# MUSCULOSKELETAL FITNESS AND BODY COMPOSITION OF NEWFOUNDLAND AND LABRADOR OFFSHORE OIL AND GAS WORKERS


by

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## ABSTRACT

Musculoskeletal fitness and body composition has been well studied as it relates to an individual's overall health in relation to non-communicable diseases such as cardiovascular disease, cancers, chronic respiratory diseases, and diabetes (World Health Organization, 2015). The objectives of this research were to investigate the current musculoskeletal fitness and body composition of the Newfoundland and Labrador (NL) Offshore Workforce and to determine how this population compares to the Canadian population. Eighty-nine men from the NL offshore workforce (mean ± standard deviation; height: 177.13 ± 6.77 cm, mass: 92.02 ± 16.07 kg, age: 42 ± 9.76 years) were included for analysis in this study. Data was collected offshore by a Definitions® wellness representative from five offshore industry companies. All measures were collected in accordance with the *Canadian Physical Activity, Fitness & Lifestyle Approach Manual* (Canadian Society for Exercise Physiology, 2004), the *Physical Activity Training for Health* manual (Canadian Society for Exercise Physiology, 2013) or *Advanced Fitness Assessment And Exercise Prescription* (Heyward & Gibson, 2010). Body composition measures included body mass index (BMI), waist circumference, and skin-folds. Musculoskeletal measures included push-ups, partial curl-ups, back extension, sit-and-reach, and grip strength. Participants were divided into two age groups: 20 – 39 and 40 – 59. Results from both groups showed that offshore workers have poor body composition, but have generally good musculoskeletal fitness compared to Canadian norms. However, both groups performed similarly on the musculoskeletal fitness tests. This means that a younger population has the physical strength and endurance of a population that is on average 14 years older. Overall, the results indicated the need to improve the overall body composition of the offshore workforce with ongoing development to maintain, or improve in some instances, musculoskeletal health. These results are an important starting point, whereby the Canadian Newfoundland and Labrador Offshore Petroleum Board can investigate the feasibility of offshore specific health and wellness programming that aims to improve the physical fitness of all offshore workers.

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**LIST OF SYMBOLS, NOMENCLATURE OR ABBREVIATIONS**

**CSEP ............................................ Canadian Society for Exercise Physiology**

**CEP ................................................ Certified Exercise Physiologist**

**MUN ............................................. Memorial University of Newfoundland**

**C-NLOPB...................................... Canadian Newfoundland and Labrador Offshore Petroleum Board**

**BMI ................................................ Body Mass Index**

**NL .................................................. Newfoundland and Labrador**

**MSK ............................................. Musculoskeletal**

**MSC ............................................... Musculoskeletal Complaints**

**PAR-Q .......................................... Physical Activity Readiness Questionnaire**

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# 1.0 REVIEW OF LITERATURE

## 1.1 Introduction

The Centre for Disease Control (CDC) defines physical fitness as “the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and respond to emergencies,” which is characterized by cardiorespiratory endurance (aerobic power), skeletal muscle strength, power and endurance, flexibility, balance, and body composition (Clarke, 1971). In particular, offshore workers should be physically capable to perform their work task safely, without worsening any existing health conditions, and be able to respond to emergencies (Geving, Jørgensen, Thi, & Sandsund, 2007; IPIECA, 2011; Mohamed, Donnelly, & Fraser, 2012). Although it is well known that NL has the most obese population in Canada, it is currently unknown how, or if, this same statistic applies to NL offshore workers (Carew, 2012; Statistics Canada, 2012).

The aforementioned physical fitness characteristics have been well studied in the general Canadian population (Canadian Society for Exercise Physiology, 2013; Tremblay et al., 2010). However, this is not the case for the NL Offshore Oil and Gas Worker population. In 2009, the tragedy of Cougar Airlines flight 491 sparked the development of Recommendation 14 of the Offshore Helicopter Safety Inquiry. Recommendation 14 highlighted the importance of physical fitness of workers, in preparation for safety training, necessary prior to employment (Carew, 2012). In particular, these fitness goals should aim to reduce obesity and increase physical activity (Carew, 2012). However, since there has been no investigation to our knowledge, musculoskeletal fitness and body composition measures of the NL offshore oil and gas workforce have been compiled. As such, the School of Human Kinetics and Recreation partnered with Definition's®, a corporate wellness company to examine the health and fitness levels of the offshore workforce in NL.

Definition's ® is an independent local company that provides health and wellness services for personal and corporate clients, including major oil and gas companies in North America. Services include ergonomic assessments, exercise and nutrition plans, pre-hire testing, manual handling training, and biometrics and health risk assessments (Definitions, 2015). These solutions have been identified, as part of the commissioned review, as having merit and may be beneficial for improving physical fitness, reducing chronic illness, and time lost due to injury, but needs to be evaluated by an external entity (Carew, 2012). The review also recommended "developing a baseline measure of the current health status and lifestyle of the NL offshore workforce." This would include measures of health, lifestyle and physical fitness. Additionally, Definitions® has developed a health and wellness manual for the offshore workforce, which provides information such as occupation specific stretches and warm-up exercises to reduce injury. The short- and long-term health and wellness programs developed through Definitions® and the Health and Wellness Manual for the NL offshore workforce may be helpful in developing future health and wellness programs.

This review of literature will discuss factors that affect musculoskeletal fitness and body composition of workers in an offshore environment. Furthermore, it will broaden our understanding of how musculoskeletal fitness and body composition impacts obesity, injury rates, physical activity levels, and the cost associated with poor physical fitness. The musculoskeletal fitness and body composition of the NL offshore oil and gas workforce has not been formally examined. Topics discussed in the literature review include: the increased risk of injury with poor musculoskeletal fitness; the cost of an unhealthy lifestyle; offshore injuries; and why good health and fitness is crucial in the offshore environment.

## 1.2 Defining Healthy Musculoskeletal Fitness and Body Composition

### 1.2.1 Health Musculoskeletal Fitness

Musculoskeletal fitness is described as muscles and bones together to produce movement (Canadian Society for Exercise Physiology, 2013). Both musculoskeletal fitness and body composition are valid predictors of one’s overall health (Payne, Gledhill, Katzmarzyk, & Jamnik, 2000). Thus, fitness tests, such as those prescribed by the Canadian Society for Exercise Physiology (CSEP), are beneficial in determining a person’s overall health and physical fitness (Canadian Society for Exercise Physiology, 2004). The Canada Health Measure survey has painted a simplistic picture of the average musculoskeletal fitness of Canadian males. Currently, the average Canadian male is described as having a grip strength of 94 kg (considered good by CSEP), and a sit-and-reach of 26.7 cm (considered good by CSEP) (Statistics Canada, 2013). Musculoskeletal fitness is imperative to reducing the risk of falls, illness, and premature death (Warburton, Gledhill, & Quinney, 2001; Woolf & Pfleger, 2003). Thus, assessing musculoskeletal fitness is crucial to give a clear picture of a participants overall physical health.

Generally speaking, grip strength has been shown to be a good predictor of total body strength and is associated with minimizing the risk of disability later in life protecting people from old age disability (T Rantanen et al., 1999; T Rantanen et al., 1998). Taina Rantanen, Era, Kauppinen, and Heikkinen (1994) further found positive significant correlations between handgrip strength and elbow flexion force, knee extension force, trunk extension force, and trunk flexion force. This provides further evidence to support the use of handgrip strength in assessing total body strength. Sit-and-reach is a commonly used test to assess hamstring and low back flexibility that is considered both valid and reliable (Allen Jackson & Langford, 1989). Flexibility in both the hamstring and low back has been shown to be a predictor of back health (Lemmink, Kemper, Greef, Rispens, & Stevens, 2003). Push-ups are used to assess upper-body muscle endurance (Canadian Society for Exercise Physiology, 2004). This includes the chest, shoulders, and arms, which are all required for daily living (American College of Sports, 2013). The back extension test used to assess back health and measure the isometric endurance of the trunk extensor muscles (Pitcher, Behm, & MacKinnon, 2008). This test was not performed by any participants with current back pain or discomfort (Canadian Society for Exercise Physiology, 2013). Partial curl-ups are used to assess abdominal muscle endurance, which is important for daily living activities (Canadian Society for Exercise Physiology, 2004).

### 1.2.2 Healthy Body Composition

For the purpose of this study, body composition was the assessment of body weight and fat distribution. According to Statistics Canada (2013), the average NL resident (29.5% obese) has a higher BMI than the average Canadian (19.3% obese). According to Statistics Canada (2013), in 1981 the average male was 173.0 cm tall, weighed 77.4 kg, overweight (BMI = 25.7 kg/m$^2$), and had a waist circumference of 90.6 cm (considered at a low risk of disease). The current average male is described as being 175.3 cm tall, weighed 86.6 kg, overweight (BMI = 27.9 kg/m$^2$), had a waist circumference of 97.0 cm (considered at an increased risk of disease), had a grip strength of 94 kg (CSEP rating of good), and a sit-and-reach score of 36.7 cm (CSEP rating of good) (Statistics Canada, 2013). See *Appendix A* for a table outlining BMI categories.

BMI, as an independent measure at the population level, is correlated with health risk and as a predictor of mortality (Carstensen, 2004). A normal BMI ranges from 18.5 – 24.9 kg/m$^2$ and a BMI $\geq$ 25 is considered overweight with further breakdowns of obese class I (30.0 – 34.9 kg/m$^2$), obese class II (35.0 – 39.9 kg/m$^2$) and obese class III ($\geq$ 40 kg/m$^2$) (Canadian Society for Exercise Physiology, 2004). This measure is useful to categorize a population's overall body fat. However, a BMI score provides no context as to the distribution of body fat nor does it take into account variations in body type (i.e. athletic versus non-athletic). Thus, BMI should be used in conjunction with other measures, such as waist circumference and skinfolds, in determining health risk associated with excess body fat (Lau et al., 2007). Dual Energy X-Ray Absorptiometry (DEXA) is considered the gold standard in assessing body composition, however, DEXA is very costly (Hannan, Wrate, Cowen, & Freeman, 1995). DEXA scans have also shown similar results as BMI when predicting body fat percentage (Goulding et al., 1996; Morabia, Ross, Curtin, Pichard, & Slosman, 1999).

Waist circumference is another measure that is useful in determining health risk due to excess body fat. Ardern, Janssen, Ross, and Katzmarzyk (2004) stated, "abdominal fat (visceral fat) is a more important determinant of health outcomes than overall body fatness." People with an elevated waist circumference, regardless of weight status, are at a higher risk of disease such as type 2 diabetes, hypertension, dyslipidemia, and metabolic syndrome. When waist circumference is used in conjunction with BMI, a more accurate assessment health risk is obtained (Ardern et al., 2004).

Skinfold measurement allows the researcher to measure the thickness of subcutaneous fat at multiple sites of the body. These measurements are based on the principle that subcutaneous fat levels are proportional to total body fat (Janssen, Heymsfield, Allison, Kotler, & Ross, 2002). Although there is potential for variability between researchers, AS Jackson, Pollock, Graves, and Mahar (1988) fount this error to be less than 2%, and cited that many other studies have a similar, or smaller level of error.

### 1.2.3 Physical Activity Levels and Health

Evidence supporting the positive benefits of physical activity has been well documented (A. S. Jackson, 2006; Janssen, 2012; Mundal, Erikssen, & Rodahl, 1987; Warburton et al., 2001). The United Nations has identified the role that lack of physical activity and poor eating habits have on non-communicable diseases (United Nations, 2012). There are four main types of non-communicable diseases. Commonly known as chronic diseases, these include cardiovascular disease, cancer, chronic respiratory disease, and diabetes (World Health Organization, 2015). Apart from general health benefits, physical activity has been shown to have a positive impact on reducing the number and severity of musculoskeletal injuries (Geving, Jørgensen, et al., 2007; Payne et al., 2000). Additionally, physical activity has been shown to be an effective method for promoting healthy behaviours, especially in those who are overweight or have musculoskeletal disorders (Geving, Jørgensen, et al., 2007; Shikdar & Sawaqed, 2003). Research has shown that healthy behaviours, such as those associated with wellness programs, increase worker productivity and reduces the risk of musculoskeletal injuries (Proper et al., 2003; Shikdar & Sawaqed, 2003). As physical activity relates to the current study, a lack of physical activity, or inactivity, can also be measured against one's musculoskeletal fitness and body composition.

**1.3 Physical Activity Levels and Injuries of Offshore Workers**

Physical inactivity in the offshore workforce has been well documented (Geving, Jørgensen, et al., 2007; Hansen, Hjarnø, & Jepsen, 2011; Hjarnoe & Leppin, 2013a, 2013b). One study reported that 70% of offshore workers were physically active at home whereas only 39% were physically active onboard during their shift (Geving, Jørgensen, et al., 2007) . No noteworthy explanations for these differences were reported, however it is plausible that these differences in physical activity levels found in the previous study also exist in the NL offshore workforce.

Free-time activities while onboard Finnish ships was assessed by Saarni and Pentti (1995). They found that half (51%) of the workers used onboard exercise facilities rarely or never, while only 30% partook in physical activity onboard at least twice a week or daily. Hjarnoe and Leppin (2013b) found that 32% of participants, self-reported, to have participated in fitness training more than 3 times per week while offshore. Furthermore, an assessment of offshore workers off time, while on shore, revealed that physical exercise is ranked as the fifth most common activity following social activities, watching TV, outdoor activities, and reading (Saarni & Pentti, 1995). Another study, by Saarni, Laine, Niemi, and Pentti (2000) found offshore workers had similar leisure time activities, of which 50% of participants exercised at least some while offshore. The most common activity was walking on deck or bicycling. Although the literature shows that some offshore workers are active, it demonstrated that physical activity, on average, is low. Physically activity once per week is below the recommended guidelines set out by CSEP, which recommends 150 minutes of physical activity per week in bouts of 10 minutes or more (Canadian Society for Exercise

Physiology, 2013). Although the aforementioned studies reference the shipping industry, it is plausible that similar statistics would be found on oil and gas platforms. It has been recommended that physical activity levels should be increased in the offshore workforce by minimizing activity barriers while offshore and subsequently preventing musculoskeletal injuries and increasing on the job performance (Geving, Jørgensen, et al., 2007). Although Geving, Jorgensen, Le Thi, and Sandsund (2007) speaks of physical activity barriers in the offshore environment, there is minimal literature that supports what specific barriers are currently present in the offshore environment. Further studies should investigate these assumed barriers.

Given the low levels of physical activity of workers when working offshore, physical activity promotion should become a priority for all offshore installations. Physical inactivity has been shown to increase the number of chronic musculoskeletal complaints (Woolf & Pfleger, 2003). A study by Holth, Werpen, Zwart, and Hagen (2008) found, after an 11 year follow up, that 51% of participants indicated chronic MSCs with 5.9% reporting these MSCs as widespread. Those who exercised regularly at the beginning of the study were 28% less likely to develop MSCs (Holth et al., 2008). Thus, there appears to be a relationship between physical activity level and injury.

**1.4 Injury**

Injuries in the offshore workforce may occur for a number of reasons, with a lack of physical fitness being the leading cause. Musculoskeletal disorders are one of the most common causes for long-term disability in the offshore industry according to a study conducted by the Norwegian Government (Woolf & Pfleger, 2003). A study by Valentić, Stojanović, Mićović, and Vukelić (2005) found that 17.5% of injuries for American oilrig workers were musculoskeletal injuries, second only to all accidents and poisonings (26.7% of all registered cases). Geving, Jørgensen, et al. (2007) found that 58% of offshore workers (*n* = 282) had low back pain, 51% had shoulder pain, and 50% had neck pain. These injuries were reported to be more common while working offshore in 47% of the participants, and are likely due to repetitive motions while working. When compared to their offshore counterparts, where 47% of work related injuries were musculoskeletal, only 10-15% of Norwegian onshore workers reported musculoskeletal injury (Morken, Mehlum, & Moen, 2007). Ross, Macdiarmid, Rostron, Watt, and Crawford (2013) reported moderate to severe musculoskeletal injury symptoms in 36% of offshore workers with neck, back and joint pain being the most common. Furthermore, overstraining and stretching were prime factors in offshore occupational injuries particularly in the lower back, neck and shoulders (Chen, Yu, & Wong, 2005; Oppong, 2014). It has been found that 80% of all injuries were a direct result of the physical labor of the job with oil drillers most frequently reporting injuries. Of all causes of injury, 31.2% were due to overstraining, 13.0% due to stretching, and 18.2% due to falling or slipping (Valentić et al., 2005). Interestingly, most of these musculoskeletal injuries occur primarily in the first 3-4 days and final 3-4 days of a 28-day shift, with very few injuries happening in the middle of the shift (Valentić et al. (2005).

