoto et al., 2014).

Moreover, dyslipidemia (low levels of HDL-cholesterol and high levels of triglycerides) has been shown to be related to cognitive decline. The areas of cognition that are affected are verbal ability, memory and processing speed. For example, in a study on 524 nondemented adults, higher triglyceride levels lead to a decrease in verbal knowledge and in episodic memory (de Frias et al., 2007). Likewise, low levels of HDL-cholesterol have been associated with greater cognitive impairment specifically poorer memory performance and encoding abilities (Singh-Manoux, Gimeno, Kivimaki, Brunner, & Marmot, 2008; Song et al., 2012; van Exel et al., 2002; Zhang, Muldoon, & McKeown, 2004). In addition, in a longitudinal study of older adults aged 65-88 years old, low HDL-cholesterol was significantly associated with poorer information processing speed and with fluid intelligence performance (Dik et al., 2007). There is also a higher prevalence of dyslipidemia in Alzheimer's, Parkinson's, Huntington's and Dementia disease patients (Hottman, Chernick, Cheng, Wang, & Li, 2014; Morley & Banks, 2010). By contrast, studies have also shown that higher levels of HDL-cholesterol have been associated with better global cognitive performance, less age-related cognitive impairment as well as better memory performance (Barzilai, Atzmon, Derby, Bauman, & Lipton, 2006; van den Kommer, Dik, Comijs, Jonker, & Deeg, 2012).

Furthermore, there is an association between components of the metabolic syndrome (MS) and cognitive impairment. That is, in a study of 2252 older adults (>60 years

old) examining the effects of the presence of different MS components on cognitive performance found that the increasing number of MS components lead to greater cognitive impairment (Tsai et al., 2016). Furthermore, there was a correlation with elevated plasma glucose levels, high blood pressure and abdominal obesity with cognitive dysfunction. Interestingly, one study has examined the cognitive profile of metabolically healthy but obese (MHO) and metabolically unhealthy obese (MAO) individuals. (Abu Saleh, Shahien, & Assy, 2015). In that study, 60 obese individuals were divided into two groups: 30 MHO (2 components of MS or less) and 30 MAO (3 or more MS components) individuals. In the MAO group, 51% had mild cognitive impairment compared to only 7% in the MHO group. In the same study, the authors also reported a negative correlation between a cognitive score and the increase number of metabolic risk factors which included blood pressure, abdominal obesity and liver disease.

1.4 Physical Activity and Cognition

#### 1.4.1 Different types of studies

In longitudinal studies, evidence has shown that older adults who partake in physical activity will experience less cognitive decline when followed up between 2-10 years later. The Aichberger et al. (2010) study found that older adults who engaged in physical activity, specifically vigorous activity, more than once a week, had less cognitive decline 2.5 years later. Likewise, a cohort of 349 persons without any physical or cognitive function problems were evaluated at baseline and 6 years later (Barnes et al., 2003). It was found that better cardiorespiratory fitness at baseline lead to better preservation of cognitive decline over a 6-year period. Similarly, women

subjects with greater baseline physical activity were less likely to develop cognitive decline during the 6 to 8 year follow-up (Yaffe et al., 2001). By contrast, those who were less active had a higher rate of cognitive decline after 2.5 years for verbal fluency and delayed word recall. Moreover, in a study of aging and dementia a reduced incidence rate of dementia was found in persons who exercised 3 or more times a week as compared to those who exercised 3 or less times a week (Larson et al., 2006). The relationship between physical activity and cognitive function was studied in a meta-analysis in which 15 studies were divided by low-to-moderate-level physical activity and high-level physical activity. During the follow-up with subjects, those in low to moderate physical activity group had a 35% protection rate against cognitive decline. However, high-level physical activity subjects had a 38% protection against cognitive decline. In sum, physical activity showed to be a protector against cognitive decline (Sofi et al., 2011). By contrast, there are studies that found there to be few improvements between aerobic exercise to cognitive performance (Blumenthal et al., 1991; Hill, Storandt, & Malley, 1993).

Furthermore, most cross-sectional studies support the view that better cardiorespiratory fitness is associated with better cognitive function. For example, a study sorted 110 adults into low and high fit groups based on a cardiorespiratory fitness assessment (Renaud, Bherer, et al., 2010). The Rockport-1-mile test was used to assess cardiorespiratory fitness and was an accurate estimate of maximal oxygen consumption (V0<sub>2</sub>max). Results show that the higher fit group were associated with higher cognitive functions for reasoning, working memory, vocabulary and reaction time (Clarkson-Smith & Hartley, 1989).

Furthermore, intervention studies have shown to be effective when older adults participate in a physical activity program. Such studies have shown that there is often a significant cardiorespiratory fitness improvement as well as improved cognitive

performance. In a four-month aerobic training program, middle age and older adults were matched with a control group (strength and flexibility). Those in the aerobic training program were the only participants that improved cardiorespiratory fitness and simple reaction-time (RT) performance (Dustman et al., 1984). Furthermore, in a study of older adults those who had taken part in a six-month aerobic program (walking) were the only subjects who showed improvement in cardiorespiratory fitness and cognitive improvement in attentional control and executive functions (Kramer, Hahn, Cohen, et al., 1999). Moreover, a physical exercise program (fast walking and aerobic dancing) found there to be enhancements in older adults executive functions only after three months of intervention (Predovan et al., 2012). In Langlois et al. (2012), 83 frail adults were assigned to an exercise-training group (1-h 3 times a week for 12 weeks) or a control (waiting list). The exercise-training program consisted of a 10-minute warm-up (stretching and balancing), 10-30 minutes of aerobic exercise (treadmill, ergocycle and elliptical) along with 10 minutes of strength training and to conclude 10 minutes of cool down. Along with physical capacity and quality of life improvement, cognitive improvement in the areas of executive functions, processing speed and working memory was also established. Moreover, in a 12-week program adults were separated into two groups: training group and control group (Renaud, Maquestiaux, et al., 2010). The participants in the training group partook in three 1h sessions per week in different physical activity routines of both stretching and cardiovascular exercises. Unlike, the participants in the control group who did not receive any training. The results showed that participants in the training group showed improvement in choice reaction time task and preparation.

Furthermore, there has been much discussion as to whether there is a method of physical activity that is better in the preservation of cognitive function. For many years, it was believed that endurance training was the best method of exercise. A

meta-analysis showed that older adults who exercise more, specifically aerobic exercise, have greater improvements on neurocognitive tasks such as controlled, spatial, speed, inhibition and divided attention tasks (Colcombe & Kramer, 2003). However, other methods of physical activity have been reported to be just as effective. For example, a study examined the effects of resistance training on working memory span among sedentary older adults (Lachman, Neupert, Bertrand, & Jette, 2006). Results suggest that resistance training has an impact on working memory span such that higher levels of resistance were associated with improvements in memory. Interestingly, a study of 67 inactive healthy older adults, comparing the effect of three different exercise programs (resistance training-RT, high intensity interval training (HIIT) and moderate continuous aerobic training (MCT)), examined the differences in cognitive function (Stroop Task) (Coetsee & Terblanche, 2017b). In relation to cognitive function, the MCT participants found to have higher improvements in executive cognitive function and higher cognitive process (Coetsee & Terblanche, 2017b). Whereas the HIIT participants had a better effect on information processing speed and lower level of cognitive process (Coetsee & Terblanche, 2017b). Moreover, the RT participants had more gains in information processing speed in comparison to MCT and executive function in comparison to HIIT participants (Coetsee & Terblanche, 2017b).

Therefore, it is still unclear if there is a more effective method of physical activity but what is clear is that physical activity can impact cognitive function of older adults regardless of the method. However, another study showed the same improvement in cognitive function for three different invention groups: lower body strength + aerobic training (LBS-A), upper body strength + aerobic training (UBS-A), and gross motor activities (GMA) (Berryman et al., 2014). This study suggests that multiple pathways could lead older adults to improve cognition through different exercise programs by targeting physical fitness and/or general motor abilities.

Furthermore, there are two levels of neurobiological mechanisms underlying exercise, supramolecular and molecular (Lista & Sorrentino, 2010). The supramolecular level can increase angiogenesis, which is the process by which new blood cell vessels are created from pre-existing blood vessels. As for the molecular mechanisms, vascular endothelial growth factor (VEGF), brain-derived neurotrophic factor (BDNF) and insulin-like growth factor 1 (IGF-1) appears to play a crucial role in the process however there is still more to be discovered and known (Lista & Sorrentino, 2010). In addition, there are several brain imaging studies and electrophysiological measures that have substantiated the view that higher cardiorespiratory fitness levels may improve the structural and functional areas of the brain either short-term or long-term. (Chaddock et al., 2010; Colcombe et al., 2003; Colcombe et al., 2004; Erickson et al., 2011).

1.4.2 High intensity interval training (HIIT) and metabolic complication and cognition

Most exercise training interventions in obesity have generally focused on more traditional programs such as resistance and moderate continuous aerobic training protocols to study the effect of numerous cognitive and metabolic outcomes (Kessler et al., 2012). HIIT is an increasingly prevalent method for exercise training. HIIT consists of alternating repetitive short bouts of high intensity exercise (>85 peak power output) with less active or passive recovery periods, which include either walking or a complete rest. Accordingly, this type of exercise is more time-efficient compared to traditional continuous exercise at a moderate intensity. Thus, HIIT becomes an interesting and a more time efficient option for exercise training protocols since this form of exercise could help break the barrier of practising
physical activity due to a lack of time. Also, a principal factor contributing to its rapid popularity among all different population groups is that the exercise intensity, rather than the duration, has been found to be crucial for determining cardiac benefits (Ingul, Tjonna, Stolen, Stoylen, & Wisloff, 2010; Wisloff, Ellingsen, & Kemi, 2009; Wisloff et al., 2006).

