Determining Energy Expenditure during Golf and Lawn-Mowing in Older Adult Males: Sufficient for Health?

BY

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ABSTRACT

This study compared the intensity and energy cost of playing nine holes of golf, with forty minutes of lawn mowing in older men, and determined whether both met the current recommendations for health benefits.

Eighteen older men (age: 71.4 ± 4.5 years, BMI: 27.3 ± 2.3, mean ± SD) completed a graded exercise treadmill test (GXT) using the Balke-Ware protocol. The GXT assessed participants' peak work intensity and heart rate, and was used to screen out participants with abnormal cardiovascular responses. During two field tests, breath-by-breath gas exchange, velocity of movement and total distance walked were measured using a portable metabolic system and GPS, while subjects played 9 holes of golf while pulling a cart, and completed 40 minutes of non-propelled self-paced lawn-mowing.

The net energy cost of the golfing and lawn-mowing sessions were 310.3 kcal and 246.0 kcal, respectively. Mean walking speed and mean distance walked during golfing were 2.4 ± 0.3 $km \cdot hr^{-1}$ and 4.4 ± 0.4 km, respectively, while the mean velocity and mean distance walked during lawn-mowing were 4.2 ± 0.5 $km \cdot hr^{-1}$ and 2.7 ± 0.3 km. The mean intensity in metabolic equivalents (METs) of golfing and lawn-mowing were 2.8 ± 0.5 and 5.5 ± 0.9, respectively. Lawn-mowing and golfing both met the intensity and energy expenditure requirements listed by the American College of Sports Medicine (ACSM). As health benefits can be derived from expending an extra 700 to 2000 $kcals \cdot week^{-1}$ in physical activity, participating frequently in nine holes of golf or performing regular lawn maintenance are suitable for maintaining and deriving cardiovascular and general health benefits in older adult men.

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Chapter 1: Introduction

The Canadian population is now comprised of approximately four million older adults, which is nearly thirteen percent of the total population (Population Reference Bureau, 2004). Current demographics of the more developed countries show that 15 percent of the population is over 65 years of age, and globally there are approximately 450 million older adults (Population Reference Bureau, 2004). The proportion of older adults over 65 years of age, especially in the more developed regions of the world, is on the rise (Population Reference Bureau, 2004; Shephard, 1997a; Tanaka & Seals, 2003). Older adults will therefore comprise a larger percentage of the global population as average life length increases (Fries, 1980). Despite this the benefits of popular leisure time physical activity on older adult health have not been adequately studied. This should be of concern as older adults have the highest rates of functional disability, morbidity and loss of independence (USDHHS, 1996). Therefore, it is necessary to examine the benefits of leisure-time physical activity and to determine the impact that preferred activities will have on functional health, quality of life and consequently health care costs in older adult populations.

At the age of retirement, many individuals see a marked drop in their daily energy expenditure due to decreased occupational physical activity (OPA) (Shephard, 1997a). Furthermore, older adults tend to choose lower-intensity, less structured and highly variable leisure-time physical activities (DiPietro, 2001). To help validate the benefits of "active living" promoted by the governing health bodies in Canada, research is necessary to accurately determine the intensity and energy cost of the more prevalent older adult leisure-time physical activity pursuits.

Regular physical activity of appropriate intensity and duration is known to confer health benefits to individuals of all ages. The current guidelines suggest that 30 minutes of moderate intensity physical activity on most days of the week is a sufficient stimulus for improving health. Frequent participation in lower intensity physical activity for greater durations has also been purported to improve health in sedentary, unfit and older individuals (ACSM, 1998b). Much of the health benefit is believed to be related to the net energy expended during physical activity. Current minimal guidelines suggest a net energy cost of 150-200 kilocalories•session^{-1} (ACSM, 1998b, USDHHS, 1996), 700 to 2,000 kilocalories•week^{-1} (ACSM, 1998b), or 3 kilocalories•kilogram^{-1}•day^{-1} (CFLRI, 1998).

Golfing and lawn-mowing are examples of leisure-time physical activities (LTPA) that have not been adequately studied in the older adult population. Golfing and yard-work/gardening are consistently ranked among the most popular leisure-time activities amongst older adult North Americans (CFLRI, 1998; USDHHS, 1996). It is very important to determine whether the growing number of older adults will benefit from these and similar types of leisure-time physical activity.

1.1 Statement of the purpose

1. To compare the absolute intensities of lawn-mowing and golfing to the MET values reported in the Compendium of Physical Activities (Ainsworth et al., 1993; Ainsworth et al., 2000).
2. To determine the average duration spent at each ACSM intensity classification during a typical nine holes of golf and 40 minutes of lawn-mowing in older adult males.
3. To examine the energy cost of nine holes of golf while pulling a cart and 40 minutes of self-paced non-propelled power lawn-mowing, in older adult males.
4. To determine if golfing and lawn-mowing meet the minimum energy expenditure (EE) and intensity criteria outlined by the American College of Sports Medicine (ACSM) and the Canadian Fitness and Lifestyle Research Institute (CFLRI).

1.2 Study hypotheses

1. Older adult males will select a pace during golfing and lawn-mowing that will result in a workload equivalent to the "moderate" or "hard" ACSM intensity categories.
2. The absolute intensity of 9 holes of golf and 40 minutes of lawn-mowing will be significantly greater than the values purported in the Compendium of Physical Activities in older adult males.
3. Older adult males will meet and surpass the minimum energy expenditure guidelines during 9 holes of golf while pulling a cart, and during 40 minutes of lawn-mowing.

1.3 Study delimitations

1. The study participants were not representative of all men aged 65 and older. The participants in this study were healthy, ambulatory and passed the pre-screening criteria. The participants were also required to have previous knowledge and experience of golfing and lawn-mowing.

2. Golf is a sport that requires significant resources; therefore the participants in the study may have had a higher socio-economic status and level of education then other older adult men.

1.4 Study limitations

To prevent confounding factors from influencing future studies, it is important to identify and address any factor that may have impacted the results of the study.

1. The sample size was limited due to practical and logistical constraints.

2. The mass of the golf equipment (cart, bag, and clubs) was not measured or controlled for, and each participant used their own equipment. Heavier gear may have increased the oxygen consumption and intensity of the golfing activity, while lighter equipment may have had the opposite effect.

3. During maximal testing, the participants true VO_2 max and HR max were not determined but rather VO_2 peak and HR peak.

4. The lawn-mowing occurred in an open field with no obstructions or detours, therefore it may not adequately represent a typical residential lawn-mowing environment.

5. Three participants were unable to golf with another golfer because their scheduled playing partner did not show for the testing period. Golf is usually played in groups of two, three or four and the other players usually help dictate the pace of play.

6. The resting metabolic rate (RMR) of each subject was assumed and not measured. Resting metabolic rate (RMR) is suggested to be less than the assumed value of 3.5 $ml•kg^{-1}•min^{-1}$. Gunn et al. (2002), suggest that resting metabolic rate decreases with increasing age, and that previous estimates over predict RMR .

1.5 Assumptions

1. Resting metabolic rate (RMR) is assumed to be 3.5 $ml•kg^{-1}•min^{-1}$ as dictated by previous research (Howley, 2001).

1.6 Definitions

Absolute intensity

Describes the actual rate of energy expenditure and is based on oxygen consumption (3.5 $ml•kg^{-1}•min^{-1}$ = 1MET= 1 $kcal•kg^{-1}•hr^{-1}$) (Howley, 2001).

Aerobic exercise (training)

Training involving dynamic activities and increases in heart rate and energy expenditure. Regular participation results in improved endurance performance and cardiovascular health. (Howley, 2001).

Aging

The gradual deterioration of a mature organism resulting from time-dependent, irreversible changes in structure (Dirckx, 2001).

Age classification

Middle age extends from age 40 to 64 years of age. Old age extends from 65 to 74 years of age. Very old age extends from 75 to 84 years of age and generally individuals of this category experience some difficulty with various daily tasks. Oldest old age concerns individuals over the age of 85 years (Shephard, 1997a).

Exercise

Planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness (USDHHS, 1996). Exercise can be considered a subgroup of recreational physical activity.

Disability

Restriction or lack of ability to perform an activity in the manner or within the range considered normal for a human being (Buchner et al., 1992).

Functional limitation

Reduced ability to complete specific activities (Morey et al., 1998).

Impairment

Related to a loss of anatomical, physiologic and mental functioning (Morey et al., 1998).

Indirect calorimetry

A method of estimating energy expenditure by measuring respiratory gases. Given that the amount of O_2 and CO_2 exchanged in the lungs normally equals that used and released by body tissues, caloric expenditure can be measured by CO_2 production and O_2 consumption (USDHHS, 1996).

Kilocalorie (kcal)

A measurement of energy. 1 kilocalorie = 1 Calorie = 4,184 joules = 4.184 kilojoules (USDHHS, 1996).

Pathology

An interruption of normal biological processes at the organ level (Morey et al., 1998).

Peak heart rate reserve

The difference between peak heart rate and resting heart rate (Howley, 2001).

Peak oxygen uptake (VO_2 peak)

The peak capacity for oxygen consumption by the body during peak exertion. It is also known as aerobic power, peak oxygen consumption and cardiorespiratory endurance capacity (Howley, 2001).

Peak heart rate (HR peak)

The highest heart rate value recording during a graded exercise treadmill test near maximal exertion and at the point of exhaustion (Howley, 2001).

Physical activity

Bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure (USDHHS, 1996).

Physiologic functional capacity

The ability to perform physical tasks of daily life and the ease in which these tasks can be performed (Tanaka & Seals, 2003).

Leisure-time physical activity

Broad descriptor of activities that an individual participates in during free time based on interest and needs. These activities result in large energy expenditures although duration and total energy expenditure may vary (Howley, 2001).

Lifestyle physical activity

Subgroup of leisure-time physical activity often characterized by activities that are considered necessary for daily life such as housework, yard-work, grocery shopping and climbing stairs.

Metabolic equivalent (MET)

A measure of energy expenditure where 1 MET is equivalent to oxygen consumption/energy expended at rest or more specifically while sleeping.

(1 MET = 3.5 ml $ml \cdot kg^{-1} \cdot min^{-1}$=1 $kcal \cdot kg^{-1} \cdot hr^{-1}$) (Howley, 2001).

Muscular endurance

The ability of a muscle to contract/perform repeatedly at a submaximal level without fatigue (USDHHS, 1996).

Recreational physical activity

Subgroup of leisure-time physical activity often characterized by activities that involve stress relief, sport and games.

Sedentary

Sedentary is a state where individuals are insufficiently active, usually quantified in terms of energy expenditure (e.g. expending < 1.4 KKD). (CFLRI, 1996b)

Chapter 2: Review of Literature

2.1 Physical activity patterns in older adults

A number of factors have lead to a general trend in North America of increasing participation of older adults in low intensity physical activity, and decreasing participation in vigorous physical activity (Canadian Fitness and Lifestyle Research Institute (CFLRI), 1998; United States Department of Health and Human Services (USDHHS), 1996). Only 6% of older adult Canadians report running during the previous three months, while 80% report walking during the previous three months (CFLRI, 2001). Some older adults exhibit greater participation in low- and moderate-intensity physical activities as compared to younger Canadians, but overall energy expenditure associated with physical activity declines with age (Pate et al., 1995; Westerterp & Meijer, 2001). The 2000/2001 Canadian Community Health Survey reports that 62% of older adults (53% of males) are inactive, expending less than 1.4 $kcal \cdot kg^{-1} \cdot day^{-1}$, and only 17 % of older adults are considered active, expending more than 3 $kcal \cdot kg^{-1} \cdot day^{-1}$ (Craig & Cameron, 2004).

After the age of 24 years, participation rates in physical activity generally decline. However, lifestyle and recreational physical activity make up an increasing percentage of physical activity choices with increasing age. Gardening/yard-work and golf are two physical activities in which participation increases with age (CFLRI, 1998). Figure 2.1 demonstrates that over the past 25 years, the prevalence of golfing and lawn-mowing have been increasing amongst the middle aged and older adult population. According to the CFLRI, gardening/yard-work and golf are ranked as the second and seventh most popular activities in adults over the age of 65, respectively (CFLRI, 2001).

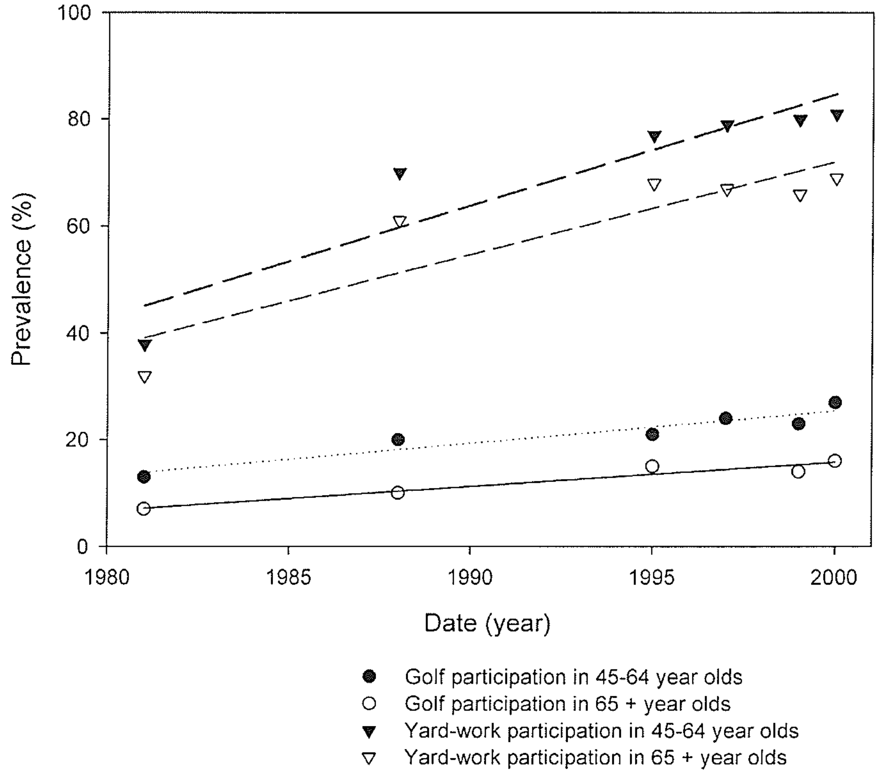

Figure 2.1. Prevalence of golfing and yard-work amongst middle-aged and older adult Canadians (Craig & Cameron, 2004; CFLRI, 1988; 1996; 1998; 2001).

2.2 Importance of physical activity in older adults

At the age of retirement, occupational physical activity is usually reduced amongst older adults, and as a result there is a significant decrease in daily energy expenditure. Shephard (1997a) reported that the average daily energy expenditure in adult males drops from 1.5 kcal•kg^{-1}•day^{-1}at age 20-29 years to 1.0 kcal•kg^{-1}•day^{-1} at age 60-69 years. As a consequence of decreased occupational activity, leisure-time physical activity has a more important role in preserving older adult health. Leisure-time physical activity consists of exercise, lifestyle physical activity and recreational physical activity. Exercise and recreational physical activity are mostly structured, while lifestyle physical activity remains primarily unstructured. Lifestyle physical activity (LPA) is often characterized by activities that are considered a necessity of life such as housework, yard-work, and grocery shopping. Recreational physical activity (RPA) is often characterized by activities that involve stress relief, sports and games. Exercise, however is a planned and structured activity that is prescribed or designed with specific health-related fitness outcomes in mind. Health-related fitness measures include: muscle strength, cardiovascular endurance, flexibility, and body composition (ACSM, 1998b).

While aging is a non-modifiable risk factor for morbidity and mortality, inactivity is a highly modifiable risk factor which may also have a profound effect on many measures of fitness including muscle strength, aerobic power and flexibility (Lee et al., 2000). In 1966, three weeks of bed-rest (inactivity) in 5 healthy young men (20 years) resulted in greater declines in maximal oxygen consumption than did the subsequent 30 years of aging (McGuire et al., 2001). Prolonged inactivity has also been significantly associated with decreased muscle strength in younger men (18-28 years) as 20 days of inactivity (bed-rest) resulted in significant muscle atrophy and decreased muscle force (Kawakami et al., 2001). Decreases in muscle strength and aerobic power are related to future disability and decreased quality of life. Physical activity of the appropriate stimulus can help preserve strength and aerobic capacity and slow the rate of decline associated with aging (Rantanen, 2003; Buchner et al., 1992). Depending upon the initial fitness level of an individual, many health related fitness measures can be improved through regular lifestyle and recreational physical activity.

2.3 Current guidelines and measures of physical activity for older adults

A great deal of research has been conducted to determine which physical activities and exercise regimens can negate the biological effects of aging, as well as prevent the onset of chronic conditions and decreases in quality of life. Exercise type, duration, intensity and subsequent energy expenditure have all been examined, and several major consensus reports have outlined the suggested participation levels for older adults to improve their health and function (ACSM, 1998a; ACSM, 1998b; USDHHS, 1996). Recent research suggests that regardless of age, improvements in functional health and fitness can be attained with appropriate activity. Until recently many of the guidelines and intensity measures were based upon a younger population group. These guidelines have now been extended to the older adult population, however few studies have focussed on the appropriateness of various physical activities for improving older adult health. Attention has now shifted to the importance of determining the minimum quantity and quality of activity to slow the age related decline in health status in healthy older adults.

2.3.1 Frequency, type and duration of physical activity

Before the late 1990's, the recommendations for physical activity focused solely on the benefits of endurance related physical activity. Continuous large muscle movements and activities such as walking are beneficial for improving physiologic function in older adults (ACSM, 1998a). According to Canada's Physical Activity Guide, the duration needed depends upon the effort or intensity of the activity (Health Canada, 1998). Current guidelines for endurance activity suggest that 60 minutes of light activity, 30 minutes of moderate activity or 20 minutes of vigorous activity is required on most days of the week to result in significant health benefits. Activity guidelines for older adults now suggest the addition of heavy resistance training two times per week, including eight to ten exercises of 8-12 repetitions.

Until the late 1990's, the ACSM had never made any specific recommendations for strengthening but the consensus statements suggest now that strength training is vital for maintaining independence in older adults. Little is known about the benefits of habitual weight/load bearing physical activities, therefore the quantity and type of lifestyle and recreational physical activity that is needed to improve strength in older adults must be examined. Some studies have noticed improvements in lower body function/strength with increases in lifestyle activity associated with increased energy expenditure and with increased load/weight bearing physical activity (Stressman et al., 2002; Brach et al., 2004; Laforest et al., 1990; Wong et al. 2003). Others have suggested that endurance exercise such as walking has not been shown to increase muscle strength or prevent muscle atrophy associated with older age (Fiatarone & Evans, 1993). Further research is required to determine whether an appropriate dose of leisure-time physical activity will prevent subsequent disability associated with lower body weakness and lack of endurance.

2.3.2 Relative and absolute intensity of physical activity

Many health organizations now recognize that unfit and older individuals can make significant health improvements by working at lower relative and absolute intensities (ACSM, 1998a; ACSM, 1998b; CFLRI, 1996; USDHHS, 1996). A relative intensity classified between 40-85 % oxygen uptake reserve (VO_2R) or % heart rate reserve (HRR) has been deemed suitable for making improvements in aerobic power or functional aerobic capacity in sedentary, unfit or older adults (ACSM, 1998b). The ACSM calculates the relative intensity as a percentage of oxygen consumption reserve. By subtracting the resting oxygen consumption from the maximal oxygen consumption researchers are better able to calculate the relative intensity of the activity. During light activity, less emphasis is placed on resting oxygen consumption and therefore resting metabolic function or intensity. Resting oxygen consumption accounts for a larger component of maximal oxygen consumption and energy expenditure in older adult, unfit and sedentary individuals (ACSM, 1998b; Gunn et al., 2002).

Absolute intensity describes the rate of energy expenditure (Howley, 2001). This rate can be described as multiples of resting metabolic rate (RMR) which is approximately 3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$ or 1 $kcal \cdot kg^{-1}$ body $mass \cdot h^{-1}$. This value is commonly equated to the term of 1 metabolic equivalent or 1 MET. In absolute terms, "moderate" intensity is defined by the American College of Sports Medicine as an activity that requires between 3.2-6.7 METs for older aged adults, and 4-8 METs in younger and middle-aged adults (ACSM, 1998b). The issue that arises from activity classifications in absolute terms is that a fit adult may find an activity with a MET rating of 5 to be very easy, while an unfit or older individual may find that the same activity may require hard to maximal effort. The maximum aerobic power of a young, fit individual may be more than double the maximum aerobic power of an unfit, sedentary older adult. This is due in part to decreasing aerobic power and decreasing motor efficiency as one becomes older and more inactive. However, the absolute intensity of physical activity may also increase with decreased fitness and increased age, because the resting metabolic rate used to determine the METs will decrease (Gunn et al., 2002). Gunn et al. (2002) suggest that as one ages the resting metabolic rate is substantially lower than the standard MET equivalent of 3.5 $ml \cdot kg^{-1} \cdot min^{-1}$. If researchers were to determine a resting MET level for young, middle, old and very old adults, we might be better able to determine a more accurate MET association for leisure-time physical activity based upon age. Exercise professionals must be cautious when prescribing activities for older and unfit adults based upon absolute intensity values, unless the maximum ability or peak aerobic power of the individual is known.

2.3.3 Compendium of physical activities intensity and energy cost

Many studies have attempted to classify the absolute intensity, a characteristic that is directly related to activity energy expense. The Compendium of Physical Activities developed and updated by Ainsworth et al. (1993, 2000) compiles the works of many researchers and lists the absolute intensity of several hundred common recreational, lifestyle and occupational physical activities. The Compendium was developed to as a tool for researchers and fitness professionals to roughly estimate the absolute intensity or energy cost of a given activity. It lists the absolute intensity or energy cost of golfing while pulling a cart as 4.3 METs or 4.3 $kcal \cdot kg$ body $mass^{-1} \cdot hr^{-1}$ or 15.0 $ml \cdot kg^{-1} \cdot min^{-1}$ (Ainsworth et al., 1993; Ainsworth et al., 2000). In the updated Compendium, lawn-mowing while using a power mower is listed as having an energy cost of 5.5 METs or 5.5 $kcal \cdot kg$ body $mass^{-1} \cdot hr^{-1}$ or 19.3 $ml \cdot kg^{-1} \cdot min^{-1}$ (Ainsworth et al., 2000).

Many of the Compendium classifications have not been adequately measured and it is unclear which estimates are valid and accurate in various age demographics. The first problem associated with the Compendium is that several activities have been examined in very limited population groups. The validity and accuracy of the estimated energy costs in the older adult population are unknown. Secondly, there is no indication of the measurements or the study designs used. This becomes problematic because estimates of energy cost have been made based on activities that are similar in type but not the actual activity (Ainsworth et al., 1993). A third problem is that the Compendium does not make any reference to pace of activity, vigor associated with the activity, fitness levels or whether the estimates are based on continuous activity or include rest (Ainsworth et al., 1993; Norgan, 1996). Increased age is often associated with increased body mass and decreased walking speed (Shephard, 1997a; Wong et al., 2003; Alexander et al., 2003). Slower walking speeds have also been reported to result in decreased energy expenditure as efficiency is increased (Donovan & Brooks, 1977). Lastly, it is unclear if the Compendium estimates are representative of net or gross energy expenditure. Ainsworth et al., (2000) cited the works of Passmore and Durnin (1955) which reported all activity energy costs as gross energy expenditure. However, other studies included in the Compendium reported net energy costs of each physical activity (Hendelman et al., 2000; Strath et al., 2000). Further research is needed to accurately determine the absolute intensity and energy cost of popular leisure-time physical activities amongst all age demographics to ensure appropriate exercise prescription.