Obesity may also play a role in increased risk for injury. Obese people are more prone to falling accidents due to impaired balance and agility (Deacon, 2007). Being obese requires more attention resources to control postural stability than their non-obese counterparts, thus obesity may be linked to falling related injuries in the offshore environment (Mignardot, Olivier, Promayon, & Nougier, 2010). Since 29.5% of the NL population are obese and because many of the NL offshore workers are from NL, it is probable that this obesity rate is reflected in the offshore population (Statistics Canada, 2013). Based on the aforementioned, it is not unreasonable to expect that the employees of the NL offshore workforce are at greater risk for musculoskeletal injury.

To help prevent musculoskeletal injury, which is common in the offshore workforce, multiple studies have placed significant importance on physical fitness and body composition (Maniscalco, Lane, Welke, Mitchell, & Husting, 1999; Rainville et al., 2004). Exercise while offshore has been linked to decreased muscular pain and stiffness. Of those who exercised less than once a week, 45% reported muscular pain or stiffness. Therefore, those who are less active while on shift have an increased risk of developing muscular pain (Geving, Jørgensen, et al., 2007). Given the perceived relationship between physical activity and musculoskeletal pain, we can assume that those with poor physical fitness are likely at risk for developing musculoskeletal pain. Thus, an inactive and obese individual is at a much higher risk for injury while working offshore. Increased physical activity may play a role in reducing the likelihood of disease or injury and may help manage chronic conditions. Altering the health and wellness of the offshore population through increased physical activity levels, may decrease the likelihood of occupational injury and disease (Chau et al., 2004).

### 1.5 Fitness, Safety, and the Offshore Worker

A safe work environment is one that is unlikely to cause danger or injury. Musculoskeletal fitness and body composition, as it relates to safety in the offshore and shipping industries has largely been neglected. Further, it is thought that obesity itself may be a safety issue while at sea (Hoeyer & Hansen, 2005). An assessment of the Danish offshore population indicated an increase in offshore jobs that were largely sedentary or required little physical effort (Hjarnoe & Leppin, 2013a). These findings were consistent with the Atlantic Canadian population stating that many jobs in the offshore environment are sedentary such as working from a control room or in an administrative role (Canadian Association of Petroleum Producers, 2013). Thus, with increasing sedentary behaviour, it is plausible that the offshore workforce's fitness is similar, if not worse, than the average Canadian. However, offshore work can also be physically demanding.

There are a number of physical and environmental demands placed on workers in the offshore environment that are absent in the onshore environment (Canadian Association of Petroleum Producers, 2013). These include heavy material handling, climbing stairs/ladders, working in confined spaces, working and walking on steel, slippery and uneven surfaces, and going through heavy doors and access ways due to fire/explosion proof requirements. Although the physical demands of the offshore workforce are well documented, there are gaps in the literature that discuss what level of physical fitness and body composition will best protect employees and be safe while on the job.

Bjerkan (2010) found that there is a strong relationship between health, safety, and work environment and offshore workers also perceive significantly more hazards in their workplace compared to those who work onshore (Bjerkan, 2011). One such hazard is helicopter transport, which is most often needed to bring workers to their worksite increasing the potential risk of accidents (Hansen et al., 2011; Horneland et al., 2011). Furthermore, obesity may itself be a safety concern: while transiting to offshore installations, performing safety tasks in emergencies, using ladders, and boarding survival craft (Hansen et al., 2011). "This can be crucial not only for the obese persons, but also for those depending on their actions or are involved in assisting them" (Hoeyer & Hansen, 2005). In essence, if an obese person is unable to complete a task in an emergency, such as helping to launch a lifeboat, other workers lives may be at risk.

Attwood, Khan, and Veitch (2006) looked at what factors are most important to offshore workers particularly in avoiding occupational accidents. These factors were classified as either individual behaviour's or individual capability. Individual capability had further subdivisions of physical (fitness, lack of fatigue, and coordination) and mental (knowledge and intelligence) capabilities. The results indicated that mental aspects were much more important than physical aspects in accident prevention. However, Attwood et al. (2006) does state that physical fitness is important, but relatively speaking, it is not as important as mental aspects. This should be further examined while paying close attention to the physical capacity needed to perform an emergency task.

### 1.6 The Cost of an Unhealthy Lifestyle

The United Nations has recognized that an unhealthy lifestyle, particularly inactivity and an unhealthy diet are strongly associated with higher health costs and reduced productivity (United Nations, 2012). Given that the average Canadian male waist circumference, weight, and BMI have all increased since 1981, the focus of this section will be primarily on obesity (Statistics Canada, 2013). A report by the Industrial Accident Prevention Association (Burton, 2008) indicated that people with lifestyle risk factors (sedentary and overweight) miss 50% more workdays and costs 2-3 times more than those without any such risk factors. Thus, poor body composition and a sedentary lifestyle have a negative influence on employers through increased sickness, which results in higher healthcare costs. Obese workers also cost employers more through larger or custom fit personal protective equipment and higher accident rates (N. Williams & Malik, 2005).

Sedentary employee behaviour is also linked to an increase in employer health care costs by $488 per year, per employee. Sedentary behaviour leads to an increase in obesity, which is shown to increase the number of workers compensation claims, and lost workdays. Further, obese employees nationally cost employers $1.3 billion per year and 35% more on health services and 77% more on medications than non-obese employees (Burton, 2008). In addition to these costs, and the increased rate of injury in those who are not physically fit, it can cost 4 – 5 times more to treat an injury in the offshore environment compared to being onshore (Bjerkan, 2011). An investment in health, wellness, and fitness could have a significant impact on the costs associated with an unhealthy lifestyle.

Ineffective employee health and safety practices are associated with low productivity and high medical and insurance costs. Conversely, effective health and safety practices led to high profitability and productivity (Shikdar & Sawaqed, 2003). A study by Quartey and Puplampu (2012) found that 32.3% of managers in the shipping industry believed that health and safety initiatives resulted in high profitability, and 22.5% of managers believed high productivity was a result of health and safety initiatives. Conversely, 30% of managers indicated low productivity and 26.7% of managers indicated high medical costs due to injury or illness among employees as a result of ineffective health and safety practices (Quartey & Puplampu, 2012).

Companies who invested in health, wellness, or fitness programs have saved a substantial amount of money. Many companies have already invested in wellness programs, which are geared at improving personal health practices of employees, and fitness programming (Burton, 2008). For every $1 invested in fitness and wellness programs, there was a return of $3.43 with the Canadian Life Insurance Company; $4.56

with Citibank; $3.63 with Pillsbury; and $6.15 with Coors Brewing Company per person. These returns, or savings, were made primarily in the way of reduced health related costs, and increased productivity all while helping to improve the health of employees (Bertera, 1990; Burton, 2008). The potential savings for large companies, through implementation for health and wellness programs, is well documented. If health and fitness standards were implemented as part of an offshore workers job requirements, it would not only save companies a lot of money, but also have a significantly positive impact on the workers overall health.

### 1.7 The Importance of Musculoskeletal Fitness and Body Composition in Offshore Occupations

Offshore work can be physically demanding depending on the person's occupation. Often times, employees must climb up and down ladders between decks, but also down the side of the structure, which may be in excess of 100 m. Physical fitness will come into play when offshore workers are engaged in emergency exercises as well as survival at sea training (Elliott, 1985; Hoeyer & Hansen, 2005). More notably, there is the potential for immersion in cold water in the event of an emergency helicopter ditching or evacuations from an offshore platform. This sudden immersion has been shown to cause a bradycardic reflex, which is the sudden decrease in heart rate and cardiac output due to immersion in cold water. Those who are cardiovascular fit are better able to withstand this reflex than those who are not (Elliott, 1985).

Next to musculoskeletal conditions, cardiovascular disorders were the second most common reason (12.6%) for Norwegian offshore workers to lose their health license (Horneland et al., 2011). Although offshore workers may still have a residual working capability, cardiovascular disease is an exclusion criteria for offshore workers (Horneland et al., 2011). A Polish study looked at the incidence of myocardial infarction (MI) of seagoing personnel and fisherman (Rosik, Jaremin, & Szymańska, 2006). This study found that more than 20 Polish seamen die each year due to MI, stroke, circularity failure or arrhythmia. Thus, individuals who are at risk for loss of license (LOL) are likely at a higher risk for bradycardia if immersed in water, or at risk for other chronic cardiovascular related conditions. Those who regularly engage in physical activity while working also felt that their health was good, the occurrence of muscle soreness due to occupational demands was less, and they adapted to work demands more readily (Saarni et al., 2000; Saarni & Pentti, 1995), thus they were at less risk to develop musculoskeletal or cardiovascular disorders.

Many countries issue health certificates to those in the offshore workforce, which indicates that they are fit to work offshore. The loss of health certificates, indicating a worker is unfit to work in the offshore environment, is known as LOL. A Norwegian study found that musculoskeletal conditions were the prime (42.5%) reason for workers LOL (Horneland et al., 2011). This is likely due to strenuous working positions such as working on hard floors, high physical workload, and climbing ladders (Horneland et al., 2011; Morken et al., 2007). In 2002, a 53-year-old offshore worker, with a BMI of 35.4 kg/m$^2$, died during a vertical chute evacuation drill. The reported cause of death was positional asphyxia, which is an unintentional bodily position that restricts pulmonary ventilation (the ability to breathe) (Belviso, De Donno, Vitale, & Introna Jr, 2003). The above mentioned case had anecdotal evidence that obesity was a contributing factor (Hoeyer & Hansen, 2005). Another study noted that obesity, and thus a higher BMI, plays a role in positional asphyxia related fatality (Conroy et al., 2007). A set limit, such as a maximum BMI of 35.0

kg/m$^2$, has been discussed as a potential way to mitigate on the job risks due to obesity. In 2002, Norway introduced this standard, but later opened it up for exemptions. A functional assessment at a certain BMI marker could indicate the need for additional testing to examine how someone's obesity may affect his or her safety (Hansen et al., 2011; Hoeyer & Hansen, 2005).

Dembe, Erickson, and Delbos (2004) proposed a model that shows how multiple variables overlap to lead to workplace injury. These include psychosocial factors, work organization and culture, biological and personal characteristics of the worker, and environmental and social conditions. Saarni et al. (2000) found that 20% of workers had poor muscular fitness and about 50% had poor cardiovascular fitness. Regardless of these factors, prevention of work related injury, specifically cardiovascular illness, requires preventative measures, which may include physical conditioning (Elliott, 1985; Petrella, Lattanzio, Demeray, Varallo, & Blore, 2005). Those at a high-risk for developing cardiovascular disease may benefit from a change in lifestyle (Rosik et al., 2006). A study by M. A. Williams et al. (2007) found substantial benefits from both resistance and cardiovascular training on weight management, and the prevention of disability and falls. Increases in skeletal muscle tissue have been linked to decreased risk of disease, obesity, and an increased metabolism. Further, Braith and Stewart (2006) found that resistance training and the resulting increased muscle mass may reduce multiple risk factors for cardiovascular disease. These benefits may reduce the risk of cardiovascular disease later in life. Therefore, optimal musculoskeletal fitness and body composition should be achieved for minimizing the risk of injury to offshore workers.

### 1.8 Anthropometric Demographics of Offshore Workers

Current physical fitness and anthropometrics demographics of the offshore workforce are limited. BMI is a measure used to correlate health risk that is independent of age, race or gender (Janssen, Heymsfield, & Ross, 2002). Waist circumference is also another valid predictor of disease risk. A healthy waist circumference in men is ≤ 102cm (Janssen, Heymsfield, & Ross, 2002). Subsequent increases in waist circumference increases the relative risk of disease. For instance, someone with a normal BMI but a waist circumference greater than 102cm has a higher relative risk of disease as compared to someone with a normal BMI and waist circumference less than 102 cm.

A study by Parkes (2003) found offshore workers of the North Sea to have an average BMI of 25.6 $kg/m^2$ with 47.3% ranked as overweight and 7.5% as obese. These body composition values are thought to be attributed to high calorie intake, lack of leisure-time physical activity, and environmental factors (Carew, 2012; Parkes, 2003). Not surprisingly, many authors have noted that access to high calories food is contributing to obesity in the offshore environment (Carew, 2012; Mannocci et al., 2015). It is worth noting that an elevated waist circumference and high BMI is a stronger predictor of relative risk of disease compared to independently classifying these values (Janssen, Heymsfield, & Ross, 2002). Another study by Saarni et al. (2000) found that only 42% of workers had a BMI within the normal range. On the job physical activity and its effect on BMI was assessed. The results showed that workers with a more physically demanding job had a lower BMI than those with more sedentary jobs (Parkes, 2003). A Danish study found that seafarers had an average BMI of 27.52 $kg/m^2$ and that ~1% of them felt that their job required very hard physical efforts (Hjarnoe & Leppin, 2013a). Thus, the lack of physical labour was reflected in the high BMI average for this study, which according to CSEP classifies the study population as overweight (Hjarnoe & Leppin, 2013a). It is worth mentioning that from 1995 – 2000 in the United Kingdom, Parkes (2003) found a BMI increase of 3.5% and 5.4% in those who were overweight and obese, respectively in offshore workers. With obesity rates continually increasing around the world, obesity management is becoming a significant area of research, particularly as it relates to health and safety (Hansen et al., 2011; Parkes, 2003). Hansen et al. (2011); (Parkes, 2003) expanded on above findings reporting that 66% of tested offshore workers were overweight. Although obesity has been thought to constitute safety issues, there is little evidence to make a direct relation. Obesity appears to be high in offshore workers potentially reducing their overall safety and increasing their risk for injury and potentially death (Hoeyer & Hansen, 2005). Since NL has the highest obesity rates in Canada and many of the offshore workers are from here, it is likely that similarities exist between both of these populations (Statistics Canada, 2013).

### 1.9.1 Conclusion

NL's offshore oil and gas industry primarily employs people from the province. A recent report by Statistics Canada (2013) indicated that NL had an obesity rate of 29.5%, which is the highest in Canada, and well above the national obesity rate of 19.3%. Though the general health implications of obesity are readily apparent, it is currently unknown what the body composition of NL offshore workers looks like. If this is the case, there may be important implications for the health and safety of offshore workers. Research has demonstrated that overweight workers are more likely to sustain injury while on the job, which also leads to other problems in the employee's life and employer's day-to-day operation, leading to a work environment with compromised safety. Currently, we do not know the musculoskeletal fitness status or body composition specifically of NL employees working offshore. The purpose of this research project is to characterize the musculoskeletal fitness and body composition of NL offshore workers with the aim to help develop, support and enhance programs that will ensure industry leading health and safety standards.

### 1.9.2 Objectives

The objectives of this research are as follows:

1. To investigate the current musculoskeletal fitness and body composition of the NL Offshore Workforce.
2. To determine how this population compares to the Canadian population.

### 1.9.3 Significance of the study

The results of this study will provide the research, professional, and industrial community with further understanding about the differences and similarities in musculoskeletal fitness and body composition of the NL offshore workforce. This research will be valuable specifically for implementation of health and fitness programs, which focus on the weaknesses of this population.