There is strong evidence that HIIT can lead to improvements in both metabolic complications and body composition (Boutcher, 2011; Hordern et al., 2009; Kessler et al., 2012; Molmen-Hansen et al., 2012; Mourier et al., 1997; Tjonna et al., 2009). For example, a review article by Boutcher (2011) suggested that HIIT could result in reduced abdominal body fat, subcutaneous fat, increased anaerobic and cardiorespiratory fitness levels (VO<sub>2 peak</sub>), lower insulin resistance as well as increase skeletal muscle oxygen capacity (measure of oxidative capacity). Similarly, in a meta-analysis comparing HIIT and continuous moderate intensity exercise (CME), found HIIT to be a significantly better method in improving VO<sub>2 peak</sub>. In that regard, in a three-month intervention in which subjects performed 4 x 4 minute intervals at 90% of maximal heart rate, each interval separated by 3 minutes at 70%, the HIIT group had a greater improvement in VO2 max at follow-up testing both at 3 and 12 months (Tjonna et al., 2009). After 3 months, VO<sub>2max</sub> increased by 15.5 ml/min<sup>-1</sup>/kg and after 12 months the increase was18.7 ml/min/kg (Tjonna et al., 2009). The literature also points to a decrease in blood pressure (BP) associated with HIIT. Specifically, in the study of Tjonna et al. (2009) systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial blood pressure (MAP) were measured. The HIIT group had a decrease in all blood pressure measurements at both the 3-month and 12month follow-ups. HIIT has also been found to contribute to a decrease in cardiovascular disease and lowering the risk of the metabolic syndrome (which translates into improved glycemic control and insulin resistance, reduced abdominal fat mass compared to other forms of exercise, lower levels of triglycerides; and

increased levels of HDL cholesterol). Evidence of improved glycemic control and insulin resistance was found in a 15-week program (ergocycle) in young women in which a 31% decrease in fasting glucose and a 33% decrease in insulin resistance (HOMA-IR) was observed (Trapp, Chisholm, Freund, & Boutcher, 2008). A further example of the effectiveness of HIIT regarding insulin sensitivity was shown in an 8week bicycle ergometer program which included sixteen middle-aged men with type 2 diabetes. The effectiveness of the program was demonstrated by a 58% improvement in insulin sensitivity in the subjects (Boudou, Sobngwi, Mauvais-Jarvis, Vexiau, & Gautier, 2003). A decrease in abdominal fat with HIIT has also been observed in the literature. In a study by Boudou et al. (2003), the HIIT program lead to a 44% decrease in abdominal fat. Similarly, in a two-month cycling training program there was a 48% reduction in abdominal fat in patients with non-insulindependent diabetes mellitus (Mourier et al., 1997). An increase in HDL-cholesterol has also been noted in HIIT related studies. That is, the study of Tjonna et al. (2009) documented an increase of 0.11 mmol/1 in the HIIT group after 3 months.

HIIT intervention studies have been completed with different at-risk populations (Drigny et al., 2014; Guiraud et al., 2010; Juneau, Hayami, Gayda, Lacroix, & Nigam, 2014; Kessler et al., 2012; Tjonna et al., 2008; Tjonna et al., 2009). A review has advocated for research on the effect of HIIT in pre- and type 2 diabetes patients since this form of exercise training could provide a more powerful stimulus in the improvement of metabolic complications than traditional moderate intensity exercises (Earnest, 2008). Accordingly, several studies have investigated the effect of HIIT on metabolic complications in patients with type 2 diabetes and results are very encouraging (Coquart et al., 2008; Karstoft et al., 2013; Little et al., 2011; Mitranun, Deerochanawong, Tanaka, & Suksom, 2014; Terada et al., 2013).

It should be noted that only one study has examined the effects of HIIT on cognition

in an at-risk population of older obese adults. In that recent study, participants completed a 4-month HIIT program which comprised 2 sessions of HIIT, 1 session of moderate intensity continuous exercise and 2 resistance training sessions per week (Drigny et al., 2014). The study found that short-term memory, attention and processing speed, verbal memory and mood improved. However, only 6 patients completed that study. Therefore, further research is needed to reproduce these results in a different at-risk population with a complete battery of neuropsychological tests.

1.5 Model: Obese Postmenopausal Women

According to the Canadian Women's Health Network, menopause begins on average around the age of 52 years old. Menopause accelerates the increase in body fatness and lowers energy expenditure (Poehlman, Toth, & Gardner, 1995). Once menopause is complete and postmenopause begins, women have a higher prevalence of chronic conditions such as obesity, metabolic complications and cardiovascular disease. The prevalence of postmenopausal women who have a BMI  $\geq 25$  kg/m<sup>2</sup> is 60% (Brochu et al., 2001). Therefore, obese postmenopausal women become an ideal population to study the relationship between obesity and metabolic complications with cognition and to examine the effects of exercise on all of these factors.

1.6 Objective and Hypotheses

The main objective of the current study was to investigate the effects of high-intensity interval training on metabolic complications and cognitive function in obese postmenopausal. We hypothesize that HIIT will improve both the metabolic and cognitive profile.

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## CHAPTER II

## METHODOLOGY

## 2.1 Participants

A total of 25 participants were recruited in this study. Subjects were recruited in the study using lists from both the *Centre de recherche de l'Institut universitaire de gériatrie de Montréal* (CRIUGM) and the Department of Exercise Science at the Université du Québec à Montréal (UQAM). Inclusion criteria were: aged 55 years old and above, sedentary for at least 6 months (< 2 hours a week of structured exercise), no orthopedic limitations, non-smoker, low to moderate alcohol consumers (< 2 drinks / day), a body mass index (BMI) between 30-40 kg/m<sup>2</sup>, a stable weight ( $\pm$  2 kg) for the last 3 months and an absence of menstruation for the past 12 months. In addition, women who had any of the following factors would be excluded: 1) cardiovascular disease, 2) diabetes (fasting glucose  $\geq$  7.0 mmol/L), 3) medication affecting metabolism and cognitive function, 4) hormonal therapy, 5) eating disorders, 6) neuropsychological diseases, 7) thyroid disease, and 8) asthma treated with oral steroids. Furthermore, women who scored 26 or less on the Mini Mental State Examination (MMSE) and/or Montreal Cognitive Assessment (MoCA) as well as scored higher than 14 or more on the Geriatric Depression Scale (GDS)

questionnaire would be excluded. The Ethics Committee of the Geriatric Hospital where the research took place approved all procedures (Appendix D). All participants were fully informed about the nature, goal, procedures and risks of the study and gave their informed consent in writing (Appendix E).

## 2.2 Protocols and Procedures

A phone interview was conducted to screen for the inclusion/exclusion criteria. Except for the MMSE, MoCA and GDS, which were administered during pre-testing. After screening, each participant was invited to the CRIUGM in the fasting state at 07h30 for a series of tests. Upon their arrival, anthropometric measurements, body composition, blood sample, blood pressure and physical capacities were measured. Afterward, each participant had a light breakfast. Thereafter, a medical and neuropsychological assessment was completed and a cardiorespiratory fitness test was performed. Post testing was performed after 48 hours of the last training session.

## 2.3 Measurements

#### 2.3.1 Anthropometric measurements

Body weight was determined using an electronic scale (Balance Industrielles, Montreal, Canada). Height was measured using a wall stadiometer (Perspective Enterprises, Michigan, USA). Body mass index (BMI) was calculated using: Body weight (kg)/height (m<sup>2</sup>). Waist, hip, and thigh circumferences were measured to the nearest 0.5 cm by using a non-elastic plastic tape with the participant standing upright.

## 2.3.2 Body composition

Total body fat percentage, fat mass and lean body mass and were measured using dual energy X-ray absorptiometry (DXA) (General Electric Lunar Prodigy; standard mode; software version 12.30.008, Madison, WI, USA). Calibration was executed daily with a standard phantom prior to each test and the intra-class coefficient correlation for test-retest for body fat mass percentage and total lean body mass was 0.99 (n = 18).

### 2.3.3 Physical capacities

The time up and go (TUG) test (Podsiadlo & Richardson, 1991) was measured as participants had to stand up from a seated position in a chair, walk 3-m in a straight line, then around a cone and 3 m back to sit down on the chair, as quickly as possible. The TUG is a marker of functional mobility in older adults and can help predict risks of falls (Podsiadlo & Richardson, 1991; Shumway-Cook, Brauer, & Woollacott, 2000). The 10-m maximal walking test (10MWT) was measured as participants had to walk 10-m as fast as possible. Like the TUG test, the 10-m walking test is also a marker of functional mobility and gait. Walking time was recorded by a handheld chronometer operated by kinesiologists. Handgrip strength was assessed with a hand-

held dynamometer (Smedley-type hand dynamometer; ERP, Laval, QC, Canada). The best of three trials with the dominant hand was recorded.

## 2.3.4 Blood analyses

After an overnight fast (12 h), venous blood samples were collected and brought to Saint-Justine hospital to be analyzed on the day of collection. Analyses were performed on the COBAS INTEGRA 400 analyzer (Roche Diagnostics, Laval, Canada) for glucose, total cholesterol, HDL-cholesterol and triglycerides. LDLcholesterol was calculated from the Friedewald equation (Friedewald, Levy, & Fredrickson, 1972). Insulin levels were quantified in duplicate using a human insulin radioimmunoassay (Linco Research, Inc., St-Charles, MO, USA). Homeostasis model assessment (HOMA) = fasting insulin x fasting glucose / 22.5 was then calculated (Matthews et al., 1985). Glycated hemoglobin (HbA1c) levels were measured by HPLC using the D-100 analyzer (Bio-Rad, Montreal, Canada). Apolipoprotein B (ApoB) was assessed by immunonephelometry on IMMAGE analyser (Beckman-Coulter, Villepinte, France).