2.3.4 Energy Expenditure

The minimum guidelines for energy expenditure have been suggested by health organizations such as the ACSM, the USDHHS and the CFLRI. The ACSM suggests that adults expend a minimum of 200 kcal•day^{-1}during bouts of physical activity on 4 days per week, or at least 700 kcal•week^{-1} (1998b). The USDHHS recommends a net energy expenditure of 150 kcal•day^{-1} or 1000 kcal•week^{-1} in order to achieve the appropriate health benefits (1996). Canadian guidelines suggest that healthy adults expend at least 3 kcal•kg^{-1}•day^{-1} (KKD) to achieve the associated health benefits (CFLRI, 1996). The CFLRI guideline may be the most beneficial because researchers and exercise professionals can prescribe an appropriate dose of exercise for each individual based upon body mass. Currently, only 24 % of Canadian adults over the age of 65 meet the guidelines developed by the CFLRI (1996a). It is important to determine whether the most popular recreational and lifestyle physical activities meet the minimum requirements for improved health.

The CFLRI and ACSM guidelines are based on the healthy adults across a wide range of ages. Due to the many physiological changes that are associated with aging, different guidelines may be required for different age groups. Because RMR decreases with age, total energy expenditure for a given duration is less for an older, unfit adult than for a younger, fit adult. When determining energy expenditure associated with "light" activity, the resting metabolic rate makes up a larger fraction of total energy expenditure. Energy cost of low intensity activities can therefore only be accurately determined by eliminating the effect of resting oxygen consumption from the calculations. Although a decrease in total energy cost would be expected as muscle mass decreases, body fat typically increases as people age (Talbot, 2000), and as a consequence, mechanical efficiency tends to decrease (Shepherd, 1997a). This may lead to an increase in energy expenditure for a specific activity in the older adult population. Decreases in aerobic power and in mechanical efficiency may lead to a slower self-selected pace which will cause the individual to work at a lower absolute intensity (Larson et al., 1979; Porcari et al., 1987). Future studies need to examine whether older or unfit adults work at a slower self-selected pace for a given endurance activity as compared to younger fit adults. Energy expenditure at different paces should also be examined in older adults.

2.4 Assessing physical activity in older adults

Many techniques are available to assess the physical activity levels of older adults. In large epidemiological studies, self-report measures are often used to assess energy cost of activity over a long period. The validity and reliability of using such measures is questionable in this population. Many of the reported measures of physical activity base the energy cost of activity upon Compendium listings of absolute intensity. As stated earlier, this poses a problem as data compiled to date has been based mainly on a younger population cohort. The Compendium values are listed in multiples of resting energy expenditure, and according to Klausen et al. (1996) resting energy expenditure decreases about 1 to 2 % per decade of adult life. Barring changes in the selected pace of activity or motor efficiency, the Compendium values may greatly underestimate the energy cost associated with various activities in older adults. To improve the accuracy of energy cost estimates, it is imperative that new Compendia be developed which include more recent data as well as intensity classifications for different age groups.

Doubly labeled water is known as the "gold standard" for measuring habitual energy expenditure (Norgan, 1996). This technique is extremely costly and does not allow for determination of intensity, but rather total energy expended. Direct calorimetry is also used to estimate the energy expended during a given activity. This technique is based upon an estimation of heat produced during activity, and requires an assumption of no change in heat stores or change in the energy potential in the system (Norgan, 1996). Direct calorimetry is restricted to a laboratory setting, and is not suitable for measuring energy expended during lifestyle and recreational physical activity in a normal environment.

Indirect calorimetry, or gas analysis, is a more mobile and popular option for estimating energy expenditure and intensity (relative and absolute) in all adult populations (USDHHS, 1996). The First Law of Thermodynamics states that energy cannot be used, but rather is transformed from one type to another (Norgan, 1996). Indirect calorimetry uses this assumption to calculate the energy expended during aerobic work. Knowing a subject's maximal aerobic work capacity, a researcher is capable of calculating the relative intensity of activity by comparing the activity oxygen uptake to the maximal oxygen uptake (aerobic power). Until recently, indirect calorimetry was limited to collection of expired gases in Douglas bags, and analyzing gas exchange variables after the testing session was complete. Advances in technology have produced small portable metabolic carts or gas analyzers which have been validated in younger populations against other criterion measures such as the Douglas bag method (McLaughlin et al, 2000; Duffield et al., 2004; Hausswirth et al., 1997; USDHHS, 1996). These portable metabolic units are beneficial in that they are especially useful for determining the metabolic cost associated with LTPA in the field. They are capable of storing a considerable amount of data including heart rate, and can greatly minimize the calculations associated with previous measures of indirect calorimetry. However, portable metabolic units are expensive, require frequent calibration, limit the testable sample size, can be uncomfortable, and have not been adequately validated in older adult populations (65+ years). The US Surgeon General's Report suggests that indirect calorimetry is a suitable method for measuring energy expenditure in older adults free from metabolic conditions which may affect resting metabolic rate (USDHHS, 1996). However, future research should validate the use of indirect calorimeters during field activity through comparisons to other criterion measures of energy expenditure and intensity in older adults.

Physical activity levels can also be assessed using estimates of energy expenditure based upon movement. Energy expended and distance walked can be roughly estimated with the use of a pedometer, if stride length and body mass are known. The accelerometry technique has been recently developed which measures body accelerations to determine the average speed of motion, and thus can allow for estimates of energy expenditure (Schutz and Herren, 2000). With the advent of light-weight global positioning system (GPS) technology, researchers have at their disposal a highly accurate and reliable tool to measure time-stamped outdoor movement (Schutz and Herren, 2000; Larsson and Henriksson-Larsen, 2001; Terrier et al., 2000; Terrier et al. 2001). Differential GPS improves the accuracy of the measured movements and assesses speed of movement even during slow, low-intensity physical activity (Schutz & Herren, 2000). Differential GPS is capable of measuring movement both horizontally and vertically.

When paired with metabolic measurements, GPS increases the ability to determine the specific energy cost associated with various tasks such as yard-work and golfing, which may include many activity components.

2.5 Effects of age and inactivity on health

2.5.1 Effects of age and inactivity on physiologic functional capacity

There are significant declines in human performance and in physiological function as people age. However, it is difficult to discern the physiological consequences of aging from the consequences associated with inactivity (Shephard, 1997a). It has been reported that the functional capacity of the human organs before the age of 30 years is four to ten times greater than that required to sustain life. After the age of thirty, the organ reserve shows a linear decline (Fries, 1980). Each body system plays a crucial role in a person's ability to function normally within the limits of their environment. As the organ reserve declines in a linear fashion, several functional and physiological limitations can develop which may lessen an individual's quality of life.

The functional capacity of the cardiovascular system declines with advancing age (Åstrand et al., 1973; ACSM, 1998b; Paterson et al., 1999; Talbot et al., 2000; Stathokostas et al., 2004; Rogers et al., 1988). Aerobic power, a measure of cardiovascular system function, decreases approximately 10 % per decade after the age of 25 years in the general population (ACSM, 1998b; Paterson et al., 1999; Talbot et al., 2000; Stathokostas et al., 2004). It has been suggested that 50% of the decline in maximal oxygen uptake may be due to inactivity or decreased lean body mass (Fleg & Lakatta, 1988; Rogers et al., 1990). In one eight year longitudinal study of Rogers et al., 18 master athletes and 14 sedentary subjects with similar physical characteristics underwent a maximal treadmill test using the Bruce protocol during the master athletes' competitive season. During the eight year period, master athletes attempted to maintain a similar training regimen, however significant decreases from initial testing were noted in average training duration, distance and intensity. Subjects were retested during the competitive season to ensure that they were in peak physiological shape. Master athletes demonstrated a 5.5 % per decade decrease in aerobic capacity, while sedentary subjects experienced a 12% per decade decrease (Rogers et al., 1990). Aside from cardiovascular and muscular changes, decreased exercise stimulus appears to be a contributing factor for decreased aerobic power.

Changes in heart and vascular structure, as well as function, have a profound impact on human functional capacity. Cardiac changes in generally healthy individuals have included increased heart mass (specifically left ventricular), decreased cardiomyocyte number and increased cardiomyocyte size (Shephard, 1997a; Oxenham & Sharpe, 2003). Vascular changes include arterial stiffening, increased arterial wall thickness, decreased arterial distensibility, decreased venous tone, increased peripheral resistance and decreased baroreceptor buffering (Oxenham et al., 2003; Jones et al., 2003). The consequences of these cardiac and vascular changes include increased systolic hypertension at rest (ACSM, 1998a; Shephard, 1997a), increased frequency of orthostatic hypotension (Boddaert et al., 2004), decreased maximal heart rate and decreased maximal cardiac output (Fleg et al., 1995; Aalami et al., 2003). Maximal heart rate, although highly variable between individuals, generally declines by approximately ten beats per decade, in part due to decreased myocardial sensitivity to catecholamine release and to increased time necessary for early-diastolic filling or preloading of the left ventricle (ACSM, 1998a; Shephard, 1997a; Oxenham & Sharpe, 2004; Aalami et al., 2003). Peak cardiac output generally decreases 20-30 % with advancing age, despite compensatory increases in stroke volume during maximal exercise (Fleg et al., 1995).

The age-related decline in aerobic power can also be attributed to a decrease in oxygen utilization by active muscle tissues represented by the arterio-venous oxygen difference. Beere et al. (1999) demonstrated that untrained older males (mean age 66 years) had a significantly lower peak arterio-venous oxygen difference and lower peak cardiac output than younger males (mean age 28 years). The decrease in oxygen uptake may be due to the well documented decrease in total muscle mass after the age of 20 (~ 6% per decade) (Fleg & Lakatta, 1988; Shephard, 1997a; Proctor et al., 2003). Decreased muscle capillary density, decreased presence of oxidative enzymes and thus decreased ability to extract oxygen are additional factors related to decreased O_2 uptake (Fleg & Lakatta, 1988; Grimby, 1988; Oxenham & Sharpe, 2003).

The loss of lean body mass is well documented in sedentary and endurance trained older adults (ACSMb, 1998; Novak, 1972; Fleg & Lakatta, 1988; Shephard, 1997a; Fiatrone & Evans, 1993; Grimby, 1988). Muscle changes associated with aging include decreased fiber cross-sectional area (Shephard, 1997a; Grimby, 1988), decreased number of type I and II fibers (Larson et al., 1979; Grimby, 1988; Lexell, 1995), and loss of functional motor units, with an increase in motor unit size (Grimby, 1988). Between the ages of 30 and 70 years there is a proportionally similar decline in aerobic power and total muscle mass (Grimby, 1988; Fleg & Lakatta, 1988). Fleg & Lakatta (1988) reported that total muscle mass was related to the age-associated reduction of maximal oxygen consumption. In a cross-sectional analysis of a sub-sample from the Baltimore Longitudinal Study on Aging, there was a strong negative correlation between VO_2max and age. A significant negative linear correlation was also determined between creatinine excretion (an index of total muscle mass) and age. When the changes in aerobic power between ages 30 and 70 years were normalized for total muscle mass (creatinine excretion), it was determined that almost half of the age-related reduction in aerobic capacity was due to muscle loss (Fleg & Lakatta, 1988).

2.5.2 Effects of age and inactivity on functional fitness and disability

Physiologic functional capacity declines with advancing age even in healthy active adults (Tanaka & Seals, 2003; Donato et al., 2003). The prevalence of disability also increases with age (Bean et al., 2004). Recall that the physiologic functional capacity has been described as the ability of individuals to complete daily tasks and the relative ease with which integral activities are completed (Tanaka & Seals, 2003). Aerobic power (VO_2peak) and maximal strength appear to be valuable indicators of reduced physiologic function fitness in older adults (Bean et al., 2004). Aerobic endurance and muscle endurance also appear to be related to older adult function. As a result, older adults tend to choose activities with lower intensities and more frequent rest periods (DiPietro, 2001; Wong et al., 2003).

Models of aging have been developed to describe how the expected physiologic decline can be directly linked to a decrease in function. Nagi's model of disability describes a pathology or disease, which leads to impairment, which results in a functional limitation and finally disability (Nagi, 1991). The Nagi model suggests that a given pathology or disease will ultimately lead to physical impairment and disability. As an example, consider any chronic condition associated with increasing age as the pathology afflicting the individual. As mentioned previously, increased age is correlated with decreased aerobic power/capacity and muscular strength. Subsequently, performance of various tasks may become impaired with increasing age. Impairment refers to the decreased capacity of a given biological system (i.e. musculoskeletal or cardiovascular) which results in a decrease from "normal" physiologic function. The rate of impairment can be increased as through the development of chronic conditions which have been associated with increasing age, including arthritis, hypertension, non-insulin dependent diabetes mellitus, obesity, chronic obstructive pulmonary disease (COPD), and osteoporosis (Anderson et al., 1999; Ferrucci et al., 2000; Shephard, 1997b).

Low aerobic power (<14 $ml{\bullet}kg^{-1}{\bullet}min^{-1}$) in very old women is associated with an impaired ability to complete endurance activities such as walking at a brisk pace or many household activities (Malbut et al., 2002). Paterson et al., (1999) report similar findings in a randomized sample of 298 males and females between the ages of 55-86 years. They suggested that the minimum aerobic power required for a fully independent life in very old men and women is 18 $ml{\bullet}kg^{-1}{\bullet}min^{-1}$ and 15 ml $ml{\bullet}kg^{-1}{\bullet}min^{-1}$ respectively (Paterson et al., 1999). With declining aerobic power, activities which are normally considered moderate or light become more difficult in comparison to the person's maximum ability (ACSM, 1998b, Shephard, 1999).

When routine tasks become difficult, a person is said to have a functional limitation. Organ reserve, aerobic power and muscle strength appear to decrease in a linear fashion with increasing age. As the physiologic capacity declines, functional fitness measures appear to decline in a curvilinear fashion (Morey et al., 1998, Buchner et al., 1992, Bean et al., 2004). Once an individual drops below the aerobic threshold (<18 ml•kg^{-1}•min^{-1} for males) which may be associated with a given age or level of inactivity, the individual may find it difficult to sustain aerobic activity for a long period (Alexander et al., 2003).

With impaired endurance, the person may have difficulty completing household chores, grocery shopping or self care. The individual is thus forced to modify the methods they use to finish tasks, including shortening or lengthening the duration required for the task and the equipment used (e.g. lighter vacuums/mowers, less groceries per bag, taking an elevator). Decreased endurance would fall into the Nagi model of disability as a functional limitation. Further declines in aerobic power would make it difficult to complete activities of daily living without assistance. Malbut et al. (2002) report that in many elderly, even a small decrease in maximal oxygen consumption due to illness may make it impossible to complete routine activities like carrying groceries or climbing stairs. Once an individual is unable to complete an activity of daily living without assistance they are said to suffer a disability (Rikli & Jones, 1997; Nagi, 1991).

The functional consequences of age-related changes in muscle mass and quality include decreased muscle strength and decreased muscle endurance (Laforest et al., 1990). Decreased lower body strength in older adults has been demonstrated to limit performance in functional fitness tests (Brill et al., 2000). Brill et al. (2000) suggest that there appears to be a threshold level of strength required for activities of daily living. This appears to agree with the aerobic power threshold of 18.0 ml•kg^{-1}•min^{-1} in males, however, no such threshold value has been suggested for strength. The decreases observed in muscle strength appear to result in increased risks of falls, decrease walking speed, impaired balance and subsequent disability (Morey et al, 1998). The majority of the lost strength is due to lost muscle mass, including muscle atrophy and selective loss of powerful type II muscle fibers (ACSM, 1998b, Fiatrone & Evans, 1993; Larson et al., 1979). Speed of locomotion may also be impaired as muscle strength decreases. For example, decreased muscle strength has been significantly associated with decreased speed of contraction in left knee extensor muscles (Larson et al., 1979). Sedentary lifestyle, aging and chronic illness may result in excessive decreases in muscle strength resulting in strength related limitation and/or disability (ACSM, 1998b; Shephard, 1997a, Buchner et al., 1992; Rikli & Jones, 1997).

2.6 Benefits of low- and moderate-intensity physical activity

2.6.1 Health benefits

Health can be described on a continuum between positive and negative health. Positive health refers to being disease free but also a person's ability to engage and enjoy life and tackle challenges they face (Tanaka & Seals, 2003). Regular physical activity has been shown to confer a wide range of health benefits for many different demographics. Ever increasing evidence supports that positive health benefits are linked to the total energy expenditure and not only to the intensity of the physical activity (Pate et al., 1995; King et al., 1995; Pescatello et al., 2000). In sedentary, unfit or older adults, low levels of physical activity have also been shown to positively impact health (ACSM, 1998b; USDHHS, 1996).

Decreasing physical activity levels have a major impact on the health of the older adult population and thus on health care. Resultant increases in morbidity and premature mortality are associated with lack of physical activity and negative health (Bouchard & Shephard, 1994). Common negative health states affecting older adults include: arthritis, cardiovascular disease, diabetes, respiratory disease and stroke (Bean et al., 2004). Epidemiological research has shown significant relationships between low-and moderate intensity activities and reductions in measures of negative health including: all-cause mortality, cardiovascular related morbidity/mortality, stroke, non-insulin dependent diabetes mellitus, bone density, cancer, respiratory disease and reductions in activity related injury (Pate et al., 1995; ACSM, 1998b; Shephard, 1997b, Bean et al., 2004; Short et al. 2003).

Franklin et al. (2003) suggest that for individuals with low VO_2max values (< 40 ml•kg^{-1}•min^{-1}), regular physical activity at an intensity threshold of 30 % VO_2R is sufficient for improving not only health but also aerobic power. Much of the improvements in aerobic power after low- and moderate-intensity training are due to increases in blood volume, stroke volume, cardiac output, increased arterio-venous difference and oxygen utilization with increased mitochondrial size and activity (Seals et al., 1984; Fleg et al., 1995; Proctor et al., 2003; Holloszy and Coyle, 1984; Beere et al., 1999). In older men, the majority of the improvements in VO_2max are due to increased cardiac output and stroke volume, while one third of the improvement is due to increased arterio-venous difference (Coudert and Van Praagh, 2000; Beere et al., 1999).

Cardiovascular disease is one of the leading causes of death in older adult males, and it is characterized by hypertension, coronary heart disease (CHD) and heart failure

(ACSM, 1998a). Low- and moderate-intensity endurance activity of appropriate duration has been shown to reduce cardiovascular risk factors (Carroll et al., 1999; Lee et al., 2000). Total energy expended during activity appears to have the greatest impact on reducing overall cardiovascular risk (Lee et al., 2000). Results from the Harvard Alumni Health Study and the Framingham Offspring Study suggest that men who expend more than 4000 kcal•week^{-1} (Lee et al., 2000), or participate in at least one hour of brisk walking (Dannenberg et al., 1989), may lower their risk of developing coronary heart disease by 30 to 40 %. It has been demonstrated in intervention studies that frequent, longer duration, low-intensity endurance exercise can substantially improve plasma lipoprotein profiles and decrease abdominal fat deposition (Anderson et al., 1999; Dunn et al., 1999; King et al., 1995). Research has also shown that short 15 minute bouts of low-intensity physical activity result in marginal improvements in aerobic power (Woolf-May et al., 1999). Others have demonstrated that a modest increase in dose of endurance activities can lower blood pressure in hypertensive individuals, and lower fasting insulin levels even without subsequent weight loss (ACSM, 1998b; Bouchard, 2001; Thornton et al, 2004; Parkkari et al., 2000; Short et al., 2003).

Bouchard (2001) proposed a theoretical dose response relationship for physical activity induced changes in relation to cardiovascular risk factors and general health benefits. Curve A is representative of the general response upon which the current guidelines for activity dose are based. Haskell (2001) suggests that with small increases in energy expenditure or duration of activity, adults experience an improvement in blood pressure, low density lipoprotein cholesterol (LDL-C) profile, decreased insulin resistance and improved plasma triglyceride levels. Curve B is representative of the linear relationship between increased weekly energy expenditure, overall mortality and weight loss. Therefore with increasing weekly activity energy expenditure one can expect a concomitant increase in fat loss and decreased risk of all-cause mortality. Finally, curve C is representative of increased high-density lipoprotein cholesterol (HDL-C), decreased plasma fibrinogen and increased coronary flow, all of which have been suggested to reduce cardiovascular risk (Bouchard, 2001; Haskell, 2001; Carroll et al., 1999).

2.6.2 Functional fitness benefits

As the older adult population increases due to increases in average lifespan, there appears to be a growing prevalence of physical impairment. Older adult independence is therefore an increasingly important public health issue (Shephard, 1997a). Positive associations have been demonstrated in the elderly population between habitual physical activity and improved physical functioning (LaCroix et al., 1993; Simonsick et al., 1993; Mor et al., 1989). Specifically, Mor et al. (1989) found that the incidence of disability over two years was 50% greater in inactive older adults than in older adults who reported regular walking and exercise. LaCroix et al. (1993) also showed a 40% decreased risk of losing mobility in older adults who engaged in physical activity three or more times per week.

Sedentary lifestyle and inactivity have been positively linked with increased functional limitation in the elderly (Mor et al., 1989; Huang et al., 1998; Boult et al., 1994; Simonsick et al., 1993). The amended Nagi model depicts the role of lifestyle/inactivity as a pathology that impacts future impairment and negatively or positively affects other pathologies that may result in disability (Rikli and Jones, 1997).

Data from three sites of the Established Populations for Epidemiologic Studies of the Elderly showed that active individuals had lower morbidity rates and subsequently impairment rates after 6 years than did inactive individuals (Simonsick et al., 1993). Increased morbidity rates typically result in lower levels of physical activity which adds to the precipitous decline in function often seen in very old adults (Santiago et al., 1993).

It is now believed that a sedentary lifestyle may have a larger role in future disability than aging alone (McGuire et al., 2001; Laforest et al. 1990; Westerterp, 2000). Many have shown the benefits of increasing aerobic power (ACSM, 1998b) as well as improved functional mobility (Wong et al., 2003; Jiang et al., 2004; LaCroix et al., 1993) with regular participation in low- and moderate- intensity LTPA. Increased levels of lifestyle physical activity during an eight week intervention resulted in improved functional mobility in independent older adults (Jiang et al., 2004). Also, an increase in energy expenditure (1000 kcal/week) from moderate leisure-time physical activity resulted in improved physical and lower body muscle strength in healthy older adults. The increase in energy expenditure associated with low and moderate intensity activity is also beneficial in that it reduces risk of obesity which has been associated with increased risk of dependence in late adult life (Lacroix et al., 1993; Brill et al., 2000; Wagner et al., 1992). While lower intensity activities have been shown to improve health, more intense forms of physical activity have resulted in better performances during tests of muscle endurance and muscle strength in inactive older adults (Brach et al., 2004).

Older adults experience an increase in body mass and a decrease in motor efficiency which increases the work associated with lifestyle physical activities (Shephard, 1997a). Regular participation in moderate intensity lifestyle and recreational physical activity has been show to improve motor efficiency and speed of movement in older adults (ACSM, 1998b; Wong et al., 2003). Mobility improvements may be related to increased energy expenditure, decreased prevalence of chronic disease states, increased lower body strength, decreased fat mass and increased lean body mass (Shephard, 1997a; LaCroix et al., 1993; Mor et al., 1989; Laforest et al., 1990; Brach et al., 2004; Brill et al; 2000). Laforest et al., (1990) compared 10 male and female older adult recreational tennis players to healthy controls and demonstrated that lifestyle activity was significantly associated with increased knee flexor/extensor muscle strength and endurance.