## 2.0 METHODOLOGY

### 2.1 Participants

Eighty-nine men from the NL offshore workforce (mean ± standard deviation; height: 177.46 ± 6.57 cm, mass: 92.54 ± 16.26 kg, age: 42 ± 8.98 years) were included for analysis in this study. Data was collected by a Definitions® wellness representative offshore from five companies. All workers completed a Physical Activity Readiness Questionnaire (PAR-Q). No formal consent was sought. Workers voluntarily signed into an online portal through Definitions® where their personal information would be entered by a Definitions® employee. At that time, all workers were made aware that their information might be used in the future for research purposes and would be included in regular reporting to the oilrig. Identity concealment from Definitions® was required to ensure privacy of this data. No names were associated with the data.

### 2.2 Experimental Approach

Memorial University's Interdisciplinary Committee on Ethics in Human Research (ICEHR #: 20141281-HK) approved this study. The data reported in this study is secondary data as the original data was collected by a wellness representative from Definitions®. All participants were apparently healthy according to the Physical Activity Readiness Questionnaire (PAR-Q) completed by each worker (Canadian Society for Exercise Physiology, 2002). The PAR-Q is a one page, seven-question questionnaire that determines if respondents between the ages of 15-69 should seek approval from a doctor before becoming physically active. All participants in this study were cleared, by the PAR-Q or a physician, to take part in the physical components of this study. This form is currently used by the CSEP. Participants must have had a resting heart rate and blood pressure values below 100 beats per minute (bpm) and 144/94 mmHg, respectively, to participate. Once cleared through the PAR-Q, participants were permitted to take part in physical fitness tests, as outlined below. Furthermore, participants were instructed to refrain from heavy exercise 24 hours before testing and following the CSEP (Canadian Society for Exercise Physiology, 2004), preliminary instructions (no eating, drinking caffeine, smoking, or drinking alcohol for 2, 2, 2, or 6 hours, respectively) prior to the start of testing.

All assessments were performed by a Certified Exercise Physiologist® (CEP) in accordance with the guidelines set forth by the CSEP at the Definitions® offshore testing facility. All testing procedures only involved sub-maximal intensity work and all examiners were trained in Standard First Aid and CPR level C.

### 2.3. Body Composition Measurements

All measurements were taken in accordance with the procedures outlined in the *Canadian Physical Activity, Fitness & Lifestyle Approach Manual* (CPAFLA) (Canadian Society for Exercise Physiology, 2004) and the *Physical Activity Training for Health* (Canadian Society for Exercise Physiology, 2013). These assessments included BMI, waist circumference, and skin-folds. These measures are important for determining not only a participant's body fat, but also the distribution of such fat. BMI, waist circumference, and skinfolds, when used in combination, provides a strong indication of health benefit based on body fat distribution (Janssen, Katzmarzyk, & Ross, 2002; Snijder, Van Dam, Visser, & Seidell, 2006).

### 2.3.1 Body Mass Index

Participant's height in centimeters (see *Figure 1 A)* and weight in kilograms (see *Figure 1 B)* was measured at time of collection. From this, BMI was calculated by dividing the participants weight over their height-squared $weight\ (kg) / [height\ (m)]^2$.

Height was measured using a vertical measuring tape on the wall. Participants were instructed to remove footwear while standing erect with their heels against the wall, arms by their sides, looking straight forward, and standing as tall as possible. The measurement was taken during the inspiration of a deep breath and was recorded to the nearest 0.5 cm. Weight was measured on a calibrated scale (Brecknell, Montreal, Québec, Canada) that was situated on a flat surface. Participants were instructed to remove their shoes, and preferably, be wearing light or minimal clothing. Weight was recorded to the nearest 0.1 kg.

### 2.3.2 Waist Circumference

Waist circumference was measured using a non-stretch, anthropometric measuring tape. Participants removed any clothing around their abdomen and stood with feet shoulder width apart with their arms by their sides. See *Figure 1 C.* The measurement was taken at the superior edge of the iliac crest after drawing a line to indicate this landmark. After positioning the tape horizontally around the abdomen, a measurement was taken using the cross-handed technique. Once the tape was snug against the skin without causing indentation and the measurement was recorded to the nearest 0.5 cm (Canadian Society for Exercise Physiology, 2013). Normative waist circumference values vary based on ethnicity.

### 2.3.3 Skinfold Measurements

Skinfold measurements were taken with Harpenden skinfold calipers (Baty International, Wes Sussex, United Kingdom) and recorded to the nearest 0.2 mm. Sites for skinfold measurements included chest, iliac crest midaxillary, triceps, subscapular, abdominal, suprailiac anterior axillary, and anterior thigh. The following skinfold site descriptions were adapted from A. S. Jackson and Pollock (1978) in Heyward and Gibson (2010). The chest skinfold was taken at a diagonal between the axilla and nipple, as high as possible on the anterior axillary fold, and 1 cm below the fingers (see *Figure 1 D)*. The iliac crest midaxillary skinfold was taken horizontally at the midaxillary line at the level of the xiphisternal junction (see *Figure 2 A)*. The triceps skinfold was taken vertically, half way between the acromial process and inferior margin of the olecranon process with the elbow flexed at 90 degrees, and 1 cm below the fingers (see *Figure 2 B)*. The subscapular skinfold was taken at a diagonal just inferior to the inferior angle of the scapula and 1 cm below the fingers (see *Figure 2 C)*. The abdominal skinfold was taken horizontally 3 cm lateral and 1 cm inferior to the centre of the umbilicus (see *Figure 2 D)*. The anterior axillary suprailiac skinfold was taken at an oblique angle, posterior to the midaxillary line, superior to the iliac crest, and with the calipers 1 cm below the fingers (see *Figure 3 A)*. The anterior thigh skinfold was taken vertically midway between the inguinal crease and proximal border of the patella while the participants weight was shifted to their left leg (see *Figure 3 B)*.

### 2.4. Musculoskeletal Fitness Measurements

All measurements were taken in accordance with the procedures outlined in the *Canadian Physical Activity, Fitness & Lifestyle Approach Manual* (Canadian Society for

Exercise Physiology, 2004) and the *Physical Activity Training for Health* (Canadian Society for Exercise Physiology, 2013). Tests included; push-ups, partial curl-ups, back extension, sit-and-reach, and grip strength.

### 2.4.1 Push-ups

Participants were advised to perform as many consecutive push-ups as possible with no time limit. Participants were instructed to lay face down on a mat with their hands directly below their shoulders with their hands pointed forward. With their concentration directly on the floor, and using their toes as a pivot point, participants were instructed to fully extend their arms while keeping their upper body in a straight line (see *Figure 5 A & B)*. When returning to the starting position, only the participant's chin may touch the mat (their stomach and thighs must not).

### 2.4.2 Partial Curl-up

Participants laid in a supine position on a mat that had two taped lines 10 cm apart with their knees bent to 90° (see *Figure 6 B)*. Arms were placed straight by their sides, parallel to their trunk, palms facing down with their middle finger touching the 0 cm line. While keeping their heels and palms on the mat, participants were instructed to curl-up their upper spine using abdominal musculature so that their middle fingers touched the 10 cm line (see *Figure 6 C)*. Following the lowering phase of the curl-up, participants shoulder blades and head must make contact with the mat and middle fingers returned to the 0 cm mark. For this test, a cadence of 50 repetitions per minute was used (Canadian Society for Exercise Physiology, 2004).

### 2.4.3 Back Extension

The participant laid on a table with the iliac crest positioned at the edge with their hips, shoulders and head aligned and supported with their hands. Two padded support straps were placed at middle of the calf and middle of the thigh to keep the participant horizontal to the floor. The participant was then instructed to cross their arms about the chest without rotational or lateral twisting (see *Figure 6 A)*.

### 2.4.4 Sit-and-Reach

Participants were instructed to begin the test by performing a static hamstring stretch on each leg (hurdlers stretch). Following this, participants sat, without shoes, with their feet 15 cm apart against a Flexometer (Total Performance, Kirkland, Quebec, Canada). Once in this position, the participant stretched their arms evenly, with the palms face down, hands overlapping. While exhaling, participants then pushed, and held for two seconds, the marker as far as possible on the Flexometer (see *Figure 4 B).*

### 2.4.5 Grip Strength

Grip strength was measured using a Jamar Hydraulic hand dynamometer (JTECH Medical, Midvale, UT, USA). The device was positioned between the fingers and palm at the base of the thumb so that the second joint of the fingers was fitted under the handle. Adjustments to device were made ensure the aforementioned grip was achieved. The participant then held the device in-line with their forearm by their side making sure to keep it away from their body for the duration of the test. While exhaling, the participant squeezed the device as tight as possible (see *Figure 4 A)*. Participants alternated sides, and each hand was measured twice.

## 2.5 Data analysis

Participants were first categorized into groups by age. These age groups were used to match that of the available Canadian normative values. Normative values have been interpreted from *CPAFLA* manual (Canadian Society for Exercise Physiology, 2004) by the CSEP, *Advanced Fitness Assessment and Exercise Prescription* by Heyward and Gibson (2010), and Statistics Canada (2012; 2013). Interpreting these values was done by using data tables that ranked measures as being excellent, very good, good, fair, and needs improvement. Health benefit zones were also assigned to musculoskeletal and body composition measures.

Body fat percentages were calculated using the Jackson- Pollock sum of seven skinfolds formula. The Jackson – Pollock method is widely used and has been proven to be a valid and reliable way of predicting body fat (A. S. Jackson, 2006; A. S. Jackson & Pollock, 1978). Participants with a calculated BMI over 30 $kg/m^2$ did not have skin-fold measurements taken due to the increased risk of error in measurement (Canadian Society for Exercise Physiology, 2004).

Musculoskeletal fitness norms were interpreted from the CPAFLA manual. The manual has age based normal ranges and these ranges were applied to the musculoskeletal fitness tests used. Data analyses for each musculoskeletal fitness test were as follows. All properly performed push-ups were counted until termination of the test. Incorrect repetitions were not counted, and the test was terminated when the participant was unable to perform two consecutive push-ups with proper form, or if the participant felt pain, discomfort, or was forcibly straining. All partial curl-ups performed properly were counted to a maximum of 25 curl-ups (or one minute). Termination of the test, before one minute, happened if the participant experienced discomfort was unable to maintain the proper form. During the back extension test, participants maintained their upper-body in the horizontal position for a maximum of 180 seconds. The test was terminated if the participant felt pain, discomfort, or dropped below the horizontal more than once. The total number of seconds was recorded. For the partial curl-up test, trials were not counted if their knees lifted off the floor, or a jerking/bouncing motion was used. Two trials were conducted with the highest value of the two recorded to the nearest 0.5 cm and terminated if the participant was unable to maintain cadence, or perform a repetition with proper technique. The grip strength test uses the highest score from each hand, based on two trials, which were then summed together and recorded to the nearest kilogram (Canadian Society for Exercise Physiology, 2013).

**2.6 Statistical analysis**

Statistical analysis was performed with SPSS for Mac (SPSS, Version 20.0.0, Polar Engineering and Consulting). Descriptive statistics, independent samples t-tests and Pearson product-moment correlation coefficients were calculated between all measures (age, weight, BMI, waist circumference, body fat, push-ups, partial curl-ups, back extension, sit-and-reach, and grip strength). Levene's Test for equality was also performed prior to the t-test to identify if equal variances were assumed. A value of $p < 0.05$ was considered statistically significant. All data are presented as mean ± standard error.

## 3.0 RESULTS

A total of 106 participants were initially included in this study. Overall, eighty-nine participants were initially included for analysis. However, 12 participants were excluded for having no reported age, and 5 participants were excluded who were over the age of 59 and therefore were not representative of this age demographic. Of the 89 participants, 34 were between the ages of 20 – 39, and 55 were between the ages of 40 – 59. The sample sizes, descriptive characteristics of the sample, and independent samples t-test results are presented by age category and fitness test in *Table 1.*

### 3.1 Body Composition

#### 3.1.1 Weight

There was a statistically significant difference ($t$ (81) = -2.23, $p < .05$) in weight between the two age groups 20 – 29 (86.28 ± 2.45 kg) and 40 – 59 (95.27 ± 2.29 kg). Between the two age groups, the percent difference was 11.13%.

#### 3.1.2 Body Mass Index

There was a statistically significant difference ($t$ (80) = -2.06, $p < .05$) in mean BMI between the two age groups 20 – 29 (27.95 ± 0.70 kg/$m^2$) and 40 – 59 (30.19 ± 0.71 kg/$m^2$). There was an 8.38% difference between groups. Based on CSEP normative data, the 20 – 29 age group in the overweight category and the 40 – 59 age group in the obese category (*Figures 7 A* and *B and Figure 8)*. The Canadian average BMI is 26.3 kg/$m^2$.

#### 3.1.3 Waist Circumference

There was a statistically significant difference (*t* (86) = -2.42, $p < .05$) in mean waist circumference between the two age groups 20 – 29 (93.64 ± 1.93 cm) and 40 – 59 (100.37 ± 1.84 cm) (*Figure 9).* This represents a 7.58% difference between groups.

### 3.1.4 Skinfold Measures and Body Fat Percentage

There was no statistically significant difference (*t* (58) = -1.13, $p > .05$) of mean body fat percentage between the two age groups 20 – 29 (23.04 ± 1.22 %) and 40 – 59 (24.93 ± 1.04 %) (*Figure 10*). However, there was still an 8.71% difference between the groups.

## 3.2 Musculoskeletal Fitness

The sample sizes and descriptive characteristics of the sample are presented by age category in *Table 1*.

### 3.2.1 Push-Ups

There was no statistically significant difference (*t* (80) = 1.293, $p >.05$) between mean number of push-ups completed for the two age groups 20 – 39 (28.79 ± 1.99) and 40 – 59 (24.41 ± 2.43) (*Figure 11*). Although there was no statistically significant difference, there was still a 20.90% difference between groups.

### 3.2.2 Partial Curl-Ups

There was a statistically significant difference (*t* (74) = 2.920, $p < .05$) between mean partial curl-up number for the two age groups 20 – 39 (43.10 ± 3.26) and 40 – 59 (30.62 ± 2.65) (*Figure 12*). There was a 37.14% difference between groups.

### 3.2.3 Back Extension

There was no statistically significant difference (*t* (19) = -.769, *p* >.05) between mean back extension time for the two age groups 20 – 39 group (71.56 ± 7.73 s) and 40 – 59 group (80.33 ± 7.99 s) (*Figure 13*). There was only a 5.23% difference between groups.

### 3.2.4 Sit-and-Reach

There was no statistically significant difference (*t* (76) = -.026, *p* >.05) of mean sit-and-reach scores between the two age groups 20 – 39 group (28.43 ± 1.68 cm) and 40 – 59 group (28.49 ± 1.45 cm) (*Figure 14*). Between groups, there was only a 0.96% difference.

### 3.2.5 Grip Strength

There was no statistically significant difference (*t* (83) = -.511, *p* >.05) between mean grip strength for the two age groups 20 – 39 (107.39 ± 5.38 kg) and 40 – 59 (110.65 ± 3.77 kg) (*Figure 15*). Between groups, there was only a 3.90% difference.

## 3.3 Correlations

*Table* 2 displays correlations between all variables. Correlations for both age groups are displayed for the 20 – 39 and 40 – 59 groups in *Table 3* and *Table 4*, respectively.

BMI had a strong and positive correlation with age ($r$ = .262, $n$ = 82, $p$ = .017) weight ($r$ = .900, $n$ = 82, $p$ < .001), waist circumference ($r$ = .880, $n$ = 81, $p$ < .001), and body fat percentage ($r$ = .769, $n$ = 59, $p$ < .001). Similarly, waist circumference also had strong positive correlation with age ($r$ = .293, $n$ = 88, $p$ = .006), and body fat percentage ($r$ = .771, $n$ = 59, $p$ < .001).