## 2.3.5 Blood pressure

Systolic and diastolic sitting blood pressure as well as active systolic and diastolic blood pressure were determined with an automatic sphygmomanometer machine (Spot Vital Signs® Devices, Welch Allyn, Mississauga, ON). An appropriate cuff size was selected for each subject based on arm circumference. Conditions were

carefully standardized: no talking, cuff on the right arm and 5 min of rest. Three measurements with 5 min of rest between measures were taken. The average of the three measures was reported.

## 2.4 Medical Evaluation and Cognitive Screening

A geriatrician evaluated each participant based on five major components: (1) medical and family medical history, (2) functional capacity (questionnaire on the ability to perform activities of daily living—ADL and instrumental activities of daily living—IADL), (3) medication list, (4) general overview of all physiological systems, and (5) physical examination. Cognitive screening measures, the MMSE and MoCA, were used to assess global cognitive functioning and to detect signs of dementia. The MMSE is a screening method for mental/cognitive impairment, as well as cognitive changes over time and the potential effects on functioning. There are 11 items under the subscales of orientation, registration, attention and calculation, evocation, language, read and follow instruction of which are scored on a total of 30 points (Folstein, Folstein, & McHugh, 1975). The MoCA is a cognitive screening test used to assess mild cognitive impairment. There are 8 subscales: visuospatial/executive, denomination, memory, attention, language, abstraction, recall and orientation. There is a total of 30 points to be given to the participant (Nasreddine et al., 2005). In addition, the Geriatrics Depression Scale (GDS) questionnaire was used as an indicator of depression in older adults. The participant had to answer with a simple 'yes' or 'no' to 30 items based on their feelings over the last week (Yesavage, 1988). Furthermore, a measure of verbal concept formation (Similarities subtest) as well as short-term and working memory (Digit Span subtest) were assessed using the WAIS-III (Wechsler, 1997).

## 2.5 Neuropsychological Assessment

The neuropsychological battery targeted memory, processing speed and executive functions. Memory was assessed with the Rey Auditory-Verbal Learning Test (RAVLT). A list of 15 words is read by the examiner and participants are asked to repeat the maximum number of words afterwards. There are five successive trials. A second 15-word list is then presented for one trial, to create interference. After this single trial, participants are asked to retrieve a maximal number of words from the first list. To evaluate long-term retention, participant must recall the words from the first list after a 30-minute delay. Measures selected from this test are the total number of words retrieved over the 5 trials, the number of words recalled after interference, and the number of words recalled after delay. The Color-Word Interference Test (CWIT) of the Delis-Kaplan Executive Functions Systems (D-KEFS) (Delis, Kaplain & Kramer, 2001) is based on the Stroop procedure (Stroop JR., 1935). The Stroop procedure has four conditions: a) in the color-naming condition, participants had to name the color of rectangles (blue, green and red), b) in the reading condition, participants were asked to read color-words printed in black ink, c) in the inhibition condition, participants were required to inhibit reading the words in order to name the incongruent ink colors in which the words are printed in, and d) in the switching condition, participants were asked to alternate between naming the incongruent ink colors and reading the words. This test assesses speed of processing for the former 2 conditions and executive functioning (inhibition and switching or cognitive flexibility) for the latter 2 conditions. Time of each condition and number of errors was recorded. The D-KEFS Trail Making Test (TMT) (Delis, Kaplain& Kramer, 2001) is composed of five parts however only parts 2-5 were used. In part 2 (number sequencing) of the TMT, participants were asked to link circled numbers from 1 to 16 in serial order with a continuous line as quickly as possible. This portion assesses speed of processing. In part 3 (letter sequencing) of the TMT, participants were asked

to link circled letters from A to P in serial order with a continuous line as quickly as possible. In part 4 (number-letter sequencing) of the TMT, participants were asked to link the circles by alternatively linking letters and numbers from 1 to P (1-A-2-B-3-C, etc.). This assessed task-switching abilities. In part 5 (motor speed), participants were asked to trace over a dotted line as quickly as possible. Both time and errors were recorded. The neuropsychological assessment lasted around an hour.

## 2.6 Aerobic Capacity

This test was completed on an ergometer. The ergometer model 'Lode Corival Recumbent 929900 ergocycle' (Lode B.V. Medical Technology, Zernikepark, Groningen, Netherlands) was used for the evaluation. The participant wore a Polar heart rate monitor during the entire test. The protocol used an original protocol by Meyers et al. The pedaling speed was maintained between 60 to 80 rpm. After 2 minutes of warm-up at 20W, the initial resistance was programmed at 30W and was increased by 10W every minute. The test ended once the participant was no longer able to maintain the level resistance or was too fatigued to continue. This test allows us to determine maximum heart rate (MHR) as well as peak power output. Active systolic and diastolic blood pressure were also measured.

## 2.7 Intervention

The high intensity interval training program on ergometer was performed three times a week for 12 weeks. The sessions were supervised by a kinesiologist. The 30-min exercise session consisted of a 5-min warm-up (60-65 % of peak power output) and 20 minutes of interval training (15 or 30 sec sprints at an intensity of 80-85 % of peak power output followed by 15 to 30 sec of active recovery). It concluded with a 5-min active recovery (60-65 % of peak power output). During the first month, each participant warmed up for 5 min followed by three series that lasted 4-min each (2 minutes of recovery between each series) followed by 5 min of active recovery. Whereas the second month, each participant warmed up for 5 min followed by three series each 5-min long (2 minutes of recovery between each series) followed by 5 min of active recovery. During the third and final month, each participant warmed up for 5 minutes followed by three series each 6 minutes long (2 minutes of recovery between each series) followed by 5 minutes of active recovery. It should be noted that participants had to complete 80 % or more of their training sessions to be included in the analysis.

#### 2.8 Statistical Analysis

Results are presented as means  $\pm$  SD (standard deviation). Normality was verified using the Kurtosis-test. Non-parametric paired t-tests (Wilcoxon Signed-Rank) were used to identify differences before and after the intervention. We also calculated the effect size (mean difference pre-post intervention / SD) for all variables after the intervention. Effect size was considered small (0.2- 0.5), moderate (0.5-0.8) or large (0.8 and above). In addition, we reported the number of subjects that presented either a positive or negative direction for all variables after the intervention. We also considered a relative change of 5 percent or more as clinically significant for all variables. Statistical analysis was performed using SPSS 22 for MAC (Chicago, IL). Significance was accepted at p < 0.05.

# CHAPTER III

## RESULTS

## 3.1 Characteristics of Participants

A total of 19 subjects completed the study and were included in the analysis. Six subjects were excluded from the analysis since they dropped out of the study leaving nineteen participants. It should be noted that the mean attendance for the exercise sessions was 88%.

## 3.2 Body Composition, Physical and Anthropometric Characteristics

Physical and anthropometric characteristics of the participants before and after the intervention are presented in Table 3.1 (Appendix A). We noted a significant improvement for thigh circumference (p=0.02) (Effect Size (ES): 0.6), VO<sub>2 peak</sub> (p=0.01) (ES: 0.7), and resistance (p=0.01) (ES: 0.9). We also noted a lower tendency for body mass index (p=0.08) (ES: 0.4). No changes were observed for all the other variables.

## 3.3 Neuropsychological Characteristics

Table 3.2 (Appendix B) shows neuropsychological characteristics of the participants before and after the intervention. Significant decreases in performance were observed for Rey-Auditory- Verbal Learning Test- Recall List A I (p=0.01) (ES: 0.7), Rey-Auditory- Verbal Learning Test- Recall List A II (p=0.01) (ES: 0.7), Rey-Auditory-Verbal Learning Test- Recall List A III (p=0.01) (ES: 0.7), Rey-Auditory-Verbal Learning Test- Recall List A III (p=0.01) (ES: 0.7), Rey-Auditory-Verbal Learning Test- Recall List A III (p=0.01) (ES: 0.7), Rey-Auditory-Verbal Learning Test- Recall List A IV (p=0.001) (ES: 0.8) and Rey-Auditory-Verbal Learning Test- Recall List A V (p=0.02) (ES: 0.6). In addition, significant decrease in performance was shown for Rey-Auditory- Verbal Learning Test- Immediate Recall List A (p=0.04) (ES: 0.5) and Rey-Auditory- Verbal Learning Test-Delayed Recall List A (p=0.05) (ES: 0.5). No change in all other cognitive function were found.

#### 3.4 Metabolic Risk Factors

The metabolic risk factors of the participants before and after intervention are presented in table 3.3 (Appendix C). There were no significant differences observed in the majority of variables with the exception of a significant improvement for resting diastolic blood pressure (p=0.01) (ES: 0.7).

## CHAPTER IV

### DISCUSSION

## 4.1 Summary and Interpretation of the Results

Obesity is associated with many comorbidities such as cardiovascular disease, hypertension, type 2 diabetes, cognitive dysfunctions, dementia and Alzheimer's, all of which lead to an increased risk of mortality (Glickman, Parker, Sim, Del Valle Cook, & Miller, 2012; Masters et al., 2013; Mokdad et al., 1999). Longitudinal studies have shown that elevated levels of obesity are associated to a decline on measures of global functioning, executive function and memory (Gunstad et al., 2010). Obesity has been found to negatively affect the prefrontal cortex leading to decline in performance of executive functions and memory. It is well established that physical activity can improve physical health of normal and at-risk populations. More specifically, there is evidence that overweight and obese adults who perform physical activity have lower morbidity and mortality than sedentary normal weight adults (LaMonte & Blair, 2006). Furthermore, most exercise training interventions in obesity have generally focused on more traditional programs such as resistance and moderate continuous aerobic training protocols to study the effect of numerous cognitive and metabolic outcomes (Kessler et al., 2012). Thus, the purpose of the

present study was to determine the impact of an ergocycle HIIT program on cognitive function and metabolic complications in obese postmenopausal women. We hypothesized that a 12-week HIIT program on the ergocycle would improve both cognitive function and metabolic complications. Results of the present study do not support our hypothesis for metabolic complications (except for one marker) and for cognitive functions.