2.7 Physiologic response to- and associated benefits of golfing

The physiologic response associated with golfing has been examined on various occasions with some of the earliest studies being completed in the mid 1900's. Most of golfing research has been done on middle aged adult males, while some has focused on adolescents, young adults, females and professional golfers. Golfing on relatively flat courses results in an energy cost ranging from 3.3 METs to 6.9 METs (Murase et al., 1989; Burkett et al., 1998; Getchell, 1968; Passmore and Durnin, 1955). The energy cost of golfing has been found to increase to almost 8.0 METS in hilly terrain (Murase et al., 1989).

The earliest known study on the energy cost of golf was completed by Passmore and Durnin (1955), who reported a gross energy cost of 4.7 METs for two holes of golf in a single skilled golfer. However, this energy cost may grossly overestimate the energy cost of a typical golfing session because golf is typically played in groups, or at least in partners. No reference was made to age of the subject, time required, distance walked or whether resting values were included in the calculations. Furthermore, the data is limited to one golfer who could not be considered representative of the general population. Getchell (1968) examined the energy cost of golfing while walking during 3 holes of golf in foursome conditions. Subjects were four middle aged males (35-43 years) who were monitored continuously using a portable dry meter. The mean gross energy cost reported for these subjects was 3.3 METs (Getchell, 1968). The estimated net energy cost of 18 holes for a 68 kilogram subject was 636 kilocalories. Another study estimated a net energy cost of 620 kilocalories for 18 holes, based on energy costs of 3.3 METs in foursome conditions or 4.8 METs while playing alone (Lampley et al., 1977).

The absolute intensity of golfing may be significantly greater than the values reported, due to an age associated increase in body mass and decrease in motor efficiency (Shephard, 1997a). However, it is also suggested that older adults may "slow down" with advancing age, specifically after the age of 70 (Himann et al., 1988). Donovan and Brooks (1977) report that there is an increase in mechanical efficiency as walking speed is decreased to 3 kilometers per hour in younger male subjects (21-30 years). If mechanical efficiency at a slower speed is maintained in older adults, the energy expenditure associated with a given activity may subsequently decline. However, if motor efficiency is not maintained after the age of retirement, energy cost of leisure-time physical activity may be significantly greater.

Dobrosielski et al. (2002), found that older adult subjects (mean age: 65 years) with heart disease spent a significant portion of their 9 hole golf round at the recommended intensity, while healthy control subjects barely met the minimum recommendation of 30 minutes of moderate activity (60-80% peak MET capacity). Stauch et al. (1999) found that while playing 9 holes of golf on a hilly course, 30 middle-aged subjects spent greater than an hour at or above the moderate intensity classification. Unverdorben et al. (1999), and Parkkari et al. (2000) report similar relative intensity scores during 9 holes of golfing while walking, with healthy subjects reporting a mean intensity of 51.2 % heart rate reserve (HRR) and 59.2% HRR, respectively. As discussed previously, the manifestation of chronic disease decreased aerobic power, and decreased motor efficiency will result in increased relative intensity of activity. Unverdorben et al. (2000) and Dobrosielski et al. (2002) demonstrated that individuals with cardiovascular disease and decreased functional capacity experience more difficulty during nine holes of golf, and meet the minimum intensity requirements recommended by the ACSM.

Walking has been shown to favorably impact many indicators of health and fitness in adults (ACSM, 1998b; Porcari et al., 1987). However, only one study has examined the health benefits of regular walking on a golf course. A single bout of walking 18 holes decreased blood glucose and increased free fatty acids (FFA) in middle-aged men (Murase et al., 1989). During prolonged low-intensity activity it is known that a greater percentage of energy is derived from fat, and the concomitant increases in FFA after four hours of golf supports that fact (Murase et al., 1989). Contrary to these findings, Stauch et al. (1999) demonstrated that serum triglycerides decreased slightly, and serum glucose levels increased, during 18 holes on an extremely hilly golf course. Golfing on a hilly course would be considerably more intense than golfing on a flatter course, and would rely more on glucose metabolism than fat metabolism (Murase et al., 1989).

Regular golf may decrease risk factor prevalence associated with cardiovascular disease, and increase functional mobility (Parkarri et al., 2000; Stauch et al., 1999; Murase et al., 1989). Risk for obesity risk may decline with regular walking on a relatively flat golf course without a change in diet patterns, as two rounds of golfing per week over a 20-week period in middle-aged men resulted in a 2 % decrease in body mass and 2% decrease in waist girth (Parkkari et al., 2000). More importantly, golfers in this study had an 8% decrease in abdominal skin folds, indicating a decrease in abdominal fat which is highly associated with cardiovascular risk. Subjects who were mildly hypertensive at study onset also experienced a mild decrease in diastolic blood pressure. Additional health benefits included significant improvement in high-density lipoprotein cholesterol (HDL-C), and improved lower back endurance. Golfing subjects significantly increased their static back extension time by ten seconds as compared to baseline measures, a change which may relate to improved functional ability and thus improved fitness (Parkkari et al. 2000).

Further research is needed to examine the physiologic response during a round of golf in healthy, ambulatory older adults. Golfing studies to date have had small sample sizes and it is often unclear whether the energy cost is a net or a gross value. Only one golfing study has characterized a golf round in terms of duration spent at given relative intensities. This was completed in middle-aged subjects and the duration of the rest periods (if any) were not defined (Stauch et al., 1999). The absolute intensity of golf most likely was over predicted in previous studies due to shorter durations (20 minutes to 1 hour) not typical of nine holes of golf, or due to the subjects golfing alone without playing partners. Greater emphasis needs to be placed on age and fitness levels when determining the intensity associated with various recreational tasks. Finally, more research is needed to determine whether regular golfing in a healthy older adult cohort safely meets the intensity recommendations for improved health, improved ambulation, and decreased risk of chronic disease.

2.8 Physiologic response to- and benefits of lawn-mowing

The absolute intensity of lawn-mowing has been determined in middle-aged healthy adults (Gunn et al., 2002; Gunn et al., 2004), as well as in less fit older adults and those with cardiovascular disease (Haskin-Popp et al., 1998; Sheldahl et al., 1996). Research is lacking on the intensity and energy cost of lawn-mowing in a healthy older adult population. The health benefits associated with regular lawn-mowing have not been documented in adults of any age.

Research prior to 1993 had suggested an intensity of 4.5 METs for lawn-mowing (Ainsworth et al., 1993). Several studies since 1993 have reported higher estimated energy costs. Bassett et al., (2000) examined 15 minutes of various yard-work activities including mowing grass and raking leaves in 12 men and women, with ages ranging from 18 to 74 years. Gunn et al. (2002) examined the same activities for 15 minutes with 12 men and 12 women between the ages of 35 and 45. Finally, Hendelman et al. (2000) also compared the same activities for 5 minutes using 25 male and female subjects between the ages of 30 and 50. All three studies found MET levels to be higher than the 1993 Compendium value of 4.5 (Ainsworth et al., 1993). It was with the results of these studies that the compendium value was changed from 4.5 to 5.5 in 2000 (Ainsworth et al., 2000). All three studies are limited in the fact that they used few middle-aged subjects, and were of a very short duration. Duration may significantly impact the selected mowing pace and a faster pace will result in a significantly greater absolute intensity (Donovan and Brooks, 1977; Porcari et al., 1987; Himann et al., 1988). The absolute intensity associated with power lawn-mowing has been reported to be between 5.5 and 6.0 METs in older males with coronary artery disease (CAD)(Sheldahl et al., 1996; Haskin-Popp et al., 1998). However, duration was limited to 10 minutes in one study (Sheldahl et al., 1996) and both studies included small sample sizes.

The proportion of time spent at various relative intensities has not been examined in a healthy older adult population during lawn-mowing. Sheldahl et al. (1996) and Haskin-Popp et al. (1998) both measured the relative intensity of lawn-mowing as compared to estimated maximal aerobic power in older male participants with CAD. Haskin-Popp et al. (1998) determined that during power lawn-mowing heart rate averaged approximately 117 beats per minute, and because many of the subjects were on beta-blockers this represented more than 80% of HRmax. When the average oxygen uptake was compared to maximal Bruce test scores, subjects were found to be working at a relative intensity of 52% VO_2peak. Sheldahl et al. (1996) reported a relative intensity of 57% VO_2peak and 74 % HRmax during 8 minutes of lawn-mowing.

Further research is necessary to determine the energy cost and health benefits associated with lawn-mowing. Several factors may impact cardiovascular load in older adult subjects. High environmental temperature, isometric muscular actions and expiratory strain may all increase the relative intensity of physical activity (Haskin-Popp et al., 1998). Furthermore, age associated changes in health status and function will greatly reduce the safe range in which older adults may work.

2.9 Summary

In summary, it is clear from the reviewed literature that moderate intensity physical activity is beneficial for older adults. Aging, and more importantly inactivity, are negatively associated with many outcome measures including morbidity and mortality. Lifestyle physical activity and recreational physical activity play an integral part in maintaining cardiovascular, respiratory, metabolic and functional health after the age of retirement. It is important for researchers to determine whether the activities that healthy community dwelling older adults regularly partake in are of sufficient intensity and duration to elicit the health benefits outlined in this review.

Chapter 3: Methods

3.1 Introduction

Recent technological advances permitted the employment of this methodology. Field measurements of oxygen uptake and precise human movement analyses are possible with compact, light-weight and completely portable equipment. The methods will be presented in 7 sections: (1) Ethics, (2) Subject recruitment and screening, (3) Study design, (4) Equipment, (5) Maximal testing, (6) Field testing, (7) Data analyses.

3.2 Ethics

Prior to recruiting subjects for this study, approval was obtained from the Education/Nursing Research Ethics Board at the University of Manitoba on March 24, 2003 (Appendix A). Any significant amendments to the protocols or consent forms were reported to the Human Ethics Secretariat prior to being implemented. Two amendments were approved on May 13, 2003 and June 24, 2003.

3.3 Subject recruitment and screening

Subjects were twenty-two healthy, ambulatory, community residing males between the ages of 65 and 80 years. Subjects were actively recruited through golf course canvassing and through announcements at golf clubs and community wellness centers in the Winnipeg area (Appendix B). The announcement was also posted on a known Manitoban golf web-site (http://www.fairwayreview.com). The subjects were required to fill out a golf/lawn-mowing familiarity survey (Appendix C) and were also required to fill out a health status questionnaire (Appendix D) and informed consent form

(Appendix E). The sample was screened to exclude smokers (within last 12 months), those with uncontrolled hypertension (diastolic > 105 mmHg), persons suffering from diseases and those taking medications known to affect heart rate and energy metabolism. The completed health status questionnaire was examined by the principal researcher and the Kinsmen Reh-Fit Centre laboratory supervisor before approval for inclusion in the study was given. If any abnormalities were noted on the health status questionnaire, subjects were required to visit their family physician with a medical consent form (Appendix F).

3.4 Study Design

Each subject first met with the principal researcher for an information session outlining the protocols and equipment used in the study. Participants completed three exercise sessions: a graded exercise treadmill test (GXT), a golfing session and a lawn-mowing session. The GXT was completed first for all subjects and the two field sessions were randomly block ordered. Using a random numbers table, half of the subjects were randomly placed into the lawn-mowing group first and the other half were delegated to the golfing group first (Figure 3.1). Most of the exercise sessions were in the early morning and all but one began before noon during the summer of 2003. Table 3.1 outlines the breakdown and timeline of the study.

Table 3.1: Study organization and timeline

Session	When	Time Required	Where
Individual Information Sessions	April, May, June 2003	1-2 hours/subject	Subject homes
GXT	May, June, July 2003	1 hour/subject	Kinsmen Reh-Fit Centre
Golfing	June, July, August 2003	3 hours/subject	John Blumberg Golf and Country Club
Lawn Mowing	June, July, August, September 2003	1 hours/subject	University of Manitoba Soccer Fields

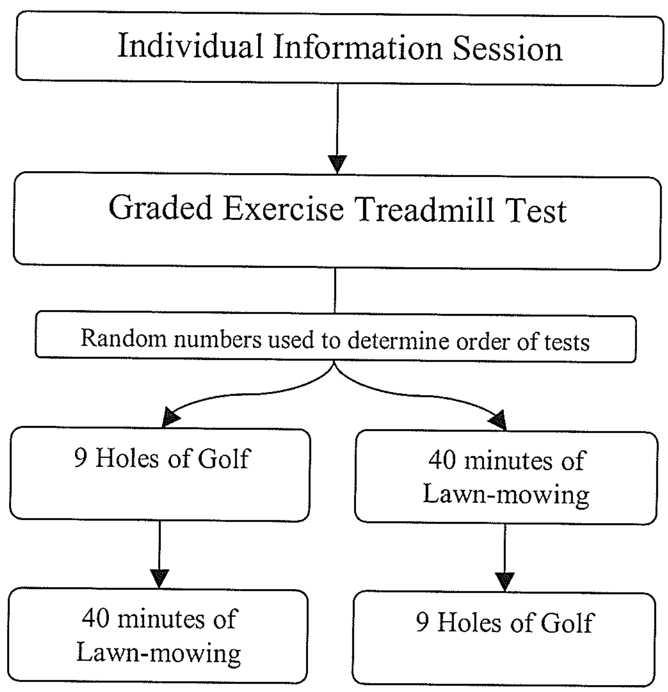

Figure 3.1. Organization of study participation

3.5 Equipment

The portable metabolic unit (Cosmed K4 b^2) and the global positioning system (GPS) (GeoExplorer II) were essential for collection of accurate energy expenditure data and human movement data in this study. The gas analysis equipment must be carefully calibrated and used according to manufacturers' guidelines to ensure accurate data collection. The GPS receiver was set up to ensure that there were as many satellites available as possible, which helped to increase the accuracy of the device. The following two subsections will outline the procedures used to calibrate/set up the Cosmed K4 b^2 portable metabolic unit which was used during all of the exercise testing sessions, and the GeoExplorer II GPS receiver which was used during the field tests.

3.5.1 Cosmed K4 b^2 portable metabolic unit

3.5.1.1 Description

The indirect calorimeter used in this study was the Cosmed K4 b^2 portable metabolic unit (Cosmed S.r.l., Rome, Italy). This unit has previously been reported to be accurate and valid when compared to other known measures such as the Douglas bag method (McLaughlin et al., 2001; Parr et al., 2001). It is a light-weight (0.4 kg) breath by breath gas exchange measurement system capable of storing 16,000 breaths, with a battery (rechargeable nickel-cadmium) life of approximately 3 hours. At the end of each completed breath the system calculates a series of different parameters. For this study parameters of importance are listed in Table 3.2. Inspired gas is not measured by the K4 b^2 unit but rather it adopts the "Haldane correction" (Wilmore & Costill, 1973). The "Haldane correction" assumes that the volume of nitrogen inspired is exactly equal to that expired and therefore it is not necessary to calculate inspired and expired air volumes rather only V_E, F_EO_2 and F_ECO_2 when calculating oxygen consumption. This technique has been previously validated in six male subjects at workloads ranging from 6.5 -12.1 km/hour (Wilmore & Costill, 1973). Through a series of calculations, oxygen consumption and carbon dioxide production are determined (Equation 3.1, 3.2, 3.3). The system contains O_2 and CO_2 analyzers with accuracies of 0.02 % O_2 and 0.01 % CO_2, respectively. It is capable of measuring changes in barometric pressure, ambient temperature, and of dealing with changes in humidity. A bidirectional turbine measures volume and flow with accuracy (± 2%) as previous research has reported minute ventilation (V_E) to be within 5 % of recorded Douglas bag values (McLaughlin et al., 2001). Eisenmann et al. (2003) also reported that recorded respiratory frequency (Rf) and V_E values were correlated (r = 0.81 and 0.97 respectively) between the Cosmed Quark b^2 (metabolic cart) and the Cosmed K4 b^2 portable unit. The system is also capable of recording heart rate values that coincide with each recorded breath using a wireless double electrode heart rate monitor (Polar Electro Inc., Woodbury, NY, USA).

Equation 3.1:

$$VI = VE * \frac{1 - FeCO_2 - FeO_2}{1 - FiO_2 - FiCO_2}$$

Equation 3.2:

$$VO_2 = FiO_2 * VI - FeO_2 * VE$$

Equation 3.3:

$$VCO_2 = FeCO_2 * VE - FiCO_2 * VI$$

where:

FiO_2 = calibration value O_2
VI = minute inhaled volume
VO_2 = oxygen uptake ($ml{\bullet}min^{-1}$)

$FiCO_2$ = calibration value CO_2
VE = minute exhaled volume
VCO_2= Carbon dioxide production ($ml{\bullet}min^{-1}$)

Table 3.2: Gas exchange and other parameters reported by Cosmed K4 b² portable unit

Symbol	Units of Measure	Breath-by-Breath Parameter
VO_2	ml/min	Absolute oxygen consumption
Rf	breath/min	Respiratory frequency
VT	l	Tidal Volume
FeO_2	%	Fraction expired oxygen
$FeCO_2$	%	Fraction expired carbon dioxide
HR	beats/min	Heart rate
RQ (RER)	--	Respiratory exchange ratio
VO_2/kg	ml/min/kg	Relative oxygen consumption
EE (Kcal/min)	Kcal/min	Gross energy expenditure per minute
MET	--	Metabolic Equivalents
T	° C	Environmental temperature

3.5.1.2 Cosmed K4 b² calibration

The unit was turned on at least 45 minutes prior to calibration as stipulated in the manufacturer's guidelines. The guidelines consisted of four calibration steps: room air calibration, reference gas calibration, delay calibration and turbine calibration. The room air calibration was completed before every test. Sampling of room air reset the baseline measure of the carbon dioxide analyzer, and the gain of the oxygen analyzer. This sampling was done to ensure that the measured values could be matched to predicted values of air (20.93% O_2 and 0.03% CO_2). The reference gas calibration was done prior to each testing session and involved the use of a calibration cylinder which contained a gas of known composition. The gas used consisted of 16.0 % oxygen and 4.0% carbon dioxide sampling mixture. The delay calibration is necessary to measure the time required for the gas sample to pass through the sampling line before analysis. The manufacturer's recommended weekly delay calibration, but a daily delay calibration was completed for the purposes of the study. The delay calibration was repeated between tests if the sample line was changed. The turbine calibration was carried out daily, using a three-liter calibration syringe to update the gain of the flow-meter to match the predicted three-liter value.

3.5.1.3 Cosmed K4 b² general testing procedures

In this study, flexible face masks of varied sizes (small, medium, large) that best covered the subject's mouth and nose and thus reduce air leakages, were used. The face mask was kept in place with a nylon mesh hairnet and Velcro straps. The Cosmed K4 b^2 was set in a harness worn by the participants. Dobrosielski et al. (2002) suggested that the portable unit (17×55×10 cm) be worn on the back rather than on the chest during the golfing protocol with the battery unit (12×2×8 cm) worn on the chest. Figure 3.2 demonstrates the use of the Cosmed K4 b² during a GXT with one of the subjects. The portable unit was always worn on the back and it served to decrease the risk of impeding the golf swing and also consequently reduced the risk of damaging the portable unit. Furthermore, by keeping the portable unit harnessed on the back, the researcher had easy access to the unit during all exercise sessions.

Figure 3.2. Photo of subject during GXT

After calibration and immediately prior to each field test, the relative humidity was entered into the portable unit. In the laboratory, a digital hygrometer was used to determine the relative humidity, and in the field a web-site was accessed to ensure the appropriate relative humidity (http://www.wunderground.com/global/stations/71852.html). This web-site had hourly updated humidity readings from the Winnipeg International Airport recorded by Environment Canada. The subject characteristics (identification number, age, height, mass and gender) were entered into the portable unit prior to each test. All the data obtained during the testing were stored in the Cosmed K4 b^2 memory using the Holter Data recorder mode.

The data was uploaded to a personal laptop computer (Compaq Presario, 1200ca, Hewlett Packard Development Company, L.P. Canada) using the K4 b^2 win software provided by the manufacturer. To do so the K4 b^2 portable unit was turned on and connected to the computer using a serial cable. Using the software, the "receive test" was chosen from the "test" menu. Tests were linked to the appropriate identification number and were subsequently downloaded to the computer hard drive.

3.5.2 Global satellite positioning system (GPS)

3.5.2.1 Description

The global position system (GPS) used in this study was the GeoExplorer II GPS receiver (Trimble Navigation Limited, Sunnyvale, CA, U.S.A.) and an external magnetic antenna (Trimble Navigation Limited, Sunnyvale, CA, U.S.A.). The unit is a light-weight (0.4 kg) receiver that is approximately 17 × 8 × 4 cm. The unit is powered by 4 nickel metal-hydride AA rechargeable batteries which are replaced with fully charged batteries after each test. The GPS has previously been reported as a valuable and accurate tool for measuring human movement and velocity, even during slow walking (< 2 km•hr^{-1}) (Schutz and Herren, 2000; Terrier et al., 2000; Terrier et al., 2001). The accuracy of the GPS can range from sub-meter to 100 meters, but most often the GPS accuracy falls within the range of two to five meters. The accuracy of GPS is improved through the use of differential corrections which use GPS data from a base station which has a known fixed longitude, latitude and altitude. The differential concept works based on the assumption that any errors in the GPS signals are common to receivers within a 300 mile area. The recorded offset differences are then used to improve the accuracy of the rover positions. The base station data used to complete the post-process differential corrections were found at a public access internet site from Cansel's Pine Falls, Manitoba location (http://www.cansel.ca/). The base station receiver was a Pro XR 12 channel receiver, and GPS signals were recorded at a 5 second data rate. The base station reference position was Latitude: 50 34 01 N, Longitude: 96 13 30 W, Altitude: 214 m. The distance between the testing site and the base station are well within the 300 mile radius required for the differential assumption to be accurate.

3.5.2.2 GeoExplorer II setup

Prior to each testing session, the researcher used the Pathfinder Office™ software provided by the manufacturer to determine the best times to collect GPS positions using the Quick plan utility. This allowed the researcher to determine when the most satellites were accessible and therefore ensured a lower position dilution of precision (PDOP) value. Data was recorded in the "NOT in FEATURE" mode because a data dictionary was not loaded into the receiver. Table 3.3 outlines the settings used during the golfing and lawn-mowing sessions for the subjects in the study.

Table 3.3: GeoExplorer II settings for field tests

ROVER OPTIONS:

Not in Feature Variables	Settings
RATE	3 seconds
POS MODE	3D
ELEV MASK	15
SNR MASK	5
PDOP MASK	8
ANTENNA HT.	1.0 meter
VELOCITY	3 seconds

The rate of position recording was selected to ensure that golfing sessions could be completed consecutively without having to upload the data between tests onto a personal computer. Recording positional data every three seconds enabled the researcher to collect approximately 5 hours worth of positional measurements. The elevation mask was set to 15 degrees as was recommended by the manufacturers for rover data. The signal to noise reduction (SNR) mask was set to 5 (recommended) which stipulated the minimum strength of included satellite signals. Once a signal from a given satellite dropped below that set level it was no longer included until the signal strength returned. The PDOP mask was set to 8. A PDOP mask value between 5 and 8 is considered acceptable by the manufacturer. If the PDOP values exceeded 8 at any point the data would not be recorded at that moment. The highest acceptable PDOP value was selected to ensure that as many data points were recorded as possible. Antenna height was kept at the same height for all individuals despite differences in stature. It was kept constant due to the continuous changes in posture that occur throughout a round of golf.

