Assessing the impact of work schedules on sleep, activity, energy balance, and food choice in adults.
SWEAT Study (Sleep Work, Energy intake, AcTivity)

A Thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of

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Abstract

In the contemporary era, characterized by a 24-hour society, it is imperative to examine the consequences of various work schedules on health. Shift work, a prevalent phenomenon in this modern age, significantly influences the behavioural components of one's lifestyle. Disrupted sleep caused by shift work can affect the behavioural regulation of energy intake and expenditure due to circadian rhythm alterations. A large number of regular shift workers are found in Newfoundland and Labrador, but they are an understudied population. It is important to identify modifiable lifestyle factors such as sleep, dietary habits, and physical activity to reduce adverse effects of shift work. The primary objective of this pilot and feasibility study was to determine the practicality of conducting a larger-scale, interventional trial with shift workers. This required evaluating aspects such as recruitment and retention rates, attrition, data collection protocols, adherence to the study protocol, data management, and potential barriers to implementing the intervention approach. The results of this study provide a foundation for further research and offer insights into the feasibility of the intervention.

Secondary outcomes included comparing food intake, diet quality, sleep, and physical activity between day and shift workers. This field-based study used both subjective and objective assessments of sleep and physical activity via GENEActiv (actigraphy watch) and two 24-hour dietary recalls. Participants had to complete questionnaires related to demographics, Pittsburgh Sleep Quality Index (PSQI), International Physical Activity

Questionnaire (IPAQ), Morningness and Eveningness Questionnaire (MEQ) and Perceived Stress Scale (PSS). The food intake was measured using the Automated-Self-Administered 24-hour (ASA24) dietary assessment web-based tool. Diet quality was assessed using the Healthy Eating Food Index-2019 (HEFI-2019).

Eleven day (41±6 years, 63% females) and thirteen shift (39±8 years, 77% females) workers from different occupations were recruited with a 100% retention rate. Daily self-reported energy and macronutrient intakes were not different between groups. HEFI-2019 score was higher ($p=0.04$) for shift workers (45±6) compared to day workers (39±5) for food recall 1. Time spent in bed on weekends was higher ($p=0.04$) for day workers (9±2 hrs) than shift workers (7±1 hrs) from the accelerometer data. Data from IPAQ showed shift workers had higher ($p<0.001$) work- and transport-related activity compared to day workers. Self-reported time spent in moderate and vigorous physical activity was higher ($p=0.02$) for shift workers compared with day workers. We found notable differences in the subjectively recorded physical activity parameters (questionnaires), of both the groups, as compared with the objectively recorded physical activity (accelerometry). Greater physical activity can be a parameter to reduce the adverse effects of shift work. These observations suggest that physical activity may be the target of intervention studies.

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AD:	All Day
ASA24:	Automated Self-Administered 24-Hour Food Recall
BMI:	Body Mass Index
CAREX:	CARcinogen EXposure
CFG:	Canada Food Guide
CHO:	Carbohydrates
CSD:	Consensus Sleep Diary
DRI:	Dietary Reference Intake
EEG:	Electroencephalogram
EER:	Estimated Energy Requirement
FFQ:	Food Frequency Questionnaire
GGIR:	Generalized Gateway for Integrative Analysis of Omics and Actigraphy Data
HEFI:	Healthy Eating Food Index
HREB:	Health Research Ethics Board
IOM EER:	Institute of Medicine – Estimated Energy Requirement
IPAQ:	International Physical Activity Questionnaire
LNAA:	Large Neutral Amino Acids
MEQ:	Morningness and Eveningness Questionnaire
MET:	Metabolic Equivalents
MPA:	Moderate Physical Activity
MVPA:	Moderate to Vigorous Physical Activity
NCD:	Non-Communicable Disease
NCI:	National Cancer Institute
NETSCC:	National Evaluation Trials and Studies Coordinating Centre
NIHR:	National Institute for Health and Care Research
PA:	Physical Activity
PSG:	Polysomnography
PSQI:	Pittsburgh Sleep Quality Index
PSS:	Perceived Stress Scale
PSS:	Perceived Stress Scale
RA:	Reference Amount
RCT:	Randomized Control Trial
REI:	Reported Energy Intake
SRI:	Sleep Regularity Index
VPA:	Vigorous Physical Activity
WASO:	Wake up After Sleep Onset
WD:	Week Day
WE:	Week End
WHO:	World Health Organisations

Chapter 1 Literature Review

1.1 Exposure to Different Work Schedules in Canada

The average person spends approximately one-third of their life at work. Responding to the demand for 24-hour availability in various industries and economies has led to the emergence of alternative working arrangements and hours. Beyond traditional day work (8 am to 4 pm or 9 am to 5 pm), other work types, such as night shifts and early morning shifts, have become essential for maintaining a consistent workflow, resulting in the prevalence of shift work. Shift work is crucial for ensuring uninterrupted support in sectors such as healthcare and public safety. In 2011, approximately 12% of the Canadian working population, totaling an estimated 1.8 million individuals (97.5% CI, 1.7-1.8 million), were exposed to night shift work (1). Additionally, around 17% of workers were potentially exposed (97.5% CI, 17-18%), and 4.9% worked evening shifts (97.5% CI, 4.6-5.2%). Among the exposed workers, about 2.1% worked regular night shifts (97.5% CI, 1.9-2.2%), while 10% worked rotating shifts (97.5% CI, 9-10%). Applying the national average percentage to the population in the Territories (Nunavut, Yukon, and the Northwest Territories) resulted in an additional 7300 exposed workers (1). Exposure to night shift work varies significantly by province and gender. Night shift work exposure by province ranges from 7% in Quebec (97.5% CI, 7–8%) to 18% in Newfoundland (97.5% CI, 15–21%) (1). Men and women work equally on shifts (2), gender variances may exist depending on the occupation. In the healthcare and social assistance sector in Canada, most women work rotating and night shifts (1). In conclusion, shift work is very common in Canada.

1.2 Shift Work

The term 'shift work' lacks a clear and consistent definition (3). It is defined as shift work when at least a portion of the work takes place between 7:00 pm and 6:00 am (4). Shift work includes diverse schedules and anything other than traditional daytime hours (8 am to 4 pm or 9 am to 5 pm, during weekdays). Shift work can include regular or permanent nights, evening work, rotating shifts, casual work hours, on-call schedules, split shifts, and any other irregular shifts (5). The definition of shift and rotational work is not fixed and varies based on interpretations by work organizations, unions, and geographical locations.

Shift work affects almost every component of life. This has been attributed to negative consequences of long work hours, lack of sleep, irregular sleep hours, more exposure to evening light, less exposure to sunlight and psychosocial factors such as poor social and family life. Many different medical issues could be induced or further impacted by shift employment mainly due to inter-related pathways such as disruption of circadian rhythm, adoption or worsening of unhealthy behaviours and stress. This has been explained in more detail in next sections of this thesis. This links shift work to negative health effects such as sleep disturbance (6), risk of cardiovascular disease (7), obesity (8), metabolic syndrome (9), various types of cancers (10), and diabetes (11). It has also been linked to psychological effects, such as increased stress levels (12), anxiety (13), depression (13), and occupational injuries (14), when compared with individuals involved in regular daytime work. In conclusion, the varied and often inconsistent definition of shift work encompasses a range of schedules outside traditional daytime hours. It is associated with pervasive impacts on multiple aspects of life, including disrupted circadian rhythms, unhealthy behaviours, and heightened stress levels, contributing to a spectrum of adverse health effects from sleep disturbances and cardiovascular risks to psychological challenges and occupational injuries. The connection between these physiological problems and shift work has been explained below.

1.2.1 Circadian rhythm

Circadian rhythms, essential 24-hour cycles within the body's internal clock, play a crucial role in coordinating fundamental processes (15). Light and dark have the biggest influence on circadian rhythms, but food intake, stress, physical activity, social environment, and temperature also affect them. The primary biological clock, located in the brain's hypothalamus, in the suprachiasmatic nucleus (SCN) consists of a group of approximately 20,000 nerve cells situated above the optic chiasm. The SCN receives input from the eyes and transmits signals about the time of day to ensure that the biological clock operate on a synchronized schedule (16). Circadian rhythm regulates diverse physiological and behavioural processes in humans, including sleep-wake cycles, metabolic functions, hormone secretion, and cognitive performance (17). Exposure to morning light regulates the normal progression of the circadian clock, while exposure to light in the evening or night negatively impacts it (18). Circadian rhythms are regulated by the master clock or suprachiasmatic nucleus (SCN) located in the anterior hypothalamus of the brain, which is highly affected by environmental light and dark cycles, and exposure to sunlight. Changes in sleep-wake and light-darkness patterns in accordance with natural (environmental) nights are unavoidably imposed by the different non-standard hours required by shift employees. Circadian misalignment, which is a condition of desynchronization between circadian clocks and the environment, results from these alterations (19). The negative health outcomes observed in shift workers are often attributed to the fundamental misalignment of their internal biological clock's circadian rhythm (20).

Key regulators of satiety and hunger, the hormones leptin and ghrelin, respectively, are also affected by circadian rhythms. Leptin, responsible for suppressing hunger and signaling the end of the eating period, exhibits a circadian rhythm driven by the biological clock and shows a brief surge following meals (21). Conversely, ghrelin, an appetite-stimulating hormone acting on the hypothalamic-pituitary axis and other brain areas to induce hunger and encourage eating, shows a diurnal pattern opposite to leptin, decreasing following meals (22). Under normal circumstances, ghrelin and leptin interact to regulate feeding behaviour with a suitable meal size, timing and nutrition (23). Both of these hormones also play a crucial role in regulating body mass in response to sleep duration (24). Sleep disruption interferes with the biological rhythms of satiety and hunger regulators, causing weight gain and obesity (25). During sleep, leptin levels typically rise, signaling to the brain that energy reserves are sufficient and reducing the need to eat. In contrast, sleep deprivation leads to lower leptin levels and increased ghrelin levels, signaling limited energy supply to the brain. This triggers a message to the gastrointestinal tract to stimulate hunger, prompting individuals to eat even when not genuinely hungry (26). Shift workers experience disrupted coordination between leptin and ghrelin due to disturbed sleep/wake patterns and incorrect meal timings, resulting in dysregulated biological systems related to nutrition, weight, and metabolism (20).

Laboratory experiments focusing on the immediate effects of circadian misalignment have reported low levels of leptin (21,27) and elevated levels of ghrelin during post-meal suppression (28). If the findings from laboratory-based sleep restriction studies are applicable to shift work, it is highly likely to lead to increased cravings for calorie-rich foods with high carbohydrate content (23), heightened food consumption at night, and ultimately, elevated caloric intake (29). These factors may contribute to weight gain.

Shift work-induced disturbances in the coordination of key hormones, such as leptin and ghrelin, may contribute to weight gain and metabolic dysregulation, potentially heightening the risk of conditions like obesity and cardiovascular diseases (30). However, there is still much to be discovered regarding how misalignment affects the risk of these diseases. Furthermore, the mechanisms underlying circadian misalignment and its causes remain unclear (30).

1.3 Shift Work and Sleep

Poor and short sleep are among the most common adverse effects of shift work. Individuals engaged in shift work often experience very early wake times, late sleep times, shorter sleep durations, and unpredictable sleep hours. The master clock, responsible for coordinating circadian rhythms, typically promotes enhanced alertness during the daytime and reduced alertness during night in healthy non-shift workers with regular sleep patterns (31). The continuous pressure for sleep, which increases throughout the day, counteracts this circadian mechanism (32). These two mechanisms ideally synchronize with the external light/dark cycle when functioning during daylight hours, facilitating alertness while awake and at work, and allowing for uninterrupted sleep during the night (20). However, working late hours or early shifts forces individuals to be awake when the circadian drive for alertness is low and asleep when it is high, disrupting the body's normal circadian cycle. This disruption results in shorter and more interrupted sleep cycles, leading to excessive daytime sleepiness (33), an increased risk of workplace mistakes, accidents, and injuries (34), as well as a decline in overall health. Shift workers commonly experience specific sleep problems, including difficulty falling asleep, difficulty waking, repetitive waking, and a feeling of not being rested (35). Complaints from shift workers often include waking up too early during daytime sleep following a night shift, and early morning shifts can make it challenging to wake up, leaving one feeling unrefreshed (36). Actigraphy-based studies have revealed that permanent night workers experience less efficient sleep, longer sleep latency, and more fragmented sleep compared to day workers (37). Permanent night employees have also reported poorer subjective sleep quality compared to shift workers who alternate nights (38). This mismatch between work hours and the body's natural circadian rhythm not only disrupts the ideal synchronization of alertness and sleep but also leads to specific sleep problems that impact the well-being and performance of shift workers.

1.3.1 Individual differences in shift workers

The tolerance and adaptation of employees to shift work exhibit significant variation (39). Differences exist among individuals in their susceptibility to nighttime sleepiness (40), ability to sleep during the day, and the extent to which their performance is impacted by different work schedules (41). Understanding the factors influencing each worker's ability to stay alert during night shift work and obtain sufficient sleep during day time is complex and not well-established. One contributing factor is the individual's chronotype, which can influence tolerance to the adverse effects of shift work (42). Chronotype is defined as intra-individual differences in the preferred timing of sleep and activity (15). There are three chronotypes: morning, evening, and intermediate. People with the morning chronotype find it easier to wake up early, perform better in the mornings, and sleep in the early evening. In contrast, evening chronotypes report difficulty rising early, a peak in activity in the late afternoon or evening, and a propensity for staying up later than individuals with different chronotypes (43). Research has shown that the majority of people (60%) fall under the category of intermediate chronotype, implying that their preferences can change between morning and evening chronotype (44). Previous research on this subject has revealed that morning workers experience a higher level of circadian misalignment when working at night shifts, and individuals with evening chronotype typically tolerate night shifts better (45,46). Shift-workers experience a significant disparity between their natural circadian and social (work-induced) sleep schedules, commonly referred to as social jet lag (47). This discrepancy arises from their bodies maintaining synchronization with the natural light and dark cycle while also adjusting to the substantial and consistent alterations in activity and sleep patterns imposed by their work (33,48).

Previous research has shown those with earlier chronotypes experienced reduced sleep durations during night shifts, increased social jet lag, and greater levels of sleep disturbance. Similarly, individuals with later chronotypes exhibited similar patterns during early shifts (48). Understanding these individual variations is crucial for developing targeted interventions and adapting work schedules to optimize alertness, performance, and overall well-being among shift workers.

1.3.2 Objective vs. self-reported sleep

Various measuring tools have been used in previous research to measure sleep related problems and effectiveness of interventions to enhance the sleep quality. Self-reported questionnaires, such as Pittsburgh Sleep Quality Index (PSQI), have been commonly used for measuring sleep quality. Additionally, sleep diaries are used to measure self-reported sleep habits and objective measures, like actigraphy, provide digital measure of sleep. Actigraphy is commonly used in conjunction with qualitative techniques to obtain a more comprehensive understanding of sleep issues and sleep-related behaviour (49). Previous research has reported even when measuring the same value (for example sleep time), subjective and objective measures appear to capture different features of sleep, for example, the time when a person started sleeping versus the time when the person actually fell asleep (50). In recent years, researchers have examined the relationship between self-reported and objective data in different sleep indices (e.g., duration, latency, and efficiency). The majority of these publications do not demonstrate agreement of the two measurements (51,52). A study measured the sleep patterns of 47 shift working and daytime working nurses using PSQI and actigraphy along with a sleep diary (53). The findings indicated that compared to daytime nurses, shift working nurses had more subjective and objective sleep disruptions. Actigraphy may be helpful to quantify the objective parts of sleep that are challenging to evaluate with only subjective questionnaires, according to this study's findings (53). Another large study conducted with 669 participants from 2003-2005 ancillary sleep study at the Chicago site of the Coronary Artery Risk Development in Young Adults Study collected in 2 waves of sleep measures, including 3 days of wrist actigraphy, a sleep log, and questions about usual sleep duration (54). Average measured sleep was 6 hours, whereas the average from subjective reports was 6.8 hours. Subjective reports increased on average by 34 minutes for each additional hour of measured sleep. The authors of this study concluded that in a population-based sample of middle-aged adults, subjective reports of habitual sleep are moderately correlated with actigraphy-measured sleep, but are biased by systematic over-reporting (54). Additionally, the potential for recall bias in self-reported data necessitates cautious interpretation of findings, emphasizing the need for a multifaceted approach in sleep research. While actigraphy provides valuable insights, discrepancies between self-reported and objectively measured sleep parameters, as highlighted in studies, underscore the importance of considering both perspectives for a comprehensive understanding of sleep issues.

1.4 Shiftwork and Food Intake

Sleep deprivation and poor sleep quality resulting from shift work can impact diet and energy intake, and these changes in eating patterns may be linked to circadian rhythms. Experimental studies have demonstrated that sleep restriction affects key hormones- leptin and ghrelin (55) Leptin, released by adipose tissue, suppresses hunger and promotes fullness, leading to reduced food consumption and is typically inversely correlated with body fat mass. Conversely, the stomach and pancreas produce ghrelin, stimulating appetite, with circulating levels changing throughout the day based on food intake (56). Sleep deprivation induces a decrease in leptin levels and an increase in ghrelin levels, as evidenced by a 28% rise in ghrelin and an 18% decrease in leptin after two days of sleep restriction in a short-term study involving 10 men (23). These hormonal changes are associated with heightened desire and appetite, particularly for high-calorie foods and carbohydrates (23). Additionally, sleep-deprived individuals may engage in overeating as a coping mechanism to compensate for lost sleep, as higher calorie intake has been shown to promote sleep (57).

Numerous studies (58–61) have highlighted the potential behavioural processes (refer to figure 1.1) linking sleep deprivation and obesity, alongside their biological correlations. In summary, those with insufficient sleep had a higher likelihood of increased calorie consumption. Fatigue associated with inadequate sleep may also reduce the likelihood of exercise (62). According to a review, reduced sleep duration is associated with increased late-night and early-morning feeding (63). It is reasonable to infer that calorie intake during late-night or early-morning hours, often characteristic of shift work schedules, may elicit distinct metabolic responses due to the time-dependent variations in metabolic processes (63). Overall, the timing of shifts can influence food intake and food choices. A narrative review (64) summarized various mechanisms that can cause weight gain from sleep deprivation (Figure 1.1).

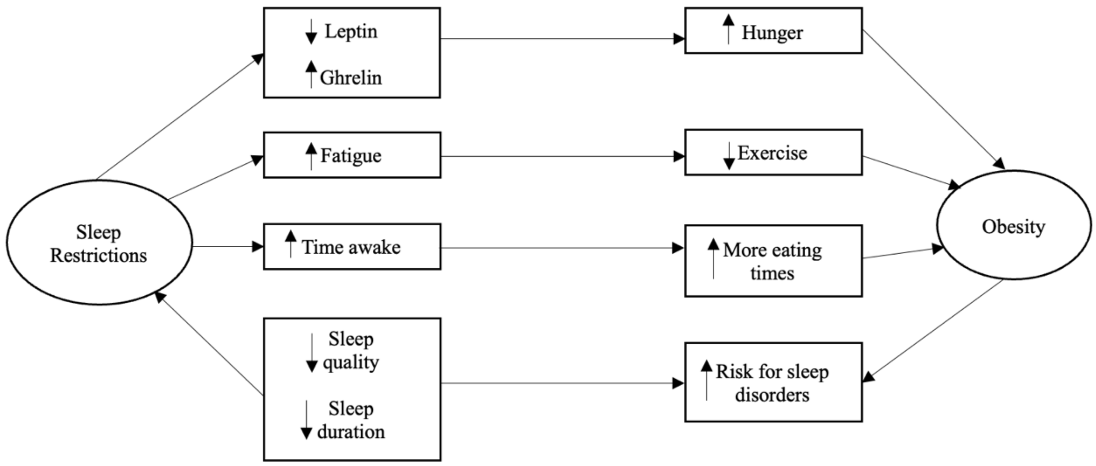


Figure 1.1: Summary of proposed mechanisms that stimulate the relationship between sleep deprivation and obesity. Figure adapted from Cooper (2018).

A comprehensive systematic review, encompassing 33 observational studies (30 cross-sectional, 2 longitudinal, and 1 case-control study), examined the association between various work shifts and individuals' eating habits. The collective evidence suggests that the food intake of shift workers is characterized by distinct patterns, notably with night shift workers consuming more food during nighttime compared to their rotational or daytime counterparts, who tend to favor daytime consumption (65). These differences in eating patterns emerge as independent risk factors for weight gain (29), glucose intolerance, insulin resistance, dyslipidemia, and obesity, as evidenced by studies involving both shift workers and non-shift workers (66–68). Irrespective of total calorie intake, skipping breakfast has been associated with weight gain and disruptions in metabolic indicators (69). Furthermore, shift workers exhibit a tendency to consume more sugar-sweetened beverages and foods high in saturated fats compared to their day shift counterparts (70,71). Insights from laboratory-based studies on sleep-restricted mice suggest that consuming calories during the normal sleep period leads to more significant weight gain, potentially indicating that night workers, who eat during their work shift, may have a higher body mass index compared to day workers (29).

In summary, research consistently highlights that shift workers exhibit variations in eating times, prolonged eating durations, irregular meal patterns, and increased intake of carbohydrates and saturated fats (72). Notably, no significant differences in total energy consumption have been reported between rotating/night shift workers and their daytime counterparts (73). The intricate interplay between sleep deprivation, altered hormonal regulation (specifically leptin and ghrelin), and disrupted eating patterns in shift workers creates a complex dynamic that contributes to increased calorie consumption and obesity-related risks. The evidence consistently underscores the importance of considering both behavioural and biological factors in understanding the link between inadequate sleep, eating habits, and metabolic outcomes.

1.4.1 Diet and sleep: cyclic relationship

A recent narrative review has identified four key themes influencing eating patterns among shift workers: the timing of meals, the types of foods consumed, the sources of food, and the reasons for choosing to eat during shifts (74). The review concluded that irregular working hours predominantly influenced when workers ate on shift, while the type of shift played a significant role in determining what they ate. Canteens and cafeterias were identified as the primary sources of food, and socializing with colleagues emerged as the primary reason for eating on shift (74). Night snacking appears to be a prevalent behaviour among shift workers across various industries (75,76). Notably, beverages with excessive sugar content, such as soft drinks and energy drinks, along with hot liquids like tea and coffee (potentially with added sugar), are frequently reported by nightshift employees. This observation may contribute to the higher sugar intake observed among shift workers (77,78). In a mixed-methods study involving firefighters, utilizing 24-hour food recalls and interviews, researchers found that while the total energy intake (kJ/day) remained consistent between day and night shifts, the diet during night shifts exhibited a higher energy density compared to day shift diets (77).

Melatonin, a crucial regulator of the sleep-wake cycle, is produced by the pineal gland in response to darkness and acts on the suprachiasmatic nucleus, serving as a circadian signal for systemic functions (79). Additionally, serotonin, a neurotransmitter responsible for inducing slow-wave sleep (80), and tryptophan, an essential amino acid found in variety of foods (81), are important sleep-related hormones. In humans, endogenous melatonin is exclusively derived from dietary tryptophan, with only 1-2% of this tryptophan being converted to melatonin via the serotonin pathway (82). Dietary habits can influence sleep through biochemical pathways connecting dietary elements to sleep regulation. The impact of carbohydrate intake on the tryptophan-to-LNAA (large neutral amino acids) ratio, which governs tryptophan uptake in the brain (83), is pivotal in these pathways. Carbohydrate consumption leads to a significant increase in blood glucose levels, prompting insulin secretion. Insulin, in turn, prompts muscle cells to absorb LNAAs, including tryptophan. Despite all LNAAs competing for the same brain transporter molecule (84), since tryptophan is present in lower amounts than other LNAAs, a meal consisting solely of carbohydrates allows more tryptophan to enter the brain. This tryptophan is then converted into serotonin and melatonin, potentially promoting sleep. Evaluating the ratio between tryptophan and total LNAAs in the blood, rather than focusing solely on plasma tryptophan concentration, is crucial. Prior research has shown a peak circulating tryptophan to LNAA ratio 2-4 hours after consuming a high carbohydrate meal (85). However, it is important to note that these metabolic pathways involve multiple regulatory steps, and increasing one component does not necessarily lead to significant increases in the metabolites of these pathways. Sleep is a complex process regulated by intricate mechanisms, leading to various stages, each with its unique mode of control and physiological effects. Assessing a diet solely based on individual food items may be imprudent, considering the presence of thousands of diverse molecules in a single diet. Consequently, establishing a straightforward correlation between all aspects of sleep and a single food or nutrient is unlikely (86).

Consuming high-carbohydrate (CHO) meals, tryptophan (87), melatonin (88), and phytonutrient-rich foods (such as cherries) (89) may enhance both the quality and quantity of sleep. While further studies are necessary to fully comprehend the underlying processes of many of these effects, the dietary influences on serotonin and melatonin activities play a pivotal role. Future studies should ensure consistency in dietary measurement techniques and employ objective methods, such as PSG/EEG, and validated sleep assessments to enhance the accuracy of findings and enable comparisons between studies (90).

1.5 Shiftwork and Physical Activity

Physical activity, a key lifestyle component, involves skeletal muscle movement and energy expenditure. Physical activity can be categorized into light, moderate, and vigorous intensity levels (91,92). Examples of light activity include casual walking and household tasks, moderate examples include brisk walking, and vigorous examples include running (92). Sedentary behaviour is a form of physical inactivity that requires only a minimal amount of energy (e.g., passively commuting, reading, watching television). Shift workers often face circadian rhythm disruptions, marked by irregular sleep, meal, and light exposure patterns, leading to sleep deprivation and insomnia (20). These disruptions, coupled with variations in physical activity and sedentary behaviour, contributes to adverse health outcomes among shift workers, highlighting the importance of addressing these factors in promoting their well-being (93).

A systematic review comparing physical activity and sedentary behaviour in shift and non-shift workers showed that physical activity levels were similar for shift and non-shift workers (94). The authors also concluded that shift workers spent more time in physical activity than non-shift workers when measured using self-reports (95). However, this was not the case when the data were measured objectively using devices, as demonstrated by many studies included in this review (96,97). It is possible that shift workers in demanding fields like healthcare and manufacturing may over-report their occupational PA levels and self-report measures do have recall bias compared to device-based measures. This is supported by a cross-sectional study among 354 rotating night shift nurses and 371 day shift nurses (98). The study employed multiple linear or logistic regression models, adjusting for age, season, number of full-term births, marital status, and BMI. Results revealed that nurses on rotating night shifts exhibited significantly higher levels of total and occupational physical activity. However, leisure time activity was notably reduced among nurses and midwives working rotating night shifts compared to those on daytime shifts, with an increased odds ratio for recreational "inactivity" (OR = 1.57, 95% CI: 1.11-2.20). This indicates that rotating night shift work among nurses and midwives is associated with increased occupational physical activity but decreased leisure time activity. It is possible that day workers can indulge in leisure time physical activity as their work times allow for more opportunities for physical activity and participation in sports. This can potentially yield comparable overall physical activity levels, albeit with discernible differences in activity types. Additionally, a notable finding of shift workers was that they spent much less time participating in sedentary behaviours, although only a few studies were included. The authors concluded that physical activity and sedentary behaviour are both complex and multidimensional behaviours. As such, it is difficult to compare physical activity and sedentary behaviour in shift workers when reported by different types (e.g., leisure related, occupation related, domestic work-related physical activities), measurement tools, and schedules. Adhering to consistent measurement tools to assess physical activity and sedentary behaviour could increase the comparability of the results across studies. There is a need to standardize definitions of shift work and shift schedules, and to report all the various factors that influence physical activity and sedentary behaviour patterns in future studies (94).

Another systematic review that focused on physical activity interventions for shift workers was conducted with seven studies that were included based on the set criteria (99). Six studies prescribed aerobic activities, including walking, jogging, or rowing. In general, the studies provided insufficient information regarding essential intervention aspects (such as site and timing), and none of them evaluated changes in physical activity behaviours. The authors of the studies focused on different outcome measures and tools for assessing PA. One or more NCD risk variable, such as body weight, BMI, fat mass, and serum cholesterol concentration, improved in the majority of studies reported in this review. The authors also discovered that the physical activity interventions led to an improvement in shift workers' cardiorespiratory fitness. Since this systematic review included only a small number of studies, the results cannot be generalized to all shift workers, but they may be used to guide future research design. The authors also concluded that a larger number of shift worker studies are required (99). This is consistent with the findings from a larger meta-analysis of interventions for workplace physical activity that did not concentrate on shift employees (100). With a total effect size of 0.57, the authors' analysis of data from 38,321 participants demonstrated an improvement in fitness (100). The development of practical physical activity-based therapies for this target population will require future studies with larger groups of shift workers. The timing of physical activity in relation to clock time and shift schedule should be reported by researchers who should also consider the usefulness of the workplace as an intervention setting. The use of reliable and valid measurements of changes in physical activity habits, both before and after the intervention, as well as reporting on recruiting techniques and rates and adherence to intervention protocols, are other responsibilities of researchers. In conclusion, physical activity, crucial for overall well-being, is intertwined with circadian disruptions faced by shift workers, leading to adverse health outcomes. The complexity of these behaviours underscores the importance of consistent measurement tools and standardized definitions for future studies.

1.6 Confounding Variables Affecting Shift Work and Its Health Outcomes

When examining the relationships between shift work, sleep, and adverse health outcomes, it is crucial to consider various potential confounding variables. A confounding factor should be unrelated to the exposure in the source population, act as an independent predictor of the outcome, while having some relation between exposure and outcome (101).

1. Age

Age emerges as a significant confounder in studies on shift work. Investigations into the impact of age on shift-work tolerance yield mixed results. Younger age is associated with better shift-work tolerance, as evidenced by subjective sleepiness, performance assessments, recovery from work, and sleep duration (102,103). However, individuals aged 40 to 50 may exhibit diminished tolerance to shift work (104). Conversely, some studies suggest that older age might enhance the tolerance of shift workers, possibly due to accumulated experience and effective adaptation to shift work, known as "the healthy shift worker effect" (105).