There is evidence supporting the improvement of anthropometric measurements and body composition after HIIT (Fex, Leduc-Gaudet, Filion, Karelis, & Aubertin-Leheudre, 2015; Whyte, Gill, & Cathcart, 2010). In several intervention studies, the measurements of waist, hip and thigh circumference are the three anthropometric parameters recorded as indicators of improvement for fat distribution. For the most part, improvement is usually shown for the measurements of waist and hip circumference. For example, a significant decrease in waist (-2.4 cm) and hip circumference (-1.1 cm) in just 2 weeks of HIIT (6 sessions of 30 seconds interval sprint with a recovery of 4.5 minutes) was shown in sedentary overweight or obese men (Whyte et al., 2010). In contrast to the above example there was a significant decrease solely in thigh circumference (-2.5 cm) observed in the current study. As for BMI, a tendency for lower values (p=0.08) was observed in the present study. The decrease in thigh circumference and the lower tendency of BMI may be suggestive of a decline in subcutaneous fat. There are certain intervention studies showing HIIT to be an effective method to lessen BMI (Tjonna et al., 2008; Tjonna et al., 2009; Trapp et al., 2008; Tremblay, Simoneau, & Bouchard, 1994). However, not all studies have found HIIT to reduce BMI (Chan, Yan, & Payne, 2013; Keating et al., 2014). In a five week HIIT (60 x 8 s cycling at 90% of peak oxygen consumption (VO<sub>2peak</sub>)) study with overweight and obese young women there was no change in BMI (Kong, Sun, Liu, & Shi, 2016). Similarly, a HIIT program on elliptical performed by pre and type 2 diabetes participants three times a week for 12 weeks for 30-min showed no

significant change in BMI (Fex et al., 2015). However, the greater issue at hand is whether this inexpensive and commonly used method of calculation is the best method of measurement for body composition. BMI does not give measurements of fat mass, lean tissue or percentage of body fat. Nor does it take into consideration the amount of muscle or other body composition changes that occur with aging (Ryan, 2010). In the current study, there was no change observed for fat mass. Similarly, a 12 week HIIT program on elliptical performed by pre and type 2 diabetes participants found no significant change in fat mass as well (Fex et al., 2015) However, there are many studies that have identified a significant reduction in fat mass after a HIIT intervention (Drigny et al., 2014; Duval, Rouillier, Rabasa-Lhoret, & Karelis, 2017; Trapp et al., 2008). In the present study, there was no significant change in lean body mass. Similar results were found in a 15-week HIIT intervention for young women where no significant pre and post intervention differences were observed (Trapp et al., 2008). However, there are also several studies that have found HIIT to be an effective method to improve lean body mass (Duval et al., 2017).

 $VO_{2 peak}$  appears to be a strong predictor of cardiovascular disease and mortality (Kodama et al., 2009). In the present study, a significant increase in  $VO_{2 peak}$  levels were observed after the HIIT intervention program, confirming the results of other studies who also showed increases in  $VO_{2 peak}$  after HIIT in at risk populations (Weston, Wisloff, & Coombes, 2014). For example, the HIIT program on the elliptical by Fex et al. (2015) showed a significant improvement in  $VO_{2 max}$  (p= 0.03). Similar findings were found in Tjonna et al. (2008) where the treadmill HIIT group improved  $VO_{2 max}$  by 35%. In the present study, a 13.8% improvement in  $VO_{2 peak}$  (+2 ml/kg/min) was shown. This was further supported by the improvement in resistance while pedaling (+15 watts). As for the physical characteristics, there was no significant improvement for TUG, 10MWT or handgrip in the present study. Recent

findings in the Berryman et al. (2014) study also found no significant improvements in handgrip, 10MWT and TUG.

Physical activity has been associated with improvements as well as maintaining and delaying cognitive decline such as global cognition and certain cognitive abilities. In addition, physical activity has been reported as a protective factor against Alzheimer's and dementia. A higher intensity level of physical activity has shown to be associated to better cognitive performance (Angevaren et al., 2007; Brown et al., 2012). To our knowledge very few studies have examined the effects of HIIT on cognitive performance in obese postmenopausal women. There is one other study that has looked at the effect of HIIT on cognitive function. It found improved cognitive function in relation to memory, attention and processing speed as well as an improvement in cerebral oxygen extraction (Exercise capacity and body composition). The results of present study do not yield significant benefits from HIIT on any of the cognitive functions; however, working memory and verbal abstract reasoning showed higher tendencies. Verbal learning and memory performance significantly declined after the HIIT intervention. A study of healthy adults recorded baseline and follow-up performance for a learning and memory test showed that higher body mass at baseline specifically overweight and obese adults had poorer performance than healthy comparisons. Furthermore, obesity has been associated with a higher risk of developing poor body composition and metabolic complications which have all been associated with a decline in cognitive function. In a review article by van den Berg et al. (2006) found that the most effected cognitive functions when comparing traditional metabolic complications (hypertension, diabetes, and dyslipidemia) and obesity were those of memory, processing speed, and cognitive flexibility. The present study did not improve body composition and metabolic complications (except for diastolic resting blood pressure); therefore, perhaps these risk factors progressed throughout the intervention having a greater effect on

cognition. However, it is unlikely that such a rapid decline would have occurred during the short intervention period, but it may a contributing factor. The deterioration in cognitive performance may also represent a decline of mood specifically anxiety at post-testing. Anxiety may have increased at post-testing as they may have recalled the difficulties they experienced with this task at pre-testing. Although not quantitatively measured, many patients verbalized their discontentment and difficulty with this task numerous times. If true, anxious symptoms may not have been detected by the GDS questionnaire. Past research has only looked at the relation of anxiety, depression and PTSD disorder in regard to the results on the RAVLT. Therefore, in future research more sensitive measures of distress symptoms such as anxiety could provide valuable information. Also considered was the discrepancy in performance due to language (English and French), gender, and different form types (Form I vs Form II). However, there is no support in favor of any of these variables. It leads us to believe that perhaps these results are indicative of error. There are several other studies that found no improvements in cognitive functions after an exercise training program (Espeland et al., 2014; Sink, Espeland, Castro, & et al., 2015).

There was even a deterioration with certain cognitive function variables in the present study. Similarly, in a lifestyle and exercise intervention program in middle-aged adults with type 2 diabetes found no improvement but rather a decline in cognitive performance after intervention (Fiocco et al., 2013). Although cognitive function did not improve after testing, it is possible that HIIT led to changes that went undetected as the current study did not use brain imaging techniques to observe the changes in brain activity and brain connectivity leading to more efficient working ability. Accordingly, a study demonstrated similar changes in brain connectivity patterns in older and younger adults after a 12 month exercise intervention (Voss et al., 2010). Therefore, future research should investigate age-related changes in brain activation with HIIT using brain imaging techniques such as NIRS or fMRI. NIRS is a measure

of cerebral oxygenation. Obesity has been associated with changes in cerebral volume and may affect cerebral hypoperfusion which may lead to cognitive deficits. In the Drigny et al. (2014) study, HIIT led to higher measures of deoxyhaemoglobin signal during exercise and recovery after training which is exemplary of the effect of HIIT on cerebral oxygenation adaptation. Therefore, it may be interesting to add such a measure to see if HIIT will lead to a change in cerebral volume in postmenopausal obese women. In addition, fMRI would provide a measurement of brain activity by detecting changes associated with blood flow. There is evidence that greater brain activation may suggest engagement of additional regions; whereas, reduced brain activation may be indicative of an improvement in task efficiency. In a 12-month longitudinal study, there were three intervention groups of older adults: cardiovascular training, coordination training, and relaxation stretching (Voelcker-Rehage, Godde, & Staudinger, 2011). Results found that the older adults in the cardiovascular training group performed similarly in cognitive performance and brain activation than younger adults. Another 16-week exercise intervention program consisting of a resistance, high-intensity interval and moderate continuous training as well as a control group comprised of sixty-seven older adults resulted in more efficient cerebral oxygenation during cortical activation (Coetsee & Terblanche, 2017a). Although there was no indication of positive change in cognitive functioning there may have been an underlying change in brain activity. Adding a measure of fMRI would allow further researchers to better understand the association between cognitive function and brain activity after HIIT in postmenopausal obese women and other at-risk populations. The lack of improvement in cognitive factors in the present study may be explained by following confounding effect of practice on cognitive measurements is not possible to rule-out with no control group. As for the neuropsychological battery, all tests are subject to practice effects, and not all tests show improvement from pre to post-test. However, by measuring the effect of HIIT on certain cognitive tasks it can lessen the confounding effect of practice.

Moreover, there is evidence that HIIT may improve metabolic characteristics in participants (Duval et al., 2017). In our study, no improvement in the metabolic profile was improved after training, except for diastolic blood pressure. This is parallel to the findings of Drigny et al. (2014) who also showed no improvement in metabolic profile after a 4-month HIIT intervention in obese patients. In contrast, several other studies have found that HIIT could be effective in improving insulin resistance, dyslipidemia and blood pressure (Tjonna et al., 2009; Trapp et al., 2008).