Push-ups had strong negative correlations with body composition measures: weight ($r$ = .262, $n$ = 82, $p$ = .017), BMI ($r$ = .262, $n$ = 82, $p$ = .017), waist circumference ($r$ = .262, $n$ = 82, $p$ = .017), and body fat percentage ($r$ = .262, $n$ = 82, $p$ = .017). Push-ups also had a strong positive correlations with other musculoskeletal measures: partial curl-ups ($r$

= .576, *n* = 74, *p* < .001), sit –and-reach (*r* = .285, *n* = 75, *p* = .013), and grip strength (*r* = .298, *n* = 78, *p* = .008). Similarly, partial curl-ups had strong negative correlations with age (*r* = -.249, *n* = 76, *p* = .030), and body composition measures: waist circumference (*r* = -.238, *n* = 76, *p* = .039), and body fat percentage (*r* = -.313, *n* = 53, *p* = .022). Lastly, sit-and-reach also had strong negative correlations with body composition measures: weight (*r* = -.293, *n* = 76, *p* = .010), BMI (*r* = -.321, *n* = 76, *p* = .005), waist circumference (*r* = -.346, *n* = 78, *p* = .002), and body fat percentage (*r* = -.332, *n* = 55, *p* = .013). See *Table 2* for correlations of all measures.

## 4.0 DISCUSSION

### 4.1 Introduction

The primary focus of this study was to investigate the current musculoskeletal fitness and body composition of the NL Offshore Workforce and to determine how this population compares to the Canadian population. Overall, compared to the Canadian normative values, the offshore workforce had poorer: BMI, body fat percentage, average waist circumference, back extension times, and sit and reach distances. Conversely, the offshore workforce had a better: push-up number, partial curl-up number, and grip strength score.

### 4.2 Body Composition

The results of this study indicate that the current offshore population has poor body composition compared to the rest of Canada. Based on a report by Statistics Canada (2013), 74.6% of NL were already overweight or obese compared to only 60% of the general Canadian population being overweight or obese. The results also revealed that 81.7% of the Offshore Workforce are categorized as being overweight or obese. It was hypothesized that the offshore workforces' body composition would be comparable to that of the NL population since many of the workers are native to the province. Interestingly, many other studies also cite that the average BMI of offshore and sea going workers is higher than the respective national average BMI (Hansen et al., 2011; Hoeyer & Hansen, 2005; Parkes, 2003).

This study's assessment of body composition included BMI, waist circumference, and body fat percentage. BMI is useful in determining an individual's weight in relation to their height; however, it does not give any indication of where the fat is distributed (Snijder et al., 2006). Waist circumference, on the other hand, provides an indication of how an individual’s fat may be distributed. Men are more likely to carry fat in their trunk area than women (Pouliot et al., 1994). The final body composition measure, body fat % (calculated via sum of seven skinfolds), is an indication of how much body fat an individual has (Heyward & Gibson, 2010). Thus, a combination of all three measures allows for a better overall understanding of body composition. It has been shown that changes in BMI and waist circumference combined, more accurately predicts relative risk of disease compared to either of these measures on their own (Janssen, Heymsfield, & Ross, 2002). Overall, the offshore workforce’s body composition is poorer than the average Canadians and obesity levels are currently on the rise.

Upon analysis of the two age groups (20 – 39 and 40 – 59), there were statistically significant differences between the three body composition measures. Based on normative data, it was anticipated that weight, BMI, and waist circumference would increase with an increase in age. In support of this, significant and positive correlations were found between age, and BMI and waist circumference. Thus, the offshore industry population had poorer body composition than the rest of Canada and as offshore workers age, their body composition also declines. A BMI greater than 25.0 kg/m$^2$ is considered to be overweight and a BMI greater than 30.0 kg/m$^2$ is considered to be obese. It is important to note that BMI is not always an accurate representation of body fat and fat-free mass (muscle and bone) and should be used in combination with other body composition measures (Burkhauser & Cawley, 2008) as was done in the current study.

Similar to BMI, offshore workers waist circumference means were greater than the Canadian average waist circumferences. Although those in the in the 20 – 39 offshore group had a waist circumference greater than the average Canadian, their mean was still less than 94. This is considered healthy by CSEP and falls within a range associated with optimal health benefits. Offshore workers in the 40 – 59 group also had a waist circumference mean greater than the Canadian average and their waist circumference mean was considered fair by CSEP and falls within a range that is associated with some health risks. Thus, offshore workers in the 40 – 59 group are at a greater risk for developing type 2 diabetes, hypertension, dyslipidemia, and metabolic syndrome (Ardern et al., 2004). The elevated waist circumference of the offshore workforce, in combination with elevated BMI, provides a clear indication that offshore workers carry excessive fat in their abdominal area. It has been documented that increases in this type of fat, centralized to the trunk, is associated with carbohydrate and lipid metabolism issues, as well as hypertension (Pouliot et al., 1994; Shea, King, Yi, Gulliver, & Sun, 2012). Further, the positive significant correlations between waist circumference, BMI, and body fat reveal that these measures are representing the body composition of the offshore workforce (Goulding et al., 1996; Morabia, Ross, Curtin, Pichard, & Slosman, 1999).

Body fat percentage ranges for the average male were taken from Heyward and Gibson (2010). Both age groups were above the highest range associated with their age. Body fat had strong positive correlations between weight, BMI, and waist circumference. Body fat percentage, in combination with BMI and waist circumference, aids in development of a clear image of the offshore workforces body composition. Given that offshore workers had greater waist circumference and BMI compared to the average

Canadian, it was not surprising that body fat % was also above the Canadian normal values. Increased body fat % (obesity) is associated with an elevated risk of developing diseases such as type 2 diabetes, hypertension, coronary artery disease, some types of cancer, and stroke (Patterson, Frank, Kristal, & White, 2004; Shea et al., 2012). Thus, measuring body fat % is an important aspect of assessing body composition and health risk.

From 1981 to 2009, the average Canadian male has gone from weighing 77.4 kg, having a BMI of 25.7 kg/m$^2$ and a waist circumference of 90.6 cm, to weighing 86.6 kg, having a BMI of 27.9 kg/m$^2$, and waist circumference of 102.7 cm (high risk) (Statistics Canada, 2012). Similar increases in BMI (+ 0.7 ± 1.3) have also been seen in the Danish population over a 5 year period (Parkes, 2003). Ample research has shown how obesity and lack of physical fitness is a financial burden on the healthcare system, increases the risk of injury, and may compromise worker safety (Bjerkan, 2010; Burton, 2008; Deacon, 2007; Geving, Jørgensen, et al., 2007; Hoeyer & Hansen, 2005; Maniscalco et al., 1999; Mignardot et al., 2010; United Nations, 2012). Given the current obesity epidemic in NL (Statistics Canada, 2013), and the fact that the offshore workforce has poorer body composition than the rest of the province, the findings from this add more merit to the need for industry fitness standards and the implementation of health and fitness programming for all offshore workers. With these current trends, the offshore workforce will be exposed to increased health risks, such as diabetes, cardiovascular disease, and musculoskeletal injury, especially if health and fitness does not become a priority (Ardern et al., 2004; Patterson, Frank, Kristal, & White, 2004; Shea et al., 2012).

### 4.3 Musculoskeletal Fitness

The results of this study indicate that the current offshore population has relatively good musculoskeletal health. Apart from partial curl-ups, there were no statistically significant differences between age groups for any musculoskeletal tests. Both groups exceeded the CSEP good range for total push-ups performed. Surprisingly, the older group (40 – 59) would be considered to have very good or excellent, upper body strength and endurance based on this test. These ratings are associated with considerable to optimal health benefits. The younger group (20 – 39) only slightly exceeded the CSEP good range for these tests, which are associated with many health benefits. After interpreting the normative musculoskeletal fitness norms by CSEP, these findings were not anticipated as overall strength and endurance appears to decline with age (Canadian Society for Exercise Physiology, 2004). In fact, the older group performed about the same as the younger group on all musculoskeletal tests. This is potentially due to the physically demanding nature of the offshore environment (Canadian Association of Petroleum Producers, 2013). This finding is problematic because as the younger group ages, they will experience a decline in physical fitness. The question remains, what will the current 20 – 39 group will look like in 10 – 20 years with respect to their musculoskeletal fitness?

Push-ups had some positive significant correlations with other musculoskeletal measures (partial curl-up, sit-and-reach, and grip strength), and negative significant correlations with some body composition measures (weight, BMI, waist circumference, and body fat percentage). From this, one can infer that good body composition (i.e., not overweight or obese) is an important factor in upper body strength and endurance. Good musculoskeletal health is also an essential part of preventing injury and performing tasks in an emergency situation (Saarni et al., 2000).

Upon analysis of the two age groups, partial curl-ups was the only measure that significantly differed. The younger group performed more partial curl-ups than the older group. This result was expected- as age increases partial curl-up repetition decreases (Canadian Society for Exercise Physiology, 2004). Despite this difference, both groups scored excellent according to the CSEP healthy musculoskeletal fitness zones, which is associated with optimal health benefits. This result may be due to the nature of working offshore, which may require moving around a lot on deck or during inclement conditions causing workers to utilize their core and trunk musculature. Good strength and endurance of the abdominals may aid in the prevention of low back pain (Hannibal, Plowman, Looney, & Brandenburg, 2006). Despite having a good score according to CSEP, partial curl-ups had negative significant correlations with some body composition measures (waist circumference, and body fat), and positive significant correlations with push-ups. Thus, poor body composition (high BMI and increased waist circumference) likely has a negative effect on core strength. Further, abdominal obesity may physically impose some limitations that prevent partial curl ups.

Analysis of the back extension test revealed that the younger group had poorer back endurance than the older group. Normative values from the CPAFLA manual indicate that younger individuals should have greater back endurance. However, the results of this particular test should be interpreted with caution, as there was a relatively small sample size and thus, may not be a true representation of the population. The younger group falls into the needs improvement category, which means that there is considerable health risk associated with this level of musculoskeletal health. The older group falls within the good range, which is associated with many health benefits. Good back endurance is important in maintaining good posture as well as minimizing the risk of low back pain (Hannibal et al., 2006). No significant correlations between any other measures were noted, however poor flexibility was noted in the sit-and-reach test.

Both groups performed well on the sit-and-reach test. However, the younger group was on the lower end of the CSEP good range and the older group was on the higher end of this range. A good score on this test is associated with many health benefits. The mean scores were near identical. These similar scores were anticipated due to the closeness of the age specific ranges.  Good flexibility is associated with good back health, which may prevent some musculoskeletal pain and injuries (Canadian Society for Exercise Physiology, 2004; Geving, Jørgensen, et al., 2007). Sit-and-reach had negative significant correlations with all body composition measures (weight, BMI, waist circumference, and body fat %), and had a positive significant correlation with push-ups. Thus, poor body composition likely had a negative effect on trunk flexibility. It is also plausible that there were biomechanical limitations, due to a high waist circumference, which prevented participants from attaining their maximal sit-and-reach distance. Thus, unhealthy body composition can affect musculoskeletal health.

Both groups exceeded the good range for the grip strength test. Interestingly, the older group had higher mean grip strength than the younger group. There was however, no statistically significant difference between the two groups. It was expected that the younger group would have a higher grip strength overall. The younger group would be classified as very good by CSEP, which is associated with considerable health benefits. The younger group had no significant correlations between grip strength and any other measures. The older group would be classified as excellent by CSEP, which is associated with optimal health benefits. Further, the older group also had a negative significant correlation between grip strength and age ($p < .05$). This ties into the predicted decline in strength with age.

Grip strength may not have a cause and effect relationship on health, but good grip strength is associated with positive health outcomes. Based on grip strength scores from this study, both groups have a decreased predicted rate of mortality from all-causes, cardiovascular disease and cancer (Gale, Martyn, Cooper, & Sayer, 2007). Although an association between grip strength, and mortality and disease exists, Gale et al. (2007) states that there is minimal literature that further explains this association. It is thought that as a person ages, they lose muscle mass, and therefore lose some grip strength, and they also tend to have increases in body fat, which is associated with negative health outcomes such as coronary heart disease (Canadian Society for Exercise Physiology, 2004; Gale et al., 2007).

Offshore workers are exposed to many hazards in the course of their work and are more susceptible to musculoskeletal injury on the job (Bjerkan, 2010; Valentić et al., 2005). Further, offshore workers are more likely to experience musculoskeletal pain than their onshore counterparts (Geving, Jørgensen, et al., 2007). With this in mind, it is important that offshore workers maintain good musculoskeletal health to prevent injury. The current study showed that NL offshore workers are strong, however they have moderate flexibility and back endurance, which may leave them susceptible to injury, especially back injury. Further, the current body composition of the NL offshore workforce is poor. Increases in physical activity may mitigate some of, if not all, the risks associate with poor musculoskeletal health and body composition (Petrella et al., 2005). Further, increases in lean muscle mass has been shown to decrease cardiovascular disease risk (Braith & Stewart, 2006).

### 4.4 Limitations

This study did not assess the potential barriers to accessing health and fitness services, such as gyms, healthy lifestyles information, or nutritional guidance, while offshore. Further, the work of offshore workers has been cited as both increasingly sedentary while also requiring physical strength and endurance to be able to perform certain tasks while on the job (Canadian Association of Petroleum Producers, 2013; Hansen et al., 2011; Hjarnoe & Leppin, 2013a; Horneland et al., 2011). No occupation specific information was collected, thus, the results can only applied to the general offshore workforce. Finally this data was collected from a secondary source, and therefore the author was unable to modify what information was collected. For example, this study included participants from 5 major oil and gas companies and some of these companies may have current health and fitness services available to employees while others may have not. Thus, affecting the overall results found in the current study.

### 4.5 Recommendations to the Canada-Newfoundland and Labrador Offshore Petroleum Board

Following the tragedy of Cougar Flight 491, in a report by Carew (2012), the C-NLOPB recommended that fitness standards be implemented for the offshore workforce. However, in order to implement such standards, an assessment of the current physical fitness of the offshore workforce is necessary. The purpose of this study was to investigate the current musculoskeletal fitness and body composition of the NL Offshore Workforce and to determine how these values compare to the Canadian population. The results indicate the need to improve the overall body composition of the offshore workforce with ongoing development to maintain, or improve in some instances, musculoskeletal health. Lastly the C-NLOPB should investigate the feasibility of offshore specific health and wellness programming that specifically aims to improve the physical fitness of the younger group so that they match Canadian norms, rather than falling into the same categories as the older group. Implementation of such programs should prompt further research on this population.

**4.6 Future Research**

Future research should include the use of ActiGraph accelerometers during a workers shift offshore and while they are off shift and on shore. Unlike a pedometer, which only counts steps, accelerometers are used to assess all directions of a person’s movement while worn. This would more clearly indicate how active a workers job is, and it will also give an indication of active they are at home. Future research should also include an assessment of physical activity participation and an on the job assessment, whereby offshore jobs can be classified as active or sedentary, would be advantageous in assessing patterns between workers. As Carew (2012) cited in their report, the current demographics off the offshore workforce should first be investigated and examined. Carew (2012) further implies that, once current demographics of the offshore workforce have been established, that the results should be used in the implementation of health promotion and safety programs for the offshore workforce. Such programs should aim to reduce the obesity rate of the offshore workforce. By using both the ActiGraph accelerometer, questionnaires, and nutritional information about offshore workers, this data will enable researchers to develop specific programs to combat the current obesity rate within this population and improve workers overall health. Therefore, the results of this study should be used to help promote physical activity, enhance, and develop programs specifically for the offshore workforce, especially in the younger workers.

## 5.0 CONCLUSION

Musculoskeletal fitness and body composition has been well studied as it relates to one's overall health and in relation to non-communicable diseases such as cardiovascular disease, cancers, chronic respiratory diseases, and diabetes (World Health Organization, 2015). Further, there is abundance research that shows the importance of healthy body composition and musculoskeletal fitness in relation to safety. The objectives of this study were to investigate the current musculoskeletal fitness and body composition of the NL Offshore Workforce and to determine how this population compares to the Canadian population.