2. Sex

A systematic review investigated individual differences, such as sex, in shift work tolerance with 60 articles, of which 10 were longitudinal and the rest were cross-sectional studies (39). They found that the majority of studies supported the male sex. Despite seemingly more hazardous work conditions, male shift workers reported better sleep, more regular work patterns, healthier lifestyles, and reduced fatigue and sleepiness during shifts. A recent cross-sectional study with a large sample of 315 retail workers and 410 police employees supported higher shift work tolerance among men than women (106). Notably, the study does not provide conclusive reasons for the observed sex-based differences, highlighting the need for further exploration. Additionally, women's domestic responsibilities, such as grocery shopping and childcare, irrespective of shift type, warrant consideration.

3. Marital Status

Limited studies directly assess the impact of relationship status on shift work tolerance. A population-based study involving 1438 nurses, utilizing self-administered questionnaires, examined the effects of marital status and shift work on family function. The findings indicated that both non-night and rotation shift work among registered nurses might negatively impact family function, with married nurses scoring better in this regard than unmarried counterparts. Interestingly, day shift emerges as the optimal work condition for family function among married nurses, whereas this doesn't hold true for single nurses. This suggests that marital status may play a moderating role in the association between shift work and family function impairment (107).

4. Chronotype

The term "chronotype" refers to an individual's specific entrainment and activity-rest preference within a 24-hour day (15). Individuals with morning chronotypes may encounter challenges in adapting to evening or night shifts compared to those with evening chronotypes, attributed to elevated levels of drowsiness and sleepiness during those hours (108). The preference for a specific chronotype can influence the adaptation to shiftwork to a certain extent.

5. Lifestyle factors and stress

A number of lifestyle factors, including the use of alcohol (109), tobacco (109), physical activity, diet, and perceived stress can impact sleep and adjustment to night work. Shift workers are more prone to engaging in unhealthy behaviours, and existing research indicates that these lifestyle choices contribute to an elevated risk of cardiovascular disease among shift workers (110).

Understanding and accounting for these factors is essential for a comprehensive analysis of the complex interplay between shift work and health outcomes.

1.7 Methodological Limitations

The current literature suggests a significant gap in assessing lifestyle behaviours of different worker groups day, shift and rotating capturing their food intake, sleep patterns, physical activity and stress levels. Particularly there is a gap between dietary habits, among people with varying work schedules in real-time. The standard methodology used for dietary assessment is often inadequate, as it fails to accurately capture food patterns over extended periods of time. To address this issue, a change in approach is needed, one that involves evaluating dietary habits over several days, both during weekdays and weekends, rather than relying solely on a single food frequency questionnaire (FFQ). This approach not only reduces the potential for recall bias but also enhances the accuracy of the data collected. In addition, the majority of existing studies rely on questionnaires to collect data on sleep. However, this proposed masters thesis study distinguishes itself by using actigraphy, a method known for its accuracy in measuring sleep. This approach enhances the study's methodological rigor. In addition to utilizing validated tools to assess dietary habits and sleep, this study also evaluates chronotype and physical activity. Moreover, the proposed study addresses an important research gap in the Canadian context, especially in Newfoundland and Labrador, where a high proportion of working people are involved in shift work. The critical need to understand the complex web of factors contributing to adverse effects of shift work drives the study's novel role within this framework.

1.8 Rationale

Research focused on the workplace is of paramount importance for enhancing overall health and lifestyle, given the substantial time individuals spend at work. The existing evidence underscores a scarcity of studies comparing the lifestyles and behavioural components of day and shift workers (111). Furthermore, the outcomes of related studies have been inconsistent due to methodological constraints. Previous observational studies have used self-report measures, such as food frequency questionnaires, to assess food intake, which are subject to bias and do not provide an ideal representation of food intake.

Utilizing more objective measures, such as 24-hour food recalls, can offer a clearer understanding of dietary habits. Additionally, real-time tracking of participants' activities using accelerometers, validated for measuring physical activity and sleep (112), can provide more meaningful insights. Investigating the interplay among sleep, eating habits, and physical activity in shift workers living their daily lives, while carefully considering confounding factors, will enhance the comprehension of how the adverse health effects associated with shift work can be mitigated. This exploration aims to provide valuable insights for minimizing negative health outcomes of shift work. This investigation aims to offer valuable insights that can inform interventions targeting specific aspects to improve the overall quality of life for shift workers. To the best of our knowledge, no such study has been conducted in a Canadian working cohort that includes a large population who are employed in some kind of shift working hours. Consequently, conducting a pilot study using appropriate methodologies is necessary. This research employs pilot and feasibility techniques to conduct a comprehensive investigation of the initial stages, encompassing various aspects such as recruiting of shift and rotational workers, tracking lifestyle of on call shift workers and intervening component.

1.9 Pilot and Feasibility Studies

The purpose of conducting pilot and feasibility studies is to evaluate the feasibility, practicality, and potential outcomes of proposed research studies, and these studies are crucial in the early stages of research. Adequate preliminary research helps gain essential insights and can inform decisions before committing to larger-scale research. A pilot study is, “A small-scale test of the methods and procedures to be used on a larger scale” (113). Evaluating the viability of methods that will eventually be applied in a larger scale study is the primary goal of a pilot study (114). The UK NIHR Evaluation Trials and Studies Coordinating Centre (NETSCC) defines a pilot study as a version of the main study run in miniature to determine whether the components of the main study can all work together (115). The aim of a pilot study is to pinpoint and rectify any issues with the design of the main study, including problems related to sample selection, data collection methods, and recruitment strategies. Therefore, it is recommended that the pilot focus on the processes of running the main study.

The NETSCC defines feasibility studies as studies used to estimate important parameters that are needed to design the main study, e.g., standard deviation of the outcome measure, willingness of patients to be randomised, willingness of clinicians to recruit participants, number of people eligible, follow-up rates, response rates and adherence/compliance rates (115). Feasibility studies may have no plan for further work and their aim is to assess whether it is possible to perform a full-scale study (115).

1.10 Study Objectives and Hypothesis

The purpose of this pilot study was to assess the feasibility of tracking shift workers' lifestyles and to generate pilot, cross-sectional data for evaluating the potential of conducting a larger-scale interventional trial in a similar cohort.

Primary Objective:

The primary objectives of this pilot and feasibility study were to determine the recruitment rate, retention and attrition of participants, data collection procedures and measurements, adherence to the protocol, data management, and any potential barriers or challenges to implementing the intervention approach. While these preliminary findings provide insights into the feasibility of the intervention, they establish a foundation for future research.

Secondary Objectives:

The secondary objectives of this study were to a) compare food intake, sleep quality and quantity, and physical activity between day and shift workers, both objectively and subjectively; b) explore the correlations between subjectively and objectively measured sleep quality and quantity, physical activity, and diet.

Hypothesis: Shift employees have shorter sleep durations, poor diet quality, and lower levels of physical activity than day workers.

Chapter 2 Methods

2.1 Study Type

This was a pilot and feasibility study, which means data collected from this study will help in the process of identifying intervention, testing the outcome measures and as well as other implementation factors in preparation for a large-scale clinical trial with the working cohort in Newfoundland and Labrador.

This was an observational study design with a cross-sectional trial design. Instead of conducting a shift work controlled study in a lab, we wanted to observe employees' free-living behaviours in natural settings. SWEAT study applied for ethics approval on July 7, 2022 and received full ethical approval from the Health Research Ethics Board (HREB) at the Memorial University of Newfoundland for one year on August 25, 2022 (with reference number #2022.134). The ethics approval letter is provided in the appendix A. This study was also registered with ClinicalTrials.gov with the identifier NCT05652842.

2.2 Study Population

There is not a single universally accepted definition for shift work. Various organisations such as the WHO's International Agency for Research on Cancer (IARC), National Institute for Occupational Safety & Health (NIOSH) have their own definitions and criteria. Our target population was comprised of three categories of workers: (a) day workers working from 9 a.m. to 5 p.m./8 a.m. to 4 p.m.; (b) shift workers, included those who were involved in any arrangement of daily working hours other than the standard daylight hours

(8 a.m. – 5 p.m.); (c) rotational workers, whose work schedules were set and work roster rotated continuously on a fixed schedule. For example, people who work continuously for 2 weeks on and 2 weeks off.

2.2.1 Participant recruitment

Convenience sampling for recruitment was used and participants were recruited on a voluntary basis. Convenience sampling is specifically beneficial in pilot studies as it recruits participants that are conveniently located around the location and identifies potential patterns (116). The recruitment process employed both direct and indirect methods. Direct approaches involved reaching out to local employment unions in Newfoundland and Labrador through emails, directly soliciting participation from employees. Study information was disseminated via the Memorial University Newsline, and posts/messages were shared on relevant Facebook groups (e.g., employee rights groups in Newfoundland) with the approval of group administrators.. An indirect approach involved advertising the study on social media platforms, specifically through a paid Facebook business account created under the name 'SWEAT Study,' where the study poster was promoted weekly. Interested participants contacted the study personnel via the provided email address.

This study implemented specific inclusion and exclusion criteria strategically designed to minimize the impact of confounding variables.

2.2.2 Inclusion criteria

The study enrolled participants aged 30 years or older, excluding those with recently diagnosed major psychiatric or physiological issues within the last six months, as indicated by self-reported health history. Inclusion was restricted to individuals whose workspace allowed for the wearing of a watch, and confirmation of the absence of any physical conditions preventing the use of a monitoring device was obtained. Participants committed to a one-week continuous wearing of a monitoring device (actigraphy), in addition to completing all provided questionnaires, forms, and two online 24-hour food recalls. While efforts were made to confirm work schedules, preferably from the employer or organization, it was not a definitive inclusion criterion.

2.2.3 Exclusion criteria

The study excluded participants who reported a change in medication within the last six months for any pre-existing medical, as documented in their self-reported health history. To ensure comparability between shifts, shifts shorter than 4.5-hours or longer than 14-hours were not considered. Additional exclusion criteria were current pregnancy, breastfeeding, having a child less than 1 year old at home, and recent travel across time zones within the last four weeks. These criteria were implemented to enhance the homogeneity of the participant group and minimize potential confounding factors.

2.2.4 Rationale for the chosen sample size

In the context of determining an appropriate sample size for a pilot study, a common guideline involves the application of sample size rules of thumb. According to Browne

(1995), a minimum of 30 subjects is generally recommended for parameter estimation. Conversely, Julious (2005) proposes a guideline of 12 subjects per treatment arm. For enhanced precision in estimating the standard deviation, Teare and colleagues (2014) advocated a larger sample size of 70 for pilot trials.

For this (SWEAT) study, the planned enrolment was 45 total participants. This included 15 daytime workers, 15 shift workers, and 15 rotational workers. This number was deemed sufficient to provide robust exposure to various work schedules and associated lifestyle (117). The decision aimed to strike a practical balance between obtaining an extensive dataset for research purposes and effectively managing constraints imposed by available resources and time limitations, particularly given the context of being a master's student.

2.2.5 Data collection procedures

The study setting encompassed Newfoundland and Labrador in Canada, with all laboratory-based procedures conducted in the Nutrition & Lifestyle Lab at Memorial University's St. John's Campus. All participants were tracked for seven days while working on their respective shift schedules (i.e., day or night) and during their free days. Interested participants contacted the research team via email, initiating the screening process. The research team emailed interested individuals a set of screening questions and an information sheet detailing the study. The questions asked were: 1) Are you 30 years or older? 2) Have you been recently diagnosed with a new medical condition in the last 6 months? 3) Did you have any change in your medications in the last 6 months for any previous medical conditions (if any)? Eligible participants received a consent form to review before coming to lab. Dates were set for participants to come to the Nutrition and Lifestyle Lab at Memorial University twice. Participants were told about the available parking options and reimbursed for the parking.

On the first visit, participants were given the study information sheet and consent form, accompanied by a brief explanation of the study. After obtaining informed written consent, anthropometric measurements (weight, height, body fat percentage, and blood pressure) were taken. Participants then completed the Participant Information Questionnaire, Morningness and Eveningness Questionnaire, and a Work Schedule form. This form captured the current work schedule and previous work history as well; it was designed by the research team for this study to get the appropriate information using questionnaires used by previous similar research groups.

Participants were instructed on how to use the ASA24, a web-based dietary assessment tool. Participants were asked to complete two 24-hour dietary recalls, one on the working day and one during their day off. Participants were provided with the GENEActiv wrist accelerometer and were instructed to use the actigraphy watch for the entire period of seven days, even during water-based activities. Consensus Sleep Diary-Core (CSD) was provided and subjects were given instructions on how to use it. Participants were instructed to complete the sleep logs (CSD) for the next 7 days, as soon as they woke from sleep, in the morning following a typical nocturnal nap or sleep, or after a daytime sleep depending on each participant's schedule but not after nap. Participants were encouraged to store the logs close to their beds for increased compliance.

The 2nd visit to the Nutrition and Lifestyle Lab occurred seven days after the first visit. During the second visit to the lab, participants were asked to fill the International Physical Activity Questionnaire (IPAQ) long-form questionnaire providing self-reported physical activity data for the previous seven days. Additionally, participants were asked to fill out the Pittsburgh Sleep Quality Index (PSQI) and the Perceived Stress Scale (PSS) questionnaires to subjectively assess sleep quality and stress levels. Participants returned the actigraphy watch and the CSD at the 2nd visit. All the questionnaires were paper based except the ASA24. The visits including the consent taking, took approximately 1.5 hours. Refer to Figure 2 for schematic overview of the study progress.

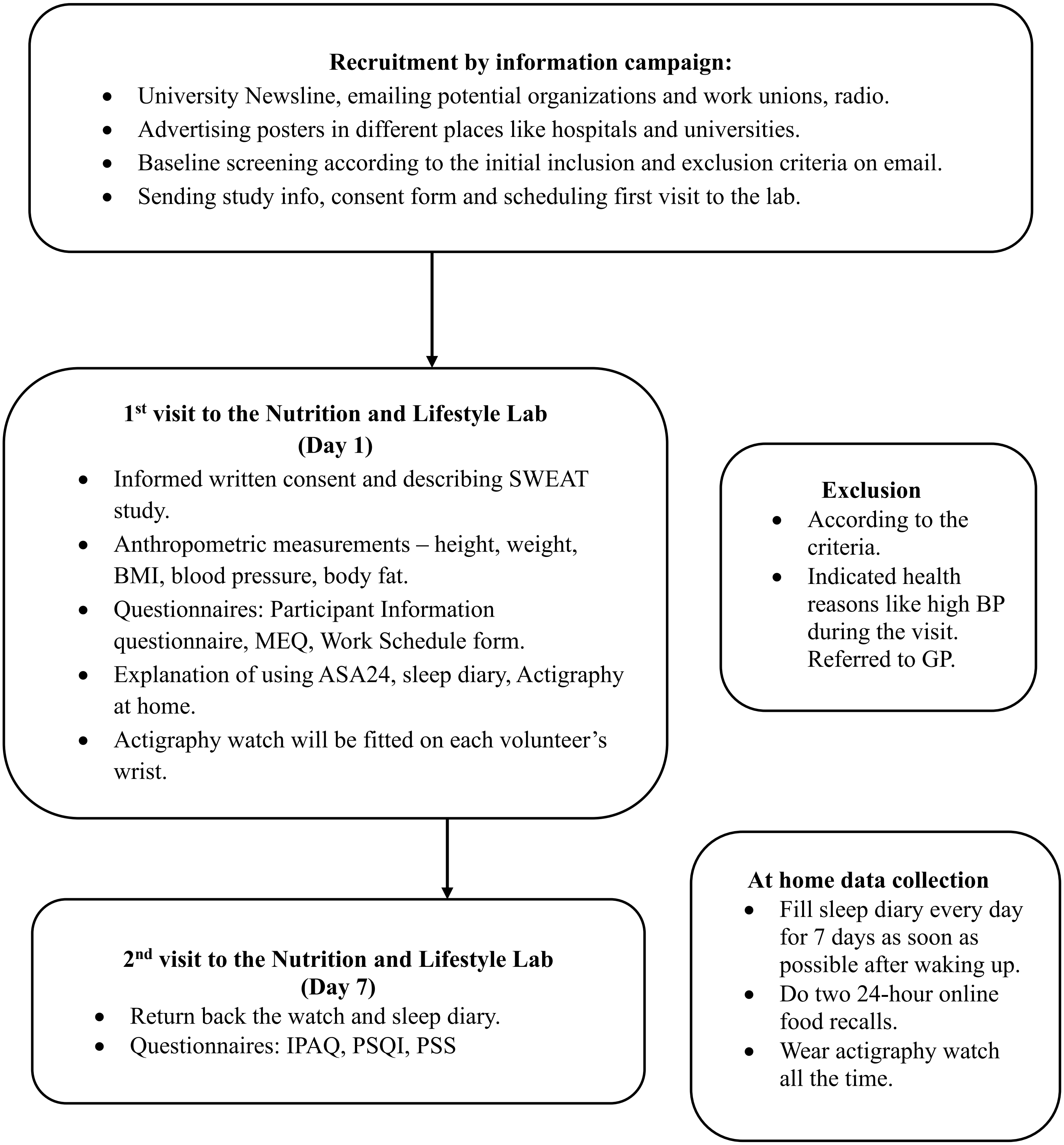


Figure 2.1: Schematic overview of study progress.

MEQ – Morningness and Eveningness Questionnaire; ASA24 – Automated Self-Administered 24-hour dietary assessment tool; GP – General Physician; IPAQ – International Physical Activity Questionnaire; PSQI – Pittsburgh Sleep Quality Index; PSS – Perceived Stress Scale.

2.3 Outcome Measurement

This section of the thesis delved into the study objectives outlined in Section 2.1, elucidating the relevant outcomes of interest associated with each objective. Additionally, itdetailed the methods employed to measure these outcomes, encompassing the data collection tools and questionnaires utilized.

Primary Objective - The primary objective was to conduct a pilot study to assess its feasibility, laying the groundwork for the subsequent clinical trial. This entailed identifying the intervention component crucial for the clinical trial's efficacy and practical implementation.

2.3.1 Primary outcome

The primary objective of this study was to implement and assess the pilot study, aiming to ascertain the feasibility of the protocol, identify intervention parameter(s) for the clinical trial, and test the tools and questionnaires employed in this investigation. Additionally, to evaluate whether the study's procedures and tools were suitable for scaling up to a larger, more comprehensive investigation. It is imperative to recognize that the potential for hypothesis testing in a pilot study is a subject of concern (118). The process followed for determining the feasibility of a pilot study involved assessing participant access, procedural barriers, and resource requirements, with outcomes guiding decisions on study continuation or modification. Surmountable challenges suggest potential for a full study, while insurmountable issues may necessitate protocol adjustments or study cessation (119) and has beenexplained in the table 2.1. The specific objectives and outcomes for assessing feasibility and pilot studies are also shown in the table 2.1. One of the following results from a pilot study can be considered typical: 1) the study may be terminated (the main study cannot be conducted) 2) it may be modified before the main study can be conducted 3) it may not need to be modified but must be thoroughly monitored during the study procedures 4) or it may be conducted as it is (120).

Table 2.1: Examples of objectives and outcomes for feasibility and pilot studies: adapted from Abbott (2014)

	Feasibility studies	Pilot studies
Objectives	a) Access to participants (e.g., the response of participants to advertising, the proportion of participants who meet the eligibility). b) Barriers to participation. c) Feasibility and suitability of assessment procedures and outcome measures. d) Time and resources required to conduct assessments. e) Need for stratification. f) Participant's adherence to treatment. g) Appropriateness of target group for intervention. h) Risk of treatment contamination.	a) Whether recruitment and screening processes are working well. b) Recruitment rates per week. c) Selection bias. d) Capacity and resources to conduct all trial processes. e) Access to equipment, space, and time. f) Adequate time, intensity, and effect of interventions. g) Participant retention among the allocation group. h) Data completeness. i) Data variability. j) Whether outcomes are consistent with expectations. k) Challenges faced by personnel and sites.
Outcomes	a) X potential participants per week can be accessed. b) X% of potential participants meet inclusion criteria. c) Identified barriers to participation. d) Problems encountered with assessment procedures.	a) Recruiting methods are accessing x potential participants per week. b) X% of potential participants meet inclusion criteria. c) X% of consenting participants complete all baseline assessments within benchmark days. d) X% of participants complete all follow-up assessments within days of the target date.

Interpretation	a) Full study is not feasible: *stop* b) Problems identified are surmountable: *a full study may be feasible with modifications.* c) Few or no major problems, but some unknowns: *a pilot study without modifications that completes the information needed to plan a full study can proceed.* d) Few or no major problems: *a full study can proceed without modifications, provided all study processes are known to be fail-safe.*	a) Insurmountable problems with necessary processes: *stop.* b) Problems identified are surmountable: *modifications will be necessary for full study protocol, and further pilot testing may be necessary.* c) Few or no major problems: *a full study can proceed without modifications or further testing.*

Secondary Objective: To compare food intake, sleep, and physical activity between day and shift workers.

2.3.2 Secondary outcome

The secondary outcomes of interest of this study were food intake, sleep and physical activity.

2.3.2.1 Dietary intake measurement

Main objective was to compare the macronutrient intake including the energy, protein, total fat, carbohydrates, and sugar in all the work categories (day, shift and rotational).. Additionally, a diet quality score was calculated for both groups to assess adherence to the recommendations for healthy food choices outlined in the Canadian Food Guide-2019 (CFG-2019). This evaluation was done using the Healthy Eating Food Index-2019 (HEFI-2019). It is an index which is intended to measure alignment of eating patterns with the CFG-2019 recommendations on food choices among Canadians aged 2 years and older (121). See the table 2.2 for the description of evaluation of HEFI-2019. According to the HEFI-2019, higher scores indicate a better alignment with the 2019 CFG recommendations for healthy eating (122).

Table 2.2: HEFI-2019 components, points and standards for scoring. Source - Health Canada

#	Component name	Measurement (ratio)	Maximum points	Unit	Standard for minimum score	Standard for maximum score
1	Vegetables and fruits	Total vegetables and fruits[a]/total foods[b]	20	RA/RA	No vegetables and no fruits	≥0.50
2	Whole-grain foods	Total whole-grain foods[c]/total foods[b]	5	RA/RA	No whole-grain foods	≥0.25
3	Grain foods ratio	Total whole-grain foods[c]/total grain foods[d]	5	RA/RA	No whole-grain foods	1.0
4	Protein foods	Total protein foods[e]/total foods[b]	5	RA/RA	No protein foods	≥0.25
5	Plant-based protein foods	Plant-based protein foods[f]/total protein foods	5	RA/RA	No plant-based protein foods	≥0.50
6	Beverages	(Plain water including carbonated + unsweetened beverages)[g]/total beverages[h]	10	g/g	No water and no unsweetened beverages	1.0
7	Fatty acids ratio	(Mono + polyunsaturated fat)/total saturated fat	5	g/g	≤1.1[i]	≥2.6[j]
8	Saturated fats	Total saturated fat/energy	5	%E (kcal/kcal)	≥15%E[k]	<10%E
9	Free sugars	Total free sugars/energy	10	%E (kcal/kcal)	≥20%E[k]	<10%E
10	Sodium	Total sodium/energy	10	mg/kcal	≥2.0[k]	<0.9[l]

Note: CCHS, Canadian Community Health Survey; CDRR, Chronic Disease Risk Reduction; CFG, Canada's Food Guide; HEFI, Healthy Eating Food Index; RA, Reference Amounts (amount of food usually eaten by an individual at 1 sitting, defined as the Table of Reference Amounts in Health Canada 2016); %E, percent of total energy.

[a] All vegetables and fruits regardless of saturated fat, sodium or free sugar content; excludes fruit juice (Ie., considered as sugary drinks in CFG-2019).

[b] Includes all foods consumed as well as beverages considered in protein foods (i.e., unsweetened milk and unsweetened plant-based beverages that contain protein); excludes all other beverages as well as solid fats, oils and spreads and culinary ingredients (e.g., spices and baking soda).

[c] Foods where the first ingredient is either whole grains or whole wheat, regardless of saturated fat, sodium or free sugar content.

[d] Foods where the first ingredient is a grain (whole or not) regardless of saturated fat, sodium or free sugar content.

[e] All protein foods regardless of fat, sodium or sugars content; excludes processed meats (i.e., not considered protein foods in CFG-2019) and sweetened milks (i.e., considered as sugary drinks in CFG-2019).

[f] All plant-based protein foods, regardless of saturated fat, sodium or free sugar content.

Unsweetened beverages include unsweetened coffee and tea, unsweetened milk and unsweetened plant-based beverages.
[h] Total beverages include water (plain or carbonated), coffee, tea, milk and plant-based beverages, fruit and vegetable juices, alcoholic drinks, artificially sweetened beverages and sugary drinks.
[I] Approximately the 15th percentile of intake based on data (single 24-hour recall) in Canadians from the 2015 CCHS-Nutrition.
[j] Corresponds to the is percentile of unsaturated to saturated fats ratios among simulated diets developed to be fully consistent with all recommendations in CFG-2019.
[k] Approximately the 85th percentile of intake based on data (single 24-hour recall) in Canadians from the 2015 CCHS-Nutrition.
[l] Standard for maximum points based on the CDRR for 14 y and older (i.e., 2300 mg) over the 90th percentile of usual energy intakes in respondents aged 2 y and older from the 2015 CCHS-Nutrition (i.e., approximately 2600 kcal, see Methods for detail).

Adapted from Brassard et al., 2022.

Dietary data were collected using two 24-hour food recalls during the 7-day tracking period using the Automated Self-Administered 24-hour (ASA24) Dietary Assessment Tool, Canadian version (2018). ASA24 was accepted as a reliable and practical indicator of food consumption (123).

Participants received instructions on how to use the ASA24 during the first visit to the lab and were provided with a username and password. Participants were asked to do one food recall on a working day and one on a non-working day. However, in order to increase participant recruitment, this was not mandatory.

2.3.2.1.1 Reported energy intake and plausibility of energy intake

Disease risk is often linked to total energy intake in epidemiologic studies due to the direct association between physical activity, body size, and the likelihood of disease (124). While the doubly labeled water (DLW) method by Goldberg is considered the gold standard for measuring energy intake as it directly measures carbon dioxide production, which reflects energy expenditure.However, it is not commonly used in epidemiological studies due to its expense and time-consuming nature (125). Instead, many studies, including this one, rely on self-reporting energy intake methods, which can introduce errors and potentially attenuate diet-disease relationships based on energy intake (126). Evaluating the plausibility of self-reported energy intake data is crucial to understanding the extent of measurement error in self-reported intake data (127). Biological/physiologically implausible reporting refers to self-reported energy intake that is outside the expected range given physiological status and physical activity level (127). It includes both over-reporting and under-reporting which can affect validity of data and results (128). A common approach is to exclude participants who report consuming fewer than 500 and greater than 3500 kcal per day (128).

To ascertain the correctness of reported energy intake (REI), a comparison with estimated energy requirement (EER) was made. The Institute of Medicine (IOM) developed factorial equations for individual EER based on a meta-analysis of studies using doubly-labeled water to measure energy requirements, considering factors such as age, sex, height, weight, and physical activity level (129). Overall physical activity levels were calculated subjectively using the IPAQ to use in the IOM EER equations. The McCrory et al. method is based on cut-offs for REI which are calculated as a percentage of EER specific to sex and age as per DRI categories and weight status (130). McCrory method (130) is the most detailed tool for finding misreporting and improves on the Goldberg method by accounting for within subject-errors (measurement error and day to day variation) in total physical activity and EI, using cut-offs of +1 SD and +2 SD for agreement (128).

$$+1\ \text{SD} = \sqrt{\frac{CV^2wEI}{d} + CV^2wpTEE + CV^2tmTEE}$$

CV_{wEI} = within-subject coefficient of variation in energy intake

d= number of days of reported dietary intake

CV_{wpTEE} and CV_{tmTEE} = technical error in the measurement and biological variation in energy expenditure

Using the above formula with the standard values of 17.7% for CV_{wpTEE} , 8.2% for CV_{tmTEE} , 23% for CV_{wEI} and 2 for *d* for two 24-hour food recalls, ± 1 SD corresponds to approximately 30% (130). Participants who report consuming calories less than 70% of their EER would be considered under-reporters, while those who report consuming more than 130% of their EER would be considered over-reporters.

2.3.2.2 Sleep Measurement

The assessment of sleep involves a multifaceted approach employing diverse methodologies that offer insights into different aspects of sleep patterns and quality. This study utilizes both objective and subjective methods to evaluate sleep.

2.3.2.2.1 Subjective Method

Sleep Diary: This study used the Consensus Sleep Diary – Core (CSD-C), which collects comprehensive information about various parameters of sleep including time of sleep, time of waking up, time taken to fall asleep, sleep quality, number of awakenings in the night, time duration of each awakening, self-reported sleep quality (131). However, none of these were taken into consideration during inclusion/exclusion. Participants were instructed to keep track of their bedtime, wake-up time, whether or not they napped, whether or not it was a work or leisure day, and any extra comments relating to their sleep. Over the course of the measuring period, participants were advised to maintain their habitual sleeping habits and to report any unusual incidents or illnesses. Average data for each participant was calculated since it gives data for 7 days. The following sleep parameters were extracted from the sleep diary and used in the analysis:

1- **Number of awakenings** – Number of times participant wakes up between the time first fell asleep and final awakening.

2- **Wake after sleep onset (WASO)** – The total time for which a participant was awake between the time first fell asleep and final awakening. For example, participant wakes for 3 times last night for 20 minutes, 35 minutes, and 15 minutes respectively, WASO = 1 hour 10 minutes.