Furthermore, many studies have reported sex-related differences in cognition and in response to physical activity intervention programs. In younger adults, men tend to outperform women in spatial abilities, task-switching, divided attention, and mathematical reasoning. Women have shown to have better verbal and inhibition abilities as well as working memory (Gale, Baxter, Connor, Herring, & Comer, 2007; Voyer, Voyer, & Bryden, 1995). In older adults, there is evidence that men have better spatial abilities and mathematical reasoning; whereas, women have better verbal abilities (Beeri et al., 2006; Duff & Hampson, 2001; Gale et al., 2007; Gerstorf, Herlitz, & Smith, 2006; McGowan & Duka, 2000; Stein et al., 2012; Tun & Lachman, 2008). However, in older adults there is inconsistency regarding the sexrelated differences in performance of working memory, inhibition, task-switching, and auditory divided attention (Beeri et al., 2006; Daniel, Pelotte, & Lewis, 2000; C. S. Li, Huang, Constable, & Sinha, 2006; Maller et al., 2007; Munro et al., 2012; Seo et al., 2008). Furthermore, the reduction of estrogen production in chronological aging of both men and women has been associated with a more rapid onset of agerelated cognitive decline and with an elevated risk of Alzheimer disease (Janicki & Schupf, 2010). Menopause has been associated with a decrease in estrogen production in women; whereas, men have a small proportion of testosterone that is converted into estradiol by the enzyme aromatase. Thereby, men have shown to have slightly higher levels of endogenous estrogen than postmenopausal women (Janicki

& Schupf, 2010). Postmenopausal women with low estrogen production have shown to be at higher risk of cognitive decline compared to men (Genazzani, Pluchino, Luisi, & Luisi, 2007; Irvine, Laws, Gale, & Kondel, 2012). Hormonal therapy (HT) in postmenopausal women is considered a potential moderator of sex-related differences in cognitive functioning. However, most studies did not control for past or present HT use when studying sex-related differences in older adults. Estrogen has been associated with plasticity in the frontal lobes and hippocampus (Brinton, 2009; Genazzani et al., 2007) related to the function of episodic and working memory as well as the executive functions (Stuss, 2011). Therefore, it is plausible that menopause transition could be associated with a decline in cognitive function. However, to present, no consensus has been met in regards to this topic (Fuh, Wang, Lee, Lu, & Juang, 2006). In cross-sectional studies, there is evidence of an association between menopausal transition and a decline in cognition for planning and task switching (Elsabagh, Hartley, & File, 2007; Herlitz, Thilers, & Habib, 2007). In longitudinal studies, menopause transition has been associated with an elevated risk of cognitive decline in spatial abilities, verbal fluency and memory (Thilers, Macdonald, Nilsson, & Herlitz, 2010). Studies of hormonal therapy (estrogen therapy), have tried to show the maintenance role of estrogen on cognitive functioning. Although studies are inconsistent, certain studies have shown improvement in the cognitive abilities of verbal, visual and work memory as well as executive functions (Duff & Hampson, 2001; Henderson & Popat, 2011; Maki & Sundermann, 2009; Sherwin & Henry, 2008). Furthermore, there is evidence supporting that hormonal therapy may influence sex-related differences on cognition (Castonguay, Lussier, Bugaiska, Lord, & Bherer, 2015; Miller, Conney, Rasgon, Fairbanks, & Small, 2002).

Moreover, there are reported sex differences in physiology and the benefits of physical activity. Men appear to be more active throughout all life stages putting

women more at risk of developing health complications and cognitive decline (Almli, Hamrick, Koshy, Tauber, & Ferriero, 2001; Pate, McIver, Dowda, Brown, & Addy, 2008; Trost, Owen, Bauman, Sallis, & Brown, 2002; Trost, Pate, et al., 2002). There are also known physiological differences between men and women. Men appear to have lower heart rates, higher  $VO_2max$ , higher red blood cells, wider airways and better lung diffusion (Abu Saleh et al., 2015; Armstrong, Tomkinson, & Ekelund, 2011; Armstrong & Welsman, 1994; Harms, 2006; Rabbia et al., 2002). Women appear to have lower VO<sub>2</sub>max attributable to smaller muscle mass, lower hemoglobin and blood volume as well as smaller stroke volume (Fletcher et al., 2001). Furthermore, in a study of forty healthy community-dwelling older male adults showed to have better balance and strength specifically in all lower limb flexor and extensor muscle groups after undergoing extensive testing in a motor-performance laboratory (Musselman & Brouwer, 2005). As for the physiological sex-differences after intervention, there is evidence that men and women respond similarly and differently. In a study of thirty-one older adults (15 men and 16 women), who partook in a 9-12-month endurance training intervention showed to have a similar increase in their maximal aerobic exercise but the mechanisms responsible differed (Spina et al., 1993). Another study, looked at the relation between cardiac output and oxygen uptake during a physical effort test. Cardiac output and oxygen uptake was linear and similar between men and women. Men showed higher cardiac output during maximal levels which allowed them to attain higher workloads because of higher stroke volume. Women on the other hand, showed to have higher heart rates during sub maximal exercise (Farinatti & Soares, 2009). This may be accounted for by a greater percentage of body fat in women (Ogawa et al., 1992) Furthermore, there are sex differences in exercise efficacy in relation to cognitive function. In a meta-analysis study, it was shown that aerobic, resistance, and multi-modal training led to greater benefits in executive functions for women. However, in subjective assessment, global cognitive function as well as executive functions led to greater benefits in men than women. No other sex-dependent effects of exercise intervention were shown for the

other cognitive functions (Barha, Davis, Falck, Nagamatsu, & Liu-Ambrose, 2017). In addition, gender differences in response to intervention for obese older adults have been reported. Specifically, a meta-analysis study of resistance and endurance training found there to be a greater impact on total and visceral fat mass in males in comparison to females according to their specific obesity phenotype being that of abdominal obesity for males and gynoid obesity, all of which occurring before menopause (Vissers et al., 2013). Another example, found there to be a greater effect on fat-mass loss in males (Morikawa et al., 2011). In an at-risk population of obese older adults, only one study has completed a comprehensive neuropsychology assessment; however, no gender differences were found (Drigny et al., 2014). However, it is difficult to know if sex-difference are more prevalent in the at-risk population of obese older adults as hormonal therapy has often not been controlled for. Therefore, further research will lead to a better understanding of the benefits of physical activity in relation to the metabolic and cognitive profiles of healthy and at-risk populations.

### 4.2 Limitations

This study has several limitations. First, our small sample was composed only of obese postmenopausal women. Therefore, limiting our findings solely to this population. Second, there was no control group due to the difficulty in recruiting subjects in this group. It should be noted that the participants did not want to be in the control group since their goal was to improve their health. Thus, these results need to be replicated with a larger sample in a randomized controlled study. However, it should be noted that a wide range and complete battery of neuropsychological tests pre and post intervention was used in the present study. Future research may want to consider studying the long-term effects of HIIT on metabolic complications and

cognitive functions using different intervention equipment (e.g. ergocycle, treadmill, elliptical) on at-risk populations (e.g. type 2 diabetes, older adults). Finally, the results of the present study should be considered preliminary, but they may stimulate interest on the impact of HIIT on metabolic and neurodegenerative diseases.

## CONCLUSION

In conclusion, results in the present study indicate that HIIT seems to benefit body composition, cardiorespiratory fitness and diastolic blood pressure in obese postmenopausal women. However, no improvement in cognitive functions were noted. Indeed, our results may be useful for clinical and practical purposes. It is important to educate health care professionals regarding the potential effects of HIIT. Healthcare professionals could recommend this form of exercise training during the planning of their interventions programs. We hope that the demonstration of the effectiveness of HIIT could stimulate the integration of physical activity protocols in the primary health care system as means of preventing metabolic diseases.

# APPENDIX A

# Table 1 Physical, body composition and anthropometric characteristics of the participants (n=19) before and after intervention

Variables	Pre	Post	% Δ	P Value	ES	Negative Direction (n)	Positive Direction (n)	No Change (n)
Age (years)	66.59 ± 5.9							
Sex	Q = 19							
Height (cm)	158.3± 5.6							
Body weight (kg)	84.59 ± 13.05	84.51 ± 13.03	-1.0 ± 0.7	.86	0.0	9/19	8/19	2/19
Body mass index (kg/m²)	34.06 ± 4.14	34.03 ± 4.16	$0.3 \pm 0.1$	.08	0.4	10/18	7/18	1/18
Waist circumference (cm)	103.53 ± 7.96	104.58 ± 8.89	1.0± 0.7	.26	0.3	9/19	8/19	2/19
Hip circumference (cm)	114.68 ± 9.38	114.55 ± 9.31	-0.1 ± 0.1	.89	0.0	10/19	6/19	3/19
Thigh circumference (cm)	61.87 ± 6.72	59.34 ± 6.72	-4.1 ± 1.8	.02	0.6	12/19	7/19	0/19
BMD (g/cm <sup>2</sup> )	1.11±0.12	1.10±0.14	$0.9 \pm 0.0$	.41	0.2	6/19	4/19	9/19
Total fat mass (%)	47.03 ± 5.07	46.55 ± 4.77	$-1.0 \pm 0.4$	.21	0.3	13/19	5/19	1/19
Total fat mass (kg)	39.70 ± 9.43	39.48 ± 9.34	$-0.6 \pm 0.2$	.57	0.1	12/19	6/19	1/19
Total lean body mass	42.74 ± 4.51	42.88 ± 4.64	0.3 ± 0.1	.67	0.1	9/19	10/19	0/19
BMC (g)	$2.20\pm0.28$	2.18 ± 0.26	$-0.9 \pm 0.0$	.22	0.3	7/19	3/19	9/19
Timed up and go	6.60 ± 1.33	6.83 ± 1.09	$3.5 \pm 0.2$	.37	0.2	10/16	6/16	0/16
10-m maximal walking speed (sec)	6.07 ± 1.04	$6.10\pm1.03$	- ± 0.1	.88	0.0	9/19	9/19	1/19
10-m +1m maximal walking speed (sec)	$5.82\pm0.85$	5.73 ± 1.10	$-1.5 \pm 01$	.60	0.1	9/19	10/19	0/19
Hand grip (Left hand)	16.83 ± 6.15	12.17 ± 6.57	-15.5 ± 1.8	.14	0.5	8/12	4/12	0/12
Hand grip (Right	18.21 ± 6.19	14.54 ± 6.68	$-4.9 \pm 0.6$	.18	0.4	8/12	4/12	0/12
VO <sub>2 peak</sub> (ml/kg/min)	18.23 ± 3.74	20.74 ± 2.18	13.8 ± 1.8	.01	0.7	3/19	16/19	0/19