Results from this study provided some expected and some unexpected outcomes. It was expected that the offshore population would reflect the same body composition as the NL population, which is worse than the Canadian population. Further, it was also expected that the older population would have a poorer body composition than the younger population. It was also anticipated, given the sometimes-physical demands of offshore work, that workers would have increased upper body strength and endurance, and grip strength. Lastly, it was thought that there would be significant differences between the age groups for most measures. For example, the older and younger group had similar (no statistical difference) push-up scores, which was not anticipated. It was expected that overall, the younger group would perform significantly better than their older counterparts in all values but this only occurred for body composition.

Results from both groups showed that the offshore workforce has poor body composition with generally good musculoskeletal fitness. However, due to limitations of the current study, whereby occupation specific information was not collected, the results may not be applicable to the entire offshore workforce. This study supported much of the research that has already been performed in the area of obesity and the offshore workforce.

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Table 1. Mean and independent samples test results for all parameters.

| | N | | ME ± SE | | Levene's Test for Equality of Variances* | t-test for Equality of Means | |
|---|---|---|---|---|---|---|---|
| Fitness Measure | 20 - 39 | 40 - 59 | 20 - 39 | 40 - 59 | *p* | *t* | *p* |
| Weight (kg) | 30 | 53 | 86.28 ± 2.45 | 95.27 ± 2.29 | .291 | -2.526 | ***.013 |
| Height (cm) | 30 | 53 | 176.15 ± 0.80 | 177.70 ± 1.07 | ** 0.004 | -1.156 | .251 |
| BMI ($kg/m^2$) | 29 | 53 | 27.95 ± 0.70 | 30.19 ± 0.71 | .240 | -2.061 | ***.043 |
| Waist Circumference (cm) | 34 | 54 | 93.64 ± 1.93 | 100.37 ± 1.84 | .513 | -2.424 | ***0.017 |
| Body Fat (%) | 21 | 39 | 23.04 ± 1.22 | 24.93 ± 1.04 | .357 | -1.125 | .265 |
| Push-Up (#) | 33 | 49 | 28.79 ± 1.99 | 24.41 ± 2.43 | .135 | 1.293 | .200 |
| Partial Curl-Up (#) | 28 | 48 | 43.10 ± 3.26 | 30.62 ± 2.65 | .955 | 2.920 | ***.005 |
| Back Extension (cm) | 9 | 12 | 71.56 ± 7.73 | 80.33 ± 7.99 | .710 | -.769 | .451 |
| Sit-and-Reach (cm) | 29 | 49 | 28.43 ± 1.68 | 28.49 ± 1.45 | .581 | -.026 | .979 |
| Grip Strength (kg) | 33 | 52 | 107.39 ± 5.38 | 110.65 ± 3.77 | .381 | -.511 | .611 |

Table displays N = number of participants by age group, mean ± standard error by age group, Levene's Test for Equality of Variances (* equal variances assumed, ** equal variances not assumed), and t-test for equality of means (*** significant difference between means).

Table 2. Correlations for all parameters for both age groups.

| | | Age | Weight (kg) | BMI (kg/m$^2$) | Waist Circumference (cm) | Body Fat (%) | Push-Ups (#) | Partial Curl-Ups (#) | Back Extension (s) | Sit-and-Reach (cm) | Grip Strength (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Pearson Correlation | 1 | .192 | .262* | .293** | .200 | -.153 | -.249* | .297 | -.170 | -.103 |
| | Sig. (2-tailed) | | .082 | .017 | .006 | .126 | .169 | .030 | .191 | .137 | .350 |
| | N | 89 | 83 | 82 | 88 | 60 | 82 | 76 | 21 | 78 | 85 |
| Weight (kg) | Pearson Correlation | .192 | 1 | .900** | .843** | .654** | -.331** | -.215 | -.012 | -.293* | .194 |
| | Sig. (2-tailed) | .082 | | .000 | .000 | .000 | .003 | .062 | .960 | .010 | .087 |
| | N | 83 | 83 | 82 | 82 | 59 | 77 | 76 | 20 | 76 | 79 |
| BMI (kg/m$^2$) | Pearson Correlation | .262* | .900** | 1 | .880** | .769** | -.355** | -.185 | .189 | -.321** | .072 |
| | Sig. (2-tailed) | .017 | .000 | | .000 | .000 | .002 | .113 | .426 | .005 | .531 |
| | N | 82 | 82 | 82 | 81 | 59 | 76 | 75 | 20 | 76 | 79 |
| Waist Circumference (cm) | Pearson Correlation | .293** | .843** | .880** | 1 | .771** | -.459** | -.238* | .095 | -.346** | .005 |
| | Sig. (2-tailed) | .006 | .000 | .000 | | .000 | .000 | .039 | .690 | .002 | .963 |
| | N | 88 | 82 | 81 | 88 | 59 | 81 | 76 | 20 | 78 | 84 |
| Body Fat (%) | Pearson Correlation | .200 | .654** | .769** | .771** | 1 | -.543** | -.313* | .424 | -.332* | -.097 |
| | Sig. (2-tailed) | .126 | .000 | .000 | .000 | | .000 | .022 | .116 | .013 | .472 |
| | N | 60 | 59 | 59 | 59 | 60 | 57 | 53 | 15 | 55 | 57 |
| Push-Ups (#) | Pearson Correlation | -.153 | -.331** | -.355** | -.459** | -.543** | 1 | .576** | -.169 | .285* | .298** |
| | Sig. (2-tailed) | .169 | .003 | .002 | .000 | .000 | | .000 | .464 | .013 | .008 |
| | N | 82 | 77 | 76 | 81 | 57 | 82 | 74 | 21 | 75 | 78 |
| Partial Curl-Ups (#) | Pearson Correlation | -.249* | -.215 | -.185 | -.238* | -.313* | .576** | 1 | -.084 | .166 | .046 |
| | Sig. (2-tailed) | .030 | .062 | .113 | .039 | .022 | .000 | | .733 | .160 | .699 |
| | N | 76 | 76 | 75 | 76 | 53 | 74 | 76 | 19 | 73 | 72 |
| Back Extension (s) | Pearson Correlation | .297 | -.012 | .189 | .095 | .424 | -.169 | -.084 | 1 | -.053 | .090 |
| | Sig. (2-tailed) | .191 | .960 | .426 | .690 | .116 | .464 | .733 | | .833 | .722 |
| | N | 21 | 20 | 20 | 20 | 15 | 21 | 19 | 21 | 18 | 18 |
| Sit-and-Reach (cm) | Pearson Correlation | -.170 | -.293* | -.321** | -.346** | -.332* | .285* | .166 | -.053 | 1 | .163 |
| | Sig. (2-tailed) | .137 | .010 | .005 | .002 | .013 | .013 | .160 | .833 | | .157 |
| | N | 78 | 76 | 76 | 78 | 55 | 75 | 73 | 18 | 78 | 77 |
| Grip Strength (kg) | Pearson Correlation | -.103 | .194 | .072 | .005 | -.097 | .298** | .046 | .090 | .163 | 1 |
| | Sig. (2-tailed) | .350 | .087 | .531 | .963 | .472 | .008 | .699 | .722 | .157 | |
| | N | 85 | 79 | 79 | 84 | 57 | 78 | 72 | 18 | 77 | 85 |

Table displays correlations between all parameters for the entire sample. N = number of participants for each parameter. *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Table 3. Correlations for all parameters for 20 – 39 years of age.

| | | Age | Weight (kg) | BMI (kg/m^2) | Waist Circumference (cm) | Body Fat (%) | Push-Ups (#) | Partial Curl-Ups (#) | Back Extension (s) | Sit-and-Reach (cm) | Grip Strength (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Pearson Correlation | 1 | .380* | .494** | .529** | .031 | -.176 | .209 | -.039 | -.305 | -.023 |
| | Sig. (2-tailed) | | .038 | .006 | .001 | .895 | .328 | .286 | .921 | .108 | .898 |
| | N | 34 | 30 | 29 | 34 | 21 | 33 | 28 | 9 | 29 | 33 |
| Weight (kg) | Pearson Correlation | .380* | 1 | .952** | .871** | .703** | -.204 | .141 | .351 | -.353 | .223 |
| | Sig. (2-tailed) | .038 | | .000 | .000 | .001 | .289 | .475 | .394 | .065 | .244 |
| | N | 30 | 30 | 29 | 30 | 20 | 29 | 28 | 8 | 28 | 29 |
| BMI ($kg/m^2$) | Pearson Correlation | .494** | .952** | 1 | .906** | .718** | -.215 | .189 | .249 | -.398* | .190 |
| | Sig. (2-tailed) | .006 | .000 | | .000 | .000 | .271 | .346 | .552 | .036 | .323 |
| | N | 29 | 29 | 29 | 29 | 20 | 28 | 27 | 8 | 28 | 29 |
| Waist Circumference (cm) | Pearson Correlation | .529** | .871** | .906** | 1 | .691** | -.427* | .170 | .128 | -.405* | -.140 |
| | Sig. (2-tailed) | .001 | .000 | .000 | | .001 | .013 | .387 | .742 | .029 | .438 |
| | N | 34 | 30 | 29 | 34 | 21 | 33 | 28 | 9 | 29 | 33 |
| Body Fat (%) | Pearson Correlation | .031 | .703** | .718** | .691** | 1 | -.353 | -.069 | .635 | -.082 | .107 |
| | Sig. (2-tailed) | .895 | .001 | .000 | .001 | | .127 | .787 | .562 | .732 | .644 |
| | N | 21 | 20 | 20 | 21 | 21 | 20 | 18 | 3 | 20 | 21 |
| Push-Ups (#) | Pearson Correlation | -.176 | -.204 | -.215 | -.427* | -.353 | 1 | .175 | -.320 | .104 | .341 |
| | Sig. (2-tailed) | .328 | .289 | .271 | .013 | .127 | | .373 | .402 | .593 | .056 |
| | N | 33 | 29 | 28 | 33 | 20 | 33 | 28 | 9 | 29 | 32 |
| Partial Curl-Ups (#) | Pearson Correlation | .209 | .141 | .189 | .170 | -.069 | .175 | 1 | -.123 | .066 | .061 |
| | Sig. (2-tailed) | .286 | .475 | .346 | .387 | .787 | .373 | | .772 | .743 | .764 |
| | N | 28 | 28 | 27 | 28 | 18 | 28 | 28 | 8 | 27 | 27 |
| Back Extension (s) | Pearson Correlation | -.039 | .351 | .249 | .128 | .635 | -.320 | -.123 | 1 | -.107 | .491 |
| | Sig. (2-tailed) | .921 | .394 | .552 | .742 | .562 | .402 | .772 | | .783 | .180 |
| | N | 9 | 8 | 8 | 9 | 3 | 9 | 8 | 9 | 9 | 9 |
| Sit-and-Reach (cm) | Pearson Correlation | -.305 | -.353 | -.398* | -.405* | -.082 | .104 | .066 | -.107 | 1 | -.078 |
| | Sig. (2-tailed) | .108 | .065 | .036 | .029 | .732 | .593 | .743 | .783 | | .686 |
| | N | 29 | 28 | 28 | 29 | 20 | 29 | 27 | 9 | 29 | 29 |
| Grip Strength (kg) | Pearson Correlation | -.023 | .223 | .190 | -.140 | .107 | .341 | .061 | .491 | -.078 | 1 |
| | Sig. (2-tailed) | .898 | .244 | .323 | .438 | .644 | .056 | .764 | .180 | .686 | |
| | N | 33 | 29 | 29 | 33 | 21 | 32 | 27 | 9 | 29 | 33 |

Table displays correlations between all parameters for the 20 – 39 age group. N = number of participants for each parameter. *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Table 4. Correlations for all parameters for 40 – 59 years of age.

| | | Age | Weight (kg) | BMI (kg/m^2) | Waist Circumference (cm) | Body Fat (%) | Push-Ups (#) | Partial Curl-Ups (#) | Back Extension (s) | Sit-and-Reach (cm) | Grip Strength (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Pearson Correlation | 1 | -.156 | .043 | .027 | .165 | -.034 | -.079 | .414 | -.266 | -.347* |
| | Sig. (2-tailed) | | .264 | .759 | .845 | .317 | .818 | .592 | .181 | .064 | .012 |
| | N | 55 | 53 | 53 | 54 | 39 | 49 | 48 | 12 | 49 | 52 |
| Weight (kg) | Pearson Correlation | -.156 | 1 | .878** | .813** | .625** | -.343* | -.248 | -.206 | -.290* | .180 |
| | Sig. (2-tailed) | .264 | | .000 | .000 | .000 | .017 | .089 | .520 | .046 | .210 |
| | N | 53 | 53 | 53 | 52 | 39 | 48 | 48 | 12 | 48 | 50 |
| BMI (kg/m$^2$) | Pearson Correlation | .043 | .878** | 1 | .863** | .790** | -.372** | -.236 | .105 | -.311* | .011 |
| | Sig. (2-tailed) | .759 | .000 | | .000 | .000 | .009 | .106 | .746 | .031 | .939 |
| | N | 53 | 53 | 53 | 52 | 39 | 48 | 48 | 12 | 48 | 50 |
| Waist Circumference (cm) | Pearson Correlation | .027 | .813** | .863** | 1 | .800** | -.450** | -.312* | .058 | -.344* | .069 |
| | Sig. (2-tailed) | .845 | .000 | .000 | | .000 | .001 | .031 | .864 | .016 | .632 |
| | N | 54 | 52 | 52 | 54 | 38 | 48 | 48 | 11 | 49 | 51 |
| Body Fat (%) | Pearson Correlation | .165 | .625** | .790** | .800** | 1 | -.622** | -.397* | .397 | -.470** | -.212 |
| | Sig. (2-tailed) | .317 | .000 | .000 | .000 | | .000 | .018 | .201 | .004 | .215 |
| | N | 39 | 39 | 39 | 38 | 39 | 37 | 35 | 12 | 35 | 36 |
| Push-Ups (#) | Pearson Correlation | -.034 | -.343* | -.372** | -.450** | -.622** | 1 | .719** | -.164 | .377** | .309* |
| | Sig. (2-tailed) | .818 | .017 | .009 | .001 | .000 | | .000 | .610 | .010 | .037 |
| | N | 49 | 48 | 48 | 48 | 37 | 49 | 46 | 12 | 46 | 46 |
| Partial Curl-Ups (#) | Pearson Correlation | -.079 | -.248 | -.236 | -.312* | -.397* | .719** | 1 | -.026 | .235 | .064 |
| | Sig. (2-tailed) | .592 | .089 | .106 | .031 | .018 | .000 | | .939 | .115 | .678 |
| | N | 48 | 48 | 48 | 48 | 35 | 46 | 48 | 11 | 46 | 45 |
| Back Extension (s) | Pearson Correlation | .414 | -.206 | .105 | .058 | .397 | -.164 | -.026 | 1 | .286 | -.275 |
| | Sig. (2-tailed) | .181 | .520 | .746 | .864 | .201 | .610 | .939 | | .456 | .473 |
| | N | 12 | 12 | 12 | 11 | 12 | 12 | 11 | 12 | 9 | 9 |
| Sit-and-Reach (cm) | Pearson Correlation | -.266 | -.290* | -.311* | -.344* | -.470** | .377** | .235 | .286 | 1 | .295* |
| | Sig. (2-tailed) | .064 | .046 | .031 | .016 | .004 | .010 | .115 | .456 | | .042 |
| | N | 49 | 48 | 48 | 49 | 35 | 46 | 46 | 9 | 49 | 48 |
| Grip Strength (kg) | Pearson Correlation | -.347* | .180 | .011 | .069 | -.212 | .309* | .064 | -.275 | .295* | 1 |
| | Sig. (2-tailed) | .012 | .210 | .939 | .632 | .215 | .037 | .678 | .473 | .042 | |
| | N | 52 | 50 | 50 | 51 | 36 | 46 | 45 | 9 | 48 | 52 |