Pittsburgh Sleep Quality Index: This was an 18 points self-reported questionnaire to evaluate sleep quality that with seven components (sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, sleep medication and day time dysfunction) with total score from zero to 21 (132). Total score ≥ 5 indicated poor sleep quality (133). The questions are based on the sleeping habits from last 4 weeks. All of its components were analyzed as continuous variables, with higher values indicating poor sleep quality. Following sleep parameters were collected from the PSQI and used in this thesis:

1- **Sleep Latency** – Time (in minutes) taken to fall asleep each night.

2- **Sleep Efficiency** - It was calculated as the percentage of sleep within the time spent in bed.

3- **Sleep Duration** - Total sleep duration (in hours and minutes), which equals the accumulated nocturnal sustained inactivity bouts within the time spent in bed. It does not include any time during the sleep period scored as wake.

4- **Sleep Quality** – This wasin the terms of global score of PSQI, calculated at the end ranging from 0 to 21. Score ≥ 5 indicated poor sleep quality. Score <5 indicated good sleep quality.

2.3.2.2.2 Objective Method

Sleep-wake cycles and physical activity outcomes were objectively monitored using the actigraphy GENEActiv Original (Activinsights Ltd., Kimbolton, United Kingdom). It was a small (43mm x 40mm x 13mm), lightweight (16g) device which looks similar to a watch. On their choice of wrist, participants were told to wear the actigraphy gadget for seven consecutive days and nights. The GENEActiv device contains tri-axial MEMS accelerometer to measure vertical, horizontal, and perpendicular movement in 12-bit resolution and record accelerations ranging from -8 to +8 G's. Data were collected at a sampling rate of 100 Hz, and downloaded onto a computer in 60-second epochs. The watch was water-resistant and participants were told to wear it all of the time.

Validity of the GENEActiv to measure sleep and activity

The GENEActiv has been validated against polysomnography, which is a gold standard in sleep measurement (134). The automated sleep detection method produces comparable measurements to polysomnography for sleep period time window and sleep length, sleep onset, and waking time, but a subpar measure of wake throughout the sleep period when data from the GENEActiv accelerometer, worn on either wrist, is used (134). The GENEActiv needs to be worn for 3 to 5 nights to achieve acceptable reliability (Intraclass correlations = 0.7) in sleep outcomes, while physical activity and sedentary time outcomes require between 3 and 4 days (135). If a person is particularly sedentary or has numerous episodes of sleep during the day, this can lead to incorrect classification of the sleep period time window (134). In this case, a sleep record can be helpful in directing the algorithm to select the primary sleep event. The following sleep parameters were taken from the actigraphy data and used in this thesis:

1- **Time in bed** – Total number of hours and minutes between bed and wakeup times during the sleep period.
2- **Wake after sleep onset (WASO)** - The total time for which a participant was awake between the time first fell asleep and final awakening.
3- **Sleep Duration** – Total sleep duration, which equals the accumulated nocturnal sustained inactivity bouts within the sleep period time. It does not include any time during the sleep period scored as wake.
4- **Sleep Efficiency** – It is calculated as the percentage of sleep within the sleep period time window.
5- **Number of Awakenings** - Number of times participant wakes up between the time first fell asleep and final awakening.
6- **Sleep Regularity Index (SRI) –** "This index calculates the percentage probability of an individual being in the same state (asleep vs. awake) at any two time-points 24 h apart, averaged across the study. The index is scaled so that an individual who sleeps and wakes at exactly the same times each day scores 100, whereas an individual who sleeps and wakes at random scores 0" (136).

2.3.2.3 Physical Activity Measurement

The evaluation of physical activity involves a range of methodologies, encompassing both objective and subjective methods. Objective approaches utilize tools such as motion sensors (accelerometers), physiological indicators (biomarkers), and direct or indirect calorimetry (92). On the other hand, subjective methods rely on self-reporting through diaries, questionnaires, and interviews. When combined, these approaches offer a comprehensive framework for assessing an individual's physical activity behaviour.

2.3.2.3.1 Objective Method

Physical activity was recorded objectively using the GENEActiv, actigraphy watch as explained more in the above section (2.3.2.2.2).. Different types of physical activities are defined in terms of energy expenditure using multiples of resting Metabolic Equivalents (MET). One MET is the rate of energy expenditure while sitting at rest (137). Following physical activity parameters were taken from the actigraphy data and used in this thesis:

1- MPA minutes/week – It refers to time spent in moderate physical activity. When the energy expenditure is between 3-<6 METs, it is called as MPA (137).

2- VPA minutes/week- It refers to time spent in vigorous physical activity. VPA activity has >6 METs. It includes jogging, running, fast swimming etc (137).

3- MVPA minutes/week – The definition for MVPA is unclear and different cut-points used vary between different guidelines (138). The MET value for MVPA is typically between 3 to 6 METs, covering lower end of VPA and all the MPA. It usually captures overall physical activity levels

2.3.2.3.2 Subjective Measurement

Participants were required to fill the IPAQ- long form during the 2nd visit to the lab to report the self-reported data and assess the level of physical activity in the last seven days. IPAQ is a self-report standardised 31-item questionnaire gives both categorical (low, medium, and high physical activity level) and continuous (using Metabolic Equivalents (METs) indicators of physical activity and sedentary behaviour (139). It measures physical activity in four domains: at work, transportation, household, and leisure time, using frequency: times per week and duration: hours and minutes per day. There is another domain also which describes the time spent in sitting. Activity should last at least 10 mins to be considered. A total time was calculated by multiplying 7 (days in a week) by the minutes per day that participants spent in walking, doing moderate intensity physical activity (MPA, metabolic equivalent value 4-6 METs (an international unit of measuring metabolic energy)), and doing vigorous-intensity physical activity (VPA, metabolic equivalent value > 6 METs). In order to estimate MVPA (metabolic equivalent value greater than 3 METs), time derived from MPA and VPA domains was summed. After combining all questions across all domains, a total physical activity score was calculated (140). Standard IPAQ protocols were used to analyse the data (141). To normalize the distribution of levels of activity which are usually skewed in population data sets, truncation process was followed according to the standard data processing protocol which involved that the variables total walking, total moderate intensity and total vigorous-intensity activity were calculated and then for each of these summed behaviours, the total value was truncated to 3 hours (180 mins) (141). All activity hours were converted into minutes before calculating MET minutes. Activity bouts of greater than 3 hours were truncated (any bout was not longer than 180 minutes). In each category a maximum of 21 hours of activity was permitted a week (3 hours x 7 days). For calculating MET minutes/week, MET value of the reported activity (e.g. walking = 3.3, moderate activity = 4, vigorous activity = 8) was multiplied by the minutes the activity was carried out and again by the number of days that the activity was undertaken. The MET minutes achieved in each category (walking, moderate, and vigorous activity) to get total MET minutes of physical activity during the reported week. Depending on their level of total physical activity and the evaluation criteria, participants were classified as low, moderate and high. To compare between two groups, day versus shift, data were used in the form of METs.

2.3.3 Measurement of other variables

2.3.3.1 Personal Characteristics

This questionnaire facilitated the collection of data pertaining to various demographic factors. The gathered information encompassed age, annual household income, relationship status, education level, disability, number of children, current and past medical conditions, current medications, and family medical history. The primary objective was to obtain descriptive data and measure certain covariates.

2.3.3.2 Chronotype

'Chronotype of an individual refers to the specific entrainment and/or activity-rest preference of that individual in a given 24-hour day' (15). It was measured using the

Morningness and Eveningness Questionnaire (MEQ) (142). This is a self-assessment questionnaire that focuses on asking questions about preferred times for various activities for an individual. It gives score ranging between 16 to 86. A higher score indicates a morning preference, and a low score indicates an evening preference. Chronotype can directly impact the tolerance to shift work (143).

2.3.3.3 Anthropometric measurements

In the initial visit, basic anthropometric measurements, including weight, height, body fat percentage, BMI, and blood pressure (BP), were conducted. Height (cm) was measured using a standard board measurement with a measuring tape. Participants were asked to stand by the board with shoes removed. Weight (kg) and body fat percentage were measured using the HBF-514C body composition monitor manufactured by Omron Healthcare, Inc. Measurements were taken with participants wearing minimal clothing, and any accessories and shoes were removed. The HBF-516B, a sensor-based device suitable for adults up to 330 pounds and 6.5 feet tall, was used for this purpose. This device uses bioelectrical impedance analysis (BIA), a method for estimated body composition where a weak electric current flows through the body and the voltage is measured in order to calculated impedance of the body. Research comparing portable body composition methods using BIA to other methods such as air displacement plethysmography (ADP), a method where volume of an object is measured indirectly by measuring the volume of air it displaces inside an enclosed chamber is limited. In a research study with male and female college students compared machines using BIA method by different companies such as

Omron, RJL and Tanita with ADP method (144). The BIA machinces including RJL (r = 0.935 for males, r = 0.924 for females), Omron (r= 0.942 for males and r= 0.897 for females), and Tanita (r=0.934 for males and r= 0.897 for females) appear to be both reliable and valid for predicting fat-free mass of male and female college students. Participants stood barefoot on the device and held the hand sensor at a 90-degree angle to their body at shoulder level to ensure correct full-body sensing. The device has a guest mode that does not store participants' personal details, maintaining research ethics. Personal information such as age, sex, and height were entered into the device to calculate body fat percentage. Later, the data for height and weight were entered into the GENEActiv software when setting up the actigraphy watch for the participant, and BMI was calculated and recorded for each participant. Blood pressure measurement was conducted using the Gold Upper Arm Blood Pressure Monitor, Model BP5350, manufactured by Omron Healthcare, Inc. Participants were asked to relax for five minutes, sit on a chair in a straight and comfortable position, and were assisted in wearing the arm cuff on the upper left arm while keeping the arm on a table.

2.3.3.4 Stress levels

Personal stress levels were measured using the Perceived Stress Scale (PSS), a validated, 10-item self-report questionnaire (145). This was an easy-to-use questionnaire with acceptable psychometric properties (146), employs a 5-point scale ranging from 0 (never) to 4 (very often) for each item. The total score, ranging from 0 to 40, categorizes stress levels into low, moderate, and high perceived stress. Participants completed this questionnaire during their second visit to the lab, reflecting their experiences over the past month.

2.3.3.5 Work history & Schedule

To document work history and current schedules, a specialized work schedule form was developed for this study, tailored to meet the study's specific requirements and drawing on insights from similar studies and previous questionnaires (147). Information pertaining to current working hours, travel duration, shift structures, and overall working duration was gathered. Participants were requested to fill out this form during their first visit to the lab.

2.4 Statistical Analyses

2.4.1 Missing data

This study encountered some instances of missing data. For one participant, body fat percentage could not be measured as the device displayed an error, despite several attempts. In another case, weight (kg) and body fat (%) were self-reported by the participant, as they exceeded the measuring limit of the HBF-514C body composition monitor manufactured by Omron Healthcare used in this study. Additionally, actigraphy data for one participant were not recorded; despite providing a fully charged and functional watch on the first visit, the device did not work upon return, and data retrieval was not possible. Despite multiple reminder emails sent and follow ups by the graduate student, one participant did not complete two food recalls. Participants with self-reported and missing data were retained in the analysis, and missing values were not considered in statistical analyses.

2.5 Description of Study Population

The statistical methodology employed in this study followed a systematic approach. The data collection and analysis were conducted for two distinct groups: day workers and shift workers. Initially, the normality and homogeneity of the data were assessed using the Kolmogorov-Smirnov test and Levene's test, respectively. To depict the study population based on socio-demographic variables, dietary intake, health behaviours and qualities, and work characteristics, means and standard deviations were calculated for continuous variables, while counts and percentages were computed for categorical variables. The comparison between day and shift workers involved independent sample t-tests for continuous variables and Chi-square and Fisher's Exact tests for categorical variables.

2.6 Primary Outcome Analysis

For evaluating the implementation of the pilot study and determining its feasibility, analysis was mostly descriptive and problems faced by the researcher were explained. The content for descriptive analysis is explained in the secion 2.1. For determining the intervention component, statistical tests as explained below were used. Based on the significant differences between the results of two groups, intervention lifestyle component was determined.

2.7 Dietary Intake Analysis

Dietary data were available in 2 formats: food groups wise and nutrient wise from the ASA24. Total daily nutrient intakes were calculated using the mean values from two recalls for energy, carbohydrates, protein, total fats, fibre, total sugars and added sugars for both the groups using the HEFI-2019. Diet quality score for each participant was calculated using the HEFI-2019 protocol (121). The HEFI-2019 components, points and standards for scoring are described in table 2.2. Data from the ASA24 recalls were divided in two groups – Recipe up (i.e., kept as a whole and assigned to a unique HEFI category) and Recipe down (i.e., separate into recipe ingredients) as per Health Canada using food codes. All these food codes led to series of variables (Vegfruits, Wholegrfoods, nonwholegrfoods, profoodsanimal, otherfoods, waterhealthybev, unsweetmilk, unsweetplantbevpro, otherbeverages, satfat, mufat, pufat, sodium, free sugars, energy) that were calculated by dividing the amount of food consumed by the respondent with its reference amount as per Canada Food Guide. An input excel file was prepared using these steps from intake data from ASA24 based on different HEFI categories using the reference amounts for each food item reported. The exact steps for making this input file are given on Health Canada website, also given in the appendix C (The Healthy Eating Food Index 2019 - Calculating HEF-2019 scores, 2023). This input file was then analysed in R software version 4.2.2 using the code hefi2019 code (R package was taken from the GitHub page of Didier Brassard which is available as an open-source package, details are given in the appendix C). A radar plot is a good way to explain scores and the multidimensional nature of the HEFI-2019 and may be helpful when utilizing it. Each component score is displayed simultaneously on a radar plot. There is a 100% score at the outer edge of the "wheel" and 0% represents the center of the circle. When component scores are illustrated in this manner, it may be easier to visualize patterns of dietary intake and compare differences between diets with similar overall scores but different component scores. Since each component has a different scale, all the mean intake values were standardized to percentage to create a radar chart. The radar chart was created in the R software version 4.2.2 using the package ‘ggradar’ which is available as an open-source package.

2.8 Sleep Outcome Analysis

Sleep quality and quantity were the secondary outcomes of interest for this study. Sleep data were available from CSD, actigraphy watch and PSQI. Using the entire week of available data from the sleep diary and actigraphy, daily means and standard deviations were calculated for all sleep parameters as mentioned in the results section of thesis. Actigraphy raw sleep data were extracted using the manufacturer’s software GENEActiv PC software, V1.1. Raw data from the monitor was processed using open-source R package GGIR (version 2.10-1) (149). The GGIR (Generalized Graded Intensity Representation) R package proves to be a valuable tool for processing and analyzing accelerometer data derived from wearable devices (149).

In the specific context of this study, GGIR was employed to analyze GENEActiv sleep and physical activity data from a convenience sample. The processing of GENEActiv accelerometer data were conducted using the GGIR package in the R programming language, as outlined by (150,151) Rigorous quality checks were implemented to identify and exclude non-wear periods or instances of device malfunction. The GGIR sleep detection algorithm was then utilized to classify accelerometer data into sleep and wake periods, with a sleep detection threshold set at 40 counts per minute, and periods lasting less than 10 minutes were subsequently excluded. Periods lasting less than 10 minutes were excluded because they were often considered as short bouts of movement or wakefulness that may not accurately represent sleep periods. By excluding these short periods, the algorithm aims to improve the accuracy of sleep detection by focusing on longer, more continuous periods of rest, which are more indicative of actual sleep episodes. This helps to minimize false positives and enhance the reliability of sleep-wake classification based on accelerometer data.

Sleep regularity index was also calculated using GGIR (136).

2.9 Physical Activity Analysis

Various organizations have recommended using Metabolic Equivalents (METs) as reference for measuring intensities of PA. The phrase "metabolic equivalents," or "METs," refers to how much oxygen certain activities demand. One MET is equivalent to the about 3.5 mL O_2/kg/min of oxygen the body requires while at rest while seated (152). Therefore, multiples of this number offer a straightforward, useful, and simple classification system to measure relative levels of energy expenditure. PA data were collected using a self-reporting questionnaire, International Physical Activity Questionnaire (IPAQ)-long form. Continuous data were expressed as MET-minutes per week = MET level x minutes of activity/day x days per week. Data were cleaned, analysed and truncated as per the IPAQ protocol. Activity bouts greater than 3 hours were truncated to 3 hours. Domain wise (work, transportation, domestic and garden, leisure time) and walking, moderate and vigorous intensity sub scores were calculated. The questionnaire is based on physical activity in the last 7 days which aligns with the actigraphy tracking period also. Using the entire week of available data from the questionnaire and actigraphy, daily means and standard deviations were calculated for all PA parameters. Actigraphy raw data were extracted using the manufacturer's software GENEActiv PC software, V1.1. Raw data from the monitor was processed using open-source GGIR version 2.10-1 as explained in the section 2.9 (149,150,153). GGIR enables the computation of diverse physical activity measures, encompassing sedentary time, light activity, moderate-to-vigorous activity, and step count. In assessing the intensity of physical activity, GGIR utilizes raw acceleration ENMONZ values (Euclidean norm less one, with negative values set to zero) alongside validated cut-points (135).

2.10 Association Between Food Intake with Sleep and Physical Activity Parameters.

The relation between sleep and physical activity parameters with food intake was evaluated using Pearson correlation coefficient. To investigate the potential impact of insufficient sleep and physical activity on dietary habits, a multiple regression analysis was performed. Odds ratios (OR) with corresponding 95% confidence intervals (CI) were calculated, accounting for potential confounding factors such as sex, age, BMI, and socio-economic level. In an observational study, confounding occurs when a risk factor for the outcome also affects the exposure of interest, either directly or indirectly. The resultant bias can strengthen, weaken, or completely reverse the true exposure-outcome association. This adjusting analyses can isolate the true association between the exposure and outcome, reducing the risk of bias and providing more accurate estimates of the effect size. The selection of statistical tests and methods was deliberate, ensuring effective addressing of research questions and alignment with the study's specific objectives.

2.11 Chronotype and Stress

One-way ANOVA test with Tukey HSD post hoc analysis was used to assess difference between stress scores from the PSS questionnaire according to chronotype.

Chapter 3 Results

3.1 Subject Accrual

Participant recruitment commenced in October 2022 and occurred in two phases: the first phase spanned from October to December 2022, and the second phase from February to March 2023. Data collection excluded the winter vacation period. A total of 11 daytime workers, 13 shift workers, and 2 rotational workers were recruited, with the numbers determined by convenience sampling, the thesis timeline, and degree duration. However, during the analysis stage, rotational workers' data were excluded to maintain statistical significance.

Daytime employees typically worked five 8-hour shifts a week, usually from Monday to Friday, followed by two days off (Saturday and Sunday). In the shift worker sample, defining specific work timings was challenging due to the diverse occupations of the participants.

The study's main contact email received 41 expressions of interest, while the researcher's personal MUN email received 6 expressions of interest. Recruitment occurred in two phases: from October to December 2022, 13 participants were recruited, and from February to March 2023, an additional 13 participants were recruited.

The study setting encompassed Newfoundland and Labrador in Canada, with all laboratory-based procedures conducted in the Nutrition & Lifestyle Lab at Memorial University's St. John's Campus. The first participant was recruited on October 6, 2022. Notably, nine participants did not respond after receiving study information and eligibility questions, and three were found ineligible based on the inclusion/exclusion criteria. Four interested and eligible participants failed to confirm a lab visit, and one participant, though initially coming to the lab, later declined to wear the monitoring device consistently and was not included. Furthermore, four participants were interested and eligible but located outside St. John's. Refer to figure 3.1 for detailed participant recruitment program.

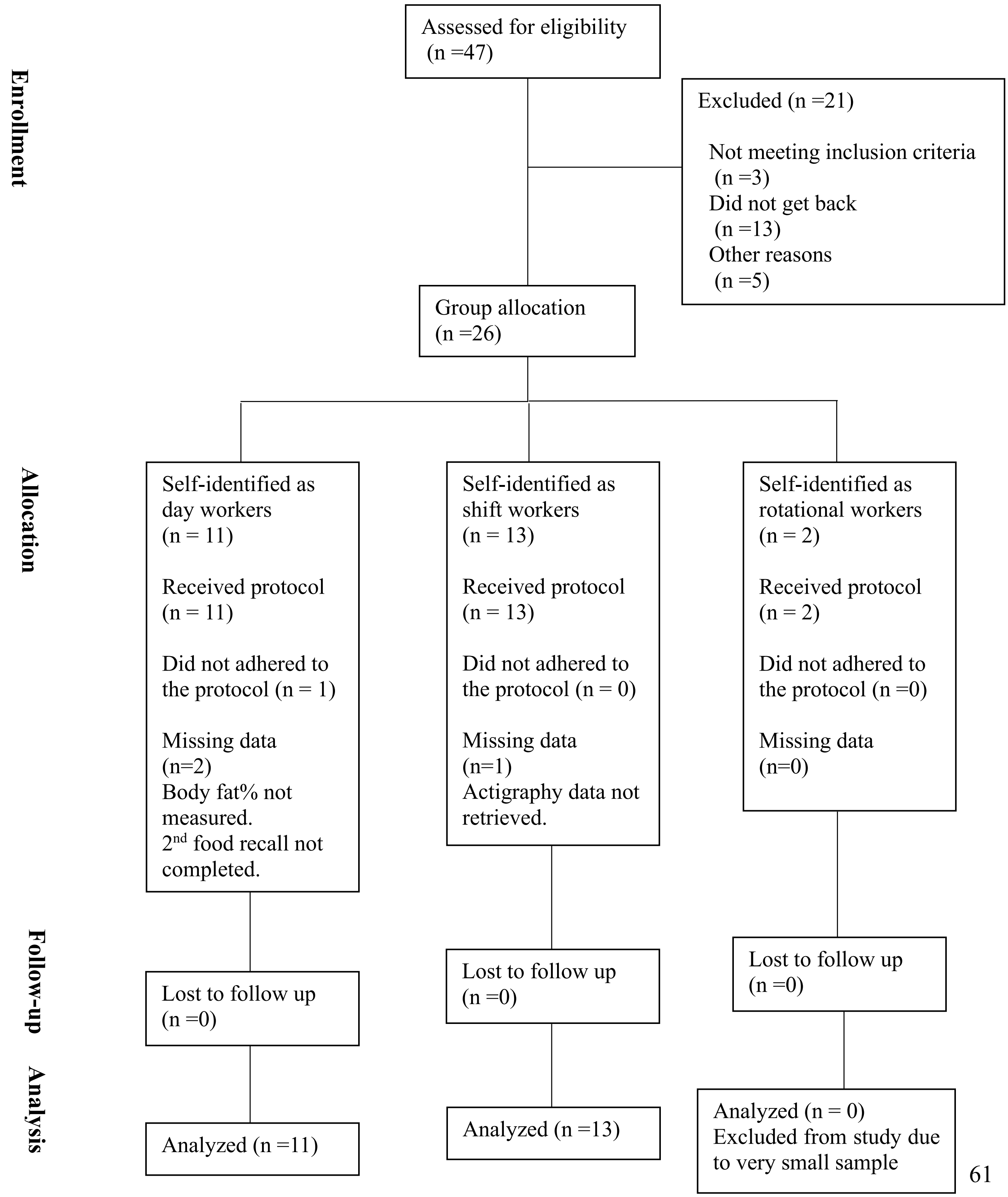


Figure 3.1. CONSORT diagram showing flow of participants through each stage of the study.

3.2 Description of the Study Population

For the 24 participants (11 day, 13 shift workers), statistically significant differences were found between the relationship status of both the groups and annual household income. Majority of the day workers were married/living with partner with no single day worker while some of the shift wokers were married/living with partner and a few were single. Secondly, there were no day workers with income less than $50,000/annum and many with family income between $100,000-$200,000 while there were four shift workers with annual household income between $30,000-$50,000.

Table 3.1. Baseline characteristics of all participants, by groups.

Characteristics	Day workers (n=11)	Shift workers (n=13)	p-value
Sex			0.3[a]
Females	7 (63.6%)	10 (76.9%)	
Males	4 (36.4%)	3 (23.1%)	
Age, years	41.7 (6.6)	39.7 (8.7)	0.5
Weight, kg	94.2 (37.1)	83.4 (36.6)	0.4
BMI, kg/m^2	31.5 (10.7)	30.2 (10.1)	0.6
BMI categories			0.4
BMI < 25	3 (27.3%)	5 (38.5%)	
BMI ≥ 25 to < 30	3 (27.3%)	1 (7.7%)	
BMI ≥ 30	5 (45.5%)	7 (53.8%)	
Relationship status			**0.04**
Married/living with partner	10 (90.9%)	8 (61.5%)	
Single	0	5 (38.5%)	
Separated/divorced/widowed	1 (9.1%)	0	
Race/ethnicity			0.1
Caucasian	9 (81.8%)	8 (61.5%)	
Hispanic	1 (9.1%)	1 (7.7%)	
South Asian	0	4 (30.8%)	
Other	1 (9.1%)	0	
Have children			0.5[a]
Yes	7 (63.6%)	9 (69.2%)	
Have disability			0.7[a]
Yes	1 (9.1%)	1 (7.7%)	
Annual household income level			0.08
$30,000 - $50,000	0	4 (36.4%)	
$50,000 - $100,000	4 (40%)	4 (36.4%)	
$100,000 - $200,000	6 (60%)	3 (27.3%)	
Education			0.1[a]
High school/post-secondary	3 (27.3%)	7 (53.8%)	
Undergraduate, graduate, etc.	8 (72.7%)	6 (46.2%)	
Dietary supplement use			0.1[a]
Yes	1 (9.1%)	5 (38.5%)	
Use any medication			0.3[a]
Yes	6 (54.5%)	5 (38.5%)	
Current health problems			0.5[a]
Yes	7 (63.6%)	9 (69.2%)	
Total work experience (years)	22 (9.5)	19.6 (10.1)	0.5
Shift system			0.4
Regular	9 (81.8%)	8 (61.5%)	
Irregular	1 (20%)	4 (30.8%)	
Flexible	1 (9.1%)	1 (7.7%)	

Values are mean (SD) or n (%). Percentages reflect proportion of participants within groups. Frequencies may not sum to the total number of participants due to missing data. p-value is calculated using Fisher's Exact test.

Table 3.2: Questionnaire groups and scores in day workers and shift workers.

Questionnaire	Day Workers (n=11)	Shift Workers (n=13)	p-value
Physical Activity Level (IPAQ)			0.09
Low	1 (9.1%)	0	
Moderate	4 (36.4%)	1 (7.7%)	
High	6 (54.5%)	12 (92.3%)	
PSS Score	14.1 (7.9)	17.7 (12.6)	0.4
Stress Level (PSS)			0.1
Low	8 (72.7%)	6 (46.2%)	
Moderate	2 (22.2%)	7 (53.8%)	
High	1 (9.1%)	0	
Chronotype (MEQ)			0.1
Definitive morning	2 (18.2%)	0	
Moderate morning	2 (18.2%)	3 (23.1%)	
Intermediate	7 (63.6%)	7 (53.8%)	
Moderate evening	0	3 (23.1%)	
Definitive evening	0	0	
MEQ Score	56.5 (9.7)	49 (10.3)	0.08

Values are mean (SD) or n (%). Percentages reflect proportion of participants within groups. IPAQ- International Physical Activity Questionnaire, PSS- Perceived Stress Scale, MEQ - Morningness and Eveningness Questionnaire.

3.3 Primary Outcome: Feasibility Study

The results and evaluation of this pilot study is done in a narrative form as shown below in the table 3.3. Overall, before conducting the clinical trial, some factors need to be modified as explained below.

Table 3.3: Aspects of feasibility that can be examined with a pilot study:

Study Component	Feasibility
Access to participants	a) Study was advertised using both direct and indirect ways. University Newsline, emailing potential organizations and work unions, radio. b) Email was the main source of contact. Phone number was not given for contact. c) In total sweat study email account (main source of contact) received 41 interest emails. d) Personal MUN email account received 6 interest emails. e) 9 participants did not reply back after sending first email with study and consent information. f) 1 participant came to lab but later denied for wearing the watch all the time due to work policy constraints, was not included. Participant was a flight attendant and was already wearing a watch which was mandatory to wear during the flight by the airline and was also not allowed to wear another watch. Participant was sent an information sheet before coming to lab which mentioned that wearing actigraphy is a requirement of this study.
Barriers to participation	a) There was an exclusion/inclusion criterion for participation to reduce the effect of confounders. 3 participants were ineligible for the study according to the set inclusion/exclusion criteria. b) For some participants, timing was an issue. Though we provided flexibility by giving options of coming to lab on weekends and during evening. 4 participants were interested and eligible but never confirmed time for visiting the lab. c) There was no monetary compensation in the study which would have affected the interest to participation. d) This study was limited to people residing in St. John's, Newfoundland. This was done to avoid loss of actigraphy data while shipping the watch and maintaining accuracy of data while doing self-anthropometric measurements. 4 participants were interested but were located out of St. John's.
Recruitment	a) The initial study plan had proposal for recruiting 15 daytime workers, 15 shift workers, and 15 rotational workers. At the end of the data collection period there were 11 daytime workers, 13 shift workers and 2 rotational workers. Data of 2 rotational workers were not included during statistical analysis to improve test significance.

	b)	Recruitment process was done in two phases: a. From October, 2022 to December, 2022 = 13 participants were recruited. b. From February, 2023 to March 2023 = 13 participants were recruited. c. Recruitment rates per week was approximately 1-2 participants/week = 8 participants in one month. The numbers were uneven and details are as follow: i. October, 2022 = 6 participants ii. November, 2022 = 5 participants iii. December, 2022 = 2 participants iv. February, 2023 = 10 participants v. March, 2023 = 3 participants
Selection bias	a)	This study had self-selection bias, since participants choose whether to or not to participate. Convenience sampling was done to increase the participation in pilot study. Participants confirmed their schedule verbally and were allocated the group.
	b)	This study had more females (17) than men (7).
Adherence to protocol	a)	There was not 100% adherence to protocol.
	b)	One participant forgot to fill in the sleep diary during the tracking period. Participant had to wear the actigraphy watch for another 1 week so that the sleep diary could match with the actigraphy data.
	c)	One participant came to lab, after explaining the study process, participant denied wearing the actigraphy watch all the time due to workplace restrictions. This participant was not included in the study as this was the main requirement of this study. Before coming to the lab, participant was provided with all the study information and consent form on the email.
Access to lab	a)	Participants were required to come to the Nutrition and Lifestyle lab, located in the Alexander Murray Building, Memorial University.
	b)	For some participants it was hard to locate the lab and the building, directions were provided on email.
	c)	Participants found it hard to locate the parking since the building had two levels of parking with different entrances and one reserved for staff. Participants were provided with the option of reimbursement for parking.