3.5.2.3 GeoExplorer II general testing procedures

For each field session, a GPS receiver (GeoExplorer II) was carried in a ""fanny pack" worn above the left hip around the waist. The magnetized antenna (Trimble Navigation Limited, Sunnyvale, California) was affixed, using a metal washer, to the subjects' hats or to the nylon mesh hairnet used to affix the flexible mask used by the portable metabolic system. Prior to each field test, four fully charged AA batteries were inserted in the unit. The GeoExplorer II receiver was turned on at least 15 minutes prior to initiation of the testing procedures. The unit requires a minimum of 3 minutes for a satellite fix when recording in 3D mode, so it was prudent to increase this time to 15 minutes to ensure that an acceptable PDOP value (<8.0) was attained. Once ready to begin data collection, the principal researcher opened a new rover file. The rover file name was noted in a journal and began with a "g" prefix for golf and "m" prefix for lawn-mowing. During data collection, the GeoExplorer II receiver screen was left on the GPS status menu page. This enabled the researcher to periodically check the PDOP value and the number of satellites being tracked. Immediately upon completion of the field test the rover file was closed using the "close file" command from the data capture menu. At the end of each testing day, the recorded rover files were transferred to a personal laptop computer using the Pathfinder Office software (Trimble Navigation Limited, Sunnyvale, California). After uploading was completed, each rover file was differentially corrected using the Pine Falls base station data.

3.6 Information session

The principal researcher met with each subject at their homes to explain the study, protocol, equipment and to answer any questions. The subjects were encouraged to ask questions before signing the informed consent form and completing the golf/lawn-mowing familiarity survey (Appendix C). During this session, the principal researcher informed the potential subjects that inclusion in the study required the subjects to adhere to the following pre-test procedures: i) no vigorous exercise in the preceding 36 hours ii) no caffeine, alcohol or non-prescribed medication 6 hours prior to the session iii) no food 2 hours prior to session (CSEP, 1996; Franklin et al., 2000). A written reminder of the pre-test procedures was also given to the subjects (Appendix G).

3.7 Peak testing

3.7.1 Graded exercise test (GXT) procedures

The stress testing sessions occurred at the Kinsmen Reh-Fit Centre (1390 Taylor Avenue, Winnipeg, Manitoba). A physician was present during all GXT procedures. The subjects were booked for test times around the normal operating schedule of the centre during the summer of 2003. Two laboratory technicians assisted in the stress testing procedures.

The participants were measured for height and weight (CSEP, 1996) by the principal researcher prior to being fitted for the 12-lead (Mason/Likar) electrocardiogram by the Reh-Fit technician (Mason and Likar, 1966; CSEP, 1996), and before being fitted for the portable metabolic system by the principal researcher. Prior to the GXT, the Cosmed K4 b^2 was calibrated as reported previously, according to the manufacturer's guidelines. Before the testing session, the participant's physical characteristics (age, gender, height and weight) and the laboratory humidity were entered into the Cosmed K4 b^2 portable unit. Data was recorded with the Cosmed K4 b^2 unit using the Holter Data Recording Mode as specified in the manufacturer's guidelines. The Cosmed K4 b^2 unit was started (by pressing "enter" twice) and each subject sat quietly in an upright position in a recovery chair for 5 minutes prior to initiation of the graded exercise treadmill test. During this period, a baseline ECG tracing was recorded, the resting heart rate of each subject was determined and the resting blood pressure was recorded. Prior to the subject standing, the "marker" button was pressed to indicate the beginning of exercise.

The test included a two minute warm up at 3.0 $km•hr^{-1}$ and 0% grade. After the 2 minute warm-up the "marker" button on the Cosmed K4 b^2 unit was pressed and the testing session began. The GXT was performed using a modified Balke-Ware treadmill protocol (Franklin et al., 2000). The protocol specifies constant speed and an increase in grade by one percent each minute. Two speeds (4.2 and 5.4 $km•hr^{-1}$) were used depending on the stride length of each subject. The goal was to get each subject to reach fatigue within 8-12 minutes. Protocols such as the modified Balke-Ware are suitable for older, sedentary individuals as the stage increments increase by 1 MET per stage or less (Franklin et al., 2000; Jetté et al., 1990). The treadmill test was terminated when the subject reached volitional fatigue. To achieve true maximal oxygen consumption measures the ACSM lists various subjective and objective indicators that can be used to confirm that maximal effort has been attained. The ACSM suggests that a subject must reach volitional fatigue, have a Borg rating of perceived exertion of 17 or greater, and an RER value greater than 1.15 (Franklin et al., 2000). The ACSM states that the achievement of age-predicted maximal heart rate should not be used due to high intersubject variability. Abnormal cardiovascular or blood pressure responses also resulted in prematurely stopping the treadmill test. During the testing procedures subjects were not verbally encouraged to continue and were not allowed handrail support for more than brief moments. Tracings from the 12-lead ECG were taken each minute. Blood pressure and ratings of perceived exertion were also recorded each minute. The Cosmed K4 b^2 unit measured all the gas exchange and respiratory variables during each breath as well as the heart rate. Once the test was stopped, the "marker" button on the portable unit was pressed and the treadmill speed was slowed to 3.0 $km \cdot hr^{-1}$ while the grade was decreased to 0 %. The subjects were expected to actively recover for at least 2 minutes before returning to the recovery chair. However, several subjects asked to sit almost immediately. Once in the recovery chair, the "cancel" and "enter" buttons were pressed on the portable unit. The flexible mask was removed and the subjects were allowed water. The subjects remained still for another 2 minutes while recovery blood pressure and a recovery ECG tracing were recorded.

3.8 Field testing

3.8.1 Golfing specific protocol

The golfing sessions took place at the John Blumberg Golf and Country Club during the summer of 2003. The John Blumberg 9-hole course is a par 34 course and the course distance is 2739 yards (2504 meters). The course consisted of two par five holes, three par four holes and four par three holes. Each participant walked while pulling their own cart and clubs for all holes. Every attempt was made to get the subjects to play with another golfer as golf is seldom played alone Speed of play is often dictated by the groups ahead or other players; therefore for accuracy it was essential to mimic real playing conditions. All but one of the sessions was initiated before noon in the summer of 2003. The one exception occurred on a cooler day in early September.

At the clubhouse subjects were fitted to the Cosmed K4 b^2 unit and the GeoExplorer II receiver and antenna. The ambient humidity and the subject's mass, height, gender, age and identification number from the GXT were inputted into the portable unit. Environmental conditions, such as wind speed and humidity, were obtained from an hourly updated website that reported data from Environment Canada (http://www.wunderground.com/global/stations/71852.html). The fitting process normally began 30 minutes prior to "teeing off" and was completed at least 15 minutes before the start of the testing session. Figure 3.3 shows a subject outfitted on the 7^{th} hole during his testing session. Before heading to the tee-box, the principal researcher hit the "enter" button twice which started the collection of gas exchange data.

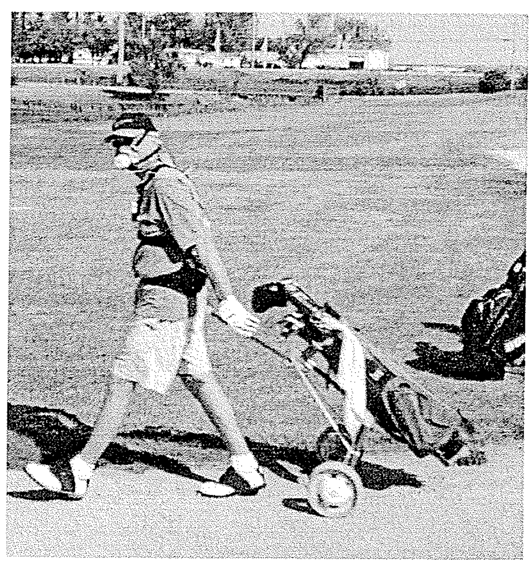

Figure 3.3. Photo of subject during golfing session.

At the first tee box, the principal researcher hit the "marker" button on the Cosmed K4 b^2 portable unit and simultaneously opened the rover file on the GeoExplorer II receiver. Each subject was asked to play golf while pulling their clubs in a pull cart at their own pace. Golfers were required to follow the normal rules of golf and "hole out" on each green without taking any "gimmies". The principal researcher walked close by and recorded each stroke/putt taken. The principal researcher pressed the "marker" button once the subject approached the tee box of the next hole and also recorded the time of day the subject reached each tee-box. During waiting periods at the tee-boxes, subjects were permitted water when requested. The principal researcher pressed "marker" prior to removing the flexible mask and again after re-fitting the mask to the subject. After "holing out" on the 9th green, the principal researcher pressed "marker" on the portable metabolic unit. Only the data collected between the first tee and the 9th green was included in the data analyses. The subject was then allowed to walk at his own pace back to the clubhouse. At the clubhouse, the principal researcher closed the rover file and hit the "cancel" and "enter" buttons on the portable metabolic unit. At this point, the testing equipment was then removed from the subject.

3.8.2 Lawn-mowing specific protocol

The lawn-mowing sessions took place at the University of Manitoba soccer grounds. All testing sessions were initiated before noon during the summer of 2003. Participants were fitted to the Cosmed K4 b^2 unit and the global position system (GPS) receiver and antenna next to the principal researcher's vehicle. The fitting process normally began 30 minutes before the lawn-mowing sessions. Figure 3.4 shows a subject during a lawn-mowing session. The vehicle was parked approximately 100 yards from the testing field. Once the subject was outfitted, the principle researcher ensured that the GPS unit was displaying an acceptable PDOP value (<8). The researcher then hit "enter" on the portable metabolic unit to begin an analysis of the measured variables but did not begin recording data.

Together the researcher and subject walked to the testing site where a Sears Craftsman Eagle II mower (Cupertino, California, USA) (16" cutting width) was waiting. The researcher demonstrated the use of the mower, including how to stop it in case of emergency. The subject was reminded that they were to select a pace that might resemble his "normal" use of a mower, and that he could take breaks whenever needed. The principal researcher also outlined the area to be cut and started the lawn-mower for the subject in order to protect equipment. Once the subject agreed that he was ready, the principal researcher opened a new rover file on the GPS receiver and simultaneously hit "enter" on the Cosmed K4 b^2 portable unit. Subjects were required to mow for 40 minutes at their own self-selected pace. When the subject required a break, the researcher stopped the mower and hit "marker" on the Cosmed K4 b^2 portable unit. The researcher then removed the flexible mask and allowed the subject water. The flexible mask was then reaffixed and the "marker" button was pressed again. The researcher once again started the mower and the subject continued on for the remaining time. The test was completed once the 40 minute duration had passed. The researcher then hit "cancel" and "enter" on the portable metabolic unit, stopping the data recording. The rover file was also closed at the same time on the GeoExplorer II receiver. Together, the subject and researcher returned to the vehicle to remove the testing equipment.

Figure 3.4. Photo of subject during lawn-mowing session.

3.9 Data Analysis

3.9.1 Subject Characteristics

The subjects completed a survey (Appendix C) which indicated how frequently they golfed, the normal duration required for lawn-mowing, and also listed other physical activity in which they participated. On the health status questionnaires (Appendix D) subjects were also required to list any medications that they were currently taking.

3.9.2 Cosmed K4 b^2 variables

Data from the Cosmed K4 b^2 portable unit was uploaded after all tests to a personal computer (Compaq Presario 1200 CA, Hewlett Packard Development Company, L.P. Canada) using a serial cable and the manufacturer's software. For all exercise test session data, the K4 b^2 win software (7.3a, Cosmed S.r.l., Rome Italy) was used to discard invalid steps (breaths) using the criteria and parameter values listed in Table 3.4. If step values fell outside of the listed ranges, the values were discarded. The K4 b^2 win software was also used to mark the beginning and ending of the each test as well as to distinguish between the different golf holes.

The breath-by-breath data from the field tests (golf and lawn-mowing) were then averaged over 15 seconds for the duration of the field tests while the GXT data remained unchanged. Using the K4 b^2 win software, all of the Cosmed data were then saved as a Microsoft Excel file (Microsoft Corporation 1983-2004) imported and opened by Sigmaplot 8.02 (SPSS Incorporated), before being saved as a "notebook" file under each subject's identification number.

Table 3.4: Parameters and criteria used to discard invalid steps

Parameter	Minimum value	Maximum value
Rf	5.0 breaths/min	80.0 breaths/min
VT	0.2 L	10.0 L
FeO_2 %	10.0	20.0
$FeCO_2$ %	1.0	10.0

3.9.2.1 GXT Cosmed K4 b^2 data analysis

The GXT data uploaded from the Cosmed K4 b^2 portable unit was used to determine several characteristics of each subject. Resting heart rate was determined by noting the lowest recorded heart rate during the 5 minutes of resting prior to the GXT completion. Peak heart rate was recorded as the highest heart rate recording during the GXT. Peak oxygen consumption (peak relative VO_2), peak respiratory exchange ratio (peak RER), and peak metabolic equivalents (peak METs) were all determined by averaging the 5 highest recorded values over any running minute during the GXT.

3.9.2.2 Field Cosmed K4 b^2 data analysis

Heart rate was recorded continuously during golfing and lawn-mowing. However, the recorded heart rate during lawn-mowing occasionally dropped below the GXT determined resting heart rates. Vibrations of the mower may have disrupted the signal received by the polar heart rate monitor, and values lower than the resting heart rates obtained during the GXT sessions were not included in the analysis. Peak heart rates during golf and lawn-mowing were determined by selecting the highest heart rate values recorded during each session.

Using the fifteen-second interval data, several parameters were calculated. Oxygen consumption data was transformed into percent oxygen consumption reserve (% VO_2R) using equation 3.1, and heart rate data was transformed into percent heart rate reserve (% HRR) using equation 3.2. Peak VO_2R was calculated by subtracting 3.5 $ml•kg^{-1}•min^{-1}$ from the peak VO_2 obtained during the GXT. Using the fifteen-second interval data, the non-resting metabolic equivalents (MET-R) were also calculated for each data step. These values were needed to calculate the net energy expenditure (netEE) of each physical activity session. Net energy expenditure (nEE) was calculated for each fifteen second interval using equation 3.3.

Once the fifteen-second interval transformations were complete, several parameters from each field test were averaged over one-minute intervals and these values were used for the remaining statistical analyses. The averaged parameters are reported in Table 3.5.

Table 3.5: Averaged minute-parameters used for statistical analyses

Units of Measure	Minute-averaged Parameter
$ml•min^{-1}$	Absolute oxygen consumption
$MET•min^{-1}$	METs
$MET\text{-}R•min^{-1}$	Non-resting METs
$Kcal•min^{-1}$	Gross energy expenditure
$Kcal•min^{-1}$	Net energy expenditure
$ml•kg^{-1}•min^{-1}$	Relative oxygen consumption
$beats•min^{-1}$	Heart rate
$\%•min^{-1}$	Percent peak oxygen consumption reserve
$\%•min^{-1}$	Percent peak heart rate reserve
$^{\circ}\,C•min^{-1}$	Ambient temperature

Once the average energy expenditures per minute were calculated, the data was summed to give the total net and gross energy expenditures (Kcal) of each field session. The total energy expended per kilogram and total energy expended per hour were calculated by using equations 3.7 and 3.8 respectively.

Equation 3.4:

$$\%\,VO_2 = \frac{\text{exercise oxygen uptake } (ml•kg^{-1}•min^{-1}) - 3.5\ ml•kg^{-1}•min^{-1} * 100\ \%}{\text{peak oxygen uptake } (ml•kg^{-1}•min^{-1}) - 3.5\ ml•kg^{-1}•min^{-1}}$$

Equation 3.5:

$$\%\,HRR = \frac{\text{HR exercise } (beats•min^{-1}) - \text{HR rest } (beats•min^{-1}) \ * 100\%}{\text{HR peak } (beats•min^{-1}) - \text{HR rest } (beats•min^{-1})}$$

Equation 3.6:

$$netEE\ (Kcal•min^{-1}) = MET\text{-}R \times \text{body weight (kg)} \times \text{duration (time[min]/60min)}$$

Equation 3.7:

$$EE\ (kcal•kg^{-1}) = \text{Total energy expenditure (kcal)} \div \text{body weight (kg)}$$

Equation 3.8:

$$EE\ (kcal•hr^{-1}) = \text{Total energy expenditure (kcal)} \div 60 \text{ minutes}$$

Absolute intensities and relative intensities were calculated per minute for each activity and subject. The intensity data was then sorted into the ACSM intensity categories (very light, light, moderate, hard, very hard and maximal). The data for each subject/activity was then pooled into each of the six categories, and percentage of the total duration (minutes) was calculated for each intensity category.

3.9.3 GeoExplorer II positional/movement data analysis

Data was uploaded from the GeoExplorer II receiver to the personal computer (Compaq Presario 1200CA, Hewlett Packard Development Company, L.P. Canada) using a serial cable and the Pathfinder Office software. The rover file was then 100% differentially corrected with Cansel's Pine Falls base station data. The corrected output file was then exported to an Excel file (Microsoft Excel XP, 1983-2004) and was saved as an Excel file under the same name. Before converting the Excel file to a Sigmaplot notebook file, the time column data was formatted to a custom category. The custom category format ensured that the time was recorded as hour, minute, second and thousandths of the second and also ensured that all time components were included in the Sigmaplot format.

In Sigmaplot, the transform function was used to calculate (x,y,z) vector velocities, gait time (seconds), gait velocities ($km{\bullet}hr^{-1}$), gait displacement (meters), accumulated distance (meters), and accumulated time (seconds). After transformation, the data duration was matched to the Cosmed K4 b^2 data, and the appropriate data was isolated and used for the remaining statistical analyses. Total distance walked was determined by summing the gait displacement values from the start to the end of each field test. Walking speed was determined by taking the mean of the velocity data. To calculate non-resting walking speed, all velocities less than 0.5 $km \cdot hr^{-1}$ were filtered out of the data set and the mean of the remaining data was calculated.

3.9.4 Statistical Analysis

Normal distribution was automatically checked by Sigmastat 3.0 (SPSS Incorporated). If normality was passed ($p<0.05$), paired t-tests were used to detect significant differences between the golfing and lawn-mowing responses and durations spent at a given intensity. If normality was not achieved, a Wilcoxon signed rank test was completed to check for significant differences between data sets. Ninety-five percent confidence intervals were calculated to determine if the absolute intensity of golfing and lawn-mowing differed from the values reported in the Compendium of Physical Activities (Ainsworth et al., 1993; Ainsworth et al., 2000). Pearson product moment correlations were calculated to determine if there were any significant associations between variables. A p value of 0.05 or less was considered significant for all statistical tests.

Chapter 4: Results

4.1 Descriptive characteristics

4.1.1 Physical characteristics and medications

Fifty-three community residing adults expressed interest in participating in the study. Several individuals admitted to being diagnosed with chronic conditions such as diabetes, heart disease and metabolic disorders, which prevented inclusion in the study. Others decided to not participate in the study after learning of the time involved, the protocols used, the equipment used and some declined participation after further discussion with their spouses. After screening, 22 ambulatory male volunteers, all community residing, were accepted to be part of the study. Two subjects were subsequently removed from the study following an abnormal blood pressure response, and an ischemic response, during the graded exercise treadmill test. Two additional subjects were removed from the final analysis due to equipment errors that made it impossible to make appropriate comparisons between all treatment conditions (the sampling line came off of the portable metabolic unit during one graded exercise treadmill test, and invalid oxygen uptake data were collected during one golfing session). Cosmed K4 b^2 calibration values for the final eighteen subjects were within the normal reference ranges provided by the manufacture for the remaining test sessions (Appendix H) (Cosmed S.r.l., 1999). The mean physical characteristics are listed in Table 4.1.

Each subject was asked to list the medications that they were taking during the study. This information was used during the screening process to ensure that no participants were taking a medication that would limit or increase heart rate, or alter normal metabolism. Several subjects had common chronic conditions, but none of the conditions prevented inclusion in the study. Eight subjects were not taking any medications. The remaining 10 subjects were taking 17 medications for various conditions. Table 4.2 lists the number of medications taken by the subjects.

Table 4.1: Mean physical characteristics of participants at study onset.

	Mean (SD) (n=18)	**Range**
Age (years)	71.2 (4.4)	65-80
Height (centimeters)	173.8 (6.4)	161.0-183.0
Mass (kilograms)	82.7 (10.8)	58.0-100.0
Body Mass Index (kg/m^2)	27.3 (2.3)	22.4-30.1
Resting HR (bpm)	62.7 (7.2)	52-74
Resting Systolic Blood Pressure	142.4 (17.6)	120-168
Resting Diastolic Blood Pressure	84.7 (9.8)	70-105

4.1.2 Physical activity characteristics

Information about lawn-mowing activity was collected using the golf/lawn-mowing questionnaire in Appendix C. Twenty-eight percent of the subjects reported needing 21 to 30 minutes to mow their home lawns, while 28 % reported living in a residence that did not require any lawn mower use. Thirty-three percent required more than 41 minutes to mow their lawns. Current (non-winter) physical activity participation was also recorded for each subject using the Health Status Questionnaire (Appendix D). The activity participation of all eighteen subjects, and the average reported duration for home lawn-mowing, is listed in Table 4.3. Golfing was the most popular leisure-time physical activity. Reported golf handicaps ranged from 8 to 48 with a mean handicap of 23.9 (8.8) reported for 18 subjects. Eighty-nine percent of the subjects golfed regularly, 50 % of the subjects reported regular gardening and 39 % of the subjects reported walking, jogging and running as their physical activity of choice.

Table 4.2: Medications reported by function and by subject

Medications	Prevalence (18 subjects)
Hypertension	3
Cholesterol	3
Asthma/Bronchiole-dilators	3
Gastrointestinal	2
Bladder/Kidneys	2
A.S.A./Aspirin	2
Non-steroidal Anti-inflammatories (NSAIDs)	1
Vitamins/Supplements	1
Subjects	**Prevalence**
1	0
2	1
3	0
4	1
5	2
6	0
7	1
8	0
9	1
10	2
11	0
12	0
13	1
14	3
15	0
16	1
17	4
18	0
Mean ±SD (range)	0.9 ± 1.2 (0 - 4)

Table 4.3: Duration of non-winter activity participation including lawn-mowing for each subject.

Subject	Activity	Duration (hours•week^{-1})	Lawn-mowing Duration (minutes•week^{-1})
1	Gardening	2-3	
	Walking	2-3	21-30
	Golfing	6-12	
2	Golfing	4	21-30
3	Gardening	1	0
	Golfing	7	
4	Golfing	20-24	
	Walking	--	0
	Weights	--	
5	Cardio/weights	9	21-30
	Golf	8-12	
6	Gardening	1	21-30
	Golf	4-8	
7	Running	3	41-50
	Golfing	10	
8	Walking	--	0
	Golfing	4-8	
9	Gardening	1.5	
	Walking	4-5	41-50
	Bowling	2	
	Golfing	8-12	
10	Cycling	5	41-50
11	Jogging	1.5	21-30
	Golf	10-12	
12	Golfing	6-10	
	Walking	3.5	51+
	Gardening	0.5 – 4	
13	Gardening	15-18	
	Golfing	4.5	51+
	Walking	1	
14	Golfing	4-5	11-20
	Gardening	1-2	
15	Gardening	3-6	1-10
	Golfing	7	
16	Gardening	15-20	300
	Golfing	15	
17	Treadmill walking	1-2	0
18	Walking	3-4	
	Swimming	0.5 – 0.75	0
	Golfing	4	

-- not reported

4.2 Graded exercise test response (GXT response)

The average response of the 18 study participants to the GXT is listed in Table 4.4. Individual results for peak VO_2 are reported by age in Figure 4.1.