Resistance (Watts) 92.06 ± 19.	7 107.22 $\pm$ 19.65	$515.5 \pm 10.2$	.00	0.9	1/18	13/18	4/18
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Values are expressed as Mean  $\pm$  SD. Statistical significance was set at p < 0.05. A relative change of 5 percent or more was considered clinically significant.

## APPENDIX B

# TABLE 2 NEUROPSYCHOLOGICAL CHARACTERISTICS OF THE PARTICIPANTS (N = 19) BEFORE AND AFTER INTERVENTION

Variables	Pre	Post	% Δ	P Value	ES	Negative Direction (n)	Positive Direction (n)	No Change (n)
MoCA- Score 30	26 53 ± 2.39	26.89 ± 2.8	$1.4 \pm 0.3$	.51	0.2	7/19	7/19	5/19
MMSE-Score 30	28.37 ± 1.30	<b>28.47 ± 0.90</b>	0.4 ± 0.1	.68	0.1	7/19	7/19	5/19
GDS- Score 30	5.26 ± 4.72	4.58 ± 5.49	$-12.9 \pm 0.5$	.50	0.2	10/19	7/19	2/19
Number Sequencing (Forward)- Score 16	9.63 ± 2.87	9.32 ± 2.16	$-3.2 \pm 0.2$	.58	0.1	8/19	9/19	2/19
Number Sequencing (Backwards)- Score 14	$5.53 \pm 2.44$	6.42 ± 1.87	16.1 ± 0.6	.11	0.4	7/19	12/19	0/19
Similarities- Score 33	21.25 ± 4.48	22.75 ± 4.69	7.1 ± 1.1	.21	0.4	6/17	9/17	2/17
	Rey	/ Auditory-Verb	al Learning 7	ſest (RA	VLT)	)		
Recall List A I- Score	$5.05\pm2.07$	3.84± 1.57	-24.0 ± 0.9	.01	0.7	13/19	2/19	4/19
Recall List A II - Score	8.05± 3.3	6.26 ± 2.35	-22.2 ± 1.3	.01	0.7	14/19	2/19	3/19
Recall List A III - Score 15	10.05± 2.72	8.16 ± 2.48	-18.8 ± 1.3	.01	0.7	15/19	3/19	1/19
Recall List A IV -	11.10 ± 2.26	9.10 ± 2.51	$-18.0 \pm 1.4$	.00	0.8	14/19	3/19	2/19
Recall List AV - Score	11.63 ± 2.27	10.21 ± 2.53	-12.2 ± 1.0	.02	0.6	12/19	2/19	5/19
Recall List B - Score	4.37 ± 1.98	$4.37 \pm 1.57$	$0.0 \pm 0.0$	1.00	0.0	6/19	7/19	6/19
Immediate Recall List A - Score 15	9.59 ± 3.76	7.12 ± 3.14	-25.8 ± 1.8	.04	0.5	10/17	4/17	3/17
Delayed Recall List A - Score 15	9.79 ± 3.58	8.11 ± 3.49	$-17.2 \pm 1.2$	.05	0.5	14/19	3/19	2/19
Recognition List A - Score 15	13.79 ± 1.58	13.74 ± 1.19	-0.4 ± 0.0	.90	0.0	8/19	6/19	5/19

#### Delis- Kaplan Executive Functions System (D-KEFS) Trail Making Test (TMT)

Condition 2 Number Sequencing	44.74 ± 18.69	40.80 ± 13.64	-8.8 ± 2.8	.27	0.3	9/19	9/19	1/19
(Seconds) Condition 3 Letter Sequencing	45.83 ± 18.97	42.50 ± 19.0	-7.3 ± 2.4	.43	0.2	9/19	10/10	0/0
(Seconds) Condition 4 Number-Letter	107.43 ± 56.01	105.71 ± 62.85	$-1.6 \pm 1.2$	.77	0.1	12/19	6/19	1/19
Condition 5 Motor Speed (Seconds)	58.03 ± 28.16	50.28 ± 19.84	-13.4 ± 5.5	.20	0.3	11/19	8/19	0/19

Color-Word Interference Test (CWIT) of the Delis- Kaplan Executive Functions System (D-KEFS)

Color Naming Condition (Seconds)	35.47 ± 10.46	33.58 ± 6.91	-5.3 ± 1.3	.40	0.2	10/18	7/18	1/18
Reading Condition (Seconds)	29.78 ± 20.37	$24.52\pm4.41$	-17.7 ± 3.7	.30	0.3	10/18	8/18	0/0
Inhibition Condition (Seconds)	66.57 ± 16.00	65.92 ± 16.95	$-1.0 \pm 0.5$	.81	0.1	11/18	7/18	0/18
Switching Condition (Seconds)	70.43 ± 18.45	74.78 ± 20.76	6.2 ± 3.1	.43	0.2	9/18	9/18	0/18

Values are expressed as Mean  $\pm$  SD. Statistical significance was set at p < 0.05. A relative change of 5 percent or more was considered clinically significant.

# APPENDIX C

# TABLE 3 METABOLIC CHARACTERISTICS OF THE PARTICIPANTS (N = 19) BEFORE AND AFTER INTERVENTION

Variables	Pre	Post	%Δ	P Value	ES	Negative Direction (n)	Positive Direction (n)	No Change (n)
Insulin (pmol/L)	58.2 ± 26.14	61.68 ± 27.74	6.0 ± 2.5	.47	0.2	8/16	8/16	0/16
Glucose (mmol/L)	5.61 ± 0.59	5.56±0.51	-0.9 ± 0.0	.59	0.1	8/16	7/16	1/16
Triglycerides (mmol/L)	$1.20\pm0.36$	1.29 ± 0.46	7.5 ± 0.1	.45	0.2	8/16	7/16	1/16
HDL Cholesterol (mmol/L)	1.50 ± 0.40	$1.57\pm0.36$	4.7 ± 0.1	.14	0.4	4/16	11/16	1/16
LDL Cholesterol (mmol/L)	3.17±0.54	$3.25\pm0.56$	2.5 ± 0.1	.35	0.2	11/16	4/16	1/16
ApoB (g/L)	1.05 ± 0.19	1.08±0.17	$2.9\pm0.0$	.19	0.4	2/16	7/16	7/16
HbAlc (%)	$0.15 \pm 0.15$	$0.89\pm0.02$	493.3 ± 0.5	.13	0.4	5/16	0/16	11/16
НОМА	$2.04\pm0.96$	$2.13\pm0.95$	4.4 ± 0.1	.63	0.1	8/16	8/16	0/16
Systolic resting	129.83 ± 11.87	$130.00 \pm 15.52$	0.1 ± 0.1	.96	0.0	9/18	9/18	0/18
Diastolic resting	80.50 ± 5.58	75.17 ± 7.34	-6.6 ± 3.8	.01	0.7	13/18	4/18	1/18
Systolic active	161.56 ± 25.77	154.56 ± 29.81	-4.3 ± 5.0	.28	0.3	11/18	7/18	0/18
Diastolic active	79.94 ± 7.15	77.83 ± 7.49	-2.6 ± 1.5	.39	0.2	10/18	5/18	3/18

Values are expressed as Mean  $\pm$  SD. Statistical significance was set at p < 0.05. A relative change of 5 percent or more was considered clinically significant.

#### APPENDIX D

## LETTER OF ETHICAL APPROVAL



d'éthique de la reche

Montréal, le 3 mai 2017

Monsieur Anthony Karells, Ph.D. a/s de Madame Lora Lohr Centre de rechercho -- IUGM 4545, chemin Queen-Mary Montréal (Québec) H3W 1W5

Objet: CER IUGM 12-13-011 : Renouvellement annuel 2017 - 2018.

Relation entre les facteurs de risques métaboliques et la fonction cognitive chez les femmes post-ménopausées obèses: L'effet d'un entraînement par intervalle.

Monsieut.

Vous avez soumis au Comité d'éthique de la recherche vieillissement neuroimagerie, par courriel, le 27 avril 2017, une demande de renouvellement pour votre projet cité en rubrique.

J'al le plaisir de vous informer que votre demande de renouvellement a été approuvée par le Comité d'éthique de la che viellissement-neuroimagerie. Ainsi, vous pouvez poursuivro votre étude pour un an, et ce, **du 10 janvier** 2017 au 10 janvier 2018.

Un mois avant la date d'échéance vous devrez faire une nouvelle demande de renouvellement auprès du Comité, en utilisant le document prévu à cet effet, accompagné du formulaire d'information et de consentement que vous utilisez.