Participant retention	a) In particular, the most impressive accomplishment was the full retention of all 24 participants who agreed to participate throughout the period of the study. b) The participation retention was 100% for this study, demonstrating the research's capacity to keep participants' interest and dedication throughout the study duration. c) Our participant engagement and communication strategies were effective.
Data completeness	a) One participant did not complete the 2nd online 24-hour food recall, multiple reminder emails were sent. b) For one participant body fat % was not measured since the device showed error, after trying few times as well. c) For one participant weight (kg) and body fat (%) was self-reported, since they were above the measuring limit of the device HBF-514C body composition monitor manufactured by Omron Healthcare used in this study. d) For one participant, actigraphy data were not recorded. On the first visit, watch was given to the participant fully charged and functional. However, on return the watch did not work and was not able to retrieve data.
Problems encountered with assessment procedure.	a) It was hard to get participants to complete both the ASA24 food recalls. A brief overview was given on the first visit on navigating the website. Some participants did not entirely report their food items which was visible from self-reported calorie intake. Many participants forgot to click complete at the end, in spite of entering all the food items. ASA24 showed those recalls as incomplete. Participants were sent constant reminders and participants reported it being time consuming. b) Many participants complimented the addition of portion size photos in ASA24, saying that it made it much easier to record portion sizes and improved the accuracy of dietary evaluations c) The work schedule questionnaire was not appropriate for day workers, as most of the questions were based on shift systems. d) Questions in PSQI were difficult to answer for people with changing shifts as they don't have a fix answer for questions like 'what time did you go to bed?' it depends on the shift for example three times a week they are doing night shift then the bedtime is 7 am in the morning for 2 days a week they are doing day shift then the bed time is 11 pm. e) Using the IPAQ was easy for participants.

Data entry and analysis	a)	No problem occurred during calculating scores and analyzing questionnaires. No problem occurred during data entry.
	b)	In the final study, a statistician should be involved with data analysis.
Main outcome	a)	This study should be modified before the main study can be conducted.

3.4 Secondary Outcomes: Pilot Study

3.4.1 Dietary intakes

23 participants completed both the 24-hour food recalls in the ASA24. One participant completed only one recall. No statistically significant differences were found while comparing nutrition variables between groups. Overall, daytime workers consumed 41.3% of their energy as carbohydrates, 41.0% as fat and 17.7% as protein while shift workers consumed 45.1% of their energy as carbohydrates, 37.8% as fat and 17.1% as protein. Overall, mean HEFI-2019 score was 39.9 for day workers and 44.7 for shift workers. In this study sample, there were no under-reporters for self-reported energy intake. We had significant number of over-reporters. HEFI-2019 score was statistically lower in day workers as compared to shift workers for food recall 1 (higher score means better diet quality). There is no significant variation at the level of individual components of HEFI-2019 in both the groups as shown in figure 3.2. None of the under- and over-reporters were excluded in this pilot study due to its small sample size and exploratory nature.

Table 3.4. Total daily dietary macronutrient intakes in day and shift workers.

Nutrition variable	Day workers	Shift workers	p-value
Energy (kcal)	1935.4 (277.2)	1701.8 (568.4)	0.2
Carbohydrate			
g/day	196.7 (82.6)	197.8 (76.7)	0.9
% total energy	40.4 (14.8)	45.6 (10)	0.3
Sugar			
Added sugar (g)	10.3 (6.4)	10.4 (6.3)	0.9
Total sugar (g)	65.8 (41.1)	73.1 (31.8)	0.6
Fibre (g)	16.8 (6.0)	14.7 (6.3)	0.4
Total Fat			
g/day	86.7 (24.4)	73.8 (31.3)	0.2
% total energy	40.2 (9.7)	39.5 (11.6)	0.8
Protein			
g/day	84.2 (35.4)	75.0 (22.5)	0.4
% total energy	17.5 (7.2)	19.4 (10.1)	0.6

Intakes were assessed with the ASA24 dietary assessment tool. Data are expressed as mean (SD). Comparison between two groups by independent samples t-tests.

Table 3.5: Plausibility of self-reported energy intakes.

Characteristics	Over-reporters	Plausible-reporters	Under-reporters	p-value
Work type				0.2[a]
Day workers	4 (36.4%)	7 (63.6%)	0	
Shift workers	8 (61.5%)	5 (38.5%)	0	
Sex				0.1[a]
Females	10 (58.8%)	7 (41.2%)	0	
Males	2 (28.6%)	5 (71.4%)	0	
BMI (kg/m^2)				0.005[a]
Below 25	1 (11.1%)	8 (88.9%)	0	
25 or above	11 (73.3%)	4 (26.7%)	0	

[a] P-values were calculated using the Fisher's Exact test. Values are n (%). The percentages add up to 100% within the columns. The plausibility of reported energy intakes was estimated using the method by (130)

Table 3.6. Estimated means of Healthy Eating Food Index (HEFI-2019) component and total scores in both the groups.

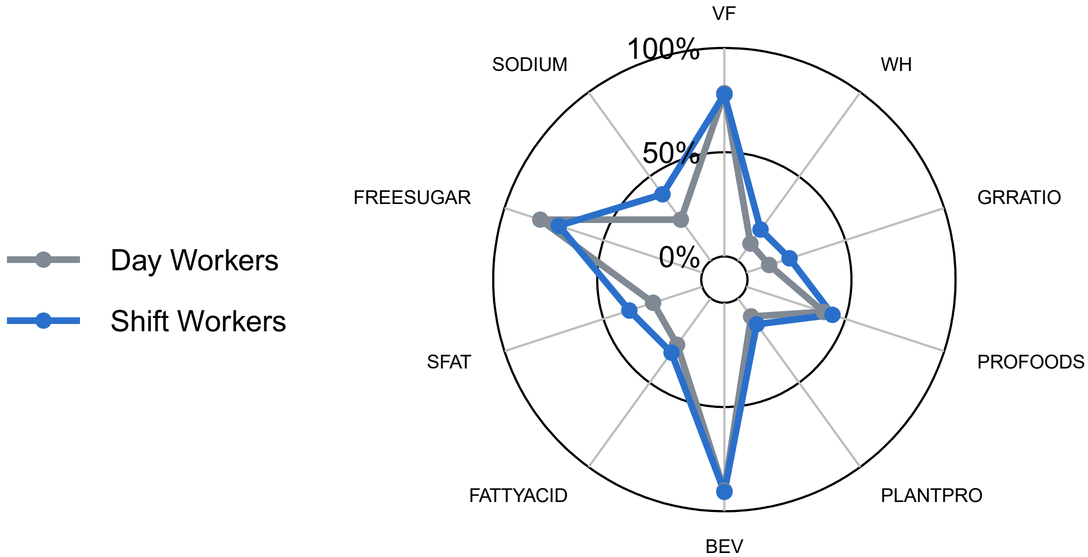
HEFI-2019 components	**Day workers**	**Shift workers**	**p-value**
Vegetables and fruits (/20)	7.8 (3.7)	7.7 (4.0)	0.9
Whole-grain foods (/5)	1.0 (1.2)	1.8 (1.6)	0.1
Grain foods ratio (/5)	1.1 (1.4)	1.2 (1.6)	0.1
Protein foods (/5)	3.9 (1.1)	4.3 (0.7)	0.2
Plant-based protein foods (/5)	1.0 (1.6)	1.5 (1.6)	0.4
Beverages (/10)	9.0 (1.0)	9.0 (1.1)	0.8
Fatty acids ratio (/5)	2.7 (1.2)	3.2 (0.8)	0.3
Saturated fats (/5)	2.4 (1.9)	3.6 (1.3)	0.1
Free sugars (/10)	8.1 (2.4)	7.5 (2.7)	0.3
Sodium (/10)	2.4 (1.8)	3.9 (2.6)	0.1
Total Score (/80)	39.9 (6.2)	44.7 (6.6)	0.08

Values are mean (standard deviation) scores. The HEFI-2019 was calculated based on two 24-hour food recalls collected using ASA24.

Table 3.7. Estimated means of Healthy Eating Food Index (HEFI-2019) scores by recalls in both the groups.

HEFI-2019 scores	**Day workers**	**Shift workers**	**p-value**
Total Score (/50)	39.9 (6.2)	44.7 (6.6)	0.08
Recall 1 score (/50)	39.9 (5.4)	45.1 (6.2)	**0.04**
Recall 2 score (/50)	40.7(11.0)	44.7 (9.8)	0.3

Values are mean (SD) scores. The HEFI-2019 was calculated based on two 24-hour food recalls collected using ASA24.



VF - Vegetable and Fruits, **WH** - Whole Grains, **GRRATIO** - Grain foods ratio, **PROFOODS** - Protein foods, **PLANTPRO** - Plant-based protein foods, **BEV** - Beverages, **FATTYACID** - Fatty Acid Ratio, **SFAT**- Saturated Fats.

Figure 3.2: Radar plot depicting mean HEFI-2019 component scores for daytime and shift workers.

3.4.2 Sleep outcome

All the participants completed the sleep diary (CSD) and PSQI. Actigraphy data were missing for one participant. Day workers had more reported good sleep quality than shift workers calculated using the PSQI global score (refer to table 3.8). All of the day workers had self-reported sleep onset latency less than 15 minutes while 61.5% shift workers had self-reported sleep onset latency more than 15 minutes. Day workers spent more time in bed (includes all the time from going to bed till getting out of bed) than shift workers on weekends. We did not see any statistically significant differences in other sleep parameters (refer to table 3.8 and 3.9).

Table 3.8. Self-reported sleep quality and quantity in day and shift workers.

Sleep parameters	Instrument	Day workers	Shift workers	p-value
Number of awakenings	CSD	1 (1.1)	1.8 (1.6)	0.1
WASO, hh:mm	CSD	0:09 (0:09)	0:21 (0:22)	0.1
Sleep efficiency, %	PSQI	87.5 (7.7)	84.3 (11.97)	0.4
Sleep duration, hh:mm	PSQI	7 (0:37)	6:30 (1:05)	0.1
Use of sleep medication	PSQI			0.2[a]
Not in the last month		9 (81.8%)	8 (61.5%)	
In the last week		2 (18.2%)	5 (38.5%)	
Sleep onset latency, mins	PSQI			**0.03**[a]
≤15 minutes		11 (100%)	8 (61.5%)	
>15 minutes		0	5 (38.5%)	
Global PSQI Score	PSQI			**0.04**[a]
Good sleep quality		9 (81.88%)	5 (38.5%)	
Poor sleep quality		2 (18.2%)	8 (61.5%)	

[a] P-value was calculated using the Fisher's exact test.
Values are mean (SD) or n (%). Percentages reflect proportion of participants within groups.

Table 3.9. Objective (actigraphy) sleep parameters during the study period.

Sleep parameters	Day workers	Shift workers	p-value
Time in bed, hh:mm			
AD	8 (0:58)	7:38 (1:20)	0.4
WD	7:33 (0:43)	7:42 (1:24)	0.7
WE	9:08 (2:18)	7:22 (1:41)	**0.04**
WASO, hh:mm	0:54 (0:22)	1 (0:30)	0.5
Number of awakenings	14.6 (3.3)	15.3 (4.4)	0.6
Sleep efficiency, %	88.6 (4.3)	87 (6.4)	0.4
Sleep duration, hh:mm	6:54 (0:33)	6:36 (1:17)	0.4
SRI			
AD	57.7 (16.8)	48.7 (24.9)	0.3
WD	59.9 (20.3)	41.7 (29.6)	0.1
WE	54.1 (15.3)	53.6 (20.9)	0.9

Values are mean (SD).
AD= All days, WD= Weekdays, WE= Weekends, SRI = Sleep Regularity Index

3.4.3 Multivariable association between food intake and sleep parameters

Correlation analysis investigated associations between continuous variables of sleep and dietary intake, revealing significant Pearson correlation results among specific sleep parameters and food intake across the entire sample.Subsequently, an adjusted regression model was constructed using linear regression results to explore the impact of food intake on both the quantity and quality of sleep. The model incorporated significant predictors and potential confounding variables, adjusting for factors like age, sex, income, relationship status, children, comorbidities, and sleep medication. Calculating odds ratios (OR) with 95% confidence intervals aimed to provide a nuanced understanding of relationships, considering potential sources of bias.

Unadjusted Model

Table 3.10. Correlation between daily dietary intakes and objective sleep parameters (using actigraphy) on full sample.

Sleep Parameters		Food Intake						
Variable		kcal	Carbs	Protein	Added sugar	Total Sugar	Fibre	Total Fat
Time in bed	r	-0.19	-0.26	0.21	-0.12	-0.26	-0.22	-0.05
	p	0.38	0.22	0.32	0.55	0.21	0.23	0.79
Time in bed, WD	r	-0.16	-0.21	0.19	-0.10	-0.18	-0.20	-0.47
	p	0.44	0.33	0.35	0.62	0.39	0.34	0.83
Time in bed, WE	r	-0.24	-0.20	0.01	-0.22	-0.31	-0.09	-0.17
	p	0.26	0.36	0.95	0.30	0.13	0.68	0.43
Sleep duration	r	-0.13	-0.21	0.24	-0.21	-0.29	-0.03	-0.03
	p	0.54	0.31	0.26	0.32	0.17	0.86	0.87
Sleep Efficiency	r	0.13	-0.03	0.12	-0.26	-0.07	0.20	0.19
	p	0.53	0.88	0.56	0.22	0.73	0.34	0.37
No. of awakenings	r	-0.0	0.22	-0.17	0.25	0.15	0.15	-0.11
	p	0.97	0.31	0.43	0.24	0.47	0.49	0.61
WASO	r	-0.23	-0.05	-0.77	0.17	0.01	-0.24	-0.28
	p	0.28	0.82	0.72	0.43	0.96	0.26	0.19
SRI	r	-0.25	0.04	-0.05	-0.30	-0.30	0.21	-0.38
	p	0.23	0.83	0.80	0.16	0.16	0.31	0.08
SRI, WD	r	-0.23	0.02	-0.10	-0.32	-0.27	0.23	-0.35
	p	0.27	0.90	0.64	0.14	0.20	0.28	0.10
SRI, WE	r	-0.37	-0.14	0.14	-0.37	**-0.44***	-0.02	-0.39
	p	0.07	0.51	0.51	0.07	**0.03**	0.92	0.05

r represents Pearson correlation coefficient.
* Correlation is significant at 0.05 level.
WD = Weekdays, WE = Weekends, PSQI = Pittsburgh Sleep Quality Index, WASO = Wake up after sleep onset, SRI = Sleep Regularity Index.

Table 3.11. Correlation between daily dietary intakes and sleep parameters (using questionnaires) on full sample.

Instrument	Sleep Parameters		Food Intake						
Questionnaire	**Variable**		**Kcal**	**Carbs**	**Protein**	**Added Sugar**	**Total Sugar**	**Fibre**	**Total Fat**
PSQI	**Sleep duration**	r	-0.27	-0.15	-0.07	-0.29	-0.37	-0.33	-0.09
		p	0.19	0.47	0.73	0.15	0.07	0.87	0.64
	Sleep Efficiency	r	0.22	**0.47***	-0.16	0.05	0.27	**0.46***	-0.07
		p	0.29	**0.02**	0.45	0.78	0.19	**0.02**	0.71
	PSQI Score	r	-0.27	-0.14	-0.20	0.09	0.04	-0.27	-0.17
		p	0.19	0.48	0.32	0.65	0.81	0.19	0.40
CSD	**No. of awakenings**	r	-0.10	0.16	-0.03	-0.07	0.16	0.06	-0.19
		P	0.64	0.43	0.86	0.73	0.45	0.76	0.35
	WASO	r	-0.33	-0.11	-0.10	0.05	0.09	-0.20	-0.34
		p	0.11	0.60	0.62	0.79	0.66	0.33	0.09

r represents Pearson correlation coefficient.
* Correlation is significant at 0.05 level.
CSD = Consensus Sleep Diary, WASO = Wake up after sleep onset.

Adjusted Model

A multiple linear regression analysis that includes all data points was employed to investigate the relationship between sleep duration and dietary intake with including covariates including age, sex, income, relationship status, children, comorbidities, use of sleep medication. A separate analysis was performed for each of the covariates to assess their individual effects of the subjective sleep efficiency and sleep regularity index on weekends on carbohydrate, fibre and total sugar. Summaries of the regression coefficients, standard errors, and level of significance are shown in table 3.12, table 3.13, table 3.14.

Table 3.12: Linear regression results for carbohydrate intake predicted by age, sex, income, use of medication, children, comorbidities and relationship status.

Variable	Coefficient	Std. Error	t-value	P-value
Intercept	217.80	368.11	0.59	0.5
Subjective Sleep Efficiency	0.92	1.97	0.46	0.6
Age	-0.82	2.99	-0.27	0.7
Sex	30.46	50.98	0.59	0.5
Income	21.92	29.20	0.75	0.4
Use of medication	-77.29	42.33	-1.82	0.09
Children	5.48	44.43	0.12	0.9
Comorbidities	-19.83	47.95	-0.41	0.6
Relationship status	-12.84	50.16	-0.25	0.8

Table 3.13: Linear regression results for fibre predicted by age, sex, income, use of medication, children, comorbidities and relationship status.

Variable	Coefficient	Std. Error	t-value	P-value
Intercept	-3.71	19.72	-0.18	0.8
Subjective Sleep Efficiency	0.16	0.10	1.52	0.1
Age	0.03	0.16	0.23	0.8
Sex	6.86	2.73	2.51	**0.02**
Income	1.42	1.56	0.91	0.38
Use of medication	-6.76	2.26	-2.98	**0.01**
Children	3.80	2.38	1.60	0.13
Comorbidities	-1.33	2.56	-0.51	0.61
Relationship status	-0.48	2.68	-0.18	0.86

Significance levels: P-values in bold were statistically significant at the 0.05 level.

The regression analysis, with fibre intake as the dependent variable, reveals two noteworthy findings. Sex (Beta = 0.465, p = 0.027) and medication use (Beta = -0.532, p = 0.011) significantly influence fibre consumption, suggesting that there could be a possibility of difference in fibre intake in both the sexes and certain medications may impact dietary fibre intake. However, other variables, including sleep efficiency subjective, age, income, kids, comorbidities, and relationship, did not demonstrate statistically significant associations with fibre intake in this analysis.

Table 3.14: Linear regression results for total sugar predicted by age, sex, income, use of medication, children, comorbidities and relationship status.

Variable	Coefficient	Std. Error	t-value	P-value
Intercept	101.24	142.42	0.71	0.4
Sleep Regularity Index, WE	-0.71	0.64	-1.11	0.2
Age	-0.71	1.68	-0.42	0.6
Sex	0.60	25.78	0.02	0.9
Income	14.35	17.73	0.80	0.4
Use of medication	-21.43	23.78	-0.90	0.3
Children	-6.17	22.94	-0.26	0.7
Comorbidities	6.61	27.36	0.24	0.8
Relationship status	29.02	35.11	0.82	0.4

3.4.4 Physical activity

Self-reported data were statistically different between the groups (refer to table 3.15). All the parameters of IPAQ except Leisure MET-mins/week and Domestic-garden MET-mins/week were higher for shift workers than day workers ($p<0.05$). Day workers spent more time in sitting which can also be due to job requirements. Self-reported data did not align with the actigraphy data. The objective PA data were less than self-reported data.

Table 3.15: Self-reported physical activity and sedentary behaviour in day and shift workers.

Physical activity parameters	Day workers	Shift workers	p-value
Physical Activity level			0.09
1. Low	1	0	
2. Moderate	4	1	
3. High	6	12	
Total PA MET-Mins/week	4561.8 (4490.9)	15016.7 (9292.7)	**0.002**
PA categories			
1. MPA MET-mins/week	2154 (2586.9)	5955 (4791.3)	**0.02**
2. VPA MET-mins/week	1527.2 (1816)	4486.1 (3829.2)	**0.02**
3. MVPA MET-mins/week	3681.3 (3885.4)	10441.1 (7274.9)	**0.005**
PA based on domain			
1. Leisure MET-mins/week	2176.3 (2629.5)	1589.6 (2371.4)	0.57
2. Domestic-garden MET-mins/week	1670.4 (1993.3)	3065.7 (3513)	0.23
3. Transport MET-mins/week	270 (460.3)	1469 (1656.1)	**<0.001**
4. Work MET-mins/week	445 (1066.7)	8989.1 (5404.3)	**<0.001**
Walking MET-mins/week	880 (797.8)	4575.5 (2987.8)	**<0.001**
PA duration			
1. MPA mins/week	80 (91.6)	213 (168.1)	**0.02**
2. VPA mins/week	27.2 (32.4)	80.1 (68.3)	**0.02**
3. MVPA mins/week	107.3 (111)	293.1 (205.1)	**0.01**
Average sitting mins/day	410.3 (135)	234.3 (155.1)	**0.008**

Values are mean (SD). Data is collected using the IPAQ during the 2nd visit to the lab. PA = Physical Activity, MET = Metabolic Equivalents, MPA = Moderate Physical Activity, VPA = Vigorous Physical Activity, MVPA = Moderate to Vigorous Physical Activity.

Table 3.16: Objective (actigraphy) physical activity parameters in day and shift workers.

Physical activity parameters	**Day workers**	**Shift workers**	**p-value**
PA duration			
1. MPA mins/week	117.5 (68.8)	122.8 (49.3)	0.8
2. VPA mins/week	4.9 (3.8)	3.1 (2.6)	0.2
3. MVPA mins/week	27. 4 (38.8)	10.4 (13)	0.1

Values are mean (SD). MPA = Moderate Physical Activity, VPA = Vigorous Physical Activity, MVPA = Moderate or Vigorous Physical Activity. Data were extracted from GENEActiv PC software, V1.1 using GGIR R package.

3.4.5 Multivariable association between food intake and physical activity

Correlation analysis investigated associations between continuous variables of sleep and dietary intake, revealing significant Pearson correlation results among specific physical activity parameters and food intake across the entire sample (refer to tables 3.17 and 3.18). Subsequently, an adjusted regression model was constructed using linear regression results to explore the impact of food intake on both the subjective and objective physical activity parameters. The model incorporated potential confounding variables, adjusting for factors like age, sex, income, relationship status, children, comorbidities, and sleep medication (refer to table 3.19, 3.20 and 3.21). Calculating odds ratios (OR) with 95% confidence intervals aimed to provide a nuanced understanding of relationships, considering potential sources of bias.

Unadjusted Model

Table 3.17: Correlation between daily dietary intakes and subjective physical activity parameters (using IPAQ) on full sample.

Physical Activity		Food Intake						
Variable		**Kcal**	**Carbs**	**Protein**	**Added sugar**	**Total Sugar**	**Fibre**	**Total Fat**
MPA mins	*r*	-0.45*	-0.39	0.01	-0.17	-0.12	-0.37	-0.20
	p	0.02	0.05	0.93	0.42	0.54	0.07	0.33
VPA mins	r	-0.30	-0.23	0.02	-0.06	-0.03	-0.21	-0.17
	p	0.15	0.26	0.90	0.77	0.86	0.30	0.42
MVPA mins	r	-0.45*	-0.39	0.02	-0.15	-0.11	-0.36	-0.21
	p	0.02	0.06	0.92	0.47	0.59	0.08	0.30
MPA MET-mins/week	r	-0.46*	-0.40	-002	-0.17	-0.12	-0.35	-0.21
	p	0.02	0.05	0.90	0.41	0.55	0.08	0.32
VPA MET-mins/week	r	-0.30	-0.23	0.02	-0.06	-0.03	-0.21	-0.17
	p	0.15	0.26	0.90	0.77	0.86	0.30	0.42
MVPA MET-mins/week	r	-0.44*	-0.37	0.02	-0.14	-0.10	-0.33	-0.22
	p	0.02	0.07	0.89	0.50	0.64	0.10	0.30
Total PA MET-Mins/week	r	-0.52**	-0.41*	0.00	-0.15	-0.14	-0.37	-0.27
	p	0.008	0.04	0.98	0.47	0.51	0.07	0.18
Leisure MET-mins/week	r	-0.10	-0.32	0.38	-0.26	-0.26	-0.11	0.01
	p	0.62	0.11	0.06	0.21	0.21	0.59	0.94
Domestic-garden MET-mins/week	r	-0.37	-0.39	0.11	-0.23	-0.15	-0.31	-0.15
	p	0.06	0.05	0.59	0.27	0.47	0.13	0.47
Transport MET-mins/week	r	-0.54**	-0.39	-0.05	-0.10	-0.10	-0.28	-0.25
	p	0.006	0.05	0.80	0.62	0.61	0.17	0.23
Work MET-mins/week	r	-0.46*	-0.21	-0.20	0.01	0.004	-0.30	-0.30
	p	0.02	0.31	0.33	0.94	0.98	0.15	0.14
Walking MET-mins/week	r	-0.60**	-0.42*	-0.05	-0.14	-0.20	-0.37	-0.35
	p	0.002	0.04	0.80	0.50	0.33	0.07	0.08
Average sitting mins/day	r	0.04	-0.18	0.22	-0.26	-0.18	-0.79	0.16
	p	0.85	0.39	0.30	0.21	0.37	0.71	0.45

r represents Pearson correlation coefficient.
* Correlation is significant at 0.05 level.
** Correlation is significant at 0.01 level.
MPA = Moderate Physical Activity, VPA = Vigorous Physical Activity, MVPA = Moderate to vigorous physical activity, PA = Physical activity, MET = Metabolic Equivalents.

Table 3.18: Correlation between daily dietary intakes and objective physical activity parameters (using actigraphy) on full sample.

Physical Activity Variable		Food Intake						
		Kcal	**Carbs**	**Protein**	**Added sugar**	**Total Sugar**	**Fibre**	**Total Fat**
MPA mins	r	0.01	0.29	-0.09	-0.13	-0.00	0.40	-0.25
	p	0.93	0.17	0.66	0.55	0.97	0.05	0.23
VPA mins	r	0.18	0.21	0.06	-0.20	-0.00	0.34	0.03
	p	0.39	0.32	0.75	0.35	0.97	0.10	0.86
MVPA min	r	0.15	0.33	-0.08	-0.06	0.07	0.46*	-0.08
	p	0.47	0.12	0.69	0.75	0.74	0.02	0.68

r represents Pearson correlation coefficient.
* Correlation is significant at 0.05 level.
** Correlation is significant at 0.01 level.
MPA = Moderate Physical Activity, VPA = Vigorous Physical Activity, MVPA = Moderate to vigorous physical activity.

Adjusted Model

A multiple linear regression analysis that includes all data points was employed to investigate the relationship between physical activity and dietary intake with considering covariates including age, sex, income, relationship status, children, comorbidities, use of sleep medication. A separate analysis was performed using a multi-covariate model to assess their individual effects on the kcal, carbohydrates and fibre. Summaries of the regression coefficients, standard errors, and level of significance are shown in table 3.19, table 3.20, table 3.21.

Table 3.19: Linear regression results for kcal predicted by age, sex, income, use of medication, children, comorbidities and relationship status.

Variable	Coefficient	Std. Error	t-value	P-value
Intercept	1614.98	2418.72	0.66	0.5
MPA mins (IPAQ)	5.47	9.25	0.59	0.5
MVPA mins (IPAQ)	-0.57	0.71	-0.81	0.4
MPA MET-mins/week	-0.35	0.34	-1.01	0.3
MVPA MET- mins/week	0.12	0.07	1.72	0.1
Transport MET- mins/week	-0.06	0.23	-0.26	0.7
Work MET- mins/week	0.02	0.04	0.48	0.6
Walking MET- mins/week	-0.14	0.12	-1.18	0.2
Age	16.24	20.10	0.808	0.4
Gender	317.28	368.51	0.861	0.4
Income	124.27	266.66	0.466	0.6
Use of medication	-483.06	290.29	-1.664	0.1
Children	-120.16	309.16	-0.389	0.7
Comorbidities	-171.27	260.65	-0.657	0.5
Relationship status	70.75	472.59	0.150	0.8

Table 3.20: Linear regression results for carbohydrates predicted by age, sex, income, use of medication, children, comorbidities and relationship status.

Variable	**Coefficient**	**Std. Error**	**t-value**	**P-value**
Intercept	325.80	269.88	1.20	0.2
Total PA MET-Mins/week	0.00	.00	0.34	0.7
Walking MET-mins/week	-0.01	0.01	-0.70	0.4
Age	-0.40	3.46	-0.11	0.9
Gender	21.32	51.78	0.41	0.6
Income	9.0	34.19	0.26	0.7
Use of medication	-81.18	48.80	-1.66	0.1
Children	11.58	46.72	0.24	0.8
Comorbidities	-28.99	50.81	-0.57	0.5
Relationship	2.00	58.16	0.03	0.9

Table 3.21: Linear regression results for fibre predicted by age, sex, income, use of medication, children, comorbidities and relationship status.