Table 4.4 Graded exercise treadmill test response.

Variable	Mean (SD) (n=18)	Range
GXT Time (minutes)	12.4 (3.9)	5.0-20.9
Peak HR (bpm)	150 (18)	111-175
Peak Systolic Blood Pressure (mmHg)	205.4 (23.9)	140-240
Peak Diastolic Blood Pressure (mmHg)	98.7 (12.0)	76-112
Peak Treadmill grade (%)	12.4 (3.9)	5-21
Peak METS	9.5 (1.5)	7.4-13.1
Peak VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	32.6 (5.9)	22.8-45.7
Peak respiratory exchange ratio (R)	1.1 (0.1)	0.8-1.2
Peak Borg Rating of Perceived Exertion (RPE)	17.8 (0.9)	17-20

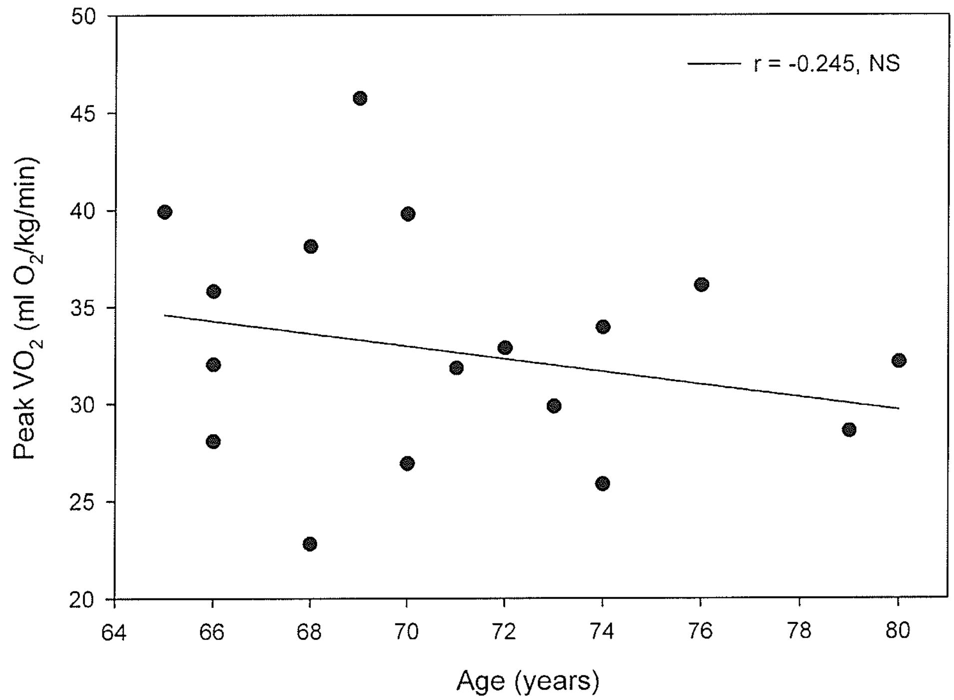

Figure 4.1. Peak aerobic power of eighteen adult males aged 65 to 80 years.

4.3 Lawn-mowing and golfing comparisons

4.3.1 Environmental data

The ambient temperature, humidity and wind speed during golfing and lawn-mowing sessions are outlined in Table 4.5. Since there were no significant differences, a comparison between the two activities does not have to adjust for environmental conditions. However, as demonstrated in Figure 4.2, ambient temperature increased over time during the lawn-mowing sessions. Similar increases in temperature are apparent during golfing but are difficult to graph as activity duration varied greatly.

Table 4.5: Environmental data averaged for golfing and lawn-mowing sessions

Variable	Golfing (n=18) Mean (SD)	Range	Lawn-mowing (n=18) Mean (SD)	Range
Ambient Temperature (° C)	27.7 (5.2)	18.6-34.8	26.0 (4.2)	18.0-32.8
Relative Humidity (%)	74.6 (15.7)	37-95	79.5 (13.1)	60-96
Wind speed (km/hr)	14.8 (11.0)	5-40	10.6 (7.8)	4-36

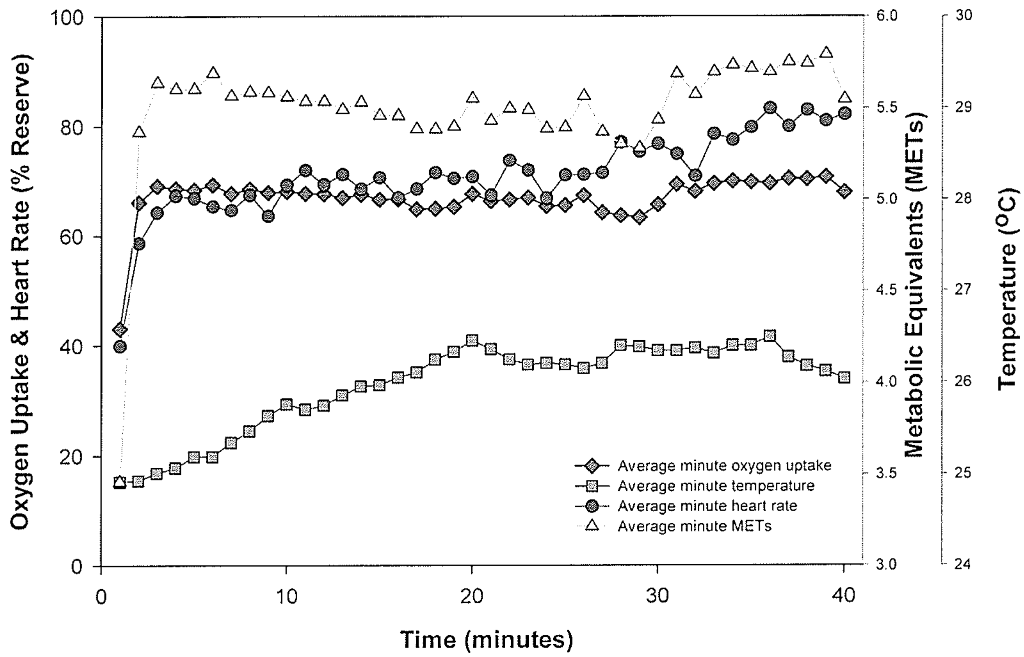

Figure 4.2. Relative and absolute intensity and ambient temperature during 40 minutes of lawn-mowing in 18 older adult men.

4.3.2 Cardiovascular response and intensity during golfing and lawn-mowing

Table 4.6 outlines the average responses to golfing and lawn-mowing. The activity durations were significantly different as were mean heart rate, % HRR, mean VO_2R, and % VO_2R. Peak heart rate also differed significantly between golfing and lawn-mowing. The mean relative intensity of golf measured in terms of %HRR was significantly greater than the mean relative intensity when classified as % VO_2R. Conversely, no significant difference was noted between the measurement of relative intensity (%HRR or %VO_2R) during lawn-mowing.

Table 4.6: Cardiovascular response and relative intensity during golfing and lawn-mowing

Variables	Golfing (n=18) mean (SD)	Range	Lawn-mow (n=18) mean (SD)	Range
Duration (minutes)	122.2 (23.1)	80-164	40.1 (0.1) *	39.9-40.2
Heart Rate (HR) (bpm)	104 (14)	81-134	123 (17) *	97-150
Peak HR (bpm)	127 (13)	99-153	141 (19) +	111-180
Percent Heart Rate Reserve (%)	48.5 (18.0) †	23.5-89.9	70.6 (19.5) *	31.8-107.4
Mean Oxygen Uptake ($ml•kg^{-1}•min^{-1}$)	9.9 (1.7)	7.5-13.3	19.2 (3.0) *	14.4-26.7
Percent Oxygen Uptake Reserve (%)	34.4 (9.1) †	22.4-51.5	66.9 (13.3) *	43.5-92.0

* denotes significant difference between activities (df = 17; $p<0.001$)
+ denotes significant differences between activities (df=17; $p<0.01$)
† denotes significant differences between %HRR and %VO_2R within activities (df=17; $p<0.001$)

Figures 4.3 and 4.4 depict the proportion of time spent at the six relative and absolute intensities as outlined by the ACSM position stand, during lawn-mowing and golfing. The greatest time was spent in the "hard" classification during lawn-mowing (60-84 % HRR) and in the "light" intensity classification (20-40% HRR) during golfing. Using the mean duration for nine holes of golf and the relative intensity classifications, approximately 64 minutes were spent within the ACSM recommended moderate to hard intensity range (40 – 85 % HRR). For lawn-mowing, approximately 34 minutes were spent within the same relative intensity range. For nine holes of golf approximately 40 minutes were spent within the ACSM recommended absolute intensity range (3.2 – 6.7 METs). For lawn-mowing, approximately 34 minutes were spent within the same absolute intensity range.

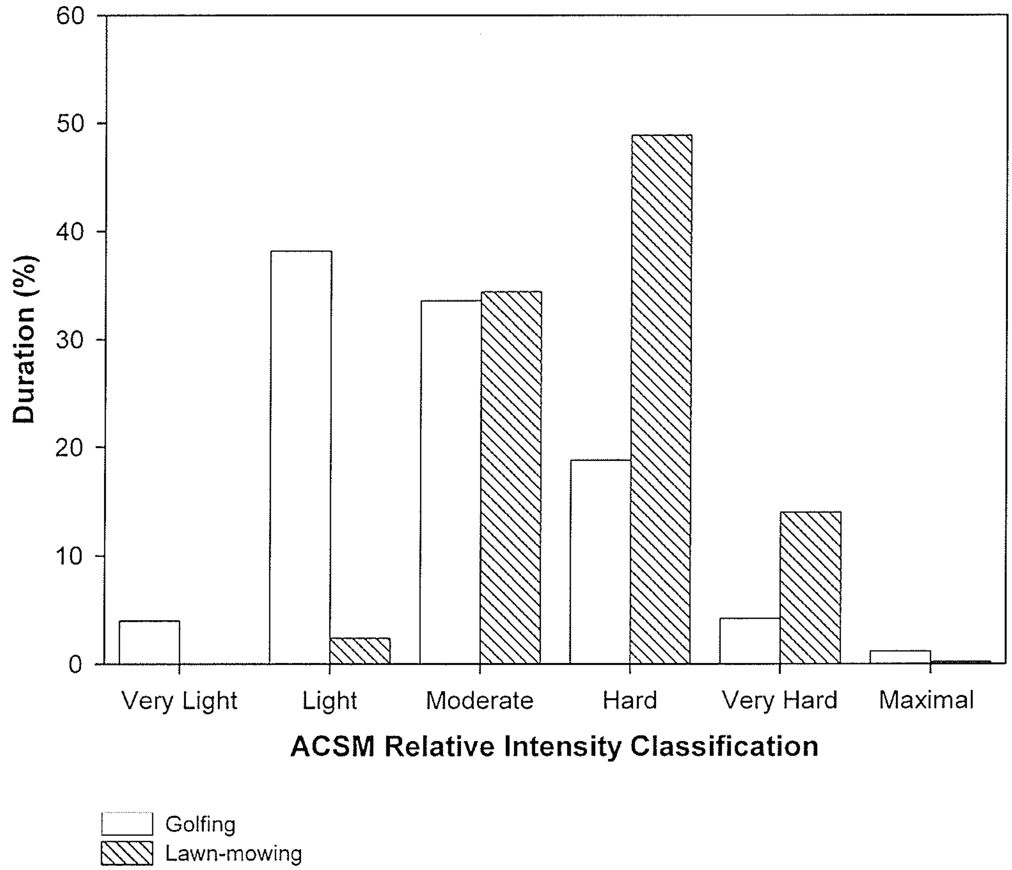

Figure 4.3. Proportion of time spent at each relative ACSM intensity classification during 9 holes of golf and 40 minutes of lawn-mowing in 18 older adult men.

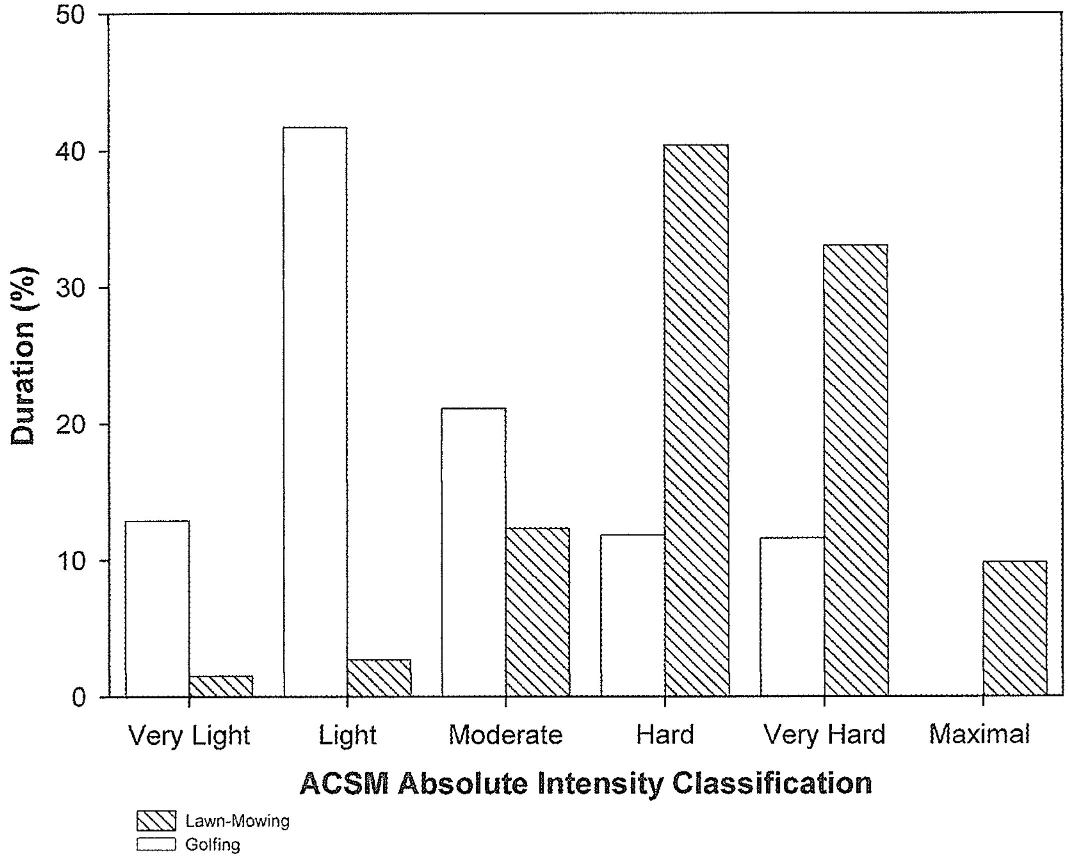

Figure 4.4. Proportion of time spent at each absolute ACSM intensity classification during 9 holes of golf and 40 minutes of lawn-mowing in 18 older adult men.

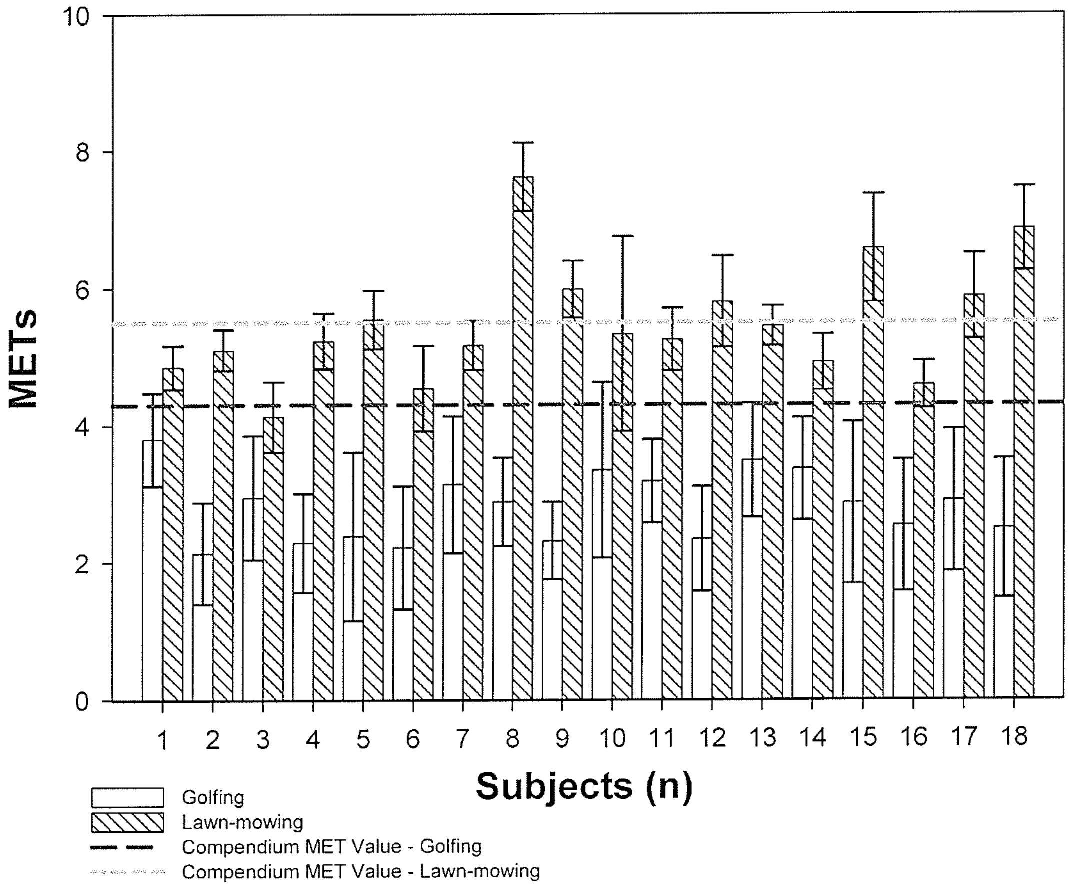

Figure 4.5. Average absolute intensity of golfing and lawn-mowing in 18 older adult subjects as compared to the Compendium of Physical Activities benchmark values (Ainsworth et al., 2000).

Figure 4.5 depicts the differences between the average absolute intensity (METs) of lawn-mowing and golfing, and the Compendium value, in the older adult subjects. It can be clearly noted from Figure 4.5 that no subject's mean absolute intensity response met the MET guideline proposed by Ainsworth et al. for golfing (1993). Calculating the 95% confidence intervals it was determined that there was a significant difference (df = 17, p<0.001) between the reported golfing MET value and the Compendium value. Also, it was determined by calculating the 95% confidence intervals that the lawn-mowing MET value was not significantly different than the reported Compendium value (Ainsworth et al., 2000). However, the MET value associated with lawn-mowing is highly variable in the range of 4.1 to 7.6 METs.

4.3.3 Energy Expenditure

The energy expense of golfing and lawn-mowing and the duration required to meet the minimum guidelines in this study are reported in Table 4.7. The duration of golfing and lawn-mowing can vary greatly, and so does the energy expense associated with each type of physical activity. Energy expenditures between individuals, also varies greatly depending upon body mass as suggested by the wider ranges reported in Table 4.7. The time required to reach the minimum CFLRI energy expenditure guideline of 3 $kcal•kg^{-1}•day^{-1}$ is based upon each subject's mass. The time required to reach the minimum ACSM energy expenditure guideline of 700 $kcal•week^{-1}$ is based upon the assumption that pace of play, terrain, and distance will remain relatively constant for the golfing and lawn-mowing durations extending beyond that which was measured.

Table 4.7: Energy expenditure (EE) during 9 holes of golf and 40 minutes of lawn-mowing, and relationship to current activity guidelines.

	Golfing (n=18) Mean (SD)	Range	**Mowing (n=18)** Mean (SD)	Range
Net EE (kcal)	310.3 (83.9)	134.2-490.7	246.0 (53.5) +	179.5-383.7
Gross EE (kcal)	511.6 (115.5)	252.1-719.8	320.9 (61.0) +	243.6-475.2
Net EE ($kcal \cdot kg^{-1}$)	3.8 (0.9)	2.8-6.2	3.0 (0.6) *	2.1-4.4
Net EE ($kcal \cdot hr^{-1}$)	155.0 (44.8)	90.8-253.8	369.1 (80.2) †	269.2-575.6
Time (minutes) to expend 150 kcal	62.5 (17.2)	35.5-98.9	25.4 (4.8) †	15.7-33.5
Time (minutes) to expend 200 kcal	83.5 (23.0)	47.3-131.9	33.8 (6.4) †	20.9-44.7
Time (minutes) to expend 700 kcal	284.1 (85.2)	165.5-461.7	115.6 (20.5) †	73.2-149.7
Time (minutes) to expend 3 $kcal \cdot kg^{-1} \cdot day^{-1}$	102.2 (26.1)	61.9-143.2	41.5 (7.5) †	27.3-57.7

* significant difference between activities (df=17, $p<0.05$)
+ significant difference between activities (df=17, $p<0.005$)
† significant difference between activities (df=17, $p<0.001$)

4.4 Movement during golfing and lawn-mowing

Table 4.8 contains movement data for the golfing and lawn-mowing sessions. Differences in average walking speed and non-rest walking speed were significantly different during golfing ($p<0.001$) and during lawn-mowing ($p<0.05$). However, the comparison of the lawn-mowing non-rest walking speed and average walking speed data resulted in a failed normality test. The resulting power (0.647) of the performed test fell below the desired power of 0.800. A consequent Wilcoxon Signed Rank test found a significant difference between the average and non-rest walking speeds during lawn-mowing ($p<0.001$). The difference in golf walking speeds indicates that a significant portion of golf is spent resting (33.5% of data steps collected were below 0.5 km•hr^{-1} compared to only 1.8% during lawn-mowing). The significant difference in lawn-mowing walking speed and non-rest walking speed may be explained by small but consistent increases in non-rest walking speed after filtering out resting values. Total walking distance was significantly greater for golfing ($p<0.001$) than lawn-mowing (Figure 4.6). There was a statistically significant correlation between walking distance and absolute and relative energy expenditure during lawn-mowing, but not during golfing (Figure 4.6 and Figure 4.7).