Nous vous rappelons que dans le cadre de son suivi continu, le Comité vous demande de vous conformer aux exigences suivantes en utilisant les formulaires du Comité prévus à cet effet :

- 1. De soumettre toute demande de modification au projet de recherche ou à tout document approuvé par le Comité
- pour la réalisation de votro projet.
  De sournettre, dès que cela est porte à votre connaissance, tout nouveau renseignement ou toute modification à l'équilibre clinique susceptible d'affecter l'intégrité ou l'éthicité du projet de recherche, d'accroître les risques et les inconvénients pour les participants, de nuire au bon déroulement du projet ou d'avoir une incidence sur le désir d'un participant de continuer à participer au projet.
- 3. De soumettre, dès que cela est porté à votre connaissance et en lien avec la réalisation de ce projet, tout accident survenu dans votre site.
- 4. De soumettre, dès que cela est porté à votre connaissance, l'interruption prématurée du projet de recherche, qu'elle solt temporaire ou permanente.
- 5. De soumettre, dès que cela est porté à votre connaissance, tout problème constaté à la suite d'une activité de surveillance ou de vérification menée par un tiers et susceptible de remettre en question l'intégrité ou l'éthicité du projet de recherche
- 6. De sournettre, dès que cela est porté à votre connaissance, toute suspension ou angulation de l'approbation octroyée par un organisme de subvention ou de réglementation.
- De soumettre, dès que cela est porté à votre connaissance, toute procédure en cours de traitement d'une plainte ou d'une aliégation de manquement à l'intégrité ou à l'éthicité ainsi que des résultats de la procédure.
  De soumettre, dès que cela est porté à votre connaissance, toute déviation au projet de recherche susceptible de remettre en cause l'éthicité du projet.
  De soumettre de souverl'envirt envirt envirt de la procédure de recherche susceptible
- 9. De soumettre une demande de renouveilement annuel de l'approbation du protet de recherche.

10. De sourneitre le rapport de la fin du projet de recherche.

Direction de l'enseignement universitaire et de la recherche (DEUR) CIUSSS du Centre-Sud-de-l'Île-Montréal 66, nue Seinte-Catherine Est, Local 462 Montréal, Québec H2X 1956, poete 3223 Courriel : Levines Lettins Maniferen sourv.oc.ck Site du Comité : http://www.cruom.oc.ca/fr/la-recherche/stiteus.html.

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Approbatica reserveilement annuel 2017 - 2018. CER IVGH 12-13-011 / Hensieur Karelis

Vous pouvez obtenir les formulaires du Comité téléchargeables à partir du site web du Centre de recherche IUGM, à l'adresse suivente: <u>http://www.cnuom.oc.ca/fr/la-recherche/ethique.html</u>

De plus, nous vous rappelons que vous devez conserver pour une période d'au moins un an suivant la fin du projet, un répertoire distinct comprenant les noms, prénoms, coordonnées, date du début et de fin de la participation de chaque participant à la recherche.

Finalement, nous vous rappelons que la présente décision vaut pour une année et pourra être suspandue ou révoquée en cas de non-respect de cas exigences.

Le Comité d'éthique de la recherche vieillissement-neuroimagene est désigné par le ministre de la Santé et des Services sociaux, en vertu de l'application de l'article 21 du Code civil du Québec et suit les règles émises par l'Énoncé de politique des trois conseils et les Bonnes pratiques cliniques.

Avec l'expression de nos sentiments les meilleurs.

6 de Caseptan

Johane de Champlain Présidente du CER vieillissement-neuroimagerie JdeC/kb

Direction de l'enseignement universitaire et de la recherche (DEUR) CIUSSS de Centre-Sud-de-Flie-Montréal 66, rue Santre-Caberine Est, Local 662 Montréal, Québec N2X 156 Téléphone : 514.527.9565, poste 3223 Courriel : <u>Ensein Jeckfelt Journ Besss cour.oc.ca</u> Site de Coméé : <u>http://www.cruges.oc.caffin-recherche/sthique.html</u>

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## APPENDIX E

## **CONSENT FORM**

## Formulaire d'information et de consentement

Titre du projet de recherche :	Relation entre les facteurs de risques métaboliques et la fonction cognitive chez les femmes post-ménopausées obèses: L'effet d'un entraînement par intervalle.
Chercheur responsable du projet de recherche :	Antony Karelis, Ph.D.
Co-chercheur :	Louis Bherer
Membre du personnel de recherche :	Lora Lehr, étudiante au doctorat.

## Préambule

.

Nous vous invitons à participer à un projet de recherche. Cependant, avant d'accepter de participer à ce projet et de signer ce formulaire d'information et de consentement, veuillez prendre le temps de lire, de comprendre et de considérer attentivement les renseignements qui suivent.

Ce formulaire peut contenir des mots que vous ne comprenez pas. Nous vous invitons à poser toutes les questions que vous jugerez utiles au médecin responsable de ce projet ou à un membre de son personnel de recherche et à leur demander de vous expliquer tout mot ou renseignement qui n'est pas clair.

## Nature et objectifs du projet de recherche

Nous vous invitons à participer à un projet de recherche qui vise à évaluer l'effet d'un entraînement par intervalle (ce type d'entrainement consiste en une phase de sprint suivie d'une phase de repos qui va se faire d'une manière répétitive et en alternance) sur les facteurs de risques métaboliques et la fonction cognitive chez les femmes post-ménopausées obèses

Pour la réalisation de ce projet de recherche, nous comptons recruter 96 participantes âgées de 50 à 70 ans.

## Déroulement du projet de recherche

Ce projet de recherche se déroulera au Centre de recherche à l'Institut universitaire de gériatrie de Montréal (IUGM). La durée de ce projet de recherche est d'environ 14 semaines et comprend une évaluation pré-entraînement, une période d'entraînement de 12 semaines et une évaluation post-entraînement. Il est entendu que votre participation au projet de recherche demande que vous participiez à toutes les séances.

## 1. Évaluation pré-entraînement

Vous serez convié à participer à une rencontre d'évaluation. La rencontre aura une durée approximative de 150 minutes. Lors de cette rencontre, vous devez vous présenter à jeun depuis 12 heures, seule l'eau est permise et nous réaliserons les activités suivantes :

## Prise de mesures physiologiques et métaboliques

À votre arrivée, une prise de sang de 45 ml (ce qui correspondant environ à 4 cuillères à soupe) sera effectuée par une infirmière dans le creux de l'avant-bras. Ensuite, une brève évaluation médicale sera réalisée par un médecin.

## Composition corporelle

Nous allons mesurer votre taille et votre poids corporel à l'aide d'un pèse-personne. Les mesures de votre circonférence de la taille, hanche et cuisse seront aussi prises. Vous passerez ensuite un scanner nommé *dual energy X-ray (DEXA)* afin de déterminer votre composition corporelle (densité osseuse, quantité de muscle et de gras). Vous devrez demeurer couché sur une table d'examen afin qu'un rayon X à faible densité balayera votre corps pendant 10 minutes. L'exposition aux rayons X de ce test se chiffre à 0,03 millirem pour le DEXA, ce qui est inférieur à l'exposition ambiante naturelle pour une journée.

## Pression artérielle

Nous allons prendre la mesure de votre pression artérielle à l'aide d'un appareil automatique en plaçant un brassard de mesure sur votre bras gauche. Durant la prise de la mesure qui dura environ moins d'une minute, vous devez rester calme (sans parler et ni bouger). Toujours en position assise, après 5 minutes de repos, une nouvelle mesure sera effectuée. À l'aide du même appareil pour la pression, la fréquence cardiaque de repos sera également prise.

## Questionnaire

Vous devrez également répondre à un questionnaire, le tout prenant environ 45 minutes. Il sera réalisé avec papier et crayon. Les questions posées chercheront à évaluer: votre motivation personnelle et vos fonctions cognitives, telles que la mémoire et l'attention. Pendant que vous remplirez le questionnaire, vous aurez l'opportunité de manger votre propre

collation que vous amènerez de chez vous.

#### Capacités physiques

#### Force musculaire

La force maximale développée par chaque main sera évaluée par un dynamomètre suivant la procédure établie. Le dynamomètre est un petit appareil en métal ressemblant à une poignée qui mesure la force de préhension, indiquée par une aiguille. Pour effectuer ce test, d'une durée d'environ 5 minutes, vous devrez vous tenir debout confortablement et amener l'épaule à 45 degrés, l'avant-bras et le poignet en position neutre (paume de la main vers le sol). Vous devrez serrer l'appareil le plus fort possible avec la main, en prenant le temps nécessaire afin de le serrer au maximum. Le test sera effectué à trois reprises, et ce, pour chaque main.

## Capacité aérobie (VO<sub>2 pic</sub>)

Le  $VO_2$  pic sert à mesurer l'habileté de votre corps à consommer de l'oxygène pendant un exercice. En d'autres mots, ce test est un indicateur de votre forme cardiovasculaire. Ce test sera effectué sur un ergocycle. Vous porterez un cardiofréquencemètre tout au long du test. Durant ce test, la puissance sera progressivement augmentée toutes les 2-3 minutes, de manière à augmenter progressivement l'intensité de l'effort. Le test se terminera lorsque vous ne serez plus en mesure de maintenir la puissance de travail ou lorsque vous serez épuisé. Votre consommation d'oxygène sera mesurée à chaque palier d'effort en mesurant votre souffle dans un appareil buccal en caoutchouc. Ce test durera environ 30 minutes (approximativement 20 minutes d'exercice). Au cours de cette rencontre, nous vous demanderons également de vous familiariser avec l'ergocycle.