Variable	Coefficient	Std. Error	t-value	P-value
Intercept	15.257	15.467	0.986	0.3
MVPA mins (Actigraphy)	0.037	0.040	0.932	0.3
Age	-0.093	0.177	-0.522	0.6
Gender	5.667	2.963	1.912	0.08
Income	1.654	1.761	0.939	0.3
Use of medication	-6.684	2.704	-2.472	**0.03**
Children	3.131	2.621	1.195	0.2
Comorbidities	-1.695	2.899	-0.584	0.5
Relationship	0.771	3.385	0.228	0.8

Significance levels: P-values in bold were statistically significant at less than 0.05 level.

In this regression analysis, with fibre intake as the dependent variable, one finding was noteworthy. Medication use (Beta = -0.531, p = 0.031) show trends towards significance, suggesting that certain medications may influence dietary fibre intake. However, none of the variables, including MVPA (Moderate to Vigorous Physical Activity) minutes, age, income, children in the home, comorbidities, and relationship, demonstrated statistically significant associations with fibre intake in this analysis.

3.5 Chronotype and Stress

We found statistically significant differences between the stress score calculated using Perceived Stress Scale among chronotype groups determined using Morning and Eveningness Quesstionnaire by one-way ANOVA (p=0.005). A Tukey post hoc test revealed that the stress score was statistically significantly lower in participants with morning chronotype (10.1 ± 3.1, p = 0.004) and with intermediate chronotype (15.6 ± 8.1, p = 0.01) compared with participants with evening chronotype (32.3 ± 18.1). There was no significant difference between participants with morning and intermediate chronotype (p = 0.37). A higher score on PSS means higher stress levels. The standard deviation was large in stress score of people with evening chronotype and number of participants werenot same in each category of chronotype, this area needs to be explored more.

Correlation analysis investigated associations between continuous variables of sleep and dietary intake (tables 3.10 and 3.11); physical activity and dietary intake (tables 3.17 and 3.18) were performedas explained in section 3.4.5 and 3.4.5. Subsequently, another adjusted regression model was constructed using correlation results to explore the impact of food intake on both the subjective and objective physical activity and sleep parameters separately. This model incorporated potential confounding variables including scores of PSS and MEQ. Multiple regression models were conducted, results were significant only in few correlations as shown below:

Table 3.22: Linear regression results for fibre predicted by chronotype and stress levels.

Variable	Coefficient	Std. Error	t-value	P-value
Intercept	-5.33	10.53	-0.50	0.6
Subjective Sleep Efficiency	0.27	0.12	2.23	**0.03**
Chronotype	-1.91	2.13	-0.89	0.38
Stress Level	0.82	2.32	0.35	0.72

Significance levels: P-values in bold were statistically significant at the 0.05 level.

In this case, the p-value for subjective sleep efficiency (0.03) is less than 0.05, suggesting that it was a statistically significant predictor of Fibre. Overall, the regression model did not provide strong evidence for a significant relationship between the predictor variables stress levels, chronotype, and fibre. However, subjective sleep efficiency appears to have a statistically significant positive effect on fibre.

Table 3.23: Linear regression results for total sugar intake predicted by chronotype and stress levels.

Variable	Coefficient	Std. Error	t-value	P-value
Intercept	87.80	37.15	2.36	0.02
Sleep Regularity Index, WE	-0.81	0.39	-2.07	**0.05**
Chronotype	-7.90	11.61	-0.68	0.50
Stress Level	27.84	12.39	2.24	**0.03**

Significance levels: P-values in bold were statistically significant at the 0.05 level. WE = Weekends

In this case, the p-values for stress level (0.03) and Sleep Regularity Index (SRI) on weekends (0.05), was suggesting that they are statistically significant predictors of sugar. Overall, the regression model provided evidence for a significant relationship between the predictor variables stress levels and SRI (WE) and the dependent variable sugar. Chronotype, however, did not appear to have a significant effect on sugar in this analysis.

Table 3.24: Linear regression results for fibre predicted by chronotype and stress levels.

Variable	Coefficient	Std. Error	t-value	P-value
Intercept	9.89	4.90	2.01	0.05
MVPA mins (Actigraphy)	0.11	0.04	2.42	**0.02**
Chronotype	1.27	2.34	0.54	0.59
Stress Level	1.21	2.31	0.48	0.63

Significance levels: P-values in bold were statistically significant at the 0.05 level.

This regression model suggests that objective MVPA mins collected using actigraphy had a statistically significant positive effect on the Fibre intake while the other predictor variables chronotype and stress level do not have statistically significant effects.

Chapter 4 Discussion

4.1 Overall data collection tools practicality and feasibility of study design

The assessment of the pilot study's feasibility provided valuable insights into the practicality and efficacy of the study design. However, certain challenges emerged, with some participants encountering difficulties aligning with the study requirements. Despite the initial plan to recruit a specific number of participants across distinct worker categories, the actual distribution deviated, showing variations in recruitment rates across different months.

The procedures for collecting participant data were deemed clear and practical. On average, participants spent approximately 10 minutes completing the demographic questionnaire and work schedule questionnaire. The MEQ required 10 minutes, the PSQI took 8 minutes, the IPAQ involved 12 minutes, and the PSS was completed in 5 minutes. Each dietary recall consumed around 30 minutes, and participants reported spending an additional 2 minutes daily on the CSD at home, totaling 14 minutes for the entire sleep diary. The overall participant burden for completing the questionnaires was reported as low, with no participants finding the process overly burdensome.

The Automated Multiple-Pass Method used by the United States Department of Agriculture was the foundation for ASA24, a program created by the National Cancer Institute (NCI). The food brands and restaurant products present in the Canadian food supply market were reflected in the Canadian edition of ASA24. Standardised images included in ASA24, food models, measuring spoons and cups, and a ruler were used to enhance estimates of portion size. The Canadian Nutrient File (2015) and the United States Department of Agriculture's 2011–2012 Food Patterns Equivalents Database, respectively, were used to compute nutrients and food groups. Unlike the commonly used self-report measures such as food diaries or food frequency questionnaires (FFQ), deemed inaccurate and biased (154,155), ASA24 was selected to objectively collect food intake data. In a study comparing different self-reported dietary intake methods, including ASA24, 4-day food records (4DFR), and food-frequency questionnaires, multiple ASA24s and a 4DFR were found to provide the most accurate estimates of absolute dietary intakes for energy, protein, potassium, and sodium (156). The authors also concluded that ASA24 is a feasible means to collect dietary data for nutrition research (156).

Additionally, the wearing of the actigraphy-device for 7 days was well-tolerated and not considered burdensome. The GGIR package conducts two types of sleep analyses: identifying the main Sleep Period Time (SPT) window or the time in bed window (TIB) and discriminating between sleeping and waking. In the realm of accelerometry, the term "sleep" was subject to debate, as accelerometers solely measure the absence of motion. Consequently, GGIR classifies sleep periods as "sustained inactivity bouts" (SIB). Presently, GGIR provides users with the flexibility to identify SIB periods based on various algorithms (151,157–159), the van Hees (2015) algorithm was selected due to its comprehensive approach and alignment with our research objectives. This algorithm has demonstrated accurate sleep and wake detection using accelerometer data. Given our focus on exploring the connections between sleep patterns and eating habits, the van Hees algorithm's ability to identify periods when the z-angle remains static for at least 5 minutes by more than 5 degrees is particularly advantageous. This feature allowed us to precisely and accurately capture sleep and waking episodes. Unlike traditional sleep detection algorithms such as Sadeh (158), Galland (157), and Cole-Kripke (159), which rely on acceleration for sleep estimation, the van Hees algorithm (150) employs advanced mathematical modeling approaches to estimate sleep and wake durations. To enhance sleep-wake categorization accuracy, it considered not only movement but also other parameters such as body position and light exposure. Additionally, it incorporates periodograms, sleep fragmentation indexes, and regression models to capture sleep and wake behaviours. Furthermore, it provided detailed sleep metrics, including sleep onset delay, sleep efficiency, and wake following sleep onset.

The initial descriptive analyses of Morningness and Eveningness questionnaires in this study, showed 2 workers were definitive morning, 5 -moderate morning, 14- intermediate, 3 -moderate evening, and 0 definitive evening, in both the work groups. With this classifying method, we had a small number of people in some groups which made it difficult to compare the groups due to decrease in statistical power. Thus, we divided the subjects into three groups forming one morning group (including both definitive and moderate), intermediate and one evening group (including both definitive and moderate). By conducting this procedure, 7 workers were morning type, 13 intermediate and 3 evening type.

In summary, despite encountering challenges in participant recruitment, protocol adherence, and assessment procedures, the pilot study demonstrated robust participant retention and effective communication strategies. Recommendations for modifying the study design were proposed, underscoring the importance of careful consideration of inclusion/exclusion criteria, participant engagement strategies, and protocol adherence. The study's practicality and feasibility for a larger-scale investigation were affirmed, recognizing the necessity for refinements based on lessons learned during the pilot phase.

4.2 Diet and Nutrient Profile

Overall, no statistically significant differences were observed when comparing nutritional variables between the two groups. These findings align with previous research investigating food intake patterns among shift and day workers (Lauren et al., 2020). Reported amounts of added sugars were significantly low in both the groups as compared to total sugar amounts (table 3.4). The reason behind it was that ASA24 Canada version was based on Health Canada food database and definitions of sugar (free vs added) in different databases. Also, the Canadian version of ASA24 calculates the nutrient profile of reported dietary intake using the Food Patterns Equivalents Database (FPED), Food and Nutrients Database for Dietary Studies (FNDDS), and Canadian Nutrient File (CNF). Plausibility checks for self-reported energy intake revealed no under-reporters in the study sample (see Table 3.5), but significant over-reporters were identified. Examining BMI group-wise classification for plausible reporting, 73.3% of participants in the BMI 25 or more group were over-reporters in this study. A common approach wasto exclude participants who report consuming fewer than 500 and greater than 3500 kcal per day (128), none were excluded in this pilot study due to its small sample size and exploratory nature. When analyzing diet-sleep associations, it was advised not to exclude participants who report their energy intake incorrectly because they may differ systematically from plausible reporters (e.g., sex and BMI) (160). Another reason was that the objective of this study wasto identify the interventional parameters for clinical trials instead of drawing conclusions about the direct impact of shift work on health or testing hypothesis. Nonetheless, assessing the plausibility of energy intake was conducted to identify under- and overreporting and ensure adherence to the study protocol.

The overall HEFI-2019 score for both recalls did not differ significantly between the groups. However, the HEFI-2019 score for food recall 1 was significantly lower in day workers compared to shift workers. This suggests that, if not better, shift workers do not necessarily have a poorer diet than day workers, contrary to the popular notion. In a study with a larger sample size, the mean overall HEFI-2019 score may even be higher in shift workers. Higher the HEFI-2019 score, better adherence to the Canada Food Guide 2019. Moreover, both groups demonstrated higher and equal compliance with the beverage component in the HEFI score (see Table 3.6). Here, "beverages" refer to the ratio of water (plain or carbonated) and unsweetened beverages to total beverages.

The radar plot in Figure 3.2 illustrates various variables contributing to the HEFI-2019 score, comparing both groups' percent compliance with the recommendations for each component. Day workers are represented by the gray line, and shift workers are represented by the blue line. Closer data points to the outer edge of the circle indicate higher values for that specific component. Some differences between the groups include:1) shift workers demonstrated higher compliance with the recommendations for sodium, and saturated fat intake compared to day workers 2) shift workers exhibited higher intake of total whole grain foods than day workers, although overall low for both the groups 3) both groups showed equal consumption of vegetable and fruits, and beverages. A previous study found the estimated mean HEFI-2019 score (/80) was 43.1 (95% CI, 42.7 to 43.6) among Canadians aged 2 years and older (122). In our sample the mean score was 39.9 ± 6.2 for day workers and 44 ± 6.6 for shift workers. Shift workers' diet score was better aligned with the national score. There can be a few reasons why shift workers had better diet quality score 1) shift workers had adverse sleep and physical activity levels compared to day workers, to compensate for that shift workers can indulge in healthy eating practices 2) workers working during night do not have options ofpurchasing food as most of the sellers are closed during night time, that's why shift workers possiblypack heathier food options to bring along. However, these ideas needs to be explored in research studies. There has been no previous has been conducted in Newfoundland working cohort measuring diet quality.

4.2.1 Planning for an intervention trial:

To enhance the efficiency of capturing food habits in a large-scale study, several measures can be implemented and can be used in future studies:

1. **Combining food recalls and records**: As the HEFI-2019 score exhibited statistical differences between the groups for recall 1, and considering the presence of under-reporters, incorporating both food recalls and records (e.g., a 4-day food diary) could enhance precision. Utilizing the ASA24 software allows for this integration. Another approach involves inviting participants to the lab after finishing their final work shift, reporting food intake over the preceding 24-hour period. This in-person method ensures clarity, and research staff can address any uncertainties (161).
2. **Recording timings of food intake**: Including the timing of food intake in future studies can provide a more comprehensive understanding. Previous research suggests that shift workers may have longer eating durations compared to day workers (74). ASA24 enables respondents to report meal timings, allowing for the assignment of clock times to each meal intake.
3. **Hormone measurement** – To obtain a comprehensive picture of food intake and biochemical controls of appetite, measuring hormones regulating hunger and satiety, such as leptin and ghrelin, in both groups is recommended (162).
4. **Population-level analysis methods** – Recognizing the pilot nature of this study, future large-scale research should utilize analysis methods like the population ratio method and NCI method when calculating the HEFI-2019 score. These approaches enable comparisons at the population level (163).
5. **Automated reminders** – Given the need for multiple reminders for most participants to complete the food recall, implementing an automatic reminding

system through emails or text messages can streamline the data collection process. This needs to be implemented further and assessed.

4.3 Sleep Patterns

The descriptive analysis revealed significant disparities in self-reported sleep measures. Our findings are consistent with a cross-sectional study involving 1,593 employed participants (164). That study which used self-reported work characteristics (traditional schedule or shiftwork) and sleep habits, demonstrated that shift workers experienced a higher prevalence of sleep problems. Specifically, compared to those on traditional schedules, shift workers reported higher rates of insomnia symptoms (24% vs. 16%), insufficient sleep (53% vs. 43%), and sleepiness (32% vs. 24%).

In our study, all day workers exhibited a sleep onset latency of ≤15 minutes, with the majority (81.88%) reporting good sleep quality (PSQI global score < 5). In contrast, only 38% of shift workers reported good sleep quality. Notably, self-reported sleep duration differed from actigraphy data. For day workers, mean self-reported duration was 7:00±0:37 h:m, while actigraphy recorded 6:54±0:33 h:m. Similarly, shift workers reported 6:30±1:05 h:m, while actigraphy showed 6:36±1:17 h:m (Table 3.8 and 3.9). This suggests an overestimation of sleep hours byday workers and underestimation of sleep hours by shift workers during self-reporting when compared with actigraphy. Our results are consistent with another study comparing objective and subjective sleep measures for shift workers only. In the ongoing prospective multi-center cohort, the CARDIA study (165), 647 healthy participants were assessed for sleep across two waves, utilizing wrist actigraphy, sleep logs, and self-reported sleep duration. On average, objectively measured sleep was 6 hours, while subjective reports averaged 6.8 hours. Errors-in-variables regression models revealed an increase of 34 minutes in subjective reports for each additional hour of measured sleep. Our model indicated that individuals sleeping 5 hours over-reported by 1.2 hours, while those with 7 hours of sleep over-reported by 0.4 hours. Noteworthy, in our study sleep duration data from the PSQI questionnaire, focusing on the past month, differed from actigraphy data collected over a week. Day workers spent more time in bed on weekends, possibly influenced by occupational factors, as shift workers often work weekends. However, this pattern was not observed in overall and weekday bedtimes.

4.3.1 Relation between sleep and food intake

Pearson correlation test between continuous variables of sleep and food intake on the full sample revealed significant results between several variables as highlighted in Table 3.10 and table 3.11. Between subjective sleep efficiency % and carbohydrates, fibre showed a moderate positive correlation (~ $r = 0.47$, $p = 0.02$). This indicates with increase in subjective sleep efficiency, intake of carbohydrates and fibre tends to increase. Between SRI on weekends and total sugar intake, showed a moderate negative correlation (~ $r = -0.44$, $p = 0.02$). This indicates that with increase in SRI on weekends, there is a possibility of a decrease in total sugar intake. Further analyses between these variables was completed using two linear regression models. First one adjusted for age, gender, income, relationship status, kids, the presence of comorbidities and use of sleep medication. Second one adjusted for stress level scores calculated using PSS questionnaire and chronotype calculated using MEQ. The association between fibre and subjective sleep efficiency was affected by various covariated such as sex (p = 0.02), use of medication (p = 0.01). The regression results for total sugar and sleep regularity index on weekends predicted by age, sex, income, use of medication, children, comorbidities and relationship status did not show any significant results. However, in the second model regression results for total sugar intake and sleep regularity index predicted by chronotype and stress levels showed significant results. The p-values for stress level (0.03) and Sleep Regularity Index (SRI) on weekends (0.05), were suggesting that they are statistically significant predictors of sugar intake. The current literature lacks exploration of the direct association between the SRI and total sugar intake. In contrast, a study focused on 100 university students aimed to investigate the link between added sugar consumption and sleep quality (166). Notably, the analysis of 24-hour dietary recall data revealed a noteworthy associations between added sugar intake and sleep regularity, marking the first instance of a study directly addressing the impact of total sugar consumption on sleep quality. The study's findings underscore a significant relationship between poor sleep quality and elevated added sugar intake.

Also, in our study, sleep efficiency showed moderate positive correlation with carbohydrates and fibre intake only when it was calculated using self-reported data (using the PSQI questionnaire) but this was not seen when sleep efficiency was calculated using the actigraphy device as shown in the table 3.10. The PSQI's calculation of sleep efficiency was based on self-reported data, which was subject to bias and personal interpretations while actigraphy was an objective method. Thus, the association with eating behaviours such as consumption of carbohydrates could be impacted by a number of variables, such as the participants' subjective perception of their sleep. There may be a difference in the duration between actigraphy and the PSQI for evaluating sleep efficiency. In contrast to actigraphy, which offers continuous data over a shorter duration (e.g., one week in this study) the PSQI usually asks about sleep over the previous month. The results may be impacted by the disparity in time frames. However, PSQI is a validated tool in sleep research, and results from PSQI cannot be ignored. In contrast to our study, in a comprehensive multi-site, longitudinal study involving 423 women (167), relationships were explored between 88 dietary nutrient variables and subjective sleep measures (sleep time, WASO), actigraphy sleep parameters (sleep time, WASO, sleep efficiency, acrophase), and napping (both subjective and actigraphy). Utilizing Type-I error control, the study identified 49 significant correlations out of 602. The majority of these correlations were observed with subjective napping and actigraphy sleep time. Notably, actigraphy total sleep time exhibited a negative association with fat intake. Additionally, subjective napping, potentially indicative of subjective sleepiness, showed significant correlations with both fat and meat intake.

4.3.2 Planning for an intervention trial

The employed measures for gathering sleep data in this study demonstrated a comprehensive approach. Both objective (actigraphy) and subjective (sleep diary and questionnaire) methods were employed which are recognized as validated and efficient tools. Actigraphy is acknowledged as a gold standard in sleep measurement when compared with polysomnography (168). Additionally, it is crucial to assess the prevalence of shift-work-related sleep issues. Utilizing tools like the 'Bergen Shift Work Sleep Questionnaire' (169), a validated instrument, allows for the evaluation of discrete sleep problems associated with various work shifts (day, evening, night shifts) and rest days.

Physical Activity

The International Physical Activity Questionnaire (IPAQ) assesses self-reported physical activity data categorically, using three population levels: low, moderate, and high, and continuously in metabolic equivalents (METs). Statistically significant differences emerged in self-reported data between shift and day workers. Shift workers reported higher total PA MET-mins/week, MPA MET-mins/week, VPA MET-mins/week, MVPA MET-mins/week, and Walking MET-mins/week. Domain-wise, they demonstrated higher work and transport MET-mins/week, though not significantly in domestic and leisure MET-mins/week. Shift workers, often engaged in physically demanding jobs, showed increased work-related self-reported physical activity energy expenditure.

Day workers, despite numerically higher leisure MET-mins/week, warrant exploration of time and energy spent in leisure activities with a larger sample size. Shift workers reported more time in MPA, VPA, MVPA weekly, and sitting minutes daily, not reflected in actigraphy data, suggesting discrepancies between self-reported and objective values. Similar findings align with prior research, in a systematic review and meta-analysis comparing physical activity (PA) and sedentary behaviour (SB) between shift and non-shift workers, 49 studies met inclusion criteria, with 21 included in the meta-analysis. The prevalence of meeting physical activity guidelines (OR 0.84, 95% CI: 0.68, 1.03) and the standardized mean difference (SMD) in time spent in moderate-to-vigorous physical activity (SMD −0.1, 95% CI: −0.4, 0.20) were found to be comparable in both shift and non-shift workers (170). Notably, IPAQ and actigraphy calculated summary scores were based on episodes or bouts of at least 10 minutes of activity in the above mentioned study.

4.3.3 Relation between physical activity and food intake

Pearson correlation test between continuous variables of physical activity and food intake assessed in the data from pooling the subject groups revealed significant results between a few variables as highlighted in Table 3.17 and 3.18. Between MPA mins (self-reported), MVPA mins (self-reported) MPA MET-mins/week, MVPA MET-mins/week, work MET-mins/week, total PA MET-Mins/week, transport MET-mins/week, walking MET-mins/week and kcal showed a moderate negative correlation ($\sim r = -0.45$-0.60, $p<0.05$). The correlation analysis revealed a moderate negative association (r approximately from -0.45 to -0.60, $p<0.05$) between various physical activity metrics, including self-reported MET-minutes/week of MVPA, MPA, work and transport related activity, total PA, walking with kcal intake. This indicated that as physical activity decreases, there was a possibility that total calorie intake tends to increase. Our results align with a cohort study that provided data to suggest that a sedentary lifestyle with lower activity was associated with higher food intake (171). A study investigating the relationship between caloric intake, body weight, and physical work was conducted on a cohort of 213 mill workers, encompassing a spectrum of physical activity levels from sedentary to very strenuous (172). The findings revealed that caloric intake increases with activity only within a specific range ("normal activity"). Contrary to expectations, below this range ("sedentary zone"), a decrease in activity does not correspond to a reduction in food intake; instead, it was associated with an increase. Additionally, body weight was observed to higher within this sedentary zone. The authors concluded that these results align with previous findings in experimental animals. Additionally in our study, between total PA MET-Mins/week, walking MET-mins/week and carbohydrates showed a negative moderate correlation ($\sim r = 0.42$, $p = 0.04$). This indicates that as physical activity decreases. carbohydrate intake tends to increase. Between MVPA mins(objective) and fibre, there was a positive moderate correlation ($r = 0.46$, $p = 0.02$). This indicates that with higher moderate to vigorous physical activity, there is possibility of higher in fibre intake. Most of these correlations were seen using the self-reported data which was collected using the IPAQ. In the explored literature, no study was found that investigated the relationship between moderate-to-vigorous physical activity and fibre intake specifically in shift workers. However, in a different context, a randomized controlled trial (RCT) assessed the indirect effects of a smartphone-based moderate-to-vigorous physical activity intervention on dietary habits in 146 patients with type 2 diabetes (171). The intervention involved using a smartphone application to promote physical activity over 12 weeks. Analysis of dietary changes, including fruit and vegetable intake, snacks, fibre, whole grains, vitamin C, saturated fat, unsaturated fat, and total energy, revealed significant differences between the intervention and control groups, particularly when stratified by sex. Women in the intervention group exhibited higher fruit and vegetable intake ($p = 0.008$) and a superior dietary index ($p = 0.007$) at three months compared to women in the control group. They increased their daily intake of fruit and vegetables by an average of 87.4 g/day ($p = 0.04$) and improved their dietary index by an average of 0.8 points ($p = 0.01$) from baseline to follow-up. Conversely, no such effects were observed in men. These findings suggest a potential increase in fibre intake following augmented physical activity. In our study, we did not find any significant effect of any macronutrient on PA variable. Further analyses between these variables was completed using two linear regression models. First one adjusted for age, gender, income, relationship status, kids, the presence of comorbidities and use of sleep medication. Second one adjusted for stress level scores calculated using PSS questionnaire and chronotype calculated using MEQ. One noteworthy finding here was that the regression results for fibre intake and MVPA minutes calculated using actigraphy predicted by age, sex, income, use of medication, children, comorbidities and relationship status showed that use of medication impacts this association ($p = 0.03$). In the second model when adjusted for chronotype and stress levels, there was direct association between MVPA mins and fibre intake.

Since this study was a pilot study with the objective of identifying variables with some degree of relationship. Significant Pearson correlation and regression results were used to identify presence or absence of association and direction of relation between variables for intervention study.

4.3.4 Planning for an intervention trial

We observed significant differences in subjectively reported physical activity between the groups, which was not apparent in sleep and food choices. Physical activity emerges as a key factor for mitigating adverse effects of shift work. Previous research lacks evaluations of changes in shift workers' physical activity habits and lacks imperative intervention characteristics (173). No intervention studies have evaluated changes in shift workers' physical activity habits and provide insufficient imperative intervention characteristics (i.e. setting and timing) (173). There are a few previous similar studies that have reported improvements in BMI in physical activity intervention (174). Even slight changes in anthropometric parameters are encouraging given that shift work is an independent predictor of higher BMI and body weight gain since reduction in BMI is linked to a lower risk of morbidity and mortality (174,175). Previous research has also suggested high physical activity levels due to work and active occupations are not related to better health outcomes and do not replace the effects of regular exercise (176). In this study, shift workers self-reported high work-related activity but not leisure-based activity. More specifically leisure based physical activity intervention could be useful to increase regular exercise. A PA-based intervention can also improve the overall sleep quality, specifically in shift workers (177). The goal is not to increase the physical activity levels since the self-reported data already hadhigh values. The primary aim of conducting a physical activity

(PA)-based intervention study for both groups is multifaceted. Firstly, the study seeks to investigate whether physical activity can effectively mitigate intermediate risk factors associated with non-communicable diseases (NCDs), such as BMI, body weight, physical fitness, and sleep quality, specifically targeting shift workers. This endeavor aims to alleviate the adverse effects commonly experienced by shift workers due to their irregular work schedules. Secondly, the study aims to evaluate the efficacy of physical activity interventions on shift workers' actual physical activity behaviour and its determinants. Utilizing objective measures, such as actigraphy, and employing a large sample size, this aspect of the research aims to provide robust evidence on the impact of interventions on physical activity engagement among shift workers. Thirdly, the study aims to contribute to the development, implementation, and evaluation of acceptable interventions geared towards promoting physical activity in shift workers. By addressing this gap, the research endeavors to inform public health policies aimed at improving the well-being of shift workers through enhanced physical activity participation. Lastly, the study aims to assess the utility of the workplace as an intervention site, recognizing the substantial amount of time shift workers spend at work. This aspect of the research seeks to explore the feasibility and effectiveness of implementing physical activity interventions within the workplace setting, potentially providing a convenient and accessible platform for promoting physical activity among shift workers. To enhance feasibility and cost-effectiveness, a collaborative approach involving the Department of Kinesiology, the medical school/university hospital at MUN, and the targeted participants, such as nurses and healthcare staff with demanding schedules, could be implemented. This collaboration allows convenient access to a university gym or labs, eliminating the need for extensive travel. By focusing on a specific occupation with similar work schedules, a more precise comparison can be achieved, facilitating supervised physical activity interventions and adherence to the study protocol. According to a prior RCT, incorporating both aerobic and combination of aerobic and resistance exercise has led to improvements participants' sleep quality in a similar way (178). Independent of the timing (morning or evening), previous research highlights the association between physical activity and high-quality sleep (179). Offering physical activities at various times accommodates the asynchronous and irregular roster patterns of shift workers. Considering participants' chronotypes in individual exercise plans aligns with optimizing activity during peak alertness.

The proposed study design suggests a longitudinal cohort study with an exercise intervention, comparing exposed participants (exposed with physical activity) with a non-exposed group (people from similar workplace but not provided with exercise intervention), and following up participants at different times. Assessments at baseline, post-intervention, and a 12-month follow-up include anthropometric measurements, diet, sleep, and physical activity levels. Inter-group comparisons (day vs. shift) and a mixed-methods approach incorporating quantitative and qualitative data collection, including interviews, enhance understanding of shift workers' challenges and improve compliance to physical activity. However, it is crucial to acknowledge potential difficulties in participant recruitment, demanding job schedules, and commitment requirements. Educating the target population on the study's benefits can be helpful, and considering financial costs, especially for actigraphy devices in a large sample size study. An alternative could involve an extended data collection period to rotate actigraphy devices among participants, reducing the need for additional devices.

4.4 Epidemiologic Considerations

This section will examine significant epidemiologic factors linked to internal validity, including some strengths and limits.

4.4.1 Confounding factors

In epidemiological research, confounders are typically categorized as theoretical or empirical (101). This project identified key confounders, primarily socio-demographic factors. The multivariate model was employed, entering confounders as covariates in multiple linear regression tests to assess the relationships between food and physical activity, as well as food and sleep. It was crucial to acknowledge that this study may have unidentified potential confounders or strong predictors of sleep problems. For instance, information on caffeine use, which could impact tolerance to shift work, was not thoroughly captured. Additionally, the study had a higher representation of females, and factors such as menstrual cycle and menopause should be considered.

4.4.2 Selection bias

In epidemiological research, volunteer selection may introduce bias, particularly when exposure and outcome status influence participation. This study was advertised as a work study rather than focusing on sleep, food, or physical activity. It was unlikely that individuals volunteered based on these specific characteristics. Recruitment efforts explicitly outlined the overarching objective of exploring how working conditions impact health. Many day workers revealed past experiences with shift work, and several shift workers expressed a desire to contribute to systemic change through participation. Studies have indicated that respondents (volunteers) tend to be more educated and health-conscious compared to non-respondents (180). While this may not necessarily true in this study since shift workers made less money and there was no control done on job type.