Table 4.8 Distance walked and velocity of movement during nine holes of golfing and 40 minutes of lawn-mowing

	Golfing (n=18) mean (SD)	Lawn-mowing (n=18) mean (SD)
Total Walking Distance (km)	4.4 (3.6)	2.7 (3.2) *
Average Walking Speed (km•hr^{-1})	2.4 (0.3)	4.2 (0.5) *
Non-Resting Walking Speed (km•hr^{-1})	3.6 (0.2) ‡	4.2 (0.5) * †

* significant difference between activities (df=17, $p<0.001$)

‡ significant difference between non-rest and total walking speed during golf (df=17, $p<0.001$)

† significant difference between non-rest and average walking speed during lawn-mowing (df=17, $p<0.001$)

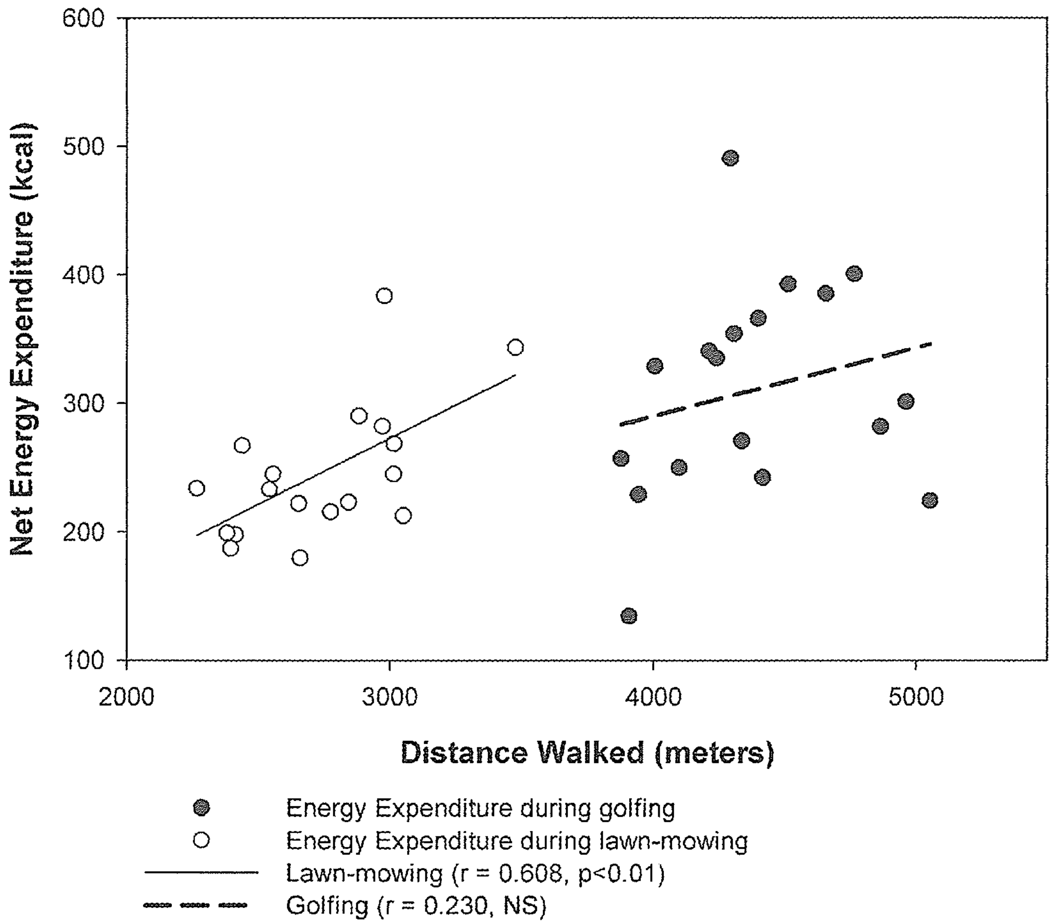

Figure 4.6 Net energy cost of golfing and lawn-mowing as compared to total distance walked.

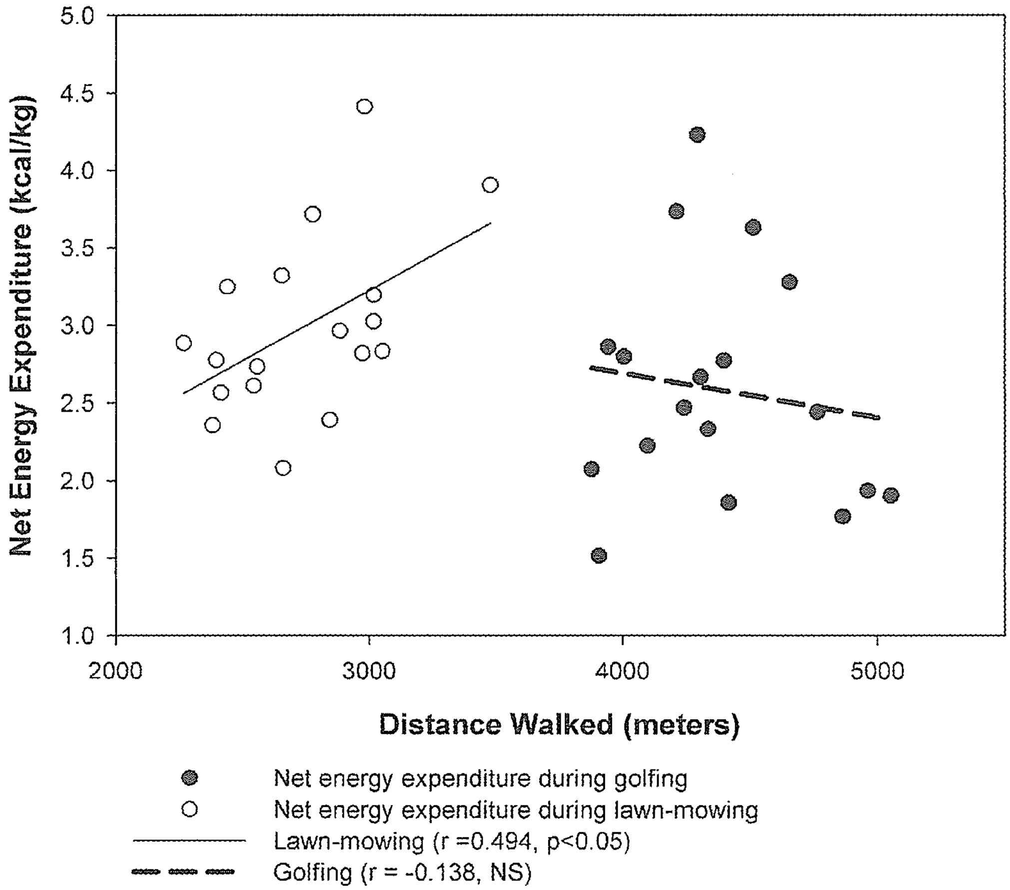

Figure 4.7 Relative net energy expenditure during golfing and lawn-mowing as compared to distance walked by 18 older adult males.

4.5 Associations

4.5.1 Associations between selected variables during golfing

Pearson product-moment correlations were calculated to determine if there were any relationships between specific independent and dependent variables. Peak aerobic power determined during the GXT was negatively correlated with relative intensity of golfing (% VO_2R) ($r = -0.598$, $p<0.01$). The average relative intensity (% VO_2R) of golfing was also significantly correlated with increased energy cost ($r = 0.516$, $p<0.05$).

Figure 4.8 demonstrates that golf handicap (or predicted score) was correlated with the recorded score during the golf test. A paired t-test revealed that the recorded golf scores were significantly greater than the predicted scores based upon reported handicaps ($df = 17$, $p<0.005$). The relative intensity of golf (% HRR) and mean heart rate were positively correlated with increased golf score (strokes) (Figure 4.9). Peak speed ($km{\bullet}hr^{-1}$) was negatively correlated with a decrease in total distance walked ($r = -0.477$, $p<0.05$), and positively associated with mean non-resting walking speed ($r = 0.493$, $p<0.05$).

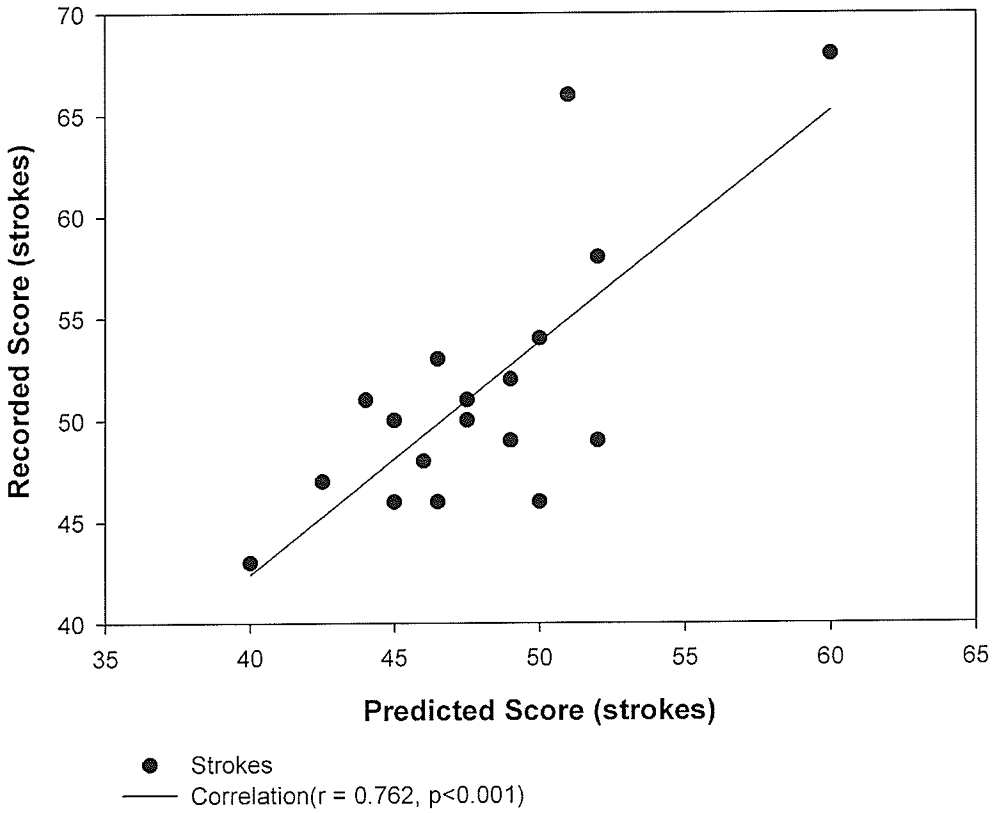

Figure 4.8 Relationship between recorded score and predicted score based upon subjects' reported handicaps.

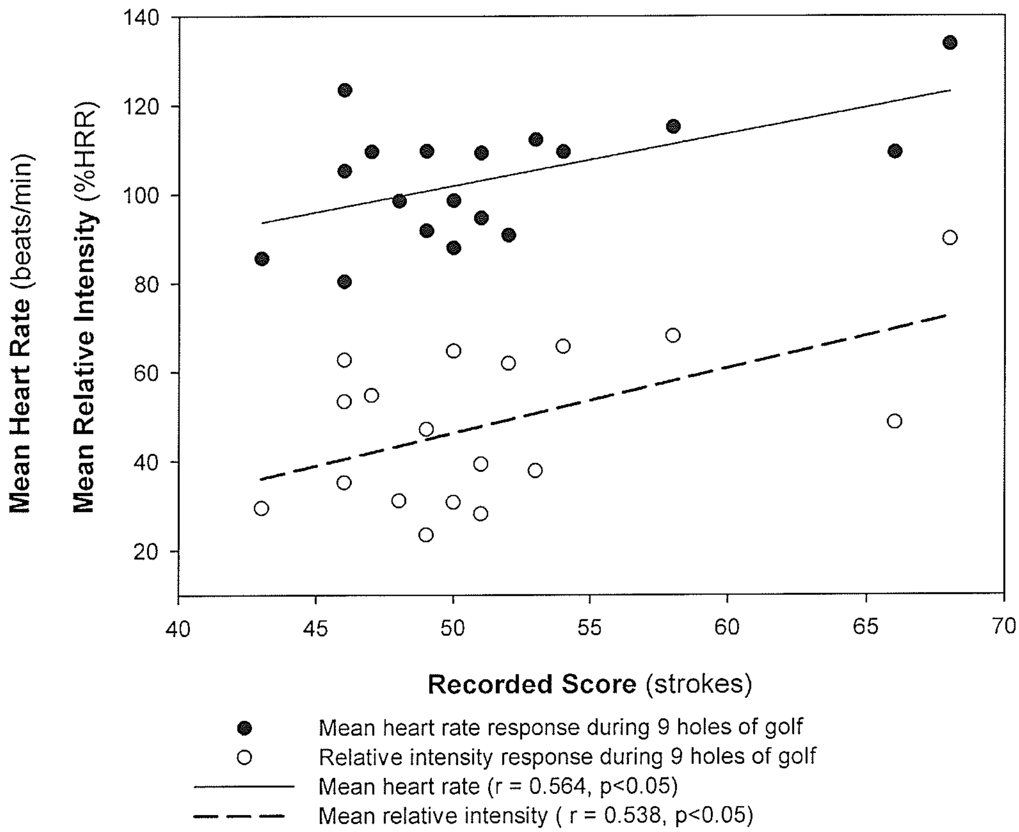

Figure 4.9 Relationship between total score and mean relative intensity and mean heart rate during nine holes of golf in 18 older adult men.

4.5.2 Associations between selected variables during lawn-mowing

Increased age was negatively correlated with mean non-resting walking speed ($r = -0.489$, $p<0.05$) during 40 minutes of lawn-mowing, while no relationship was noted during golfing. Peak heart rate during lawn-mowing was positively correlated with VO_2peak ($r=0.663$, $p<0.005$), and VO_2peak was negatively correlated with both measures of relative intensity, % VO_2R ($r =-0.598$, $p<0.01$) and % HRR ($r =-0.575$, $p<0.05$). As relative intensity (% VO_2R) increased, a positive correlation suggests that net energy cost of lawn-mowing increases ($r = 0.516$, $p<0.05$). Self-selected peak and mean non-resting walking speeds were correlated with total walking distance during 40 minutes of lawn-mowing ($r = 0.516$, $p<0.05$ and $r = 0.661$, $p<0.05$ respectively).

4.5.3 Associations between walking speed and aerobic power

Figures 4.10 demonstrates that during 40 minutes of lawn-mowing, peak walking speed was not significantly correlated with VO_2peak in 18 older adult men. However, one subject ran during the last moments of his lawn-mowing session. Once this outlier was removed from analysis a significant correlation was noted between peak walking speed and VO_2peak. Three subjects briefly ran during their golf sessions to retrieve forgotten items, however, no significant correlation was apparent upon further analysis (Figure 4.11).

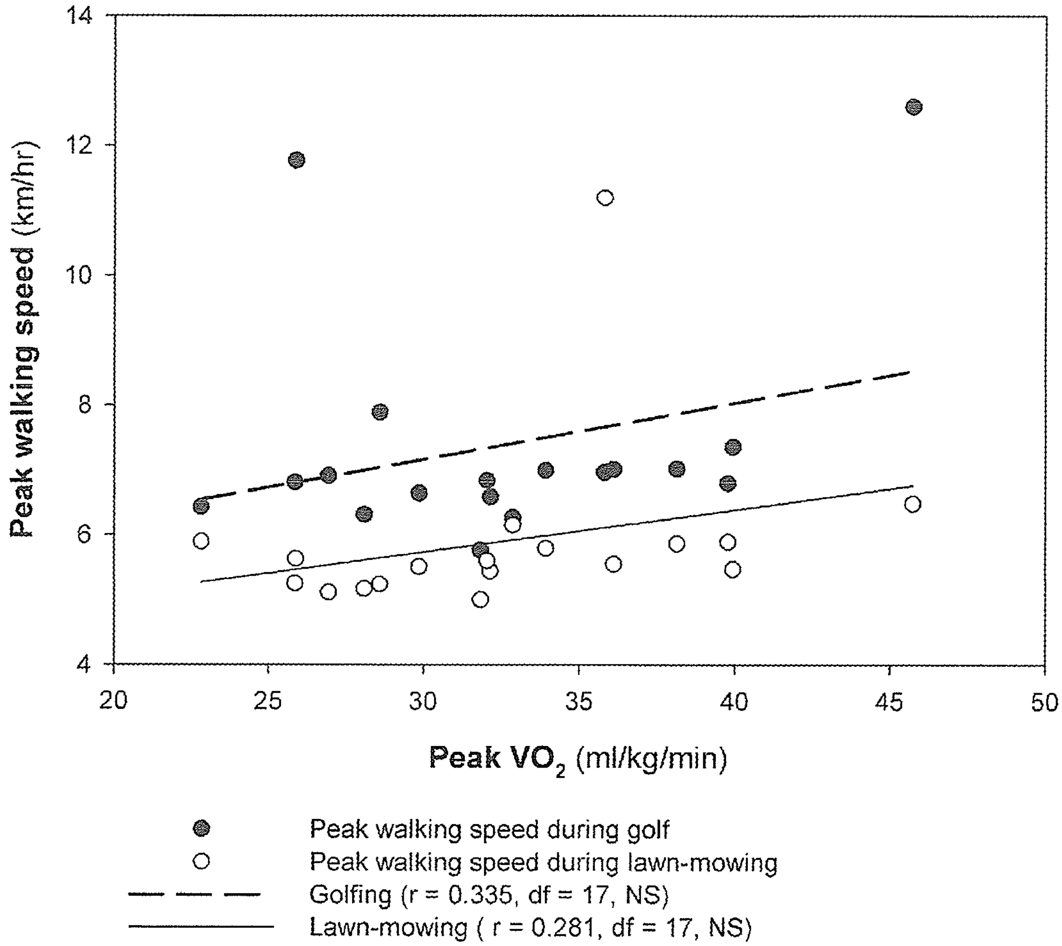

Figure 4.10 Relationship between aerobic power and selected peak walking speed in 18 older adult men, outliers included.

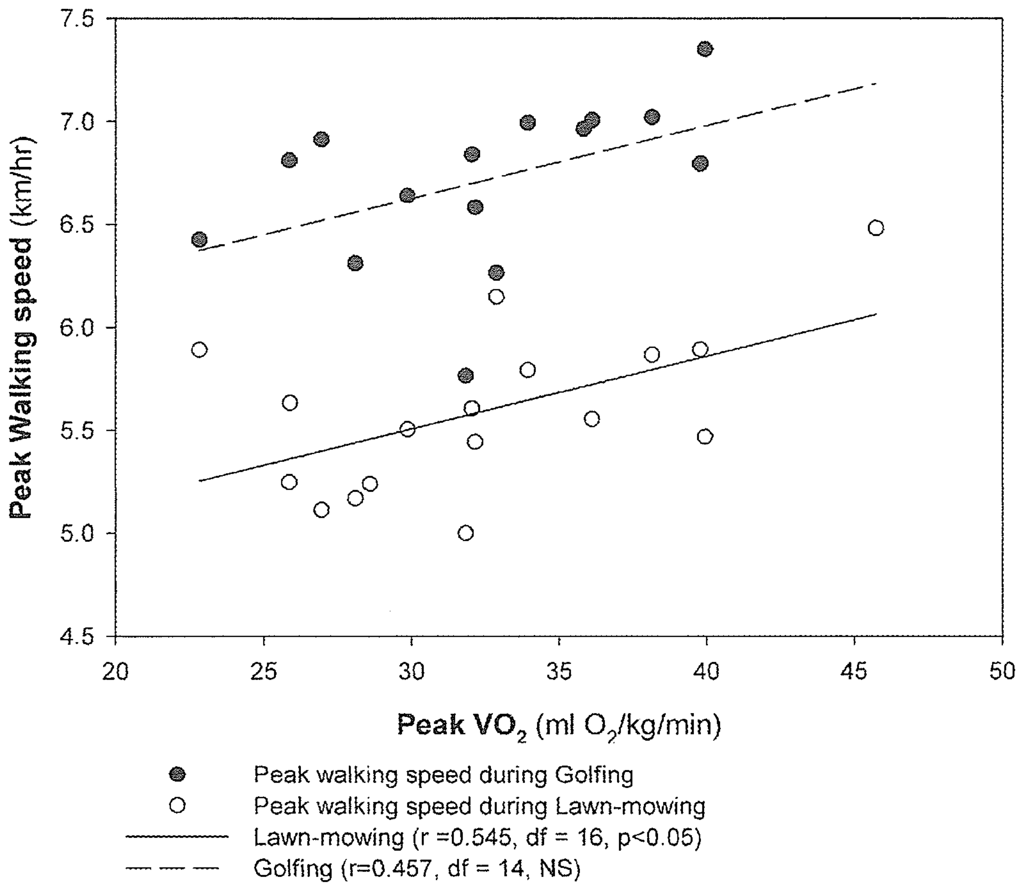

Figure 4.11 Relationship between aerobic power and selected walking speed during golfing and lawn-mowing in older adult males once outlying data has been removed.

Chapter 5: Discussion

The purpose of this study was to compare the intensity and energy cost of golfing and lawn-mowing in an older adult male population. It was hypothesized that the subjects would select a walking pace that would result in a relative intensity equivalent to the "moderate" or "hard" intensity classifications as developed by the American College of Sport Medicine (1998b). The second hypothesis was that the absolute intensity of nine holes of golf while pulling a cart, and during forty minutes of lawn-mowing, would be significantly greater than the values reported in the Compendium of Physical Activities (Ainsworth et al., 1993; Ainsworth et al., 2000). The third hypothesis was that the energy cost of golfing and lawn-mowing would surpass the minimum recommended daily energy expenditure guidelines.

Regular moderate physical activity is known to have many health benefits. Therefore, it is important to determine if popular leisure-time physical activities (e.g. golfing and yard-work) are appropriate for health improvements in older adults. The results from chapter four will be critically discussed and interpreted. Comparisons will be made with results from the literature and future research considerations and recommendations resulting from this study will be discussed.

5.1 Participant characteristics

5.1.1 Variables at study onset

Research examining the benefits, intensity and energy cost of golfing and lawn-mowing in healthy older adults has been minimal. Most research into the energy cost and intensity of golfing and lawn-mowing has either examined middle-aged subjects or older adults with cardiovascular disease. Little research has examined golfing and lawn-mowing in a seemingly healthy, older adult male population. The subjects in this study were selected because they were reportedly healthy, active, ambulatory, and independent. Participants did not report any functional limitation or life threatening conditions in their health status questionnaires. The subjects were all community residing with 28 % living in condominiums and 72 % living within houses. All but one were classified as older, with an average age of 71.2 years (± 4.4) and range of 65-80 years. However, one subject had just turned 80 years of age and would therefore be classified by the ACSM as very old (ACSM, 1998b).

Eighty-nine percent of the subjects reported golfing as a regular activity. Fifty percent of the subjects reported frequent gardening and 39 % of the subjects reported walking, jogging or running. This is in contrast to the 2000 Physical Activity Monitor, where 16% of Canadians over 65 years reportedly golfed, 69% gardened and 83% reported walking as a regular leisure-time physical activity (CFLRI, 2001). Yet, these results are not surprising, as the majority of subjects were recruited from golf courses around Winnipeg. Only six subjects (33%) reported participating in more than 3 types of physical activity during an average non-winter week.

5.1.2 Peak testing response

Ideally, a peak GXT in an older adult population should last eight to twelve minutes (Franklin et al., 2000; Seals et al., 1984). The mean GXT duration is this study was 12.4 ± 3.9 minutes, therefore the GXT protocol appears appropriate for the subject pool. However, nine subjects exceeded the 12-minute mark indicating that the ramping protocol may have increased intensity at too slow an intensity. One subject, a regular runner, surpassed the 20 minute mark. All subjects indicated a Borg RPE >17 at test end, and tests were terminated by the subject when they felt they could no longer continue (reached volitional fatigue).

The mean peak heart rate response (150.3 ± 18.0 bpm) closely resembles the mean age-predicted heart rate max of the subject pool (148.8 bpm). Twelve of the 18 subjects achieved a peak heart rate within 10 beats/min of their age predicted maximum (Franklin et al., 2000). Peak heart rate response also closely resembles the peak heart rate of the healthy controls in the study by Dobrosielski et al. (2002). However, one subject was not close to meeting his age predicted heart rate of 146 beats per minute. This subject only reached a peak value of 111 beats per minute despite complaining of fatigue, recording a rating of perceived exertion (RPE) of 17 and an R value >1.0. This proved problematic upon analyses of the golfing and lawn-mowing data as the subject experienced heart rate values which exceeded his peak testing heart rate value.