Table displays correlations between all parameters for the 40 – 59 age group. N = number of participants for each parameter. *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

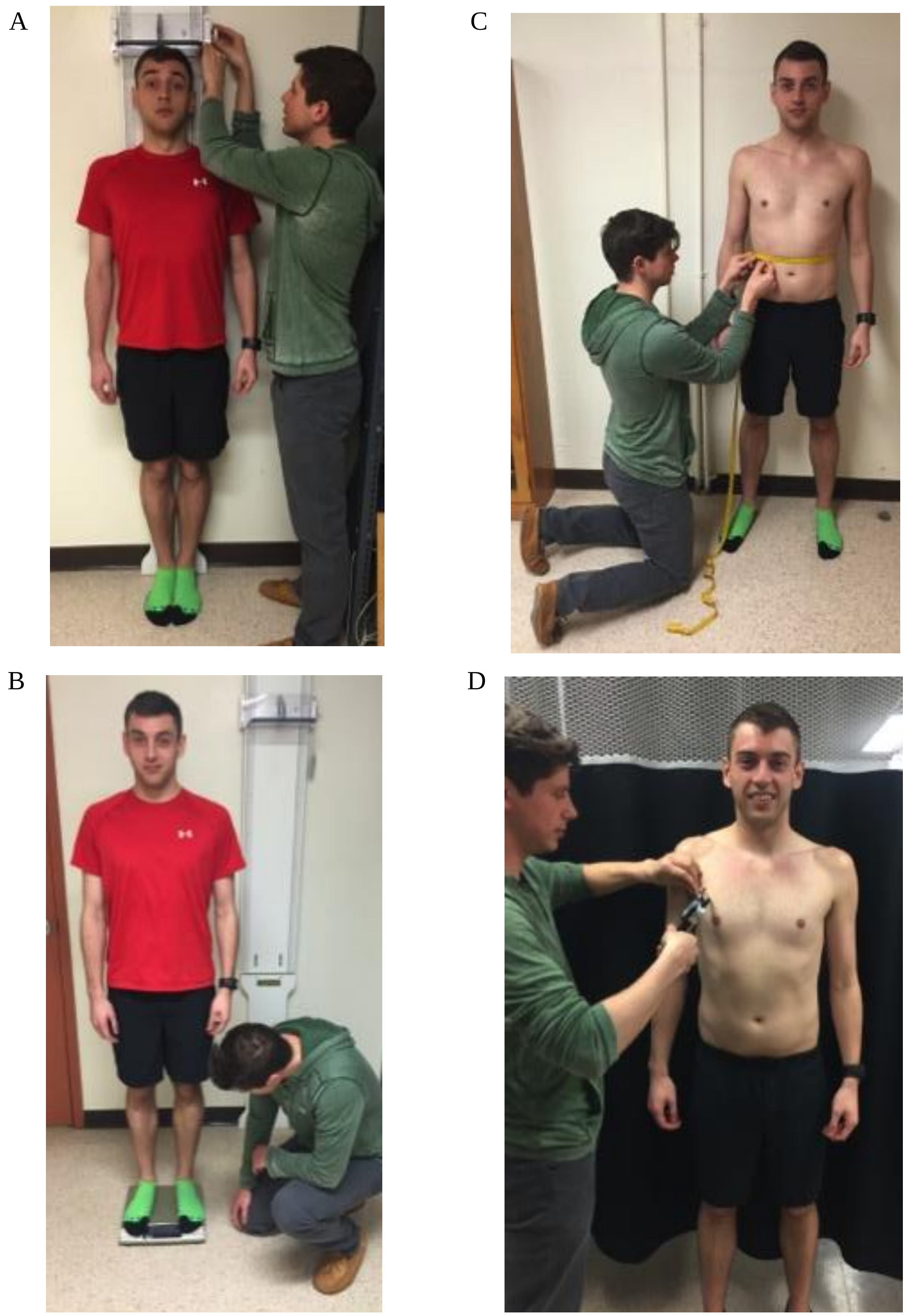



**Figure 1.** A) Participant having height measured. B) Participant having weight measured. C) Participant having waist circumference measured. D) Participant having chest skinfold measured.


**Figure 2.** Participant having skinfolds measured using Harpenden skinfold calipers. A) Midaxillary. B) Triceps. C) Subscapular. D) Abdominal.

A

B

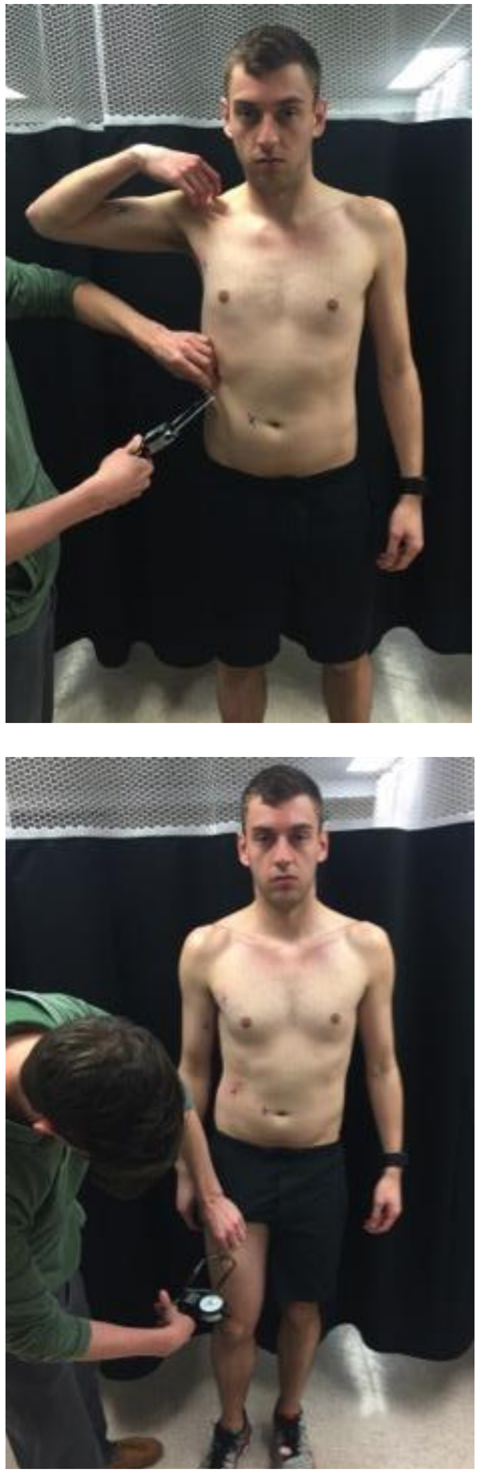
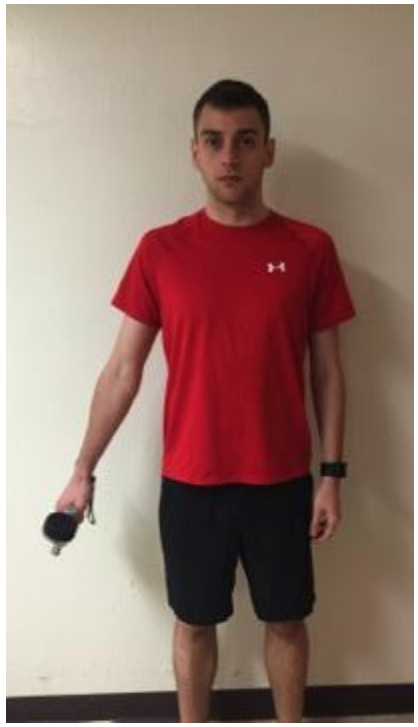


**Figure 3.** Participant having skinfolds measured with Harpenden skinfold calipers. A) Suprailiac. B) Anterior thigh.

A



B

**Figure 4.** A) Participant using a hand dynamometer to measure grip-strength. B) Participant using a flexometer to measure flexibility.

A

B

**Figure 5.** A) Participant in the up phase of a push-up test. B) Participant in the down phase of a push-up test.

A

B

C

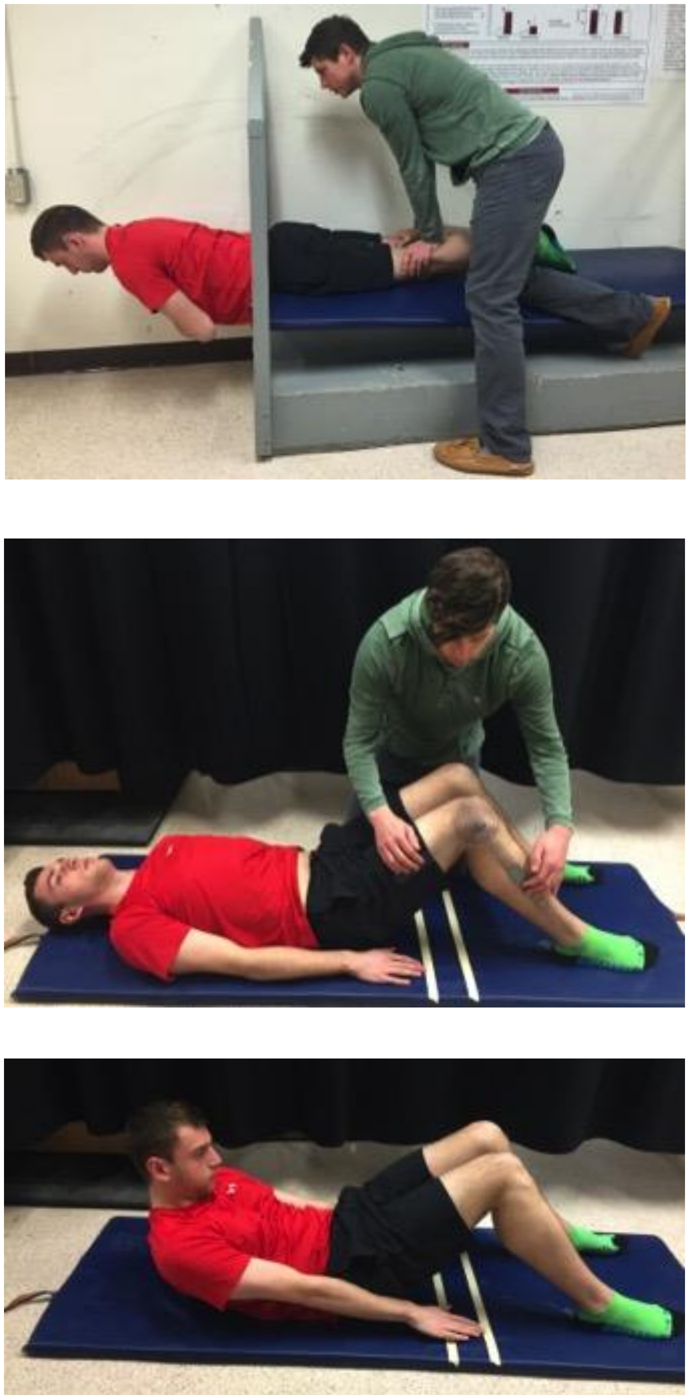


**Figure 6.** Participant performing a back extension. B) Participant in the down phase of a partial curl-up with knee angle being measured to 90°. C) Participant in the up phase of a partial curl-up.

A

B

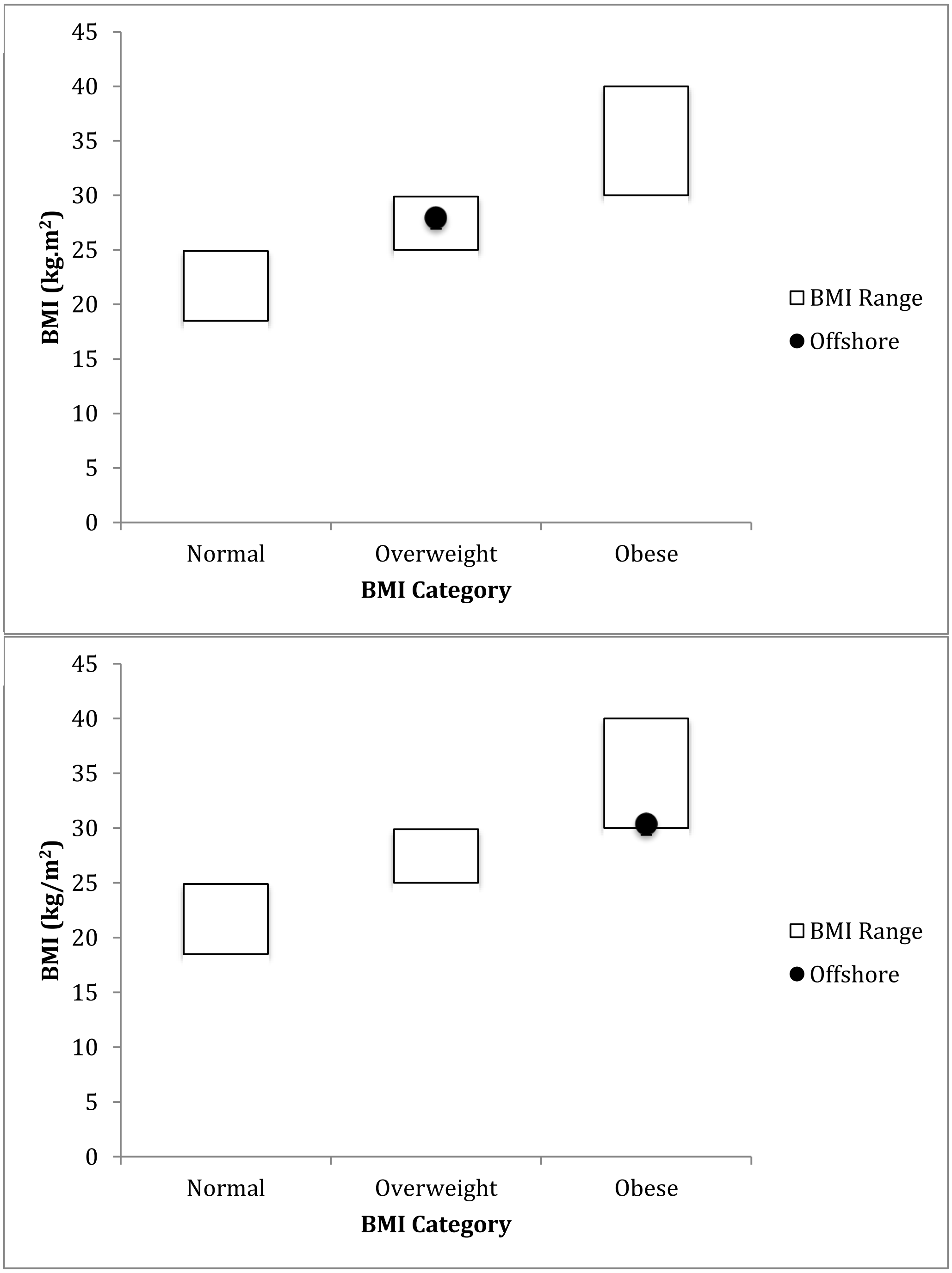



**Figure 7.** BMI category ranges for different age groups. A, 20 – 39 age group. B, 40 – 59 age group. Black dots indicate the mean BMI for each age group. BMI normal range is 18.5 – 24.9 kg/m$^2$, BMI overweight range is 25.0 – 29.9 kg/m$^2$, and BMI obese range is > 30.0 kg/m$^2$.