4.4.3 Information bias

Work status was self-reported, and the likelihood of misclassifying shiftwork was very low. This information did not rely on retrospective memory, as participants were asked to report their current work schedule. While there was one participant working shifts part-time and studying, and a few participants juggling multiple jobs. Previous validity studies strongly suggest minimal misclassification of self-reported employment history (180). Additionally, participants might have provided under-reported sleep data in hopes that something will change for shift workers.

4.4.4 Generalizability

The results of this study should not be generalized to all shift workers at a population level, given its status as a pilot study with a small sample size. The purpose of pilot research was to evaluate the acceptability and practicality of a method for use in a larger study, not to test hypotheses regarding intervention effects. Consequently, a pilot trial cannot definitively answer whether an intervention works; rather, it contributes data to determine "Can I do this?" (181). Moreover, these findings should not be extended to individuals with a rotating shift schedule, as their work schedule significantly differs.

It was important to approach the correlation results of this study with caution, particularly concerning diet and sleep. The relationship between these two parameters wasbidirectional. Insufficient sleep negatively affects dietary intake, but diet can also influence sleep through melatonin synthesis from tryptophan-rich foods.

4.5 Strengths

We assessed sleep, physical activity, and food consumption among individuals engaged in free-living shifts in the field, aiming to enhance the external validity of the research by focusing on lifestyle factors contributing to health risks. Unlike many shiftwork studies exclusive to shift workers, our project included a group of day workers as a comparison. The study utilized both objective and subjective measurements of sleep and physical activity to increase validity. The use of accelerometry for the objective measurement of 24-hour activity over seven days enhances validity, while many studies typically record daily activity for 3-5 days.

This study stands out as the first to employ a valid tool (HEFI-2019) for prospectively assessing diet quality as it relates to the CFG-2019, specifically within the Canadian working cohort. Additionally, we used an objective measurement of food intake (ASA24) instead of relying on food frequency questionnaires and diaries. Adherence to assessment measures was high, with very few missing values. The inclusion of individuals of all sexes contributes to a more representative sample, as opposed to many studies that focus exclusively on female shift workers. However, it was crucial to consider sex differences in the interpretation of the findings.

4.6 Limitations

This study employed a cross-sectional design, limiting our ability to establish a definitive relationship between shift work and lifestyle components without the benefit of a longitudinal-cohort study. Consequently, we cannot infer causality, as eating habits tend to change over time. Notably, sleep quality and tolerance to shift work have been significantly correlated, with more tolerant shift workers reporting higher-quality sleep (182). However, we did not include individual tolerance to shift work, influenced by factors such as experience working shifts.

Additionally, we did not evaluate the impact of social aspects of shift work, such as the predictability of working hours, work environment, availability of healthy food choices at work, the option to engage in physical activity during long shifts, and shift length, on sleep, diet, and physical activity.

Data on the current week's work schedule for all participants were collected but not included in the analysis due to large variability. The definition of shift work remains unclear in Canada and at the international level (183). Outliers were not removed from the study to maintain the sample size, considering the study's objective was to assess the feasibility of the protocol rather than establishing significant relationships between parameters. Prior research addressing vital methodological issues in pilot studies has advised against the removal of outliers (184). The rationale was that eliminating outliers may compromise the integrity of the data, as these outliers could represent valid data points, especially in research domains such as social or behavioural studies. Researchers are cautioned against hasty removal of outlier data without a thorough understanding of the underlying reasons for their presence.

Participants classified as under-reporters of energy intake were not excluded from the study, as they represented a significant proportion of the sample. Information on dietary restrictions or specific diet patterns was not gathered; all participants were asked to report their food intake regardless of any dietary practices. Data regarding secondary employment, a potentially significant factor in establishing a link between shift work and health outcomes, were not collected.

Information on exposure to daylight in shift workers, which can impact sleep, diet, and physical activity, was not gathered. While sleep data from actigraphy were calculated based on all sleep (accelerometer-calculated sleep during periods of inactivity), we lack specific information on the number of naps taken, as the algorithm used to objectively collect data on naps and differentiate them from sleep differs from the one employed in this study to analyze actigraphy data.

4.7 Future Work

Future research should continue to investigate the impact of shift work on sleep, diet, and physical activity, with more specific considerations outlined in the discussion section of this thesis. Moreover, a targeted approach focusing on a particular occupation, such as night workers, is essential. Since different shifts present distinct sleep challenges, using general questionnaires might not capture the variability in sleep across various shifts. Additionally, it is crucial to establish a clear and explicit definition of shift work.

A specific study design should be planned for rotational workers, considering their unique work schedules that differ significantly from other shift workers. Rotational workers often work continuously for a number of days with consecutive work-off days. Research exploring the lifestyle of shift workers who nap and those who do not, as well as the beneficial napping schedules for alleviating the negative effects of shift work, is warranted. The benefits of napping, established in terms of work performance and alertness (185), need further investigation.

Lastly, given the limited use of cohort designs in existing research, there is a need for lengthy, longitudinal studies examining the effects of shift work on health outcomes over different periods. Cohort studies are essential for demonstrating temporal correlations and overcoming biases observed in other observational methods. Shift work has been associated with various detrimental health effects, including cancer, metabolic syndrome, sleeplessness, obesity, type 2 diabetes, and insomnia (186–189). Therefore, a focused approach is required when researching how shift work contributes to specific adverse health consequences. Considering that sleep, diet, and physical activity are modifiable factors, exploring their role can offer insights into alleviating the adverse effects of shift work.

4.8 Summary

Self-reported data suggested that shift workers had high levels of physical activity, but this trend was not reflected in the objective activity data. Consistent with previous findings, we did not observe a statistically significant difference in food intake and sleep parameters between the two groups (73). While most day workers reported good sleep quality, only a few shift workers indicated the same according to the PSQI. Surprisingly, day workers had a notably lower HEFI-2019 score than shift workers in food recall 1. This suggests that shift workers might not necessarily have a worse diet than day workers, and it could even be better. This contradicts the common belief that shift workers tend to make unhealthy food choices. In general, the diet quality score in this sample was lower compared to the national average. This project serves as an introductory work, contributing to the existing literature on lifestyle challenges related to shift work. The study has played a crucial role in identifying the strengths and weaknesses of the current study protocol. These results can serve as valuable insights to inform and plan an intervention trial aimed at mitigating the negative effects of shift work through physical activity. Ultimately, public health initiatives targeting the reduction of detrimental impacts from shift work can benefit from incorporating mechanistic knowledge gained through this study.

References

1. Rydz E, Hall AL, Peters CE. Prevalence and Recent Trends in Exposure to Night Shiftwork in Canada. Ann Work Expo Health. 2020 Mar 10;64(3):270–81.
2. Wong IS, McLeod CB, Demers PA. Shift work trends and risk of work injury among Canadian workers. Scand J Work Environ Health. 2011 Jan;37(1):54–61.
3. Knutsson A. Methodological Aspects of Shift-Work Research. Chronobiol Int. 2004 Jan 7;21(6):1037–47.
4. Caruso CC. Negative Impacts of Shiftwork and Long Work Hours. Rehabilitation Nursing. 2014 Jan;39(1):16–25.
5. Costa G. Shift work and occupational medicine: an overview. Occup Med (Chic Ill). 2003 Mar 1;53(2):83–8.
6. Niu SF, Chung MH, Chen CH, Hegney D, O'Brien A, Chou KR. The effect of shift rotation on employee cortisol profile, sleep quality, fatigue, and attention level: a systematic review. J Nurs Res. 2011 Mar;19(1):68–81.
7. Vyas M V, Garg AX, Iansavichus A V, Costella J, Donner A, Laugsand LE, et al. Shift work and vascular events: systematic review and meta-analysis. BMJ. 2012 Jul 26;345:e4800.
8. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. Obesity (Silver Spring). 2008 Mar;16(3):643–53.
9. Sookoian S, Gemma C, Fernández Gianotti T, Burgueño A, Alvarez A, González CD, et al. Effects of rotating shift work on biomarkers of metabolic syndrome and inflammation. J Intern Med. 2007 Mar;261(3):285–92.
10. Kolstad HA. Nightshift work and risk of breast cancer and other cancers--a critical review of the epidemiologic evidence. Scand J Work Environ Health. 2008 Feb;34(1):5–22.
11. Gan Y, Yang C, Tong X, Sun H, Cong Y, Yin X, et al. Shift work and diabetes mellitus: a meta-analysis of observational studies. Occup Environ Med. 2015 Jan;72(1):72–8.
12. Härmä M. Workhours in relation to work stress, recovery and health. Scand J Work Environ Health. 2006 Dec;32(6):502–14.
13. Zhai L, Zhang H, Zhang D. SLEEP DURATION AND DEPRESSION AMONG ADULTS: A META-ANALYSIS OF PROSPECTIVE STUDIES. Depress Anxiety. 2015 Sep;32(9):664–70.
14. Kucharczyk ER, Morgan K, Hall AP. The occupational impact of sleep quality and insomnia symptoms. Sleep Med Rev. 2012 Dec;16(6):547–59.
15. Adan A, Archer SN, Hidalgo MP, Di Milia L, Natale V, Randler C. Circadian Typology: A Comprehensive Review. Chronobiol Int. 2012 Nov 24;29(9):1153–75.
16. Jagannath A, Taylor L, Wakaf Z, Vasudevan SR, Foster RG. The genetics of circadian rhythms, sleep and health. Hum Mol Genet. 2017;26:R128–38.

17. Bhatwadekar AD, Rameswara V. Circadian rhythms in diabetic retinopathy: an overview of pathogenesis and investigational drugs. Expert Opin Investig Drugs. 2020 Dec;29(12):1431–42.
18. Blume C, Garbazza C, Spitschan M. Effects of light on human circadian rhythms, sleep and mood. Somnologie. 2019 Sep 20;23(3):147–56.
19. Boivin DB, Boudreau P, Kosmadopoulos A. Disturbance of the Circadian System in Shift Work and Its Health Impact. J Biol Rhythms. 2022 Feb 30;37(1):3–28.
20. James SM, Honn KA, Gaddameedhi S, Van Dongen HPA. Shift Work: Disrupted Circadian Rhythms and Sleep-Implications for Health and Well-Being. Curr Sleep Med Rep. 2017 Jun;3(2):104–12.
21. Nguyen J, Wright KP. Influence of weeks of circadian misalignment on leptin levels. Nat Sci Sleep. 2010;2:9–18.
22. Schoeller DA, Cella LK, Sinha MK, Caro JF. Entrainment of the diurnal rhythm of plasma leptin to meal timing. J Clin Invest. 1997 Oct 1;100(7):1882–7.
23. Spiegel K, Tasali E, Penev P, Van Cauter E. Brief communication: Sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. Ann Intern Med. 2004 Dec 7;141(11):846–50.
24. Taheri S, Lin L, Austin D, Young T, Mignot E. Short Sleep Duration Is Associated with Reduced Leptin, Elevated Ghrelin, and Increased Body Mass Index. PLoS Med. 2004 Dec 7;1(3):e62.
25. SCHMID SM, HALLSCHMID M, JAUCH-CHARA K, BORN J, SCHULTES B. A single night of sleep deprivation increases ghrelin levels and feelings of hunger in normal-weight healthy men. J Sleep Res. 2008 Sep 21;17(3):331–4.
26. Garaulet M, Sánchez-Moreno C, Smith CE, Lee YC, Nicolás F, Ordovás JM. Ghrelin, Sleep Reduction and Evening Preference: Relationships to CLOCK 3111 T/C SNP and Weight Loss. PLoS One. 2011 Feb 28;6(2):e17435.
27. McHill AW, Melanson EL, Higgins J, Connick E, Moehlman TM, Stothard ER, et al. Impact of circadian misalignment on energy metabolism during simulated nightshift work. Proc Natl Acad Sci U S A. 2014 Dec 2;111(48):17302–7.
28. Schiavo-Cardozo D, Lima MMO, Pareja JC, Geloneze B. Appetite-regulating hormones from the upper gut: disrupted control of xenin and ghrelin in night workers. Clin Endocrinol (Oxf). 2013 Dec;79(6):807–11.
29. Spaeth AM, Dinges DF, Goel N. Effects of Experimental Sleep Restriction on Weight Gain, Caloric Intake, and Meal Timing in Healthy Adults. Sleep. 2013 Jul 1;36(7):981–90.
30. Baron KG, Reid KJ. Circadian misalignment and health. Int Rev Psychiatry. 2014 Apr;26(2):139–54.
31. Edgar DM, Dement WC, Fuller CA. Effect of SCN lesions on sleep in squirrel monkeys: evidence for opponent processes in sleep-wake regulation. J Neurosci. 1993 Mar;13(3):1065–79.

32. Daan S, Beersma DG, Borbely AA. Timing of human sleep: recovery process gated by a circadian pacemaker. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology. 1984 Feb 1;246(2):R161–83.
33. Akerstedt T. Shift work and disturbed sleep/wakefulness. Occup Med (Chic Ill). 2003 Mar 1;53(2):89–94.
34. Akerstedt T, Peters B, Anund A, Kecklund G. Impaired alertness and performance driving home from the night shift: a driving simulator study. J Sleep Res. 2005 Mar;14(1):17–20.
35. Åkerstedt T, Nordin M, Alfredsson L, Westerholm P, Kecklund G. SLEEP AND SLEEPINESS: IMPACT OF ENTERING OR LEAVING SHIFTWORK—A PROSPECTIVE STUDY. Chronobiol Int. 2010 Jun 19;27(5):987–96.
36. Akerstedt T, Kecklund G, Knutsson A. Spectral analysis of sleep electroencephalography in rotating three-shift work. Scand J Work Environ Health. 1991 Oct;17(5):330–6.
37. Burch JB, Yost MG, Johnson W, Allen E. Melatonin, Sleep, and Shift Work Adaptation. J Occup Environ Med. 2005 Sep;47(9):893–901.
38. Chan OY, Gan SL, Yeo MH. Study on the health of female electronics workers on 12 hour shifts. Occup Med (Chic Ill). 1993;43(3):143–8.
39. Saksvik IB, Bjorvatn B, Hetland H, Sandal GM, Pallesen S. Individual differences in tolerance to shift work – A systematic review. Sleep Med Rev. 2011 Aug;15(4):221–35.
40. Åkerstedt T, Wright KP. Sleep Loss and Fatigue in Shift Work and Shift Work Disorder. Sleep Med Clin. 2009 Jun;4(2):257–71.
41. Axelsson J, �kerstedt T, Kecklund G, Lowden A. Tolerance to shift work?how does it relate to sleep and wakefulness? Int Arch Occup Environ Health. 2004 Feb 1;77(2):121–9.
42. van de Ven HA, van der Klink JJL, Vetter C, Roenneberg T, Gordijn M, Koolhaas W, et al. Sleep and need for recovery in shift workers: do chronotype and age matter? Ergonomics. 2016 Feb 1;59(2):310–24.
43. Simor P, Polner B. Differential influence of asynchrony in early and late chronotypes on convergent thinking. Chronobiol Int. 2017 Jan 2;34(1):118–28.
44. Barclay NL, Myachykov A. Sustained wakefulness and visual attention: moderation by chronotype. Exp Brain Res. 2017 Jan 13;235(1):57–68.
45. Juda M, Vetter C, Roenneberg T. The Munich ChronoType Questionnaire for Shift-Workers (MCTQ ^{Shift}). J Biol Rhythms. 2013 Apr 19;28(2):130–40.
46. Vetter C, Fischer D, Matera JL, Roenneberg T. Aligning Work and Circadian Time in Shift Workers Improves Sleep and Reduces Circadian Disruption. Current Biology. 2015 Mar;25(7):907–11.
47. Wittmann M, Dinich J, Merrow M, Roenneberg T. Social Jetlag: Misalignment of Biological and Social Time. Chronobiol Int. 2006 Jan 7;23(1–2):497–509.

48. Juda M, Vetter C, Roenneberg T. Chronotype Modulates Sleep Duration, Sleep Quality, and Social Jet Lag in Shift-Workers. J Biol Rhythms. 2013 Apr 19;28(2):141–51.
49. Sadeh A. III. SLEEP ASSESSMENT METHODS. Monogr Soc Res Child Dev. 2015 Mar 22;80(1):33–48.
50. Benz F, Riemann D, Domschke K, Spiegelhalder K, Johann AF, Marshall NS, et al. How many hours do you sleep? A comparison of subjective and objective sleep duration measures in a sample of insomnia patients and good sleepers. J Sleep Res. 2023 Apr 18;32(2).
51. Lemola S, Ledermann T, Friedman EM. Variability of Sleep Duration Is Related to Subjective Sleep Quality and Subjective Well-Being: An Actigraphy Study. PLoS One. 2013 Aug 14;8(8):e71292.
52. Jackowska M, Ronaldson A, Brown J, Steptoe A. Biological and psychological correlates of self-reported and objective sleep measures. J Psychosom Res. 2016 May;84:52–5.
53. Yoon BH, Kwon YJ, Lee K, Lee SY, Bahk WM, Jon DI. Comparisons of subjective and actigraphic measurements of sleep between shift-working and daytime psychiatric nurses. Sleep Med. 2022 Dec;100:S46.
54. Lauderdale DS, Knutson KL, Yan LL, Liu K, Rathouz PJ. Self-Reported and Measured Sleep Duration. Epidemiology. 2008 Nov;19(6):838–45.
55. Klok MD, Jakobsdottir S, Drent ML. The role of leptin and ghrelin in the regulation of food intake and body weight in humans: a review. Obesity Reviews. 2007 Jan;8(1):21–34.
56. Ibrahim A, Mona M. Ghrelin – Physiological Functions and Regulation. Eur Endocrinol. 2015;11(2):90.
57. Penev PD. Sleep deprivation and energy metabolism: to sleep, perchance to eat? Curr Opin Endocrinol Diabetes Obes. 2007 Oct;14(5):374–81.
58. Klok MD, Jakobsdottir S, Drent ML. The role of leptin and ghrelin in the regulation of food intake and body weight in humans: a review. Obesity Reviews. 2007 Jan 24;8(1):21–34.
59. Xiao Q, Arem H, Moore SC, Hollenbeck AR, Matthews CE. A Large Prospective Investigation of Sleep Duration, Weight Change, and Obesity in the NIH-AARP Diet and Health Study Cohort. Am J Epidemiol. 2013 Dec 1;178(11):1600–10.
60. Patel SR, Ayas NT, Malhotra MR, White DP, Schernhammer ES, Speizer FE, et al. A Prospective Study of Sleep Duration and Mortality Risk in Women. Sleep. 2004 May;27(3):440–4.
61. Cappuccio FP, Taggart FM, Kandala NB, Currie A, Peile E, Stranges S, et al. Meta-Analysis of Short Sleep Duration and Obesity in Children and Adults. Sleep. 2008 May;31(5):619–26.
62. Ogilvie RP, Patel SR. The epidemiology of sleep and obesity. Sleep Health. 2017 Oct;3(5):383–8.

63. Dashti HS, Scheer FA, Jacques PF, Lamon-Fava S, Ordovás JM. Short Sleep Duration and Dietary Intake: Epidemiologic Evidence, Mechanisms, and Health Implications. Advances in Nutrition. 2015 Nov;6(6):648–59.
64. Cooper CB, Neufeld E V, Dolezal BA, Martin JL. Sleep deprivation and obesity in adults: a brief narrative review. BMJ Open Sport Exerc Med. 2018 Oct;4(1):e000392.
65. Souza RV, Sarmento RA, de Almeida JC, Canuto R. The effect of shift work on eating habits: a systematic review. Scand J Work Environ Health. 2019 Jan;45(1):7–21.
66. Garaulet M, Gómez-Abellán P. Timing of food intake and obesity: A novel association. Physiol Behav. 2014 Jul;134:44–50.
67. Jakubowicz D, Barnea M, Wainstein J, Froy O. Effects of caloric intake timing on insulin resistance and hyperandrogenism in lean women with polycystic ovary syndrome. Clin Sci. 2013 Nov 1;125(9):423–32.
68. Aljuraiban GS, Chan Q, Oude Griep LM, Brown IJ, Daviglus ML, Stamler J, et al. The Impact of Eating Frequency and Time of Intake on Nutrient Quality and Body Mass Index: The INTERMAP Study, a Population-Based Study. J Acad Nutr Diet. 2015 Apr;115(4):528-536.e1.
69. Jakubowicz D, Barnea M, Wainstein J, Froy O. High Caloric intake at breakfast vs. dinner differentially influences weight loss of overweight and obese women. Obesity. 2013 Dec;21(12):2504–12.
70. Lennernas M, Akerstedt T, Hambraeus L. Nocturnal eating and serum cholesterol of three-shift workers. Scand J Work Environ Health. 1994 Dec;20(6):401–6.
71. Nea FM, Kearney J, Livingstone MBE, Pourshahidi LK, Corish CA. Dietary and lifestyle habits and the associated health risks in shift workers. Nutr Res Rev. 2015 Dec 9;28(2):143–66.
72. Di Lorenzo L, De Pergola G, Zocchetti C, L'Abbate N, Basso A, Pannacciulli N, et al. Effect of shift work on body mass index: results of a study performed in 319 glucose-tolerant men working in a Southern Italian industry. Int J Obes. 2003 Nov 23;27(11):1353–8.
73. Lauren S, Chen Y, Friel C, Chang BP, Shechter A. Free-Living Sleep, Food Intake, and Physical Activity in Night and Morning Shift Workers. J Am Coll Nutr [Internet]. 2019/11/19. 2020 Jul;39(5):450–6. Available from: https://pubmed.ncbi.nlm.nih.gov/31743081
74. GUPTA CC, COATES AM, DORRIAN J, BANKS S. The factors influencing the eating behaviour of shiftworkers: what, when, where and why. Ind Health. 2019;57(4):419–53.
75. Flanagan A, Lowson E, Arber S, Griffin BA, Skene DJ. Dietary Patterns of Nurses on Rotational Shifts Are Marked by Redistribution of Energy into the Nightshift. Nutrients. 2020 Apr 10;12(4).

76. Waterhouse J, Buckley P, Edwards B, Reilly T. Measurement of, and Some Reasons for, Differences in Eating Habits Between Night and Day Workers. Chronobiol Int. 2003 Jan 7;20(6):1075–92.
77. Bonnell E, Huggins C, Huggins C, McCaffrey T, Palermo C, Bonham M. Influences on Dietary Choices during Day versus Night Shift in Shift Workers: A Mixed Methods Study. Nutrients. 2017 Feb 26;9(3):193.
78. Novak RD, Auvil-Novak SE. Focus Group Evaluation of Night Nurse Shiftwork Difficulties and Coping Strategies. Chronobiol Int. 1996 Jan 7;13(6):457–63.
79. Tzischinsky O, Shlitner A, Lavie P. The Association between the Nocturnal Sleep Gate and Nocturnal Onset of Urinary 6-Sulfatoxymelatonin. J Biol Rhythms. 1993 Oct 29;8(3):199–209.
80. Rancillac A. Serotonin and sleep-promoting neurons. Oncotarget. 2016 Nov 29;7(48):78222–3.
81. Zuraikat FM, Wood RA, Barragán R, St-Onge MP. Sleep and Diet: Mounting Evidence of a Cyclical Relationship. 2021; Available from: https://doi.org/10.1146/annurev-nutr-120420-
82. Barik S. The Uniqueness of Tryptophan in Biology: Properties, Metabolism, Interactions and Localization in Proteins. Int J Mol Sci. 2020 Nov 20;21(22):8776.
83. Fernstrom JD, Wurtman RJ. Brain Serotonin Content: Physiological Regulation by Plasma Neutral Amino Acids. Science (1979). 1972 Oct 27;178(4059):414–6.
84. Porkka-Heiskanen T. Adenosine in sleep and wakefulness. Ann Med. 1999 Jan 8;31(2):125–9.
85. Wurtman RJ, Wurtman JJ, Regan MM, McDermott JM, Tsay RH, Breu JJ. Effects of normal meals rich in carbohydrates or proteins on plasma tryptophan and tyrosine ratios. Am J Clin Nutr. 2003 Jan;77(1):128–32.
86. Benton D, Bloxham A, Gaylor C, Brennan A, Young HA. Carbohydrate and sleep: An evaluation of putative mechanisms. Front Nutr. 2022;9:933898.
87. Bravo R, Matito S, Cubero J, Paredes SD, Franco L, Rivero M, et al. Tryptophan-enriched cereal intake improves nocturnal sleep, melatonin, serotonin, and total antioxidant capacity levels and mood in elderly humans. Age (Omaha). 2013 Aug 24;35(4):1277–85.
88. González-Gómez D, Lozano M, Fernández-León MF, Ayuso MC, Bernalte MJ, Rodríguez AB. Detection and quantification of melatonin and serotonin in eight Sweet Cherry cultivars (Prunus avium L.). European Food Research and Technology. 2009 Jun 10;229(2):223–9.
89. Kim DO, Heo HJ, Kim YJ, Yang HS, Lee CY. Sweet and Sour Cherry Phenolics and Their Protective Effects on Neuronal Cells. J Agric Food Chem. 2005 Dec 1;53(26):9921–7.
90. Binks H, E. Vincent G, Gupta C, Irwin C, Khalesi S. Effects of Diet on Sleep: A Narrative Review. Nutrients. 2020 Mar 27;12(4):936.
91. Westerterp KR. Physical activity and physical activity induced energy expenditure in humans: measurement, determinants, and effects. Front Physiol. 2013;4.

92. Hu F. Assessment of Physical Activity in Nutritional Epidemiology. In: Nutritional Epidemiology. Oxford University Press; 2012. p. 241–59.
93. Kervezee L, Kosmadopoulos A, Boivin DB. Metabolic and cardiovascular consequences of shift work: The role of circadian disruption and sleep disturbances. Eur J Neurosci. 2020 Jan;51(1):396–412.
94. Monnaatsie M, Biddle SJH, Khan S, Kolbe-Alexander T. Physical activity and sedentary behaviour in shift and non-shift workers: A systematic review and meta-analysis. Prev Med Rep. 2021 Dec;24:101597.
95. Vandelanotte C, Short C, Rockloff M, Millia L Di, Ronan K, Happell B, et al. How Do Different Occupational Factors Influence Total, Occupational, and Leisure-Time Physical Activity? J Phys Act Health. 2015 Feb;12(2):200–7.
96. Loef B, van der Beek AJ, Holtermann A, Hulsegge G, van Baarle D, Proper KI. Objectively measured physical activity of hospital shift workers. Scand J Work Environ Health. 2018 May;44(3):265–73.
97. Zafiropoulos B, Alison JA, Heard R. Physical activity levels of allied health professionals working in a large Australian metropolitan health district – an observational study. J Multidiscip Healthc. 2019 Jan;Volume 12:51–62.
98. Peplonska B, Bukowska A, Sobala W. Rotating night shift work and physical activity of nurses and midwives in the cross-sectional study in **Ł** ódź, Poland. Chronobiol Int. 2014 Dec 12;31(10):1152–9.
99. Flahr H, Brown WJ, Kolbe-Alexander TL. A systematic review of physical activity-based interventions in shift workers. Prev Med Rep. 2018 Jun;10:323–31.
100. Conn VS, Hafdahl AR, Cooper PS, Brown LM, Lusk SL. Meta-Analysis of Workplace Physical Activity Interventions. Am J Prev Med. 2009 Oct;37(4):330–9.
101. Jager KJ, Zoccali C, MacLeod A, Dekker FW. Confounding: What it is and how to deal with it. Kidney Int. 2008 Feb;73(3):256–60.
102. Bonnefond A, Härmä M, Hakola T, Sallinen M, Kandolin I, Virkkala J. Interaction of Age With Shift-Related Sleep-Wakefulness, Sleepiness, Performance, and Social Life. Exp Aging Res. 2006 Apr;32(2):185–208.
103. Reid K. Comparing performance on a simulated 12 hour shift rotation in young and older subjects. Occup Environ Med. 2001 Jan 1;58(1):58–62.
104. Costa G, Di Milia L. Aging and Shift Work: A Complex Problem to Face. Chronobiol Int. 2008 Jan 7;25(2–3):165–81.
105. Knutsson A. Methodological Aspects of Shift-Work Research. Chronobiol Int. 2004 Jan 7;21(6):1037–47.
106. Saksvik-Lehouillier I, Sørengaard TA. Comparing shift work tolerance across occupations, work arrangements, and gender. Occup Med (Chic Ill). 2023 Aug 17;
107. TAI SY, LIN PC, CHEN YM, HUNG HC, PAN CH, PAN SM, et al. Effects of Marital Status and Shift Work on Family Function among Registered Nurses. Ind Health. 2014;52(4):296–303.