Six subjects experienced a peak respiratory exchange ratio value during the last minute on the treadmill, exceeding the criteria for a "true" VO_2max score (R>1.15) (Franklin et al., 2000). Thirteen subjects exceeded an R of 1.0 while 5 subjects did not achieve an R value greater than 1.0. However, previous research by Parr et al. (2001) has suggested that the Cosmed K4 b^2 significantly underestimates VCO_2 and R compared to the Douglas bag method at high workloads (250 W). McLaughlin et al. (2001) also reported that VCO_2 is underestimated, and that a slight overestimate of VO_2 results in significantly lower R values at workloads ranging from 50 W to 250 W. Moreover, it has been reported that there is significant variability in the respiratory exchange ratio response (Franklin et al., 2000). Therefore, the R values lower than the true VO_2max criteria may be due to equipment errors associated with the portable metabolic unit. Lastly, the possibility remains that localized fatigue and discomfort may have caused subjects to quit before achieving an R value that met the VO_2max criteria.

According to the Campbell Survey on Well-being, the mean peak oxygen uptake recorded for the study participants (32.6 $ml•kg^{-1}•min^{-1}$) ranks them above the 85^{th} percentile for males over the age of 65 years (CFLRI, 1988) and in the "average" health category for males aged 60 to 69 years (CSEP, 1996). The VO_2peak data is in agreement with previous research that has reported a peak oxygen uptake of 33.1 ± 7.3 $ml•kg^{-1}•min^{-1}$ in 30 healthy older men in their 60's (Porcari et al., 1987). Sheldahl et al. (1996) also reported a similar maximum oxygen uptake of 34.9 ± 1.1(SEM) $ml•kg^{-1}•min^{-1}$ in nine older adult men.

There appears to be a trend that peak oxygen consumption decreases as age increases (r=-0.245, NS). The best fit line in Figure 4.4 demonstrates the related decline. While not significant in this study, the age related decrease has been demonstrated in several cross sectional studies (Malatesta et al., 2004; Talbot et al., 1999), longitudinal studies (Åstrand et al., 1973; Stathokostas et al., 2004; Rogers et al., 1988; Paterson et al,

1999) and has been reported in several recent consensus statements (ACSM, 1998a; ACSM, 1998b; USDHHS, 1996).

Peak aerobic power was highly variable with a ranging from 22.8 to 45.7 ml•kg^{-1}•min^{-1}. The lowest aerobic power of 22.8 ml•kg^{-1}•min^{-1} was reported for a 68 year old subject who was a condominium resident, but reported frequent golfing during the summer months. His peak HR was 145 beats•min^{-1}, peak RPE was 19 and peak R was 0.8. Error may have resulted in the gas analysis, despite calibration values within the manufacturer's acceptable range. The low aerobic power of this 68 year old subject approached the minimal level required for independent living at the age of 85 years (18 ml•kg^{-1}•min^{-1}) (Paterson et al., 1999). The highest value of aerobic power was achieved by a 69 year old home-owner who frequently reported jogging as his leisure activity of choice. His peak HR was 175 beats•min^{-1}, peak RPE was 17 and peak R was 1.22. Oxygen uptake values equal to or exceeding 43 ml•kg^{-1}•min^{-1}are considered "high" for males between the ages of 50 to 59, whereas values greater than 38 ml•kg^{-1}•min^{-1} are considered "high" for subjects 60-69 years of age (CSEP, 1996). The broad range of peak aerobic power scores indicates that the subjects represent a diverse older male population.

5.2 Physiologic response during golfing and lawn-mowing in older adult males

5.2.1 Heart rate response during golfing and lawn-mowing

Significant differences in the peak and mean heart rate responses were apparent between golfing and lawn-mowing. Subjects experienced a significantly higher peak heart rate during lawn-mowing (141 ± 19 bpm) than during golfing (127 ± 13) ($P<0.01$). The peak heart rate during lawn-mowing was lower in this study than in another study, where healthy controls (~62 years) mowed for 30 minutes on a 5 degree slope with an average peak heart rate response was 154 ± 4 (SE) bpm (Sheldahl et al., 1996). The increased difficulty associated with slope walking may be responsible for the higher peak heart rate in the Sheldahl study. The mean age of the subjects was also younger than subjects in this study.

Significant differences were also apparent between mean heart rates during golfing and lawn-mowing. Golfing while pulling a cart resulted in a mean heart of 104 ± 14 bpm and power lawn-mowing resulted in a higher mean heart rate value of 123 ± 17 bpm ($p<0.001$). Similar mean heart rates have been reported in other studies. Parkkari et al. (2000) reported a mean heart rate response of 104 ±16 beats•min^{-1} in 55 healthy middle aged golfers. Haskin-Popp et al. (1998) reported a mean heart rate of 117 ± 14 beats•min^{-1} during 10 minutes of self-paced level surface power lawn-mowing. Other studies with older adults have been done in cooler temperatures and were of shorter duration (Gunn et al., 2002; Haskin-Popp et al. 1998).

Use of heart rate as an estimate of intensity and energy expense is limited in that it may be significantly affected by changes in emotional state, hydration status and the muscle mass used. Many subjects neglected taking any rest or water during the lawn-mowing session, and subsequently may have become dehydrated which could have resulted in decreased stroke volume and increased heart rate for maintenance of cardiac output (McArdle, Katch & Katch, 2001). As well, significant correlations existed between the total recorded score and relative intensity (% HRR), as well as mean heart rate response during nine holes of golf ($r = 0.564$ and 0.538, respectively). Anecdotally, higher scores (which may include putts) may often result in increased frustration and subsequent increases in heart rate.

Increased ambient temperature and increased relative humidity have also been reported to result in reflex increases in peripheral blood flow for cooling purposes, without an increase in oxygen consumption (Kenney & Munce, 2003). Figure 4.2 depicts the increase in mean heart rate during 40 minutes of lawn-mowing. The increase in external temperature was met with a simultaneous increase in mean heart rate response. All subjects performed 40 minutes of lawn-mowing before noon throughout the summer of 2003. However the testing period was extremely warm, with temperatures often exceeding 30 degrees Celsius, and humidity frequently exceeding 70 %.

5.2.2 Relative intensity

5.2.2.1 Relative intensity response to golfing

The mean relative intensity during golfing (expressed as % HRR) met the "moderate" intensity classification as purported by the ACSM. However, when the relative intensity was expressed as $\%VO_2R$, the "moderate" intensity classification was not met. The significant difference noted between measures of relative intensity during golfing may be attributed to several factors. Prolonged exposures to high temperatures result in an increased heart rate response required to maintain cardiac output as well as increase peripheral blood flow response which in turn results in older adult males working at a greater percentage of their heart rate reserve (Kenney & Munce, 2003). A lack of a steady state during golfing may also have resulted in lower VO_2 values being recorded (Norgan, 1996).

Significant differences may also be attributed to equipment and testing error. Percent VO_2R may also be significantly lower than % HRR during golf, since high humidity levels during the summer of 2003 may have contributed to excessive water vapor in the sampling line. As a result, the measured exercise VO_2 may have been reduced in some instances (Harris, 2003). In addition, the relative humidity range experienced during golf frequently exceeded the manufacturer's recommended operational range of 20% to 80% (Cosmed S.r.l., 1999). Lastly, during golfing 2 subjects exceeded their peak heart rate obtained during the GXT which could have contributed to an increased relative intensity based upon percent heart rate reserve. One subject greatly exceeded his GXT peak HR (111 beats•min^{-1}) during both golfing (120 beats•min^{-1}) and lawn-mowing (128 beats•min^{-1}). This subject had an R>1.0, an RPE of 17 and an aerobic power of 25.9 ml•kg^{-1}•min^{-1}. Another subject exceed his GXT determined peak HR (141 beats•min^{-1}) briefly during golfing (153 beats•min^{-1}) and lawn-mowing (163 beats•min^{-1}). This subject had an R=1.0, an RPE of 18 and an aerobic power of 23.4 ml•kg^{-1}•min^{-1}.

Literature has suggested that the relative intensity of golf may not be of sufficient intensity (38% of VO_2max in 5 middle-aged subjects) to benefit cardiovascular health and muscle endurance (Murase et al., 1989). However, the pace and intensity of golfing can be extremely variable. Despite having a mean relative intensity resulting in an overall classification of "light", a significant portion may be spent at the recommended intensities. Results indicate that when classified in terms of % HRR, approximately 54% of a typical nine-hole session was spent at the "moderate-hard" intensity classifications, 39. % was spent at the "light" classification, and 4.2 % at a "very hard" classification. Thus, 64 minutes were spent in the "moderate" to "hard" categories, which easily met the minimum guidelines of 30 minutes, set by the ACSM. Previously, only one study had classified walking nine holes of golf in terms of duration spent at a given intensity. During nine holes of golf on a hilly course, Stauch et al. (1999) determined that the greatest proportion of the golf session (32 ± 21 %) was spent at the moderate intensity level (50-74 % HRR) in middle-aged males.

The current results support the hypothesis that golfing is generally a "moderate-hard" activity for older adult males. Accordingly, older adult players who frequently walk the course should acquire the health benefits associated with moderate physical activity. To date, one study has examined cardiorespiratory performance after golf-training. Parkkari et al. (2000) determined submaximal oxygen consumption and heart rate decreased in middle-aged golfers significantly after 20 weeks, but that improvements in maximal oxygen consumption were not significant. The average heart rate response during 18 holes of golf was 59% HRmax in 50 middle-aged healthy subjects, a level that met the moderate intensity guidelines suggested by the ACSM (1998b).

5.2.2.2 Relative intensity response to lawn-mowing

Expressed as % HRR, 83.3 % of the 40 minute lawn-mowing session was spent at the "moderate-hard" intensity classification. This translated into 33 minutes in the appropriate training classifications outlined by the American College of Sports Medicine (1998b). These results support the first hypothesis that older males will select a pace resulting in an intensity equivalent to the "moderate" and "hard" intensity classification. On average, an additional 6 minutes of lawn-mowing (14.2 % of a 40 minute session) exceeded the "hard" relative intensity classification outline by the ACSM. Consequently, safety may be an issue during lawn-mowing in older adults, especially in hot and humid environments. Special considerations should be made for older adult mowers, especially those who are inactive or who suffer from various health conditions. To date no other lawn-mowing study has quantified duration spent at each of the ACSM intensity classifications. However, the current results are in close agreement with those of Sheldahl et al. (1996) which reported a mean intensity of 57 % VO_2max and 74 % HRmax in older males (mean age: 62 years) during 8 minutes of non-propelled power lawn-mowing.

5.2.3 Absolute intensity classification of golfing and lawn-mowing

Expressed in metabolic equivalents (METs), 32 minutes were spent at "moderate" intensity and over 40 minutes were spent within the "moderate-hard" categories during 9 holes of golf. In classifying golf in absolute terms, there appears to be a shift to a lower intensity as compared to the relative classifications. The greatest proportion of time was spent in the "light" category, resulting in approximately 62 minutes (51.0%) not meeting the minimum intensity guidelines. As mentioned previously, high heat and humidity may have augmented the heart rate response. It is also possible that a long duration may have increased the likelihood of equipment error resulting from water vapor in the sampling line, leaks in the face mask developing during water breaks at the tees, and possibly analyzer drift. Previous research has determined that the carbon dioxide and oxygen analyzers may experience a slight drift. McLaughlin et al. (2001) utilized two separate reference gas mixtures (3% CO_2, 18% O_2 and 6 % CO_2, 15% O_2) to check for analyzer drift immediately post-test. Post-test calibrations established that the CO_2 analyzer underestimated the high CO_2 tank values by 0.24% and the low CO_2 calibration tank by 0.33 % CO_2 (McLaughlin et al., 2001). On average, the oxygen analyzers experienced a drift of 0.115% for the high CO_2 tank and 0.145 % for the low CO_2 calibration tank.

During 40 minutes of power lawn-mowing, 34 minutes were spent in the "moderate-hard" intensity categories. However, 5.6 minutes were spent in the "very hard" and "maximal" categories. In this context, the majority of lawn-mowing is spent within the "moderate-hard" intensity range which supports the first hypothesis.

The American College of Sports Medicine dictates the "moderate-hard" MET range to be 3.2-6.7 METs for older adults (65-79 years) (ACSM, 1998b), and from 2.0-4.3 METs for very old adults. Differences between the relative and absolute classifications may also occur because absolute intensity is set upon age-related thresholds, and not individual health. Age-adjusted absolute intensity cut points may not be completely valid for use in exercise prescription as fitness levels can vary significantly for individuals within a specific age cohort. Developing thresholds based upon individual fitness levels may result in a more valid tool for exercise prescription and reduce the risk of prescribing "moderate" activities which are too difficult for individuals suffering from chronic conditions or poor health. Strath et al. (2000) studied the intensities of several "moderate" (3-6 MET) activities in 81 participants (19-74 years). Despite the absolute classification of "moderate", several older subjects achieved heart rates above 80 % of their estimated % HRR. Had the researchers measured maximal exercise values, they may have found that subjects had a number of health conditions or lower fitness scores and thus experienced difficulty. The current results suggest that lower fitness scores may result in subjects working at a greater percentage of their peak functional capacity during golfing and lawn-mowing.

5.3 Absolute intensity and Compendium intensities of golfing and lawn-mowing

It was hypothesized that the absolute intensity of golfing and lawn-mowing would be significantly greater than the values purported in the Compendium of Physical Activities (Ainsworth et al., 2000). Data from the current research did not support the second hypothesis. Golfing nine holes while walking had an average absolute intensity of 2.8 METs, and self-paced power lawn-mowing had an average absolute intensity of 5.5 METs. The absolute intensity of golfing was significantly lower than the reported Compendium value, but the lawn-mowing MET value did not differ significantly from the Compendium.

The average MET value during golfing in the current study is also significantly lower than all other reported golfing MET levels. Getchell (1968) and Lampley et al. (1977) reported that the absolute intensity of golfing in foursomes was 3.3 METs. The absolute intensity of golf is extremely variable and depends upon group size, course terrain, pace of course play, pace of group play and waiting time at each tee (Burkett et al., 1998). The current study involved playing on a public course, and subjects were forced to rest at each tee box for considerable periods as the group ahead finished the hole. Previous studies have reported subjects had very little waiting time at each tee box and that pace of play was dictated solely by members of the group (Lampley et al., 1977; Stauch et al., 1999; Dobrosielski et al., 2000). An average of 122 minutes were required to play 9 holes in this study, while others have reported an average duration ranging from

85 to 113 minutes (Lampley et al., 1977; Stauch et al., 1999; Dobrosielski et al., 2000). The increased waiting time at each tee box will significantly lower the overall absolute intensity of golfing.

Further disagreement may be due to the Compendium values being based primarily on data from younger subjects, who typically self-select a faster walking pace than older adults (Himann et al., 1988; Paterson et al., 2004; Wong et al., 2003; Porcari et al., 1987). Buchner et al (1996) reported that a "comfortable" walking pace of 5 $km \cdot hr^{-1}$ (83 $m \cdot min^{-1}$) typically requires an absolute intensity of approximately 3 METs. Subjects averaged a walking speed of less than 3 $km \cdot hr^{-1}$ during nine holes of golf while walking. Aging often results in increased body mass and decreased motor efficiency at given workloads (Shephard, 1997a). This might lead one to assume that the absolute intensity would be significantly greater during both activities. However, Donovan and Brooks reported in nine younger males that motor efficiency can be improved by selecting a slower gait speed (1977). Reducing walk speed from 6 $km \cdot hr^{-1}$ to 3 $km \cdot hr^{-1}$ was shown to increase apparent efficiency by 15 %, which in turn would decrease the absolute intensity or energy cost required during locomotion.

No difference was noted between the Compendium lawn-mowing value and the value determined in the current study. Previous research reported similar self-paced power lawn-mowing MET values in middle-aged subjects during field tests (Haskin-Popp et al., 1998; Sheldahl et al., 1996; Gunn et al., 2002; Gunn et al., 2004). Gunn et al. (2004) reported that intensity of lawn-mowing in a residential or home setting (4.8 METs) was significantly lower than in the laboratory setting (5.6 METs). They suggested that in the laboratory and field setting, the high absolute intensity is maintained because there are fewer obstacles to avoid and therefore less bending is required. Despite repeated reminders to mow at the same pace they would at home, and to rest when desired, subjects in the current study may have mowed at a higher intensity because they were being observed. During the 40 minute lawn-mowing session, only two subjects chose to take water breaks at any point.

Compendium intensities listed for golfing and lawn-mowing may also be underestimated in unfit and older adult individuals because the MET values are based upon multiples of an assumed resting metabolic rate of 3.5 $ml \cdot kg^{-1} \cdot min^{-1}$. However, it has been suggested that older adults have a lower resting metabolic rate. Therefore it may be important to measure individual metabolic rates to determine an accurate absolute intensity of various physical activities. Resting metabolic rates of 2.9 $ml \cdot kg^{-1} \cdot min^{-1}$ (Gunn et al., 2002) and 3.0 $ml \cdot kg^{-1} \cdot min^{-1}$ (Gunn et al., 2004) have been reported in middle-aged men and women. Using the mean oxygen consumption values for golfing (9.9 $ml \cdot kg^{-1} \cdot min^{-1}$) and lawn-mowing (19.1 $ml \cdot kg^{-1} \cdot min^{-1}$) and a lower resting metabolic rate of 2.9 $ml \cdot kg^{-1} \cdot min^{-1}$, the mean intensity of golf would be 3.4 METs and would be characterized by the ACSM as a "moderate" activity for older adults. The resultant mean intensity of lawn-mowing would be 6.6 METs and an intensity rating of "hard".

5.4 Energy expenditure during golfing and lawn-mowing

Current energy expenditure guidelines suggest a minimum net daily activity energy expenditure of 150 $kcal \cdot day^{-1}$ (USDHHS, 1996), 200 $kcal \cdot day^{-1}$ (ACSM, 1998b) or 3 $kcal \cdot kg^{-1} \cdot day^{-1}$ (CFLRI, 1998). These results support the hypothesis that nine holes of golfing and forty minutes of lawn-mowing meet the minimum energy expenditure guidelines developed by these organizations. A net energy expenditure of 200 kcal•session^{-1} is easily met during golfing nine holes (83.5 minutes required) and during lawn-mowing for 40 minutes (33.8 minutes required).

During golfing there was a larger difference between gross and net energy expenditure than during lawn-mowing. This is due to the fact that a great deal of time is spent at a near rest state during golfing and very little was spent at rest during lawn-mowing. The amount of rest during each activity also affected the hourly rate of energy expenditure which was also significantly different between the two modes of activity ($p<0.05$). This is in direct relation to the absolute intensity of both activities.

The energy cost of golfing nine holes was lower than previously reported measures of energy expenditure. However, it is often unclear whether net or gross energy expenditures were reported. Getchell (1968) estimated that 636 kilocalories would be expended during 18 holes of golf by a 68 kilogram man. Lampley et al. (1977) determined that an 80 kilogram man would expend 732 kilocalories during 18 holes of golf while pulling a cart. Expired gas was collected for 15 seconds each minute during the nine holes of play, and it is unclear whether researchers collected gas during rest periods, or only between the tee-boxes and greens. Using a Cosmed K4 b^2 portable unit, Dobrosielski et al. (2002) continuously monitored subjects (mean mass = 86.3 kg) during 9 holes of golf, and determined that 458 kilocalories were expended in 10 healthy subjects and 10 subjects with heart disease. The mean energy cost for nine holes of golf was considerably lower in the current study as subjects (mean mass = 81.3 kg) expended 310.3 kcal.

The differences in reported net energy expenditures may be related to changes in course terrain, resting time, course distance, walking distance, walking speed and the procedures used to measure energy expenditure. Getchell (1968) estimated energy expenditure after subjects played 3 holes of golf. The total distance estimated for 18 holes would have been 6200 yards, however terrain was not described. Lampley et al. (1977) reported a distance of 6300 yards for 18 holes of golf, however the terrain was also not described. In the current study, golf course distance was 2739 yards (5478 yards for 18 holes) which would be a shorter distance than that reported by others (Getchell, 1968; Lampley et al., 1977). Walking distance was not significantly correlated with net energy expenditure (kcal and $kcal \cdot kg^{-1}$) during golfing. This apparent lack of association may be due to the fact that a significant portion of golfing was spent standing and waiting at tee-boxes. This may have resulted in elevated oxygen consumption above resting values, indicating greater than resting energy consumption despite lack of movement. This is supported by the fact that 33.5 % of the movement data points were recorded at speeds less than 0.5 $km \cdot hr^{-1}$. Gross energy expenditure is associated with golfing time, which suggests that the longer the golfing round, the greater the gross energy expended.

Net energy expenditure during golfing may have been underestimated. An assumed resting metabolic rate of 1 $kcal \cdot kg^{-1} \cdot hr^{-1}$ (or 3.5 $ml \cdot kg^{-1} \cdot min^{-1}$) was used to allow for net energy expenditure calculations. However, it has been shown that older adults have a lower resting metabolic rate, therefore it may have been more appropriate to subtract less than 1 MET during the calculations (Gunn et al., 2002). Subjects in the studies of Getchell (1968) and Lampley et al. (1977) were middle aged. The current study is limited in that true resting metabolic rate was not determined. Due to the significant duration spent at rest during golfing, one can assume that net energy expenditure would be greater as the older adult resting oxygen consumption may be less than 3.0 $ml{\bullet}kg^{-1}{\bullet}min^{-1}$ or 1 $kcal{\bullet}kg^{-1}{\bullet}hr^{-1}$ (Gunn et al., 2002). In activities that involve a significant rest period or a greater time at a lower intensity, a more accurate resting metabolic rate is necessary, as resting energy expenditure makes up a greater portion of total activity energy cost.

The ACSM suggests that by expending an extra 700 to 2000 $kcals{\bullet}week^{-1}$ in physical activity one can significantly improve metabolic health, improve cardiovascular health and decrease the incidence of chronic diseases (ACSM, 1998b). Less than five hours of golfing (284.1 minutes) is required to meet this guideline, and less than 2 hours (115.6 minutes) of lawn-mowing per week would meet the same guideline. Similar energy expense would require approximately 4.4 hours of golfing according to the results presented by Getchell (1968) and 3.5 hours according to Lampley et al. (1977).

The energy cost of 40 minutes of lawn mowing was 246 kcal, or 369.1 $kcal{\bullet}hr^{-1}$. Previous studies have not reported the total net energy cost associated with lawn-mowing, but absolute intensity has been determined (4.4 METs – 6.0 METs) (Gunn et al., 2002; Sheldahl et al., 1996; Hendelman et al., 2000; Haskin-Popp et al., 1998). Estimates for total net energy expenditure associated with 40 minutes of lawn-mowing are in the range of 176 kcal – 240 kcal (Gunn et al., 2002; Sheldahl et al., 1996; Hendelman et al., 2000; Haskin-Popp et al., 1998). This is in agreement with the current study where energy expenditure was calculated each minute and subsequently summed to give a more accurate total for net lawn-mowing energy expenditure. Unlike golfing, net energy cost is associated with total distance walked during lawn-mowing ($r=0.608$, $p<0.01$). Lawn-mowing had very little resting or standing positions, so a great deal of energy was consistently expended. Energy expended may be greater depending upon grass height, terrain and type of lawn-mower used.