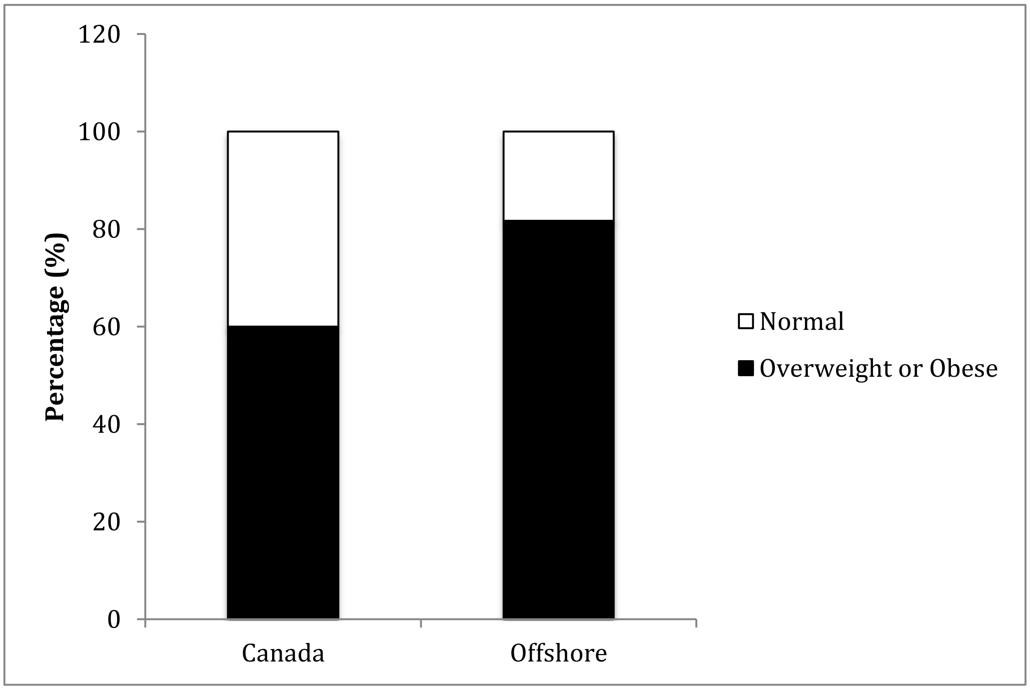



**Figure 8.** Average BMI distribution of Canada and the NL offshore workforce. The figure displays the percentage of normal and overweight or obese people as a percentage for each sample.

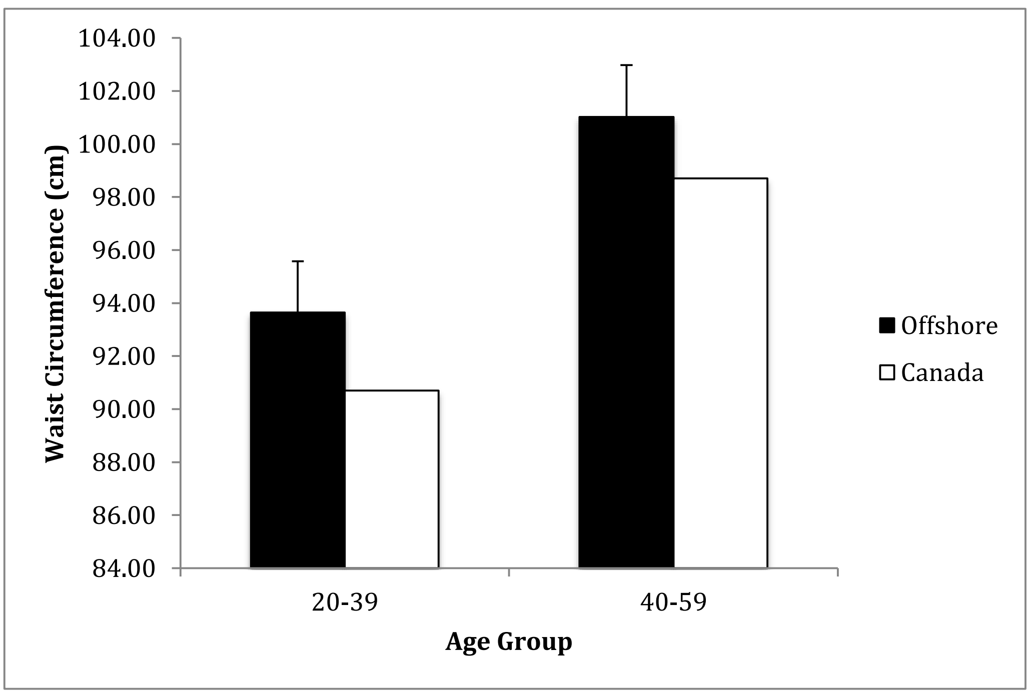



**Figure 9.** Mean waist circumference of Canada and the NL offshore workforce grouped by age. The figure displays the mean waist circumference with standard error mean bars of the NL offshore workforce.

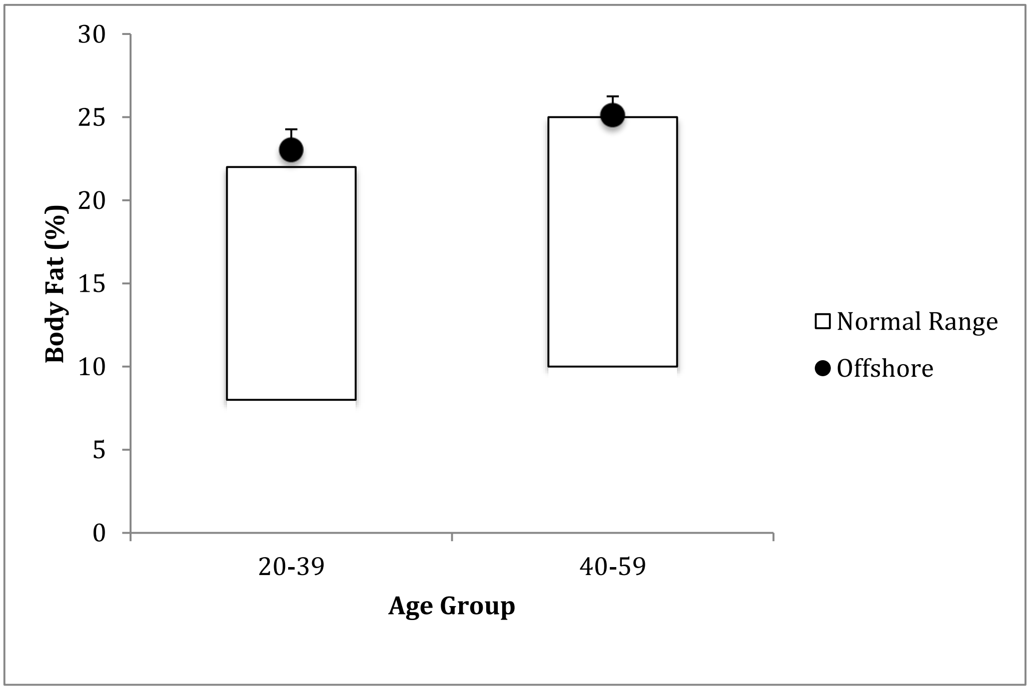



**Figure 10.** Normal male body fat parentage ranges displayed by age group with NL offshore workers mean. Mean body fat percentages are plotted with standard error mean bars.

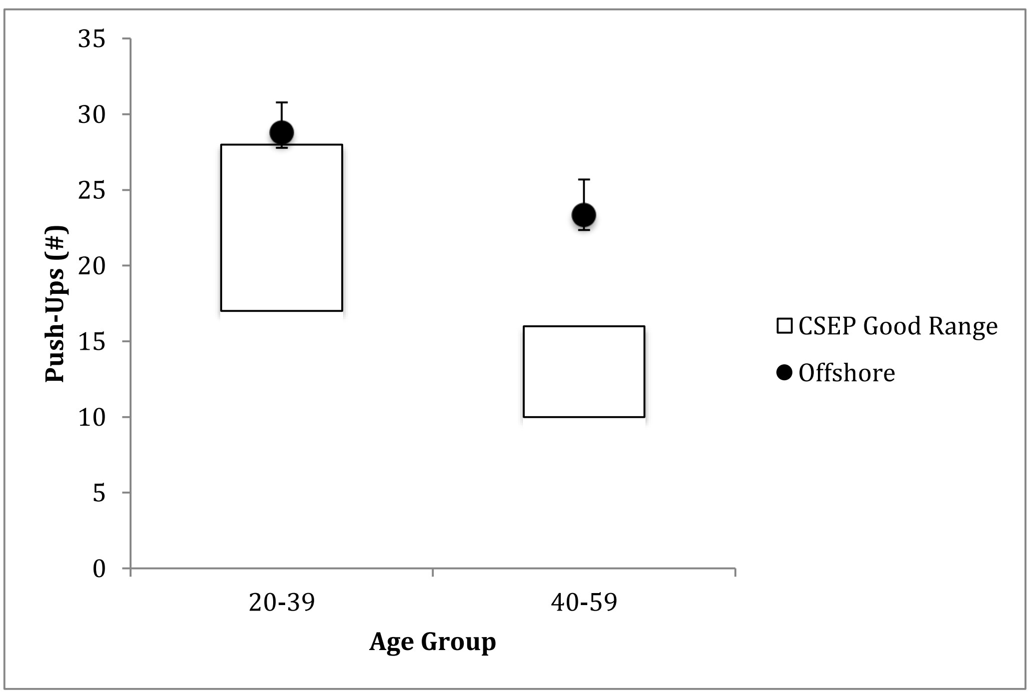



**Figure 11.** Canadian Society for Exercise Physiology healthy musculoskeletal push-up ranges and mean offshore scores for both age groups. Mean total push-ups are plotted with standard error mean bars.

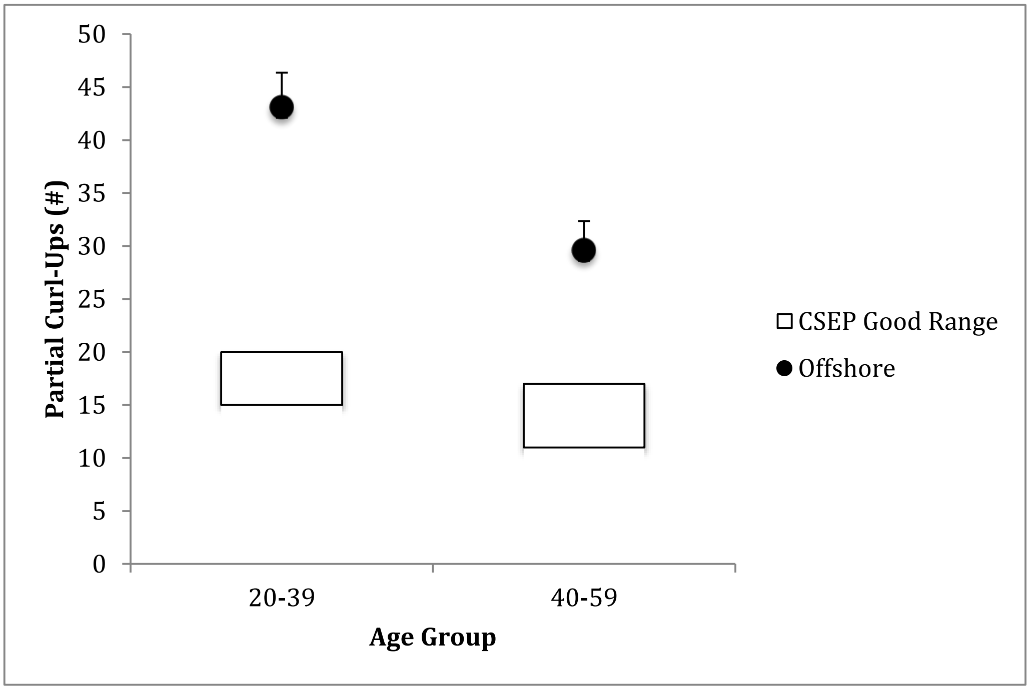



**Figure 12.** Canadian Society for Exercise Physiology healthy musculoskeletal partial curl-up ranges and mean offshore scores for both age groups. Mean total partial curl-ups are plotted with standard error mean bars.

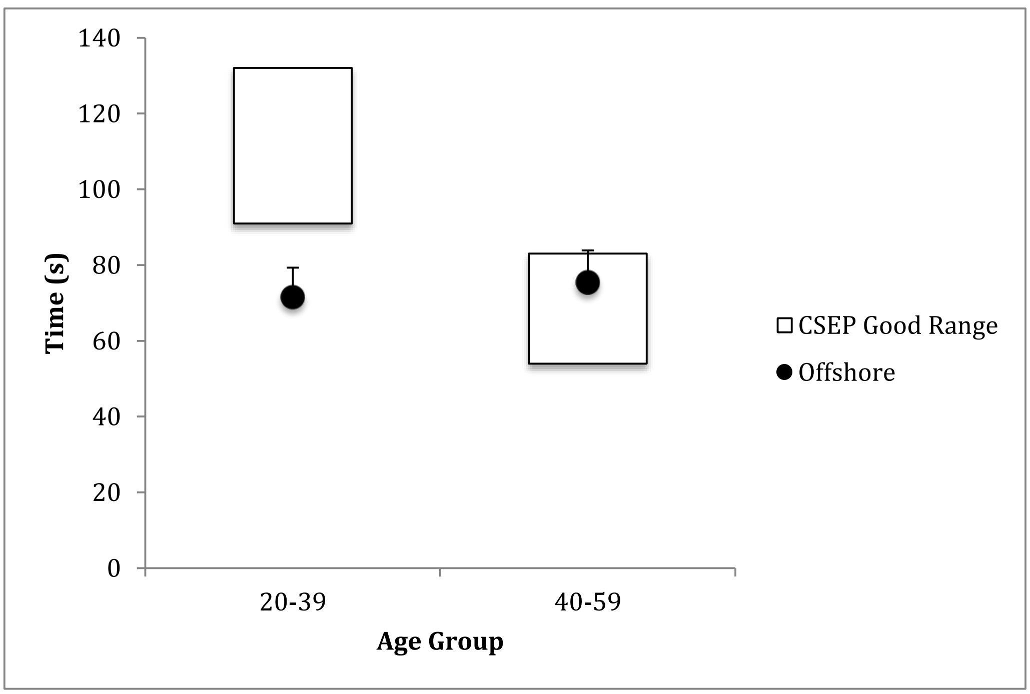



**Figure 13.** Canadian Society for Exercise Physiology healthy musculoskeletal back extension ranges and mean offshore scores for both age groups. Mean back extension times are plotted with standard error mean bars.

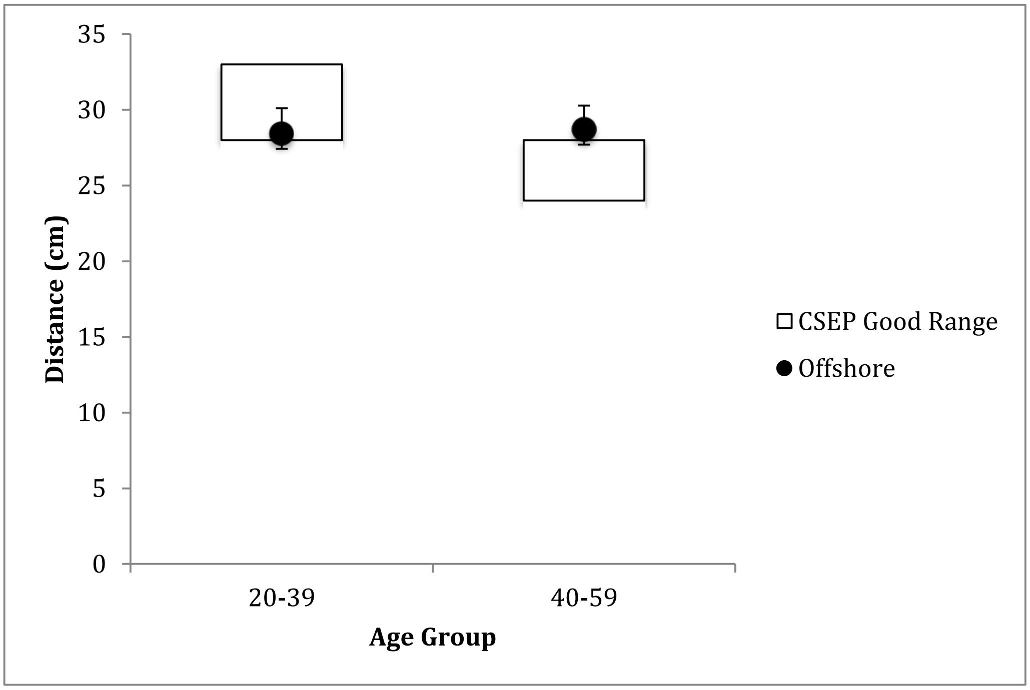



**Figure 14.** Canadian Society for Exercise Physiology healthy musculoskeletal good sit-and-reach ranges and mean offshore scores for both age groups. Mean sit-and-reach scores are plotted with standard error mean bars.