108. Seo Y jin, Matsumoto K, Park Y man, Shinkoda H, Noh T jeong. The Relationship between Sleep and Shift System, Age and Chronotype in Shift Workers. Biol Rhythm Res. 2000 Dec 9;31(5):559–79.
109. Sun K, Liu J, Ning G. Active Smoking and Risk of Metabolic Syndrome: A Meta-Analysis of Prospective Studies. PLoS One. 2012 Oct 17;7(10):e47791.
110. Puttonen S, Härmä M, Hublin C. Shift work and cardiovascular disease – pathways from circadian stress to morbidity. Scand J Work Environ Health. 2010 Mar;36(2):96–108.
111. Pease EC, Raether KA. Shift Working and Well-being: A Physiological and Psychological Analysis of Shift Workers. 2003.
112. McDevitt B, Moore L, Akhtar N, Connolly J, Doherty R, Scott W. Validity of a Novel Research-Grade Physical Activity and Sleep Monitor for Continuous Remote Patient Monitoring. Sensors. 2021 Mar 13;21(6):2034.
113. Samet JM, Wipfli H, Platz EA, Bhavsar N. A Dictionary of Epidemiology, Fifth Edition: Edited by Miquel Porta. Am J Epidemiol. 2009 Dec 1;170(11):1449–51.
114. Leon AC, Davis LL, Kraemer HC. The role and interpretation of pilot studies in clinical research. J Psychiatr Res. 2011 May;45(5):626–9.
115. Whitehead AL, Sully BGO, Campbell MJ. Pilot and feasibility studies: Is there a difference from each other and from a randomised controlled trial? Contemp Clin Trials. 2014 May;38(1):130–3.
116. Emerson RW. Convenience Sampling Revisited: Embracing Its Limitations Through Thoughtful Study Design. J Vis Impair Blind. 2021 Jan 15;115(1):76–7.
117. Julious SA. Sample size of 12 per group rule of thumb for a pilot study. Pharm Stat. 2005 Oct;4(4):287–91.
118. Lancaster GA, Dodd S, Williamson PR. Design and analysis of pilot studies: recommendations for good practice. J Eval Clin Pract. 2004 May;10(2):307–12.
119. Abbott JH. The Distinction Between Randomized Clinical Trials (RCTs) and Preliminary Feasibility and Pilot Studies: What They Are and Are Not. Journal of Orthopaedic & Sports Physical Therapy. 2014 Aug;44(8):555–8.
120. Thabane L, Ma J, Chu R, Cheng J, Ismaila A, Rios LP, et al. A tutorial on pilot studies: the what, why and how. BMC Med Res Methodol. 2010 Jan 6;10(1):1.
121. Brassard D, Elvidge Munene LA, St-Pierre S, Guenther PM, Kirkpatrick SI, Slater J, et al. Development of the Healthy Eating Food Index (HEFI)-2019 measuring adherence to Canada's Food Guide 2019 recommendations on healthy food choices. Applied Physiology, Nutrition, and Metabolism. 2022 May;47(5):595–610.
122. Brassard D, Elvidge Munene LA, St-Pierre S, Gonzalez A, Guenther PM, Jessri M, et al. Evaluation of the Healthy Eating Food Index (HEFI)-2019 measuring adherence to Canada's Food Guide 2019 recommendations on healthy food choices. Applied Physiology, Nutrition, and Metabolism. 2022 May;47(5):582–94.
123. Kupis J, Johnson S, Hallihan G, Olstad D. Assessing the Usability of the Automated Self-Administered Dietary Assessment Tool (ASA24) among Low-Income Adults. Nutrients. 2019 Jan 10;11(1):132.

124. Willett W, Howe G, Kushi L. Adjustment for total energy intake in epidemiologic studies. Am J Clin Nutr. 1997 Apr;65(4):1220S-1228S.
125. Schoeller DA, Bandini LG, Dietz WH. Inaccuracies in self-reported intake identified by comparison with the doubly labelled water method. Can J Physiol Pharmacol. 1990 Jul 1;68(7):941–9.
126. Schoeller DA. Limitations in the assessment of dietary energy intake by self-report. Metabolism. 1995 Feb;44:18–22.
127. Poslusna K, Ruprich J, de Vries JHM, Jakubikova M, van't Veer P. Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice. British Journal of Nutrition. 2009 Jul 1;101(S2):S73–85.
128. Banna JC, McCrory MA, Fialkowski MK, Boushey C. Examining Plausibility of Self-Reported Energy Intake Data: Considerations for Method Selection. Front Nutr. 2017;4:45.
129. Trumbo P, Schlicker S, Yates AA, Poos M. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. J Am Diet Assoc. 2002 Nov;102(11):1621–30.
130. Mccrory MA, Hajduk CL, Roberts SB. Procedures for screening out inaccurate reports of dietary energy intake. Public Health Nutr. 2002 Dec 22;5(6a):873–82.
131. Carney CE, Buysse DJ, Ancoli-Israel S, Edinger JD, Krystal AD, Lichstein KL, et al. The consensus sleep diary: standardizing prospective sleep self-monitoring. Sleep. 2012 Feb 1;35(2):287–302.
132. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989 May;28(2):193–213.
133. Backhaus J, Junghanns K, Broocks A, Riemann D, Hohagen F. Test-retest reliability and validity of the Pittsburgh Sleep Quality Index in primary insomnia. J Psychosom Res. 2002 Sep;53(3):737–40.
134. Plekhanova T, Rowlands A V., Davies MJ, Hall AP, Yates T, Edwardson CL. Validation of an automated sleep detection algorithm using data from multiple accelerometer brands. J Sleep Res. 2023 Jun 31;32(3).
135. Antczak D, Lonsdale C, Del Pozo Cruz B, Parker P, Sanders T. Reliability of GENEActiv accelerometers to estimate sleep, physical activity, and sedentary time in children. Int J Behav Nutr Phys Act. 2021 Jun 6;18(1):73.
136. Phillips AJK, Clerx WM, O'Brien CS, Sano A, Barger LK, Picard RW, et al. Irregular sleep/wake patterns are associated with poorer academic performance and delayed circadian and sleep/wake timing. Sci Rep. 2017 Jun 12;7(1):3216.
137. MacIntosh BR, Murias JM, Keir DA, Weir JM. What Is Moderate to Vigorous Exercise Intensity? Front Physiol. 2021 Sep 22;12.
138. van Remoortel H, Camillo CA, Langer D, Hornikx M, Demeyer H, Burtin C, et al. Moderate Intense Physical Activity Depends on Selected Metabolic Equivalent of

Task (MET) Cut-Off and Type of Data Analysis. PLoS One. 2013 Dec 20;8(12):e84365.
139. CRAIG CL, MARSHALL AL, SJ??STR??M M, BAUMAN AE, BOOTH ML, AINSWORTH BE, et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity. Med Sci Sports Exerc. 2003 Aug;35(8):1381–95.
140. Craig CL, MARSHALL AL, SJ??STR??M M, BAUMAN AE, BOOTH ML, AINSWORTH BE, et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity. Med Sci Sports Exerc. 2003 Aug;35(8):1381–95.
141. Bauman A, Bull F, Chey T, Craig CL, Ainsworth BE, Sallis JF, et al. The International Prevalence Study on Physical Activity: results from 20 countries. International Journal of Behavioral Nutrition and Physical Activity. 2009;6(1):21.
142. Horne JA, Ostberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int J Chronobiol. 1976;4(2):97–110.
143. van de Ven HA, van der Klink JJL, Vetter C, Roenneberg T, Gordijn M, Koolhaas W, et al. Sleep and need for recovery in shift workers: do chronotype and age matter? Ergonomics. 2016;59(2):310–24.
144. Vasold KL, Parks AC, Phelan DML, Pontifex MB, Pivarnik JM. Reliability and Validity of Commercially Available Low-Cost Bioelectrical Impedance Analysis. Int J Sport Nutr Exerc Metab. 2019 Jul 1;29(4):406–10.
145. Baik SH, Fox RS, Mills SD, Roesch SC, Sadler GR, Klonoff EA, et al. Reliability and validity of the Perceived Stress Scale-10 in Hispanic Americans with English or Spanish language preference. J Health Psychol. 2019 Apr 5;24(5):628–39.
146. Lee EH. Review of the Psychometric Evidence of the Perceived Stress Scale. Asian Nurs Res (Korean Soc Nurs Sci). 2012 Dec;6(4):121–7.
147. Kirsh VA, Skead K, McDonald K, Kreiger N, Little J, Menard K, et al. Cohort Profile: The Ontario Health Study (OHS). Int J Epidemiol. 2023 Apr 19;52(2):e137–51.
148. Open GovernmentThe Healthy Eating Food Index 2019 - Calculating HEFI- 2019 scoresThe Healthy Eating Food Index 2019 - Calculating HEFI- 2019 scoresThe Healthy Eating Food Index 2019 - Calculating HEFI- 2019 scores [Internet]. 2023. The Healthy Eating Food Index2019 - Calculating HEF-2019 scores. Available from: https://open.canada.ca/data/dataset/29892c85-2ff5-484c-873c-f494ffba6e1b/resource/11dd43d4-0c5c-4a2e-b066-e875ebc319b4/download/calculating-hefi-2019-scores.pdf
149. Migueles JH, Rowlands A V., Huber F, Sabia S, van Hees VT. GGIR: A Research Community–Driven Open Source R Package for Generating Physical Activity and Sleep Outcomes From Multi-Day Raw Accelerometer Data. J Meas Phys Behav. 2019 Sep 1;2(3):188–96.
150. van Hees VT, Gorzelniak L, Dean León EC, Eder M, Pias M, Taherian S, et al. Separating Movement and Gravity Components in an Acceleration Signal and Implications for the Assessment of Human Daily Physical Activity. PLoS One. 2013 Apr 23;8(4):e61691.

151. van Hees VT, Sabia S, Anderson KN, Denton SJ, Oliver J, Catt M, et al. A Novel, Open Access Method to Assess Sleep Duration Using a Wrist-Worn Accelerometer. PLoS One. 2015 Nov 16;10(11):e0142533.
152. Franklin BA, Brinks J, Berra K, Lavie CJ, Gordon NF, Sperling LS. Using Metabolic Equivalents in Clinical Practice. Am J Cardiol. 2018 Feb;121(3):382–7.
153. Sabia S, van Hees VT, Shipley MJ, Trenell MI, Hagger-Johnson G, Elbaz A, et al. Association Between Questionnaire- and Accelerometer-Assessed Physical Activity: The Role of Sociodemographic Factors. Am J Epidemiol. 2014 Mar 15;179(6):781–90.
154. Dhurandhar N V, Schoeller D, Brown AW, Heymsfield SB, Thomas D, Sørensen TIA, et al. Energy balance measurement: when something is not better than nothing. Int J Obes (Lond). 2015 Jul;39(7):1109–13.
155. de Castro JM. Eating behavior: lessons from the real world of humans. Nutrition. 2000 Oct;16(10):800–13.
156. Park Y, Dodd KW, Kipnis V, Thompson FE, Potischman N, Schoeller DA, et al. Comparison of self-reported dietary intakes from the Automated Self-Administered 24-h recall, 4-d food records, and food-frequency questionnaires against recovery biomarkers. Am J Clin Nutr. 2018;107(1):80–93.
157. Galland BC, Kennedy GJ, Mitchell EA, Taylor BJ. Algorithms for using an activity-based accelerometer for identification of infant sleep–wake states during nap studies. Sleep Med. 2012 Jun;13(6):743–51.
158. Sadeh A, Sharkey M, Carskadon MA. Activity-Based Sleep-Wake Identification: An Empirical Test of Methodological Issues. Sleep. 1994 May;17(3):201–7.
159. Cole RJ, Kripke DF, Gruen W, Mullaney DJ, Gillin JC. Automatic Sleep/Wake Identification From Wrist Activity. Sleep. 1992 Sep;15(5):461–9.
160. Huang TTK, Roberts SB, Howarth NC, McCrory MA. Effect of Screening Out Implausible Energy Intake Reports on Relationships between Diet and BMI. Obes Res. 2005 Jul;13(7):1205–17.
161. Bailey RL. Overview of dietary assessment methods for measuring intakes of foods, beverages, and dietary supplements in research studies. Curr Opin Biotechnol. 2021 Aug;70:91–6.
162. Hajishizari S, Imani H, Mehranfar S, Saeed Yekaninejad M, Mirzababaei A, Clark CCT, et al. The association of appetite and hormones (leptin, ghrelin, and Insulin) with resting metabolic rate in overweight/ obese women: a case-control study. BMC Nutr. 2022 Apr 29;8(1):37.
163. Freedman LS, Guenther PM, Krebs-Smith SM, Kott PS. A Population's Mean Healthy Eating Index-2005 Scores Are Best Estimated by the Score of the Population Ratio when One 24-Hour Recall Is Available1,. J Nutr. 2008 Sep;138(9):1725–9.
164. Givens ML, Malecki KC, Peppard PE, Palta M, Said A, Engelman CD, et al. Shiftwork, sleep habits, and metabolic disparities: results from the Survey of the Health of Wisconsin. Sleep Health. 2015 Jun;1(2):115–20.

165. Lauderdale DS, Knutson KL, Yan LL, Liu K, Rathouz PJ. Self-Reported and Measured Sleep Duration. Epidemiology. 2008 Nov;19(6):838–45.
166. Alahmary SA, Alduhaylib SA, Alkawii HA, Olwani MM, Shablan RA, Ayoub HM, et al. Relationship Between Added Sugar Intake and Sleep Quality Among University Students: A Cross-sectional Study. Am J Lifestyle Med. 2022 Jan 23;16(1):122–9.
167. Grandner MA, Kripke DF, Naidoo N, Langer RD. Relationships among dietary nutrients and subjective sleep, objective sleep, and napping in women. Sleep Med. 2010 Feb;11(2):180–4.
168. Marino M, Li Y, Rueschman MN, Winkelman JW, Ellenbogen JM, Solet JM, et al. Measuring Sleep: Accuracy, Sensitivity, and Specificity of Wrist Actigraphy Compared to Polysomnography. Sleep. 2013 Nov 1;36(11):1747–55.
169. Flo E, Bjorvatn B, Folkard S, Moen BE, Grønli J, Nordhus IH, et al. A Reliability and Validity Study of the Bergen Shift Work Sleep Questionnaire in Nurses Working Three-Shift Rotations. Chronobiol Int. 2012 Aug 23;29(7):937–46.
170. Monnaatsie M, Biddle SJH, Khan S, Kolbe-Alexander T. Physical activity and sedentary behaviour in shift and non-shift workers: A systematic review and meta-analysis. Prev Med Rep. 2021 Dec;24:101597.
171. Sjöblom L, Bonn SE, Alexandrou C, Dahlgren A, Eke H, Trolle Lagerros Y. Dietary habits after a physical activity mHealth intervention: a randomized controlled trial. BMC Nutr. 2023 Feb 2;9(1):23.
172. Mayer J, ROY P, MITRA KP. Relation between Caloric Intake, Body Weight, and Physical Work. Am J Clin Nutr. 1956 Apr;4(2):169–75.
173. Flahr H, Brown WJ, Kolbe-Alexander TL. A systematic review of physical activity-based interventions in shift workers. Prev Med Rep. 2018 Jun;10:323–31.
174. Atlantis E, Chow CM, Kirby A, Singh MAF. Worksite intervention effects on sleep quality: A randomized controlled trial. J Occup Health Psychol. 2006 Oct;11(4):291–304.
175. Lim ST, Min SK, Kwon YC, Park SK, Park H. Effects of intermittent exercise on biomarkers of cardiovascular risk in night shift workers. Atherosclerosis. 2015 Sep;242(1):186–90.
176. da Silva RP, Martinez D, Pedroso MM, Righi CG, Martins EF, Silva LMT, et al. Exercise, Occupational Activity, and Risk of Sleep Apnea: A Cross-Sectional Study. Journal of Clinical Sleep Medicine. 2017 Feb 15;13(02):197–204.
177. Gerber M, Lindwall M, Börjesson M, Hadzibajramovic E, Jonsdottir IH. Low leisure-time physical activity, but not shift-work, contributes to the development of sleep complaints in Swedish health care workers. Ment Health Phys Act. 2017 Oct;13:22–9.
178. Bonardi JMT, Lima LG, Campos GO, Bertani RF, Moriguti JC, Ferriolli E, et al. Effect of different types of exercise on sleep quality of elderly subjects. Sleep Med. 2016 Sep;25:122–9.

179. Buman MP, Phillips BA, Youngstedt SD, Kline CE, Hirshkowitz M. Does nighttime exercise really disturb sleep? Results from the 2013 National Sleep Foundation Sleep in America Poll. Sleep Med. 2014 Jul;15(7):755–61.
180. Lindsted KD, Fraser GE, Steinkohl M, Beeson WL. Healthy volunteer effect in a cohort study: Temporal resolution in the adventist health study. J Clin Epidemiol. 1996 Jul;49(7):783–90.
181. Kistin C, Silverstein M. Pilot Studies. JAMA. 2015 Oct 20;314(15):1561.
182. Lammers-van der Holst HM, Kerkhof GA. Shift work tolerance and the importance of sleep quality: a study of police officers. Biol Rhythm Res. 2015 Mar 4;46(2):257–64.
183. Härmä M, Ropponen A, Hakola T, Koskinen A, Vanttola P, Puttonen S, et al. Developing register-based measures for assessment of working time patterns for epidemiologic studies. Scand J Work Environ Health. 2015 May;41(3):268–79.
184. Hazzi O, Maldaon I. A Pilot Study: Vital Methodological Issues. Verslas: Teorija ir Praktika. 2015 Mar 30;16(1):53–62.
185. Härmä M, Knauth P, Ilmarinen J. Daytime napping and its effects on alertness and short-term memory performance in shiftworkers. Int Arch Occup Environ Health. 1989 Mar;61(5):341–5.
186. Parkes KR. Shift work and age as interactive predictors of body mass index among offshore workers. Scand J Work Environ Health. 2002 Feb;28(1):64–71.
187. Wagstaff AS, Sigstad Lie JA. Shift and night work and long working hours--a systematic review of safety implications. Scand J Work Environ Health. 2011 May;37(3):173–85.
188. Arendt J. Shift work: coping with the biological clock. Occup Med (Lond). 2010 Jan;60(1):10–20.
189. Erren TC, Morfeld P, Groß JV, Wild U, Lewis P. IARC 2019: “Night shift work” is probably carcinogenic: What about disturbed chronobiology in all walks of life? Journal of Occupational Medicine and Toxicology [Internet]. 2019;14(1):29. Available from: https://doi.org/10.1186/s12995-019-0249-6

Appendix A
Ethics Approval

Research Ethics Office
Suite 200, Eastern Trust Building
95 Bonaventure Avenue
St. John's, NL
A1B 2X5

NEWFOUNDLAND AND LABRADOR HREB HEALTH RESEARCH ETHICS BOARD

August 25, 2022

Department of Biochemistry,
Memorial University, Rm. CSF-3235

Dear Dr Harding:

Researcher Portal File # 20230493
Reference # 2022.134

RE: Assessing the impact of rotational and shift work on sleep, activity, energy balance, and food choice in adults.

Your application was reviewed by the Health Research Ethics Board (HREB) at the meeting held on July 28, 2022 and your response was reviewed by the Chair and the following decision was rendered:

X	Approval
	Approval subject to changes
	Rejection

Ethics approval is granted for one year effective August 25, 2022. This ethics approval will be reported to the board at the next scheduled HREB meeting.

This is to confirm that the HREB reviewed and approved or acknowledged the following documents (as indicated):

- Application, approved
- Research proposal, approved
- Participant Information Questionnaire Updated, approved
- Consent form, approved
- Updated Ad Template, approved
- Perceived Stress Scale, approved
- Pittsburg Sleep Quality Questionnaire, approved
- Morning or Eveningness Questionnaire, approved

- Physical Activity Questionnaire, approved
- Consensus Sleep Diary, approved
- Work Schedule form, approved
- Project budget and proposal information, approved

Please note the following:

- This ethics approval will lapse on August 25, 2023 It is your responsibility to ensure that the Ethics Renewal form is submitted prior to the renewal date.
- This is your ethics approval only. Organizational approval may also be required. It is your responsibility to seek the necessary organizational approvals.
- Modifications of the study are not permitted without prior approval from the HREB. Request for modification to the study must be outlined on the relevant Event Form available on the Researcher Portal website.
- Though this research has received HREB approval, you are responsible for the ethical conduct of this research.
- If you have any questions please contact info@hrea.ca or 709 777 6974.

The HREB operates according to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2), ICH Guidance E6: Good Clinical Practice Guidelines (GCP), the Health Research Ethics Authority Act (HREA Act) and applicable laws and regulations.

We wish you every success with your study.

Sincerely,

Dr Fern Brunger, Chair Non-Clinical Trials Committee
Health Research Ethics Board

Appendix B
Questionnaires

Participant Information Questionnaire

Participant ID: ________________ Date: ______________

1. What is your current age?
   ____

2. Where do you currently live? Please include the postal code as well.
   ____
   - ☐ Prefer not to say

3. What was your sex assigned at birth?
   - ☐ Male
   - ☐ Female
   - ☐ Rather not say

4. What gender do you identify as?
   - ☐ Male
   - ☐ Female
   - ☐ Others
   - ☐ Prefer not to say

5. What is your ethnicity?
   - ☐ Caucasian
   - ☐ East Asian
   - ☐ South Asian
   - ☐ Latino or Hispanic
   - ☐ Two or more
   - ☐ Other
   - ☐ Unknown
   - ☐ Rather not say

6. Were you born in Newfoundland?
   - ☐ Yes
   - ☐ No
   - ☐ Prefer not to say

7. What is your annual household income?

- ☐ Less than $30,000
- ☐ $30,000-$50,000
- ☐ $50,000-$100,000
- ☐ $100,000-$200,000
- ☐ Greater than $200,000
- ☐ Prefer not to answer

8. Which of the following best describes your current relationship status?
   - ☐ Married
   - ☐ Divorced
   - ☐ Separated
   - ☐ Widowed
   - ☐ Single, never married
   - ☐ In a domestic partnership or civil union
   - ☐ Other
   - ☐ Prefer not to say

9. What is your highest level of education?
   - ☐ Less than high school
   - ☐ High school diploma
   - ☐ Trade/apprenticeship certificate
   - ☐ Community college diploma
   - ☐ Some university, but no degree
   - ☐ Bachelor degree
   - ☐ Postgraduate degree
   - ☐ Prefer not to say

10. Do you consider yourself living with any disability?
    - ☐ Yes
    - ☐ No
    - ☐ Rather not say

11. How many children do you have?
    - ☐ More than 5
    - ☐ Between 3-5
    - ☐ Between 1-3
    - ☐ No children
    - ☐ Prefer not to say

Health History

12. Do you have any of the following health problems?

MEDICAL HISTORY	Yes / No	Unknown	If Yes, Explain	Current / Resolved
1. Head, Eye, Ear, Nose, Throat	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
2. Respiratory	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
3. Cardiovascular	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
4. Gastrointestinal	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
5. Genitourinary	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
6. Musculoskeletal	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
7. Neurological	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
8. Endocrine-Metabolic	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
9. Blood/Lymphatic	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
10. Dermatologic	☐ Yes ☐ No	☐		☐ Current ☐ Resolved

MEDICAL HISTORY	Yes / No	Unknown	If Yes, Explain	Current / Resolved
11. Psychiatric	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
12. Allergy	☐ Yes ☐ No	☐		☐ Current ☐ Resolved
13. Other, specify: ______________	☐ Yes ☐ No	☐		☐ Current ☐ Resolved

13. Do you take any medications for any of the following (or any other medications known to effect sleep or eating)?

- ☐ Hypothyroidism (e.g. Synthroid)
- ☐ Narcotic analgesic (e.g. Methadone)
- ☐ Antihypertensive (e.g. Sandoz-Bisoporlol, Sandoz-Amlodopine)
- ☐ Vitamins (e.g. Jamp-Vitamin D)
- ☐ Diuretic (e.g. Teva-Furosemide)
- ☐ Anti-diabetic (e.g. Sandoz-Metformin)
- ☐ Cholesterol lowering (e.g. Apo-Rosuvastatin)
- ☐ Antidepressant (e.g. Teva-Trazadone)
- ☐ Other, please specify __________________

14. Do you have any family history of diseases? (*If possible, please specify*)

	Maternal	Paternal
☐ Cancer	_________	________
☐ Heart Disease	_________	________
☐ Brain Disorders	_________	________
☐ Respiratory Diseases	_________	________
☐ Diabetes Mellitus	_________	________

- ☐ Psychiatric Disorders ________ ________
- ☐ Kidney Disorders ________ ________
- ☐ High Blood Pressure ________ ________
- ☐ Gastrointestinal Disorders ________ ________
- ☐ Others, please specify ________ ________

MEMORIAL UNIVERSITY

Consent to Take Part in Research

TITLE: Assessing the impact of Rotational and Shift Work on Food Choices, Physical Activity, Sleep, and Energy Balance in adults.

RESEARCHER(S): Varleen Kaur **Phone Number:** 864-8539 / 864-4711

SUPERVISOR(S): Dr. Scott Harding

SPONSOR/FUNDER: Memorial University of Newfoundland

You have been invited to take part in a research study. Taking part in this study is voluntary. You may choose to take part or you may choose not to take part in this study. You also may change your mind at any time.

This consent form has important information to help you make your choice. It may use words that you do not understand. Please ask the study staff to explain anything that you do not understand. It is important that you have as much information as you need and that all your questions are answered. Please take as much time as you need to think about your decision to participate or not, and ask questions about anything that is not clear. You may find it helpful to discuss it with your friends and family. The study staff will tell you about the study timelines for making your decision.

1. Why am I being asked to join this study?

You are being invited to join this study because our target group is shift, day time and rotational workers in the age of 30+. The purpose of this research is to study the impact of shift and rotational work on food choices, sleep pattern, stress levels and physical activity in adult workers. This study is being done to find out more information about the health conditions caused by shift work and rotational work.

2. How many people will take part in this study?

This study will take place in Newfoundland, Canada, North America. The study will enroll a total of 75 people.

3. How long will I be in the study?

You will be expected to come to the Nutrition and Lifestyle Lab in Memorial University for 2 visits over the next 12 months. Each visit will last ½ to 1 hour.

4. What will happen if I take part in this study?

If you agree to take part in this study, the following procedures will take place:

- You will have to come to the Nutrition and Lifestyle Lab twice. On the first visit your height, weight, blood pressure, waist and hip circumference will be measured. This will be done by the members of the research team.

- On your first visit, you will be provided with a Participant Information questionnaire with questions like age, sex, health history, location, education etc. Along with that, you will be asked to fill a questionnaire related to your sleeping habits. To protect your identity this data will be securely stored and will be limited to supervisor and graduate student only. Please talk to the research team if there is any information that you do not feel comfortable sharing.

- You will have to wear Actigraphy device for seven days all the time even during water based activities like bathing/swimming. The Actigraphy device will monitor your rest/activity cycles (motor activity). It is a non-invasive method.

- You will be given questionnaires related to Sleep and Work Schedule. You will have to fill those questionnaires at home. The purpose of the questionnaires is to understand how different kind of work schedules like day schedules, shift work and rotational shifts affect health. Each questionnaire will take about 15-20 minutes to complete. The information you provide is for research purposes only. Some of the questions are personal. You can choose not to answer questions if you wish.

- You have to complete two 24-hour online dietary recall using the US National Cancer Institute web-based, diet recording software. This means entering your food habits (diet) in the software.

- After a period of 7 days, on your 2^{nd} visit, you will be given questionnaires related to sleep, stress levels and physical activity to fill out. Along with that you have to return the device and previous questionnaires.

5. Are there risks to taking part in this study?

- An Actigraphy device looks similar to a wristwatch. It must be worn all day and all night as it is waterproof. It measures the amount of physical activity and sleep. There are no reported side effects of wearing an actigraphy watch. The wristband may aggravate sensitive skin due to the long-term use.
- During the study, there are several questionnaires which can be a discomfort at times. It may also interfere with your work time. Maximum efforts will be done to accommodate participant's work schedule. If you are not comfortable in answering any question, you may take a break or skip it. The following resources are available for you to contact for psychological support:

  Mental health resources – Doorways (709) 752-4903;
  Mobile Crisis Response Team – 811
  Adult Central Intake – (709) 752-8888 (for St. John's area only)
  bridgethegap.com
  Any Hospital Emergency Room

- There can be an inconvenience of time. First study visit will take about 1 hour and second study visit will take about 30-45 minutes. It will take approximately 2 hours for the entire research study visits.
- Despite protections being in place, there is a risk of unintentional release of information. Researchers will make every attempt to protect your privacy.

6. What are the possible benefits of participating in this study?

There may not be direct benefit to you from taking part in this study. We hope that the information learned from this study can be used in the future to benefit shift workers.

If I decide to take part in this study, can I stop later?

It is your choice to take part in this study, participation is voluntary. You can change your mind at any time during the research study. The study team may ask why you are withdrawing for reporting purposes, but you do not need to give a reason to withdraw from the study if you do not want to. If you decide to leave the study, you can contact your researcher. They will discuss other options with you.

Researcher will no longer access your data for research and all data collected about you will be destroyed. We will no longer contact you for any reason. We can remove your data up to the point of publishing the data or presenting it in form of abstract at a conference. Any data that has already been merged with other data and analyzed cannot be destroyed or removed from the study. This is because we have to preserve the study's scientific integrity.

7. What are my rights when participating in a research study?

You have the right to receive all information that could help you make a decision about participating in this study, in a timely manner. You also have the right to ask questions about this study at any time and to have them answered to your satisfaction.

Your rights to privacy are legally protected by federal and provincial laws that require safeguards to ensure that your privacy is respected.

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form, you do not give up any of your legal rights against the researcher or involved institutions for compensation, nor does this form relieve the researcher or their agents of their legal and professional responsibilities.

You have the right to be informed of the results of this study once the entire study is complete. A lay summary of results will be sent to each participant next six months after completing the data. Also, results with detail will publish through the conference and papers.

You will be given a copy of this signed and dated consent form prior to participating in this study.

8. What about my privacy and confidentiality?

Protecting your privacy is an important part of this study. If you decide to participate in this study, the study staff will collect information from you. They only collect and use the information they need for this study, including:

- sex and gender
- date of birth (year only)
- new or existing medical tests or procedures and medical conditions
- recently changed medications in last 6 months
- information from study interviews and questionnaires
- diagnosed medical conditions
- family medical history

The personal health information or personal information collected about you will have your directly identifiable information removed (i.e., name) and replaced with a code or with a “study number”. There will be a master list linking the code numbers to names. The researcher is responsible for keeping it separate from the samples and personal health information.

Study information collected during the study will be kept at Memorial University of Newfoundland and stored in a secure, locked place that only the study staff will be able to access. After the study closes, study information will be kept as long as required by law, which could be 7 years. Dr. Scott Harding is the person responsible for keeping it secure.

When the results of this study are published or presented at scientific meetings, your name and other personal information will not be used in the publication.