Gross and net oxygen consumption ($ml \bullet kg^{-1} \bullet min^{-1}$) can be estimated based upon the speed of walking by using the ACSM metabolic equation for walking (Franklin et al., 2000) and from this the energy expenditure associated with activity can be estimated. Golfing resulted in a mean non-resting walk speed of 3.6 $km \bullet hr^{-1}$ or 60 $m \bullet min^{-1}$ and lawn-mowing resulted in a mean non-resting walk speed of 4.2 $km \bullet hr^{-1}$ or 70 $m \bullet min^{-1}$. Based upon the ACSM equation for walking, the mean gross oxygen consumption for golfing is estimated as 9.5 $ml \bullet kg^{-1} \bullet min^{-1}$ (net VO_2 of 6.0 $ml \bullet kg^{-1} \bullet min^{-1}$) and for lawn-mowing is estimated as 10.5 $ml \bullet kg^{-1} \bullet min^{-1}$ (net VO_2 of 7.0 $ml \bullet kg^{-1} \bullet min^{-1}$). Gross and net energy expenditure can therefore be calculated based upon the assumption that approximately 1 $kcal \bullet kg^{-1} \bullet hr^{-1}$ for every 3.5 ml $O_2.kg^{-1} \bullet min^{-1}$ consumed. The estimated gross energy expenditure associated with golfing is 2.7 $kcal \bullet kg^{-1} \bullet hr^{-1}$ (net EE = 1.7 $kcal \bullet kg^{-1} \bullet hr^{-1}$) and with lawn-mowing is 3.0 $kcal \bullet kg^{-1} \bullet hr^{-1}$ (net EE = 2 $kcal \bullet kg^{-1} \bullet hr^{-1}$). Therefore, the ACSM estimates of total gross energy expenditure during golfing and lawn-mowing are approximately 439 kcal and 163 kcal, respectively. The estimates of total net energy expenditure during golfing and lawn-mowing would be 276 kcal and 109 kcal, respectively.

The estimates of oxygen consumption and energy expenditure closely match the measured mean oxygen consumption and energy expenditures during golfing but do not match the measured oxygen consumption and energy cost of lawn-mowing. However, the estimates were made based upon normal walking and also upon the assumption of 0%

grade. While subjects mowed on a flat surface during lawn-mowing, oxygen consumption and energy expenditure are greatly elevated by added resistance in the form of friction and mower weight. The differences in measured and estimated VO_2 during lawn-mowing may also be due to extra energy expended during consistent isometric contractions in the upper body and thus greater amounts of active muscle tissue.

In the current study subjects walked a total of 4.4 kilometers (2.8 miles) during nine holes of golf, and 2.7 kilometers (1.7 miles) during 40 minutes of lawn-mowing. Distance walked and walking speed have previously been shown to affect energy expenditure (Donovan & Brooks, 1977). However, previous golfing and lawn-mowing studies have not reported walking speed or distances associated with each activity. Donovan and Brooks suggested that slower pace will dictate a decrease in energy expenditure due to increased efficiency (1977).

Theoretically, an 82 kilogram subject, walking 1 mile would expend an equivalent of 131 kilocalories (McArdle, Katch and Katch, 2001). Therefore, estimations based upon the total distance walked suggest that subjects in the current study expended 367 kilocalories during golfing and 223 kilocalories during lawn-mowing. Both values are in fairly close agreement with the indirectly measured energy expenditure.

5.5 Summary and general conclusions

The purpose of the study was to investigate whether golfing and lawn-mowing, as examples of LTPA, were of sufficient intensity and resulted in energy expenditure suitable for health benefits. It was hypothesized that for both activities, subjects would self-select a walking pace that would result in a relative intensity equivalent to the "moderate" or "hard" intensity classifications as developed by the American College of Sport Medicine (1998). The second hypothesis was that the absolute intensity of nine holes of golf while pulling a cart, and forty minutes of lawn-mowing, would be significantly greater than the values reported in the Compendium of Physical Activities. The third hypothesis was that the energy cost of golfing and lawn-mowing would surpass the minimum recommended daily energy expenditure guidelines (ACSM, 1998b; USDHHS, 1996; CFLRI, 1996b).

Eighteen older male subjects, who completed all three testing sessions at the Kinsmen Reh-Fit Centre, John Blumberg Golf and Country club and at the University of Manitoba, were included in the data analysis. Forty minutes of lawn-mowing and 9 holes of golfing both met the minimum intensity guidelines recommended by the American College of Sports Medicine. Nearly 45 % of a 9-hole round of golf, and 65% of a 40 minute lawn-mowing session, were considered "moderate-hard" according to the American College of Sports Medicine intensity classifications. This supported the hypothesis that older subjects would select a pace equivalent to "moderate-hard".

The second hypothesis was not supported, as golfing while pulling a cart was found to be significantly less intense than the Compendium value, and lawn-mowing was not significantly different. However, the finding may also suggest a procedural difference in the determination of absolute intensity. Thirty-three percent of the golfing duration was spent at rest while other studies report little to no waiting time on tee-boxes. The current study did demonstrate that the lawn-mowing intensity was equivalent to the listed Compendium values, and validates the values reported in the Compendium of Physical Activities.

Nine holes of golfing and forty minutes of lawn-mowing met the minimum guidelines for daily energy expenditure outlined by the American College of Sports Medicine, the United States Department of Health and Human Services and the Canadian Fitness and Lifestyle Research Institute. This supports the third hypothesis that subjects would experience energy expenditures greater than the minimal daily/session standards. Furthermore, subjects could easily meet the minimum weekly guidelines of 700 kcal•week^{-1} by walking during golf for less than 27 holes•week^{-1}. Frequent yard care may also be sufficient for attaining health improvements through increased energy expenditures. Approximately 2 hr•week^{-1} of grass cutting with a power mower would be sufficient to meet the minimum weekly energy expenditure guidelines.

Lifestyle and recreational physical activity are important components of older adult well-being. Further evaluations into the health benefits and safety of leisure-time physical activities are warranted and will help reinforce the benefits of an active lifestyle in the older adult population. As well, future research is needed to determine the functional health and functional fitness benefits related to golfing and lawn-mowing as well as to other leisure-time physical activities.

5.6 Recommendations

5.6.1 Practical recommendations

Based on the findings of this study, golfing and lawn-mowing are both suitable activities in which healthy older adult males can increase their energy expenditure. However, due to the decreased thermoregulatory capabilities in older adults, caution should be exercised when exercising and working in hot and humid environments

(Kenney & Munce, 2003). Based on our findings, a considerable portion of golfing and lawn-mowing is spent above the training range recommended by the ACSM. Older adults should also minimize the duration at such high intensities during hot and humid days as it may increase their risk of suffering from heat stroke (Kenney & Munce, 2003). For safety, older adults should try to participate in the early morning, wear appropriate clothing, avoid direct sunshine and very hot and humid weather. It is also important that seniors drink plenty of water and rest every ten to fifteen minutes. Despite the low intensity, golfing 18 holes consecutively may not be advisable on hot days for less fit, sedentary older adults.

The current results suggest that during summer months, older adult males could improve their cardiovascular and metabolic health by golfing nine holes of golf three days per week. Older males could expect to expend approximately 900 kcal which would meet the ACSM weekly energy expenditure guideline of 700 to 2000 kcal•week^{-1}. Older adult males who are home-owners may experience a greater energy expenditure and thus health benefit if they mow their lawn with caution at least once per week. It is recommended that older adult males break their lawn-mowing sessions into shorter 10 minute periods which would help keep their heart rates lower and decrease the relative intensity associated with the activity. During each ten-minute lawn-mowing session, older males could expect to expend approximately 60 kcal. Energy expenditure is additive and thus older male homeowners who golf three times per week could see substantial metabolic improvements as weekly energy expenditure would likely exceed 1000 kcal•week^{-1}.

5.6.2 Future research recommendations

The results of this study provide some useful measures of the intensity and appropriateness of golfing and lawn-mowing for improving health in older adult males. Improving the understanding of the benefits of lifestyle and recreational physical activity in older adults, requires that researchers focus on the health benefits related to regular participation in leisure time physical activities such as golfing and lawn-mowing. Measurement of basal metabolic rate, equipment calibration, modifications maximal testing protocol, course selection, field testing equipment and participants are all methodological considerations that may warrant further examination.

The current study did not measure the resting metabolic rate of each individual, but rather employed a standard value used in most of the literature reviewed. It would be beneficial in future studies to use individual resting metabolic rate values which would be more accurate. The current use of the known standard may have resulted in a reduced measure of net energy expenditure and reduced measure of absolute intensity. However, comparisons to previous literature would have become problematic as most literature has used the standard value. Determination of the basal metabolic rate or the oxygen consumption equivalent to 1 MET in different age cohorts may result from further analysis. Absolute intensity thresholds may be generally appropriate for prescribing exercise if appropriate age-associated resting energy expenditures can be determined.

The current study employed a peak graded exercise treadmill test because it was determined that many of the subjects could not meet all criteria required for a maximal graded exercise treadmill test. Future research may find it beneficial to increase the stage duration to 2 minutes to allow older participants to reach steady state which is a requirement of "true" VO_2max measures. Future studies may choose to use different protocols for determining maximal oxygen consumption. The current study employed a modified Balke-Ware protocol, where the treadmill speed was set at either 4.2 or 5.4 $km \cdot hr^{-1}$ and the treadmill grade was increased each minute.

The current study is also limited in that subjects used their own equipment for golfing which was not quantified and differences in the mass associated with golfing equipment may have accounted for the great variability in energy expenditure and intensity. Researchers would be wise to control for equipment mass by using a standard cart and golf bag and limit the golfers to the same numbers of clubs. Or researchers could measure the mass associated with each subject's equipment.

Select cohorts may be susceptible to less frequent participation in regular leisure-time physical activity. These cohorts may include sedentary adults, women, frail older adults, less education and subjects of lower economic status. Finally, the current results are only representative of a healthy older adult male population, familiar with golfing and lawn-mowing. The mean mass of the current sample was 82 kilograms with a mean body mass index of 27. Women were not studied and neither were older adults with any known impairments. Future studies may wish to look at the energy cost associated with golfing and lawn-mowing in these cohorts to enable generalizations about these activities to all Canadians.

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Appendices

A Ethics approval

B Recruitment announcement

C Golf/lawn-mowing familiarity survey

D Health status questionnaire

E Informed consent form

F Medical consent form

G Pre-testing procedures

A - APPROVAL CERTIFICATE

24 March 2003

TO: **James Dear**
(Advisor A. E. Ready)
Principal Investigator

FROM: **Stan Straw, Chair**
Education/Nursing Research Ethics Board (ENREB)

Re: **Protocol #E2003:026**
"Determining Energy Expenditure during Golf and Lawn Mowing in Older Adult Males: Sufficient for Health?"

Please be advised that your above-referenced protocol has received human ethics approval by the **Education/Nursing Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement. This approval is valid for one year only.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note that, if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.

B- Research Study:

Determining Energy Expenditure during Golf & Lawn Mowing in Older Adult Males: Sufficient for Health?

- Are you a non-cardiac patient and a physically active male over the age of 65 years?
- Have you ever golfed or used a lawn-mower?
- This study will involve completion of a health status questionnaire during one information session of 2 hours at the Kinsmen Reh-Fit Centre.
- This study will also require three exercise sessions at the Kinsmen Reh-Fit Centre, John Blumberg Golf Course and the University of Manitoba. Total session time should not exceed 5 hours.
- This study is being conducted in the Faculty of Physical Education and Recreation Studies at the University of Manitoba and has received approval of the University Research Ethics Board.
- If you are interested in learning more about the study or being a participant in this study, contact**:**

Jim Dear
Principle Researcher
474-2536
jamesbdear@yahoo.ca

Dr. Elizabeth Ready
Faculty Advisor
474-8641
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C- Survey – *Golf/Lawn Mowing Familiarity*

Name or Initials:____________________ ***Date:***________________________
Age:____________________________

Golf:

What is your handicap? ____

If handicap unknown, what is your average score for 18 holes? ___________________

When was the last time you played golf? ___________________________________

Between May and August 2002, how many full golf rounds did you play approximately? (circle the most appropriate answer)

1-10 11-20 21-30 31-40 41-50 50+

Between May and August 2002, how many 9 hole golf rounds did you play approximately? (circle the most appropriate answer)

1-10 11-20 21-30 31-40 41-50 50+

Do you walk or ride a golf cart more often when playing golf? ___________________

Do you perceive yourself as comfortably capable of walking 9 holes?______________
If not, please explain your concerns. _______________________________________

____

____

At which course are you a member? If not a member, what course do you play most often? ____

Lawn Mowing:

When was the last time you used a lawn mower? _____________________________

Do you presently have a residence that requires you to use a lawnmower? __________

How long on average does it take you to mow your lawn (in minutes)?
(circle the best answer)

1-10 11-20 21-30 31-40 41-50 51 +

What is the make of your lawn mower (e.g. John Deere, Toro, other)? _____________

Is your lawn mower gas, electric or manual powered? ___________________________

Is your lawn mower manually propelled or self propelled?________________________

Do you have any concerns about using a lawn mower? If yes, please clarify.__________

____

D - Thesis Study: ***Determining Energy Expenditure***
Health Status Questionnaire

A. Personal Information:

NAME ______________________________ DATE ________________________

PHONE _____________________________ DATE OF BIRTH _______________

ATTENDING PHYSICIAN ____

The following questions are designed to obtain a general description of your health status. Complete Confidentiality is assured.

For most people physical activity should not pose any problem or hazard. The Physical Activity Readiness Questionnaire (PAR-Q) has been designed by the Canadian Society of Exercise Physiologists (CSEP) in conjunction with Health Canada to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them (2002). The questions below have been taken from the PAR-Q.

Common sense is your best guide in answering these questions. Please read them carefully and check YES or NO opposite the question if it applies to you. If a question is answered with YES, *please use the available space to explain your answer and give additional details.*

1. Has a doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor? ☐ **YES** ☐ **NO**

2. Do you feel pain in your chest when you do physical activity? ☐ **YES** ☐ **NO**

3. In the past month, have you had chest pain when you were not doing physical activity? ☐ **YES** ☐ **NO**

4. Do you lose your balance because of dizziness or do you ever lose consciousness? ☐ **YES** ☐ **NO**

5. Do you have a bone or joint problem that could be made worse by a change in your physical activity? ☐ **YES** ☐ **NO**

6. Is your doctor currently prescribing drugs for your blood pressure or heart condition? ☐ **YES** ☐ **NO**

7. Do you know of <u>any other reason</u> why you should not participate in physical activity? ☐ **YES** ☐ **NO**

8. Do you currently participate in any regular activity program designed to improve or maintain your physical fitness? ☐ **YES** ☐ **NO**

If yes, what activity program do you participate in? ______________________________
____

Cardiovascular Disease Risk Factor:
Has a doctor or health professional ever told you that you have any of the following conditions?

☐ Heart Disease
☐ Family History of Heart Disease
☐ High Blood Pressure (>145/90)
☐ High Cholesterol
☐ Obesity
☐ Lack of physical activity
☐ Diabetes

If appropriate please explain above:

Medication Use:
Are you currently taking any of the following medications?

☐ Blood Pressure Medication
☐ Cholesterol Medication
☐ Blood Sugar Medication
☐ Heart Medication
☐ Other medication(s)

Please List:

Do you have any of the following?

☐ Back Pain
☐ Joint, tendon, or muscle pain
☐ Lung disease (asthma, emphysema, etc.)

Please Explain:

Which best describes your current smoking status?

☐ I have NEVER smoked or I quit more than 12 months ago.
☐ I CURRENTLY smoke or quit within the last 12 months.

Current Physical Activities

Activity	Frequency	Duration
e.g. Gardening	2-3 times/week	1 hour

Overall State of Health

How would you rate your overall state of health?

☐ Poor ☐ Fair ☐ Good ☐ Excellent

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

NAME: ______________________________

SIGNATURE: ______________________________

DATE: ______________________________

WITNESS: ______________________________

E - *Informed Consent*

Research Project Title: Determining Energy Expenditure during Golf and Lawn Mowing in Older Adult Males: Sufficient for Health?

Researcher: James Dear

This consent form, a copy of which will be left with you for your records and reference, is only 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. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

---

3. The purpose of the proposed study is to examine the energy cost of one hour of non-propelled power lawn mowing, and of nine holes of golf while pulling a cart, in older adult males. Specifically, the purpose of this assessment is to determine whether these activities are sufficient for health benefits in older adult males.

4. In this study you will participate in laboratory and field assessments that will include:

i. One maximal (to exhaustion) graded exercise test (GXT) on a treadmill at the Kinsmen Reh-Fit Centre using the Balke-Ware protocol. This protocol requires walking/running at a constant treadmill speed of 4.2 to 5.4 km/hour. Participants are subjected to a 1 % increase in treadmill grade every minute. This test persists until volitional fatigue;

ii. Nine holes of golf (pulling a cart) at John Blumberg Golf and Country Club;

iii. One hour of non-propelled self-paced lawn mowing at the University of Manitoba soccer grounds;

iv. Height and mass measurements

5. There are certain risks associated with a maximal exercise test. These include abnormal blood pressure, fainting, irregular, fast or slow heart rhythm and in rare instances, heart attack, stroke, or death. Every effort has been made to minimize these risks by evaluation of preliminary information relating to your health and fitness. Careful observations will be made during the exercise testing procedure both by the principal researcher and the physician supervising the procedure. Emergency equipment and well-trained personnel will be present that can deal with any unusual conditions that may arise.

6. During the testing procedures several recording devices will be used to collect data required for the research, these will include;

i. Portable metabolic unit (Cosmed K4b^2, Rome, Italy) which will be used to analyze and record gas exchange and ventilation on breath-to-breath basis;
ii. A 12-lead Electrocardiogram (ECG) which will measure heart function;
iii. A global positioning satellite receiver (GeoExplorer II, Sunnyvale, California) which will be used to movement speed and distance during the field testing procedures;
iv. A research notebook will be used to manually record blood pressure data and any observations made during the laboratory or field tests;

7. Any personal information and experimental data obtained during the course of this research study will be treated as privileged and confidential.

i. Information obtained through the Health Status Questionnaire will be used to help describe (in general terms) the study participants and for screening of the potential participants. It will not be released to any individual without prior written consent from you.
ii. Data obtained during the experimental procedures will be recorded in association with a subject number that only the principal researcher and yourself will know.
iii. The information obtained during this research will be used for statistical analyses and scientific purposes only, with your rights to privacy maintained.

8. The total time commitment required by the participant **will not exceed 8 hours** over several months.
i. A maximum of **2 hours** will be required for the information/screening session at the Kinsmen Reh-Fit Centre in summer, 2003.
ii. A maximum of **1 hour** will be required for the GXT session at the Kinsmen Reh-Fit Centre in summer, 2003.
iii. A maximum of **3 hours** will be required for the golfing session at John Blumberg Golf and Country Club in summer 2003.
iv. A maximum of **2 hours** will be required for the lawn mowing session at the University of Manitoba.

8. Upon study completion you will be informed by mail of the results specific to your participation (i.e. total energy expenditure, intensity equivalents) as well as the general results of the study. If you wish, a copy of the final bound thesis will be available to borrow for a brief period.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and/or refrain from answering questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

James Dear Telephone:
Dr. Elizabeth Ready (advisor) Telephone: 474-8641

This research has been approved by the *Education/Nursing Research Ethics Board.* If you have any concerns or complaints about this project you may contact any of the above-named person or the Human Ethics Secretariat at 474-7122. A copy of this consent form has been given to you to keep for your records and reference

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Participant's Signature	Date
Researcher and/or Delegate's Signature	Date

G - *Preliminary Instructions*

•To increase test validity and maintain data accuracy please adhere to the following instructions prior to you exercise testing session•

1. No vigorous exercise in the preceding 36 hours

2. No caffeine, alcohol or non-prescribed drugs, 6 hours prior to the testing session

3. No food 2 hours prior to the testing session

4. Clothing should permit freedom of movement and include walking, running or golf shoes (for field testing)

5. The assessment may be fatiguing and you may wish to have someone to drive you home after the testing session.

6. Please bring a list of all current medications, including the dosage and administration frequency to the initial testing session. This will be recorded for informational purposes.

Appendix H – Calibration reference ranges and acceptable values

Table H.1: Cosmed calibration values for graded exercise treadmill (GXT) tests.

Variable	Mean (SD)	Range	Predicted Values	Acceptable Values
Digital trimmer	61 (3)	58 - 64	50	0-100
Turbine expiratory gain	1073 (10)	1040-1081	1000	500-1500
Turbine inspiratory gain	1068 (4)	1059-1076	1000	500-1500
Ambient O_2 (%)	20.93 (0)	20.93	20.93	20.83-21.03
Calibration O_2 (%)	16.0 (0)	16.0	16.00	15.90-16.10
O_2 baseline (mV)	-128 (42)	-87-(-282)	0	-500-+500
O_2 gain	1033 (25)	996-1063	1000	500-1500
O_2 delay (msec)	540 (58)	490-650	450	300-1000
Ambient CO_2 (%)	0.03 (0)	0.03	0.03	-0.07-+0.13
Calibration CO_2 (%)	4.0 (0)	4.0	4.00	3.90-4.10
CO_2 baseline (mV)	89 (5)	83-97	100	40-160
CO_2 gain	1019 (10)	1003-1033	1000	500-1500
CO_2 delay (msec)	489 (56)	430-590	450	300-1000

Table H.2: Cosmed calibration values for golfing tests.

Variable	Mean (SD)	Range	Predicted Values	Acceptable Values
Digital trimmer	58 (1)	57 - 60	50	0-100
Turbine expiratory gain	1046 (15)	1028-1092	1000	500-1500
Turbine inspiratory gain	1064 (7)	1046-1074	1000	500-1500
Ambient O_2 (%)	20.93 (0)	20.93	20.93	20.83-21.03
Calibration O_2 (%)	16.0 (0)	16.0	16.00	15.90-16.10
O_2 baseline (mV)	-188 (45)	-102-(-282)	0	-500-+500
O_2 gain	1106 (70)	923-1241	1000	500-1500
O_2 delay (msec)	518 (54)	460-640	450	300-1000
Ambient CO_2 (%)	0.03 (0)	0.03	0.03	-0.07-+0.13
Calibration CO_2 (%)	4.0 (0)	4.0	4.00	3.90-4.10
CO_2 baseline (mV)	87 (6)	78-97	100	40-160
CO_2 gain	1034 (18)	1009-1067	1000	500-1500
CO_2 delay (msec)	468 (53)	410-580	450	300-1000

Table H.2: Cosmed calibration values for lawn-mowing tests.

Variable	Mean (SD)	Range	Predicted Values	Acceptable Values
Digital trimmer	58 (1)	57 - 60	50	0-100
Turbine expiratory gain	1048 (10)	1041-1068	1000	500-1500
Turbine inspiratory gain	1062 (13)	1035-1075	1000	500-1500
Ambient O_2 (%)	20.93 (0)	20.93	20.93	20.83-21.03
Calibration O_2 (%)	16.0 (0)	16.0	16.00	15.90-16.10
O_2 baseline (mV)	-188 (27)	-145-(-223)	0	-500-+500
O_2 gain	1098 (47)	1043-1223	1000	500-1500
O_2 delay (msec)	558 (112)	460-770	450	300-1000
Ambient CO_2 (%)	0.03 (0)	0.03	0.03	-0.07-+0.13
Calibration CO_2 (%)	4.0 (0)	4.0	4.00	3.90-4.10
CO_2 baseline (mV)	87 (5)	78-97	100	40-160
CO_2 gain	1040 (19)	1005-1058	1000	500-1500
CO_2 delay (msec)	508 (111)	410-720	450	300-1000