#### 2. Participation au programme d'entrainement

Suite à cette rencontre d'évaluation, vous serez inclus dans un groupe d'entrainement par intervalle. Vous prendrez part à un programme d'entrainement de 12 semaines, composé de 3 séances par semaine qui dure 34 minutes chaque séance. Les séances seront supervisées par des kinésiologues. De plus, un cardiofréquencemètre sera installé à chaque session d'entrainement. La séance de 30 minutes consistera en 5 minutes d'échauffement, 20 minutes d'exercice en intervalle soit deux séances de 10 minutes séparées par une pause de 4 minutes, puis de 5 minutes de retour au calme. Les horaires seront les lundis, mercredis et vendredis entre 8 h et 11 h 45 et entre 13 h et 16 h 45.

#### 3. Évaluation post-entraînement

Une fois le programme d'entraînement terminé, vous compléterez à nouveau la prise de sang et les tests évaluant vos capacités physiques et cognitives. Cette séance d'évaluation se déroulera aussi à l'intérieur d'une semaine.

#### Avantages associés au projet de recherche
Il se peut que vous retiriez un bénéfice personnel de votre participation à ce projet de recherche, mais nous ne pouvons pas vous l'assurer. Par ailleurs, nous espérons aussi que les résultats obtenus nous permettront de faire avancer l'état de nos connaissances dans le domaine de l'obésité, la neurophysiologie et de la physiologie de l'exercice et éventuellement d'en faire profiter la société.

#### Inconvénients associés au projet de recherche

Outre le temps consacré à la participation à ce projet et les déplacements, ce projet pourrait vous occasionner les inconvénients suivants : un certain état de frustration, de stress, de courbatures ou de fatigue.

## Risques associés au projet de recherche

Il est entendu que votre participation à ce projet de recherche ne vous fera courir, sur le plan médical, aucun risque, si vous ne présentez aucune contre-indication.

La prise de sang peut parfois causer des effets secondaires. Tel qu'un inconfort momentané au moment de l'insertion de l'aiguille, de la douleur, de la rougeur, un hématome (petit bleu), un évanouissement ou des vertiges. Ces effets secondaires sont cependant de courte durée. Certaines douleurs musculaires et articulaires ainsi qu'un essoufflement et de la fatigue peuvent survenir suite à une séance d'exercice. Cependant, ces douleurs sont passagères et les périodes de repos prévues sont suffisantes pour assurer une récupération adéquate. Des blessures musculaires et articulaires plus importantes peuvent également survenir suite à une mauvaise utilisation des équipements.

#### Participation volontaire et possibilité de retrait

Votre participation à ce projet de recherche est volontaire. Vous êtes donc libre de refuser d'y participer. Vous pouvez également vous retirer de ce projet à n'importe quel moment, sans avoir à donner de raisons, en faisant connaître votre décision au chercheur responsable de ce projet ou à l'un des membres de son personnel de recherche.

Le chercheur responsable de ce projet, le Comité d'éthique de la recherche de l'IUGM peuvent mettre fin à votre participation, sans votre consentement, si de nouvelles découvertes ou informations indiquent que votre participation au projet n'est plus dans votre intérêt, si vous ne respectez pas les consignes du projet de recherche ou s'il existe des raisons administratives d'abandonner le projet.

Si vous vous retirez ou êtes retiré du projet, l'information déjà obtenue dans le cadre de ce projet sera conservée aussi longtemps que nécessaire pour rencontrer les exigences réglementaires.

Toute nouvelle connaissance acquise durant le déroulement du projet qui pourrait affecter votre décision de continuer d'y participer vous sera communiquée sans délai verbalement et par écrit.

# Confidentialité

Durant votre participation à ce projet, le chercheur responsable de ce projet ainsi que son personnel recueilleront et consigneront dans un dossier de recherche les renseignements vous concernant. Seuls les renseignements nécessaires pour répondre aux objectifs scientifiques de ce projet seront recueillis.

Ces renseignements peuvent comprendre les informations concernant votre état de santé passé et présent, vos habitudes de vie ainsi que les résultats de tous les tests, examens et procédures que vous aurez à faire durant ce projet. Votre dossier peut aussi comprendre d'autres renseignements tels que votre nom, votre sexe, votre date de naissance et votre origine ethnique.

Tous les renseignements recueillis demeureront confidentiels dans les limites prévues par la loi. Afin de préserver votre identité et la confidentialité des renseignements, vous ne serez identifié que par un numéro de code. La clé du code reliant votre nom à votre dossier de recherche sera conservée par le chercheur responsable.

Le chercheur responsable du projet utilisera les données à des fins de recherche dans le but de répondre aux objectifs scientifiques du projet décrits dans le formulaire d'information et de consentement.

Les données de recherche pourront être publiées dans des revues spécialisées ou faire l'objet de discussions scientifiques, mais il ne sera pas possible de vous identifier. Également, les données de recherche pourraient servir pour d'autres analyses de données reliées au projet ou pour l'élaboration de projets de recherches futurs. Par ailleurs, vos renseignements personnels, tels que votre nom ou vos coordonnées, seront conservés pendant 5 ans après la fin du projet par le chercheur responsable et seront détruits par la suite.

À des fins de surveillance et de contrôle, votre dossier de recherche pourra être consulté par une personne mandatée par le Comité d'éthique de la recherche de l'IUGM ou par l'établissement ou par une personne mandatée par des organismes publics autorisés. Toutes ces personnes et ces organismes adhèrent à une politique de confidentialité.

À des fins de protection, notamment afin de pouvoir communiquer avec vous rapidement, vos noms et prénoms, vos coordonnées et la date de début et de fin de votre participation au projet seront conservés pendant un an après la fin du projet dans un répertoire à part maintenu par le chercheur responsable de ce projet.

En conformité avec la loi sur l'accès à l'information, vous avez le droit de consulter votre dossier de recherche pour vérifier les renseignements recueillis et les faire rectifier au besoin, et ce, aussi longtemps que le chercheur responsable de ce projet détient ces informations.

## Participation à des études ultérieures

Acceptez-vous que le chercheur responsable du projet ou un membre de son équipe de recherche reprenne contact avec vous pour vous proposer de participer à d'autres projets de recherche? Bien sûr, lors de cet appel, vous serez libre d'accepter ou de refuser de participer aux projets de recherche proposés. 
□ Oui □ Non

## Indemnisation en cas de préjudice et droits du sujet de recherche

Si vous deviez subir quelque préjudice que ce soit dû à votre participation au projet de recherche, vous recevrez tous les soins et services requis par votre état de santé, sans frais de votre part.

En acceptant de participer à ce projet, vous ne renoncez à aucun de vos droits ni ne libérez les chercheurs, l'organisme subventionnaire et l'établissement de leur responsabilité civile et professionnelle.

#### Procédures en cas d'urgence médicale

Veuillez noter que l'IUGM n'est pas un centre hospitalier de soins de courte durée qui offre des services d'urgence et qui compte sur la présence sur place d'un médecin 24 heures sur 24. Par conséquent, advenant une condition médicale qui nécessiterait des soins immédiats, les premiers soins vous seront dispensés par le personnel en place et des dispositions seront prises afin de vous transférer, si nécessaire, aux urgences d'un hôpital avoisinant.

## Identification des personnes-ressources

Si vous avez des questions concernant le projet de recherche ou si vous éprouvez un problème que vous croyez relié à votre participation au projet de recherche, vous pouvez communiquer avec le chercheur responsable du projet de recherche, Antony Karelis, au (514) 987-3000 poste 5082.

Pour toute question concernant vos droits en tant que sujet participant à ce projet de recherche ou si vous avez des plaintes ou des commentaires à formuler, vous pouvez communiquer avec le commissaire local aux plaintes et à la qualité des services de l'IUGM au (514) 340-2109.

#### Surveillance des aspects éthiques du projet de recherche

Le Comité d'éthique de la recherche de l'IUGM a approuvé ce projet de recherche et en assure le suivi. De plus, il approuvera au préalable toute révision et toute modification apportée au protocole de recherche et au formulaire d'information et de consentement. Pour toute information, vous pouvez joindre le secrétariat du Comité, par téléphone au (514) 340-2800, poste 3250 ou par courriel à l'adresse suivante:<u>karima.bekhiti.iugm@ssss.gouv.qc.ca</u>

# Consentement

Titre	du	projet de	Relation	entre	les	facteurs	de	risques	métaboliques	et la
recherche	:		fonction	cogn	itive	chez	les	femmes	post-ménop	ausées
	obeses : L'effet d'un entrainement par intervalle.									

## I. Consentement du sujet

J'ai pris connaissance du formulaire d'information et de consentement. Je reconnais qu'on m'a expliqué le projet, qu'on a répondu à mes questions et qu'on m'a laissé le temps voulu pour prendre une décision.

Je consens à participer à ce projet de recherche aux conditions qui y sont énoncées.

Nom du sujet de recherche Date

# II. Signature de la personne qui a obtenu le consentement si différent du chercheur responsable du projet de recherche.

J'ai expliqué au sujet de recherche les termes du présent formulaire d'information et de consentement et j'ai répondu aux questions qu'il m'a posées.

# Nom de la personne qui obtient le consentement Date

## III. Signature et engagement du chercheur responsable du projet

Je certifie qu'on a expliqué au sujet de recherche les termes du présent formulaire d'information et de consentement, que l'on a répondu aux questions que le sujet de recherche avait à cet égard et qu'on lui a clairement indiqué qu'il demeure libre de mettre un terme à sa participation, et ce, sans préjudice.

Je m'engage, avec l'équipe de recherche, à respecter ce qui a été convenu au formulaire d'information et de consentement et à en remettre une copie signée au sujet de recherche.

Nom du chercheur responsable du projet de recherche Date

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