All information that identifies you will be kept confidential, and to the extent permitted by applicable laws, will not be disclosed or made publicly available, except as described in this consent document. Every effort to protect your privacy will be made. Even though the risk of identifying you from the study data is very small, it can never be completely eliminated. If there is a breach of your privacy any time after your participation in this study you will be notified. There is no time point when there will be no personal assigned for notifying on privacy breach.

You will be using ASA24 (Automated Self-Administered 24-Hour Dietary Assessment Tool) diet recording software by National Cancer Institute (NCI). Respondent confidentiality is of the utmost importance within the ASA24 system. We will not provide the National Cancer Institute (NCI) or the ASA24 system with any personally identifiable data associated with study Respondents. We will use a specific USER ID for each respondent and download system-generated usernames and passwords that respondents use to access the application. You will be wearing actigraphy watch for the time period of seven days. Actigraphy watch is very similar to other watches and collects data about your gross motor activity. It will record your physical activity and sleeping habits. We will be using the GENEActiv software for extracting the data from the actigraphy watch which will delete the data from the watch. The extracted data will be converted into .csv files and securely stored in an external hard drive in a locked cabinet.

Communication via e-mail is not absolutely secure. We do not recommend that you communicate sensitive personal information via e-mail.

9. Who will see my personal information?

Representatives from the Health Research Ethics Board may come to look at the study records and your personal information under the supervision of the study staff to check that the information collected for the study is correct and to make sure the study followed the required laws and guidelines:

- HREA staff
- Principal Investigator
- Study Staff

We may continue to review your study information that you have consented for the study to access for a period of time after your last study visit in order to check that the information, we collected is correct.

<u>Your access to records</u>
You have the right to see the information that has been collected about you for this study. If you wish to do so, please contact your study staff.

10. Commercialization:

In this study there is no possibility that a commercial product be developed.

11. Declaration of financial interest, if applicable

There are no conflicts of interest to declare related to this study.

13. What about questions or problems?

If you have any questions about taking part in this study, you can meet with the principal investigator who is in charge of the study. That person is:
Dr. Scott Harding
Phone Number: 864-8539 / 864-4711

Or you can talk to someone who is not involved with the study at all, but can advise your on your rights as a participant in a research study. This person can be reached through: Ethics Office at 709-777-6974 or email at info@hrea.ca

Signature Page

My signature on this consent form means:

- I have had enough time to think about the information provided and ask for advice if needed.
- All of my questions have been answered and I understand the information within this consent form.
- I understand that my participation in this study is voluntary.
- I understand that I am completely free at any time to refuse to participate or to withdraw from this study at any time, without having to give a reason, and that this will not change the quality of care that I receive.
- I understand that it is my choice to be in the study and there is no guarantee that this study will provide any benefits to me.
- I am aware of the risks of participating in this study.
- I do not give up any of my legal rights by signing this consent form.
- I understand that all of the information collected will be kept confidential and that the results will only be used for the purposes described in this consent form.
- I agree, or agree to allow the person I am responsible for, to take part in this study.

____

Signature of participant	Printed name	Day Month Year

____

Signature of person conducting the consent discussion	Name printed	Day Month Year

To be signed by the investigator:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant/substitute decision maker fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

Signature of Researcher	Name Printed	Day Month Year

Participant Assistance

Complete the following declaration only if the participant is <u>unable to read</u>:

- The informed consent form was accurately explained to, and apparently understood by, the participant, and
- Informed consent was freely given by the participant

Signature of Impartial Witness	Printed Name	Day Month Year

Complete the following declaration only if the participant has limited proficiency in the language in which the consent form is written and interpretation was provided as follows:

- The informed consent discussion was interpreted by an interpreter and
- A sight translation of this document was provided by the interpreter as directed by the research staff conducting the consent.

Interpreter Declaration and Signature:
By signing the consent form I attest that I provided a faithful interpretation for any discussion that took place in my presence, and provided a sight translation of this document as directed by the research staff conducting the consent.

Signature of Interpreter	Printed Name	Day Month Year

Are you interested in joining our research study on Sleep & Work?

Study title:

SWEAT Study

Sleep, **W**ork,
Energy Intake
Activi**T**y Study.

Principal Investigator:

Dr. Scott Harding

Memorial University

Interested? To ask questions contact:

sweatstudy@mun.ca

vkaur@mun.ca

Deadline to enroll: Now to December 2022

MEMORIAL UNIVERSITY

Are you a working individual of age 30 years and above?
Consider participating in our study:

What is the study about?

In this study, we are going to measure sleep time, physical activity, stress levels, food habits and work schedule. We want to determine the impact of different work schedules on risk of chronic diseases.

Who can participate?

We are looking for 75 workers aged 30 years and above doing regular day time work, rotational work or odd hour shifts and are living in Newfoundland.

What's involved?

You need to come to Nutrition and Lifestyle lab at Memorial University for some data collection and for basic description about the study.

If you have questions regarding your rights as a research participant please contact the Health Research Ethics Authority at (709) 777-6974 or info@hrea.ca.

ARE YOU INTERESTED IN JOINING OUR RESEARCH STUDY ON SLEEP & WORK?

SWEAT STUDY

Are you a working individual age 30 years and above? Consider participating in our study:

- This study will measure sleep time, physical activity, food habits and work schedule. We want to determine the impact of different work schedules on the risk of chronic diseases and sleep levels.
- We are looking for 45 workers of age 30 years and above doing regular daytime work, rotational work or shift work and are living in Newfoundland.
- You need to come to Nutrition and Lifestyle lab at Memorial University twice for data collection.

Principal Investigator - Dr. Scott Harding

Interested? Contact - sweatstudy@mun.ca or vkaur@mun.ca

MEMORIAL UNIVERSITY

Perceived Stress Scale

A more precise measure of personal stress can be determined by using a variety of instruments that have been designed to help measure individual stress levels. The first of these is called the **Perceived Stress Scale**.

The Perceived Stress Scale (PSS) is a classic stress assessment instrument. The tool, while originally developed in 1983, remains a popular choice for helping us understand how different situations affect our feelings and our perceived stress. The questions in this scale ask about your feelings and thoughts during the last month. In each case, you will be asked to indicate how often you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer fairly quickly. That is, don't try to count up the number of times you felt a particular way; rather indicate the alternative that seems like a reasonable estimate.

For each question choose from the following alternatives:
0 - never 1 - almost never 2 - sometimes 3 - fairly often 4 - very often

________ 1. In the last month, how often have you been upset because of something that happened unexpectedly?

________ 2. In the last month, how often have you felt that you were unable to control the important things in your life?

________ 3. In the last month, how often have you felt nervous and stressed?

________ 4. In the last month, how often have you felt confident about your ability to handle your personal problems?

________ 5. In the last month, how often have you felt that things were going your way?

________ 6. In the last month, how often have you found that you could not cope with all the things that you had to do?

________ 7. In the last month, how often have you been able to control irritations in your life?

________ 8. In the last month, how often have you felt that you were on top of things?

________ 9. In the last month, how often have you been angered because of things that happened that were outside of your control?

________ 10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

Figuring Your PSS Score

You can determine your PSS score by following these directions:

- First, reverse your scores for questions 4, 5, 7, and 8. On these 4 questions, change the scores like this:

  0 = 4, 1 = 3, 2 = 2, 3 = 1, 4 = 0.

- Now add up your scores for each item to get a total. **My total score is ___________.**

- Individual scores on the PSS can range from 0 to 40 with higher scores indicating higher perceived stress.
  - ► Scores ranging from 0-13 would be considered low stress.
  - ► Scores ranging from 14-26 would be considered moderate stress.
  - ► Scores ranging from 27-40 would be considered high perceived stress.

The Perceived Stress Scale is interesting and important because your perception of what is happening in your life is most important. Consider the idea that two individuals could have the exact same events and experiences in their lives for the past month. Depending on their perception, total score could put one of those individuals in the low stress category and the total score could put the second person in the high stress category.

Disclaimer: *The scores on the following self-assessment do not reflect any particular diagnosis or course of treatment. They are meant as a tool to help assess your level of stress. If you have any further concerns about your current well being, you may contact EAP and talk confidentially to one of our specialists.*

PITTSBURGH SLEEP QUALITY INDEX (PSQI)

INSTRUCTIONS: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, when have you usually gone to bed at night?

   USUAL BED TIME ______________________________

2. During the past month, how long (in minutes) has it usually take you to fall asleep each night?

   NUMBER OF MINUTES ______________________________

3. During the past month, when have you usually gotten up in the morning?

   USUAL GETTING UP TIME ______________________________

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spend in bed.)

   HOURS OF SLEEP PER NIGHT ______________________________

INSTRUCTIONS: For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
(a) ...cannot get to sleep within 30 minutes	☐	☐	☐	☐
(b) ...wake up in the middle of the night or early morning	☐	☐	☐	☐
(c) ...have to get up to use the bathroom	☐	☐	☐	☐
(d ...cannot breathe comfortably	☐	☐	☐	☐
(e) ...cough or snore loudly	☐	☐	☐	☐
(f) ...feel too cold	☐	☐	☐	☐
(g) ...feel too hot	☐	☐	☐	☐
(h) ...had bad dreams	☐	☐	☐	☐
(i) ...have pain	☐	☐	☐	☐

(j) Other reason(s), please describe

____

____

How often during the past month have you had trouble sleeping because of this?	☐	☐	☐	☐

	Very good	Fairly good	Fairly bad	very bad
6. During the past month, how would you rate your sleep quality overall?	☐	☐	☐	☐

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
7. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?	☐	☐	☐	☐
8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	☐	☐	☐	☐

	No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	☐	☐	☐	☐

	No bed partner or roommate	Partner/ roommate in other room	Partner in same room, but not same bed	Partner in same bed
10. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	☐	☐	☐	☐

If you have a roommate or bed partner, ask him/her how often in the past month you have had...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
(a) ...loud snoring	☐	☐	☐	☐
(b) ...long pauses between breaths while asleep	☐	☐	☐	☐
(c) ...legs twitching or jerking while you sleep	☐	☐	☐	☐
(d) ...episodes of disorientation or confusion during sleep	☐	☐	☐	☐
(e) Other restlessness while you sleep; please describe	☐	☐	☐	☐

____

____

PSQI Page 2

SCORING INSTRUCTIONS FOR THE PITTSBURGH SLEEP QUALITY INDEX:

The Pittsburgh Sleep Quality Index (PSQI) contains 19 self-rated questions and 5 questions rated by the bed partner or roommate (if one is available). Only self-rated questions are included in the scoring. The 19 self-rated items are combined to form seven "component" scores, each of which has a range of 0-3 points. In all cases, a score of "0" indicates no difficulty, while a score of "3" indicates severe difficulty. The seven component scores are then added to yield one "global" score, with a range of 0-21 points, "0" indicating no difficulty and "21 " indicating severe difficulties in all areas.

Scoring proceeds as follows:

Component 1: Subjective sleep quality

Examine question #6, and assign scores as follows:

Response	Component 1 score
"Very good"	0
"Fairly good"	1
"Fairly bad"	2
"Very bad"	3

Component 1 score:________

Component 2: Sleep latency

1. Examine question #2, and assign scores as follows:

Respo\nse	Score
≤15 minutes	0
16-30 minutes	1
31-60 minutes	2
> 60 minutes	3

Question #2 score: ________

2. Examine question #5a, and assign scores as follows:

Response	Score
Not during the past month	0
Less than once a week	1
Once or twice a week	2
Three or more times a week	3

Question #5a score: ________

3. Add #2 score and #5a score

Sum of #2 and #5a: ________

4. Assign component 2 score as follows:

Sum of #2 and #5a	Component 2 score
0	0
1-2	1
3-4	2
5-6	3

Component 2 score:________

Component 3: Sleep duration

Examine question #4, and assign scores as follows:

Response	Component 3 score
> 7 hours	0
6-7 hours	1
5-6 hours	2
< 5 hours	3

Component 3 score:______

Component 4: Habitual sleep efficiency

1. Write the number of hours slept (question #4) here:______
2. Calculate the number of hours spent in bed:

   Getting up time (question #3):______

   Bedtime (question #1):______

   ____

   Number of hours spent in bed:______

3. Calculate habitual sleep efficiency as follows:

   (Number of hours slept/Number of hours spent in bed) X 100 = Habitual sleep efficiency (%)

   (______/______) X 100 = %

4. Assign component 4 score as follows:

Habitual sleep efficiency %	Component 4 score
> 85%	0
75-84%	1
65-74%	2
< 65%	3

Component 4 score:______

Component 5: Step disturbances

1. Examine questions #5b-5j, and assign scores for each question as follows:

Response	Score
Not during the past month	0
Less than once a week	1
Once or twice a week	2
Three or more times a week	3

5b score: ________

5c score: ________

5d score: ________

5e score: ________

5f score: ________

5g score: ________

5h score: ________

5i score: ________

5j score: ________

2. Add the scores for questions #5b-5j:

Sum of #5b-5j: ________

3. Assign component 5 score as follows:

Sum of #5b-5j	Component 5 score
0	0
1-9	1
10-18-4	2
19-27	3

Component 5 score: ________

Component 6: Use of sleeping medication

Examine question #7 and assign scores as follows:

Response	Component 6 score
Not during the past month	0
Less than once a week	1
Once or twice a week	2
Three or more times a week	3

Component 6 score: ________

PSQI Page 5

Component 7: Daytime dysfunction

1. Examine question #8, and assign scores as follows:

Response	Score
Never	0
Once or twice	1
Once or twice each week	2
Three or more times each week	3

Question#8 score: ________

2. Examine question #9, and assign scores as follows:

Response	Score
No problem at all	0
Only a very slight problem	1
Somewhat of a problem	2
A very big problem	3

Question #9 score: ________

3. Add the scores for question #8 and #9:

Sum of #8 and #9: ________

4. Assign component 7 score as follows:

Sum of #8 and #9	Component 7 score
0	0
1-2	1
3-4	2
5-6	3

Component 7 score:________

Global PSQI Score

Add the seven component scores together:

Global PSQI Score:________

Morningness and Eveningness Questionnaire

MORNINGNESS-EVENINGNES05S QUESTIONNAIRE
Self-Assessment Version (MEQ-SA)[1]

Name: ____________________________ Date: _______________________

For each question, please select the answer that best describes you by circling the point value that best indicates how you have felt in recent weeks.

1. *Approximately* what time would you get up if you were entirely free to plan your day?

   [5] 5:00 AM–6:30 AM *(05:00–06:30 h)*
   [4] 6:30 AM–7:45 AM *(06:30–07:45 h)*
   [3] 7:45 AM–9:45 AM *(07:45–09:45 h)*
   [2] 9:45 AM–11:00 AM *(09:45–11:00 h)*
   [1] 11:00 AM–12 noon *(11:00–12:00 h)*

2. *Approximately* what time would you go to bed if you were entirely free to plan your evening?

   [5] 8:00 PM–9:00 PM *(20:00–21:00 h)*
   [4] 9:00 PM–10:15 PM *(21:00–22:15 h)*
   [3] 10:15 PM–12:30 AM *(22:15–00:30 h)*
   [2] 12:30 AM–1:45 AM *(00:30–01:45 h)*
   [1] 1:45 AM–3:00 AM *(01:45–03:00 h)*

3. If you usually have to get up at a specific time in the morning, how much do you depend on an alarm clock?

   [4] Not at all
   [3] Slightly
   [2] Somewhat
   [1] Very much

---

[1]Some stem questions and item choices have been rephrased from the original instrument (Horne and Östberg, 1976) to conform with spoken American English. Discrete item choices have been substituted for continuous graphic scales. Prepared by Terman M, Rifkin JB, Jacobs J, White TM (2001), New York State Psychiatric Institute, 1051 Riverside Drive, Unit 50, New York, NY, 10032. January 2008 version. Supported by National Institute of Health Grant MH42931. *See also:* automated English version (AutoMEQ) at www.cet.org.

Horne JA and Östberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. International Journal of Chronobiology, 1976: 4, 97-100.

4. How easy do you find it to get up in the morning (when you are not awakened unexpectedly)?

   [1] Very difficult
   [2] Somewhat difficult
   [3] Fairly easy
   [4] Very easy

5. How alert do you feel during the first half hour after you wake up in the morning?

   [1] Not at all alert
   [2] Slightly alert
   [3] Fairly alert
   [4] Very alert

6. How hungry do you feel during the first half hour after you wake up?

   [1] Not at all hungry
   [2] Slightly hungry
   [3] Fairly hungry
   [4] Very hungry

7. During the first half hour after you wake up in the morning, how do you feel?

   [1] Very tired
   [2] Fairly tired
   [3] Fairly refreshed
   [4] Very refreshed

8. If you had no commitments the next day, what time would you go to bed compared to your usual bedtime?

   [4] Seldom or never later
   [3] Less that 1 hour later
   [2] 1-2 hours later
   [1] More than 2 hours later

9. You have decided to do physical exercise. A friend suggests that you do this for one hour twice a week, and the best time for him is between 7-8 AM *(07-08 h)*. Bearing in mind nothing but your own internal "clock," how do you think you would perform?

    [4] Would be in good form
    [3] Would be in reasonable form
    [2] Would find it difficult
    [1] Would find it very difficult

10. At *approximately* what time in the evening do you feel tired, and, as a result, in need of sleep?

    [5] 8:00 PM–9:00 PM *(20:00–21:00 h)*
    [4] 9:00 PM–10:15 PM *(21:00–22:15 h)*
    [3] 10:15 PM–12:45 AM *(22:15–00:45 h)*
    [2] 12:45 AM–2:00 AM *(00:45–02:00 h)*
    [1] 2:00 AM–3:00 AM *(02:00–03:00 h)*

11. You want to be at your peak performance for a test that you know is going to be mentally exhausting and will last two hours. You are entirely free to plan your day. Considering only your "internal clock," which one of the four testing times would you choose?

    [6] 8 AM–10 AM *(08–10 h)*
    [4] 11 AM–1 PM *(11–13 h)*
    [2] 3 PM–5 PM *(15–17 h)*
    [0] 7 PM–9 PM *(19–21 h)*

12. If you got into bed at 11 PM *(23 h)*, how tired would you be?

    [0] Not at all tired
    [2] A little tired
    [3] Fairly tired
    [5] Very tired

13. For some reason you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which one of the following are you most likely to do?

[4] Will wake up at usual time, but will not fall back asleep
[3] Will wake up at usual time and will doze thereafter
[2] Will wake up at usual time, but will fall asleep again
[1] Will not wake up until later than usual

14. One night you have to remain awake between 4-6 AM *(04-06 h)* in order to carry out a night watch. You have no time commitments the next day. Which one of the alternatives would suit you best?

[1] Would not go to bed until the watch is over
[2] Would take a nap before and sleep after
[3] Would take a good sleep before and nap after
[4] Would sleep only before the watch

15. You have two hours of hard physical work. You are entirely free to plan your day. Considering only your internal "clock," which of the following times would you choose?

[4] 8 AM–10 AM *(08–10 h)*
[3] 11 AM–1 PM *(11–13 h)*
[2] 3 PM–5 PM *(15–17 h)*
[1] 7 PM–9 PM *(19–21 h)*

16. You have decided to do physical exercise. A friend suggests that you do this for one hour twice a week. The best time for her is between 10-11 PM *(22-23 h)*. Bearing in mind only your internal "clock," how well do you think you would perform?

[1] Would be in good form
[2] Would be in reasonable form
[3] Would find it difficult
[4] Would find it very difficult

17. Suppose you can choose your own work hours. Assume that you work a five-hour day (including breaks), your job is interesting, and you are paid based on your performance. At *approximately* what time would you choose to begin?

    [5] 5 hours starting between 4–8 AM *(04–08 h)*
    [4] 5 hours starting between 8–9 AM *(08–09 h)*
    [3] 5 hours starting between 9 AM–2 PM *(09–14 h)*
    [2] 5 hours starting between 2–5 PM *(14–17 h)*
    [1] 5 hours starting between 5 PM–4 AM *(17–04 h)*

18. At *approximately* what time of day do you usually feel your best?

    [5] 5–8 AM *(05–08 h)*
    [4] 8–10 AM *(08–10 h)*
    [3] 10 AM–5 PM *(10–17 h)*
    [2] 5–10 PM *(17–22 h)*
    [1] 10 PM–5 AM *(22–05 h)*

19. One hears about "morning types" and "evening types." Which one of these types do you consider yourself to be?

    [6] Definitely a morning type
    [4] Rather more a morning type than an evening type
    [2] Rather more an evening type than a morning type
    [1] Definitely an evening type

____ **Total points for all 19 questions**

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE
(October 2002)

LONG LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ
The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ
Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation
Translation from English is encouraged to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information
More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective.* Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

   ☐ Yes

   ☐ No → ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

   _____ **days per week**

   ☐ No vigorous job-related physical activity → ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

   _____ **hours per day**
   _____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

   _____ **days per week**

   ☐ No moderate job-related physical activity → ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**
_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**
_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**
_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days **walking** from place to place?

_____ **hours per day**
_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**
_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**
_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?
_____ **hours per day**
_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day**
_____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ **hours per day**
_____ **minutes per day**

This is the end of the questionnaire, thank you for participating.

LONG LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised October 2002.

Sleep Diary Instructions - Core

General Instructions

What is a Sleep Diary? A sleep diary is designed to gather information about your daily sleep pattern.

How often and when do I fill out the sleep diary? It is necessary for you to complete your sleep diary every day. If possible, the sleep diary should be completed within one hour of getting out of bed in the morning.

What should I do if I miss a day? If you forget to fill in the diary or are unable to finish it, leave the diary blank for that day.

What if something unusual affects my sleep or how I feel in the daytime? If your sleep or daytime functioning is affected by some unusual event (such as an illness, or an emergency) you may make brief notes on your diary.

What do the words "bed" and "day" mean on the diary? This diary can be used for people who are awake or asleep at unusual times. In the sleep diary, the word "day" is the time when you choose or are required to be awake. The term "bed" means the place where you usually sleep.

Will answering these questions about my sleep keep me awake? This is not usually a problem. You should not worry about giving exact times, and you should not watch the clock. Just give your best estimate.

Item Instructions

Use the guide below to clarify what is being asked for each item of the Sleep Diary.

Date: Write the date of the morning you are filling out the diary.

1. *What time did you get into bed?* Write the time that you got into bed. This may not be the time that you began "trying" to fall asleep.

2. *What time did you try to go to sleep?* Record the time that you began "trying" to fall asleep.

3. *How long did it take you to fall asleep?* Beginning at the time you wrote in question 2, how long did it take you to fall asleep.

4. *How many times did you wake up, not counting your final awakening?* How many times did you wake up between the time you first fell asleep and your final awakening?

5. *In total, how long did these awakenings last?* What was the total time you were awake between the time you first fell asleep and your final awakening. For example, if you woke 3 times for 20 minutes, 35 minutes, and 15 minutes, add them all up (20+35+15= 70 min or 1 hr and 10 min).

6. *What time was your final awakening?* Record the last time you woke up in the morning.

7. *What time did you get out of bed for the day?* What time did you get out of bed with no further attempt at sleeping? This may be different from your final awakening time (e.g. you may have woken up at 6:35 a.m. but did not get out of bed to start your day until 7:20 a.m.)

8. *How would you rate the quality of your sleep?* "Sleep Quality" is your sense of whether your sleep was good or poor.

9. *Comments* If you have anything that you would like to say that is relevant to your sleep feel free to write it here.

Sample **Consensus Sleep Diary-Core** ID/Name:______________________________

Today's date	4/5/11							
1. What time did you get into bed?	10:15 p.m							
2. What time did you try to go to sleep?	11:30 p.m							
3. How long did it take you to fall asleep?	55 min.							
4. How many times did you wake up, not counting your final awakening?	3 times							
5. In total, how long did these awakenings last?	1 hour 10 min.							
6. What time was your final awakening?	6:35 a.m.							
7. What time did you get out of bed for the day?	7:20 a.m							
8. How would you rate the quality of your sleep?	☐ Very poor ☑ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good
9. Comments (if applicable)	I have a cold							

Work Schedule Form

Participant ID- ________ **Date-** _________

1- How long have you worked altogether?
__________ years

2- How long **altogether** have you been working shifts?
_______ years _______ months

3- What is your current occupation and where do you work (please include the postal code)?
____

4- How long have you worked in your **present** shift system?
_______ years _______months

5- On average, how many hours do you work each week excluding overtime?
________ hours ______ minutes

6- On average, how many hours unpaid overtime do you work each week, (e.g., over-run of shifts)
________ hours _______ minutes

7- On an average, how many hours **paid** overtime do you work each week?
_________ hours _______ minutes

8- Do you have a second paid job in addition to your main one? *(Tick one)*
________ yes ______ no

9- If you have taken a career break (or breaks), how long was this for in total?
________ hours _______ minutes

10- Are you also doing rotational work? (For e.g., you work continuously for 14 days and take off for 7 days then again work continuously for 14 days.)
______ yes _____ no

11- If yes, please explain your work schedule.
____

<u>Your Shift Details</u>

10- On average, how long does it take you to travel to and from work?

		TO WORK	FROM WORK
(a)	Morning Shift	_________ mins	________ mins
(b)	Afternoon Shift	_________ mins	________ mins
(c)	Night Shift	_________ mins	________ mins
(d)	Other .... *(Please specify)*	_________ mins	________ mins

11- How do you normally travel to work? *(Tick one)*

(a) By public transport ________

(b) By private transport ________

(c) By a combination of public and private ________

(d) By company transport ________

(e) By foot ________

12- For each of the shifts that **you normally work**, on average how many successive shifts of **the same kind** do you normally work before changing to another shift or having some days off?

NUMBER

(a) Number of successive morning shifts ________

(b) Number of successive afternoon shifts ________

(c) Number of successive night shifts ________

(d) Total number of successive shifts (Of any kind) before days off ________

(e) Other .... *(Please specify)* ________

13- On average, how many days off in succession do you normally have? ________

14- In general, when changing from one type of shift to another, what type of shift is each shift or day off followed by?

(a) Morning shifts are normally followed by: ________

(b) Afternoon shifts are normally followed by: ________

(c) Night shifts are normally followed by: ________

(d) Other .... are normally followed by: ________

(e) Days off are normally followed by: ________

15- On average how many nights do you work per year? ________

16- When you are working at night, and you go to sleep in the morning, do you still see day light on waking up?
________ yes ________ no

17- How are these night shifts organised? Please ignore this question if you are not doing night shifts.
(Please tick the <u>one</u> which best describes your night work)

(a) permanent nightshift ________
(b) a single block of night duty per year ________
(c) occasional blocks of night duty per year ________

(d) a block of nights each month __________
(e) one or two nights each week __________
(f) any other? (*please specify)* __________

18- On average how many weekends do you have off per 28 days? __________

19- How regular is the shift system you work?
(Please tick one)

(a) **REGULAR** i.e., a fixed roster which is repeated when the cycle of shifts finishes, even if occasional variations occur to meet special requests. __________

(b) **IRREGULAR** i.e. the duty roster does not cycle or repeat in any regular manner and individual preferences are not taken into account. __________

(c) **FLEXIBLE** i.e. where the individuals concerned are consulted about their preferred duty hours before the duty roster is drawn up. __________

20- If your shift system is **regular**, over how many weeks does the cycle run before it is repeated? __________

21- What are your main reasons for working shifts?
(Please circle one number for each)

		Not a reason for me		**Partly a reason reason for me**		**Very much a reason for me**
(a)	It is part of the job	1	2	3	4	5
(b)	It was the only job available	1	2	3	4	5
(c)	More convenient for my domestic responsibilities	1	2	3	4	5
(d)	Higher rates of pay	1	2	3	4	5
(e)	Other .... *(Please give your reasons)*	1	2	3	4	5

Your Shift System

For each of the shifts that **you normally work**, at what time do they start and finish? (Please use 24h time, e.g. 21:30 or clearly indicate "am" or "pm"). Please use the following symbols to describe the shifts that you work.

D = Day Shift
M = Morning or Early Shift
A = Afternoon, Late, Evening or Swing Shift
N = Night Shift
R = Rest Day
O = Other - Please specify
(Use different symbols for each if more than one)

Shift e.g. Night	**Symbol** e.g. "N"	**Start Time** e.g. 23:00	**End Time** e.g. 07:00

Think about the last month. Now use the symbols to show a complete cycle of your shift system including rest days.

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Week 1							
Week 2							
Week 3							
Week 4							

In regard to the previous question, do you think in the past 6 months you had a similar schedule?

____

Appendix C
HEFI-2019

Detailed steps for calculating HEFI-2019 score by Health Canada can be found at Open Government > The Healthy Eating Food Index 2019

The scoring algorithm is shown below and can also be found at GitHub page of didierbrassard/hefi2019.

```
devtools::install_github("didierbrassard/hefi2019")

# Install the hefi2019 scoring algorithm from GitHub, if not already one
# devtools::install_github("didierbrassard/hefi2019")

# Load library
library(hefi2019)

# Apply the scoring algorithm to user-provided data
mydata_scored <-
hefi2019(indata             = mydata,
vegfruits                   = RA_vegfruits,
wholegrfoods                = RA_wholegrfoods,
nonwholegrfoods             = RA_nonwgfoods,
profoodsanimal              = RA_profoodsanimal,
profoodsplant               = RA_profoodsplant,
otherfoods                  = RA_otherfoods,
waterhealthybev             = G_waterhealthybev,
unsweetmilk                 = G_milk,
unsweetplantbevpro = G_plantbevpro,
otherbeverages              = G_otherbeverages ,
mufat                       = G_mufa ,
pufat                       = G_pufa ,
satfat                      = G_sfa ,
freesugars                  = G_freesugars,
sodium                      = MG_sodium,
energy                      = energy
        )
## Healthy Eating Food Index-2019 Scoring Algorithm R version 1.3
```

Screenshot of GitHub page of Didier Brassard