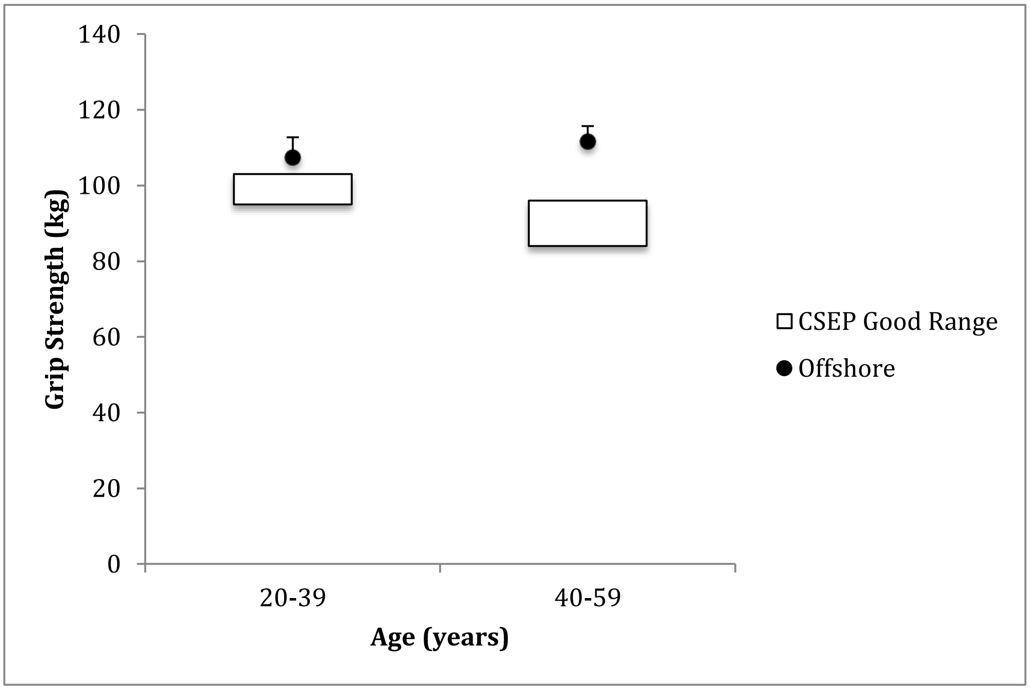



**Figure 15.** Canadian Society for Exercise Physiology healthy musculoskeletal good grip strength ranges and man offshore scores for both age groups. Mean grip strength scores are plotted with standard error mean bars.

**APPENDIX A: BODY MASS INDEX TABLE**

| BMI Category | BMI (kg/m$^2$) |
|---|---|
| Underweight | <18.5 |
| Normal Weight | 18.5 – 24.9 |
| Overweight | 25.0 – 29.9 |
| Obese | >30 |

Adapted from the Canadian Physical Activity, Fitness, and Lifestyle Approach Manual (Canadian Society for Exercise Physiology, 2004).

## APPENDIX B: PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

# PAR-Q & YOU

**(A Questionnaire for People Aged 15 to 69)**

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

| YES | NO | |
|---|---|---|
| ☐ | ☐ | **1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?** |
| ☐ | ☐ | **2. Do you feel pain in your chest when you do physical activity?** |
| ☐ | ☐ | **3. In the past month, have you had chest pain when you were not doing physical activity?** |
| ☐ | ☐ | **4. Do you lose your balance because of dizziness or do you ever lose consciousness?** |
| ☐ | ☐ | **5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?** |
| ☐ | ☐ | **6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?** |
| ☐ | ☐ | **7. Do you know of any other reason why you should not do physical activity?** |

**If you answered**

### YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

### NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

**DELAY BECOMING MUCH MORE ACTIVE:**

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

**PLEASE NOTE:** If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

**No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.**

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ________________________________________

SIGNATURE ________________________________________ DATE ____________________

SIGNATURE OF PARENT ________________________________________ WITNESS ____________________
or GUARDIAN (for participants under the age of majority)

**Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.**

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## APPENDIX C: INFORMED CONSENT FORM

**Informed Consent Form**

Title: "Musculoskeletal Fitness and Body Composition of Newfoundland and Labrador Offshore Oil and Gas Workers


| | |
|---|---|
| Researcher(s): | Thomas Dymond<br>School of Human Kinetics and Recreation<br>Email: thomas.dymond@mun.ca |
| Supervisor: | Dr. Kevin Power<br>School of Human Kinetics and Recreation<br>Room PE 2022A<br>Email: kevin.power@mun.ca<br>Phone: 864-7275 |


You are invited to take part in a research project entitled *"Musculoskeletal Fitness and Body Composition of Newfoundland and Labrador Offshore Oil and Gas Workers."*

This form is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. It also describes your right to end your involvement up until the end of the testing session and you may request the removal of your data until approximately one year later. In order to decide whether you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is the informed consent process. Take time to read this carefully and to understand the information given to you. Please contact the researcher, Dr. Kevin Power, if you have any questions about the study or for more information not included here before you consent.

It is entirely up to you to decide whether to take part in this research. If you choose not to take part in this research or if you decide to withdraw from the research once it has started, there will be no negative consequences for you, now or in the future.

**Introduction**

This research is being conducted by Thomas Dymond for the purpose of his master's thesis under the supervision of Dr. Kevin Power, an assistant professor in the School of Human Kinetics and Recreation at Memorial University of Newfoundland. Following the tragedy of Cougar Flight 491 in 2009, Recommendation 14 of the Offshore Helicopter Safety Inquiry was developed. It proposed that the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) set goals for physical fitness for workers in preparation for safety training, mainly as it relates to one's ability to exit a ditched helicopter. As a result, a review was commissioned by the C-NLOPB entitled, "Review of Health and Wellness Programs for the Newfoundland and Labrador (NL) Offshore Workforce." This comprehensive review tended to focus on the negative impact of obesity on the health and safety of offshore workers. Though obesity levels may be a contributing factor to the overall health and safety of the offshore worker, the review also acknowledges, as does Recommendation 14, that physical fitness plays a major role in the health and safety of offshore workers. Currently there are no data available on the health and fitness of the NL offshore workforce. Thus, recommendations to reduce obesity and/or increase 'physical fitness' levels amongst the offshore workforce have not been addressed.

**Purpose of study:**

Overall health and wellness is known to have an impact on the safety of those who work offshore. The objective is to characterize the health and fitness demographics of NL offshore workers with the aim to help develop, support and enhance programs that will ensure industry leading health and safety standards. The development of these standards will be done through the use of submaximal fitness tests: anthropometric, body composition, musculoskeletal and cardiovascular assessments. Overall, we are addressing these issues by characterizing the health and lifestyle behavior, physical fitness levels and obesity rates in NL offshore workers.

**What you will do in this study:**

This study will consist of one testing session lasting approximately 2 hours. Testing will involve a number of anthropometric (height and weight), body composition (BMI, waist circumference, and skinfold), cardiovascular health and aerobic fitness (cycle ergometer, step test and pulmonary function), musculoskeletal health (grip-strength, push-ups, partial curl-ups, sit- and- reach, vertical jump, and back endurance) assessments. In addition, behavioural assessments related to both onshore and offshore lifestyle habits will be administered. Demographics (age, gender, educational background, annual income, marital status, and pre-existing health conditions), lifestyle (physical activity, nutrition, smoking, alcohol consumption, and sedentary time), stress (using a perceived stress scale) and quality of life (36 questions related to an individual's overall quality of life- social, physical function and mental health) questionnaires will be administered.

**Length of time:**

Participation in this study will require you to come to a lab located in the School of Human Kinetics and Recreation at Memorial University for one testing session or at Definitions Crosbie Training Complex on Logy Bay Road . The total time commitment will be approximately 2 hours. You will be asked to not engage in weight training or vigorous exercise prior to the session.

**Withdrawal from the study:**
You will be free to end your involvement up until the end of the testing session. To do so you simply need to inform the researchers and you will be free to leave. You may request the removal of your data until approximately one year later. Any data collected up to that point will not be used in the study and will be destroyed. If you are a student, your participation in and/or withdrawal from this study will not in any way, now or ever, negatively impact either your grade in a course, performance in a lab, reference letter recommendations and/or thesis evaluation.

**Possible benefits:**
Participants will receive information and feedback on their health and fitness levels. They will also have the opportunity to discuss the results and any questions they have with a highly trained Certified Exercise Physiologist.
As pointed out in the 'rationale', the purpose of the current study is "to characterize the health and fitness demographics of NL offshore workers with the aim to help develop, support and enhance programs that will ensure industry leading health and safety standards. Specifically to characterize the health and lifestyle behaviour, physical fitness levels and obesity rates of NL offshore workers."

**Possible risks:**
There are several minor risks associated with participating in this study:

**Physical**: the physical tests being administered are submaximal in nature and thus unlikely to create significant physical risks. A strict pre-screening process will be put in place and each participant's heart rate and blood pressure will be monitored throughout the assessment. Participants may experience sore muscles common to any exercise regime.

**Psychological/emotional:** measurements of physical attributes have the potential to be embarrassing. For example, skinfold measurements, weight, and waist circumference are all measurements of body composition (e.g. fat vs muscle) and may make some people feel vulnerable. Participants will not be required to perform any task they are uncomfortable with. This will be explained to the participants. Not performing certain assessments will not mean they are not able to perform the rest (i.e. we do not require a complete data set for each individual). Each researcher will be trained in effective counseling techniques and have previous experience working with clients in a similar fashion (i.e. administration of physical assessments and questionnaires).

**Confidentiality vs. Anonymity**
There is a difference between confidentiality and anonymity: Confidentiality is ensuring that identities of participants are accessible only to those authorized to have access. Anonymity is a result of not disclosing participant's identifying characteristics (such as name or description of physical appearance). Every reasonable effort will be made to

ensure participants' anonymity and that they will not be identified in any reports of publications without their explicit permission.

**Confidentiality and Storage of Data:**

a. Your identity will be guarded by maintaining data in a confidential manner and in protecting anonymity in the presentation of results (see below)

*b.* All data collected for this study will be kept in a secured location for 5 years, at which time it will be destroyed. Paper based records will be kept in a locked cabinet in the office of Dr. Power while computer based records will be stored on a password protected computer in the office of Dr. Power. The only individuals who will access to this data are those directly involved in this study.

*c.* Data will be retained for a minimum of five years, as per Memorial University policy on Integrity in Scholarly Research after which time it will be destroyed.

*d.* The data collected as a result of your participation can be withdrawn from the study at your request up until the point at which the results of the study have been accepted for publication (~1year post study).

**Anonymity:**
Your participation in this study will not be made known to anyone except researchers who are directly involved in this study.

**Recording of Data:**
There will be no video or audio recordings made during testing.

**Reporting of Results:**
Results of this study will be reported in written (scientific article) and spoken (local and national conferences and lectures). Generally all results will be presented as group averages. In cases where individual data needs to be communicated it will be done in such a manner that your confidentiality will be protected (i.e. data will be presented as coming from a representative subject). Data will also be reported in a master's thesis prepared by Thomas Dymond which will be publically available through the QEII Library of Memorial University.

**Sharing of Results with Participants:**
Following completion of this study please feel free to ask any specific questions you may have about the activities you were just asked to partake in. Also if you wish to receive a brief summary of the results then please indicate this when asked at the end of the form.

**Questions:**

You are welcome to ask questions at any time during your participation in this research. If you would like more information about this study, please contact: Dr. Kevin Power (kevin.power@mun.ca) or Thomas Dymond M.Sc. (Candidate) (thomas.dymond@mun.ca).

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861.

**Consent:**

Your signature on this form means that:

- You have read the information about the research.
- You have been able to ask questions about this study.
- You are satisfied with the answers to all your questions.
- You understand what the study is about and what you will be doing.
- You understand that you have the right to end your involvement up until the end of the testing session and you may request the removal of your data until approximately one year later, without having to give a reason, and that doing so will not affect you now or in the future.
- You understand that any data collected from you up to the point of your withdrawal will be destroyed.

If you sign this form, you do not give up your legal rights and do not release the researchers from their professional responsibilities.

**Your signature:** I have read what this study is about and understood the risks and benefits. I have had adequate time to think about this and had the opportunity to ask questions and my questions have been answered.

☐ I agree to participate in the research project understanding the risks and contributions of my participation, that my participation is voluntary, and that I may end my participation up until the end of the testing session.

A copy of this Informed Consent Form has been given to me for my records.

______________________________ ______________________________

Signature of participant Date

**Researcher's Signature:**

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant 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 Principal Investigator Date

Upon completion of this study, would you like a brief summary of its results? (Circle answer)

Yes No

If yes, please provide email

Email:

# APPENDIX D: ETHICS APPROVAL

MEMORIAL UNIVERSITY

**Interdisciplinary Committee on Ethics in Human Research (ICEHR)**

Office of Research Services
St. John's, NL Canada A1C 5S7
Tel: 709 864 2561 Fax: 709 864 4612
www.mun.ca/research

| | |
|---|---|
| ICEHR Number: | **20141281-HK** |
| Approval Period: | April 2, 2014 – April 30, 2015 |
| Funding Source: | RDC |
| Responsible Faculty: | Dr. Kevin Power<br>School of Human Kinetics and Recreation |
| Title of Project: | *Health and Fitness Demographics of Workers in the Newfoundland and Labrador Offshore Oil and Gas Industry* |

April 2, 2014

Mr. Thomas Dymond
School of Human Kinetics and Recreation
Memorial University of Newfoundland

Dear Mr. Dymond:

Thank you for your email correspondence of March 30, 2014 addressing the issues raised by the Interdisciplinary Committee on Ethics in Human Research (ICEHR) concerning the above-named research project.

The ICEHR has re-examined the proposal with the clarification and revisions submitted, and is satisfied that the concerns raised by the Committee have been adequately addressed. In accordance with the *Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (TCPS2)*, the project has been granted *full ethics clearance* to April 30, 2015.

If you need to make changes during the course of the project, which may raise ethical concerns, please forward an amendment request form with a description of these changes to icehr@mun.ca for the Committee's consideration.

The *TCPS2* requires that you submit an annual update form to the ICEHR before April 30, 2015. If you plan to continue the project, you need to request renewal of your ethics clearance, and include a brief summary on the progress of your research. When the project no longer requires contact with human participants, is completed and/or terminated, you need to provide the annual update form with a final brief summary, and your file will be closed.

The annual update form and amendment request form are on the ICEHR website at http://www.mun.ca/research/ethics/humans/icehr/applications/.

We wish you success with your research.

Yours sincerely,

Gail Wideman

Gail Wideman, Ph.D.
Vice-Chair, Interdisciplinary Committee on
Ethics in Human Research

GW/th

copy: Supervisor – Dr. Kevin Power, School of Human Kinetics and Recreation
Director, Research Grant and Contract Services

Research Grant and Contract Services, Bruneau Centre for Research & Innovation Page 1 of 1