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MASTERING LIFE: EXPLORING THE PHYSICAL HEALTH OF OLDER MASTERS ATHLETES AND CHESS PLAYERS

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Abstract

The population of older adults is continuing to grow in Canada, due to the proportion of increase in life expectancy and decrease in fertility rate. Unfortunately, a large segment of these older adults are living longer, but with multiple chronic diseases as well as sustaining moderate to severe injury. As a result, unhealthy older adults are at an increased risk for disability, longer hospital stay and rehabilitation, physical dependency, as well as death. Interestingly, participation in various activities have been advocated to improve the well-being of older adults – namely sport and chess. Furthermore, some studies have proposed Masters sport participants as the ideal model of *successful aging*. To investigate this notion, this thesis aimed to examine the rates of injury and prevalence of chronic diseases among Masters Athletes and competitive chess players in comparison to normative data from the Canadian Community Health Survey.

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CHAPTER ONE

General Introduction

Globally, the population of older adults continues to rise. In Canada, the proportion of adults aged 65 and above now outnumbers those aged 0 to 14 years and will account for approximately 20.1% of the population by the year 2024 (Statistics Canada, 2015). This trend has been linked to a decrease in fertility rate and an increase in life expectancy (Canadian Institute for Health Information [CIHI], 2011; Canadian Medical Association, 2016; Statistics Canada, 2015). According to the World Population Aging Report (United Nations, 2015), this change in social structure is proposed to be a significant economic and social transformation, with implications for all sectors of the society. For instance, advances in technology and medicine may have increased the human lifespan, but a large segment of older adults are now living longer with multiple comorbidities such as hypertension, arteritis, heart disease and more (Canizares, Gignac, Hogg-Johnson, Glazier, & Badley, 2016). According to the Canadian Medical Association (2016), approximately 70 to 80% of older persons reported one or more chronic disease in the past year.

In an effort to sustain the health care of this population, the current combined Canadian operating budget deficit of $15 billion is expected to rise to a net borrowing of $30 billion in the coming years (Canadian Medical Association, 2016). Moreover, chronic disease medications for older adults with a low household income are primarily financed through private insurance or personal expenditures (Hennessy et al., 2016). For instance, 9% of older adults indicated spending $2000 or more per a year on services, while those who faced cost-related barriers choose to ignore medical treatments and instead spend on other daily necessities. (Canadian Medical Association, 2016; The Globe and Mail, 2015). Sacrificing either daily necessities (e.g., food, rent) or chronic disease treatments (e.g., prescriptions, medical tests) can have serious consequences on the overall health. In contrast, while prescribed medications are important in managing chronic disease, older adults who take five or more medications (i.e., polypharmacy) may also increase the risks of side effects and negative drug interactions (CIHI, 2011). Therefore, the Canadian Health Care system urgently needs to recognize the complex issues surrounding chronic diseases sufferers, as well as fund programs that either help manage or mitigate them.

Another growing concern among aging Canadians is the increased risk of injury from falling. Up to 40% of admissions to nursing homes and 62% of hospitalizations involve older adults who were injured from a fall (Canadian Medical Association, 2013). In some cases, the manifestation of cognitive impairment (e.g., dementia,), side effects from medications (e.g., dizziness), and/or chronic diseases increase the risk of a fall (Chippendale, Gentile, James, & Melnic, 2016; Health Canada, 2011). Furthermore, 20 to 30% of falls are associated with moderate to severe injury such as traumatic brain injury (TMI), sprains, fractures, torn tendons, and/or dislocations (Chippendale et al., 2016). In comparison to younger adults, severe injuries sustained by older adults can result in disability, longer hospital stay and rehabilitation, a high risk of dependency, as well as a high risk of death (World Health Organization, 2002).

Interestingly, a key constraint for involvement in physical activity is the presence of chronic disease or injury, which is paradoxical since involvement in physical activity is a key preventative strategy for mitigating chronic disease risk. Given the well-established health benefits of lifelong physical engagement, as well as other preventive strategies such as participation in cognitively engaging activities, eating a balanced diet and limiting use of tobacco and alcohol (CIHI, 2011; Canadian Medical Association 2013, 2016; Ministry of Health, 2005;

Public Health Agency of Canada, 2010; WHO, 2002), it is not surprising that many governments now endorse the concept of *successful aging* which includes related terms such as healthy aging, positive aging, and active aging (Rowe & Kahn, 1987, 1997). According to Rowe and Kahn's (1987, 1997) model, successfully aging adults (i) avoid disease and disability, (ii) maintain a high cognitive and physical function, and (iii) are actively engaged with life. Older adults who regularly engage in a wide array of activities are generally considered *healthier* than inactive older adults. These leisure activities can encompass a wide spectrum of activities that can be physical (e.g., sports activities, walking and dancing), cognitive (e.g., playing chess, crosswords or reading) and social (e.g., spending time with friends).

Previous research on the value of physically and cognitively engaging leisure activities among older adults has demonstrated a lower risk of developing chronic diseases (e.g., diabetes, heart disease or osteoporosis) among those who are long-term engagers (Ashe, Miller, Eng, & Noreau, 2008; Bassuk & Manson, 2005). In addition, Booth and colleagues (2000) established that at least 17 unhealthy conditions, the majority of which were chronic diseases, could be mitigated in individuals who are physically active. Yet despite the beneficial relationships with physical activity, older adults with a chronic disease are at an even greater risk of inactivity than older adults in general (Health Canada, 2002). Evidence from the Canadian Community Health Survey, a representative survey of health and preventive behaviours of the Canadian population, indicated that only 23% of older adults with a chronic condition met the physical activity guidelines in contrast to 30% of older adults without any chronic conditions (Ashe et al., 2008).

Interestingly, because of their active engagement in competitive sport, older *Masters Athletes* have emerged as an important group for many researchers (e.g., Dionigi, 2006; Lyons & Dionigi, 2007). Generally, Master Athletes are over the age of 35 who continue to train and participate in athletic competitions designed for older adults, such as the World Masters Games (Tayrose, Beutel, Cardone, & Sherman, 2015; Weir, Baker, & Horton; 2010). They may be experienced competitors who participated in sport from early age or individuals returning after an injury and/or inactivity (Tayrose et al., 2015). Intriguingly, Masters Athletes have been proposed as the gold standard of successful aging (Hawkins, Wiswell & Marcell, 2003) despite having a limited understanding on the value of competitive sport on the health and functioning of older adults (Dionigi, Baker & Horton, 2011; Heo et al., 2013). Instead, a large body of literature has focused on the benefits of low to moderate exercise intensity (e.g., walking, dancing and fitness classes; Dionigi, Baker & Horton, 2011), or on areas such as maintaining performance despite declines in physical function and modulating factors responsible for age-related decline (Maharam, Bauman, Kalman, Skolnik & Perle, 1999; Reaburn & Dascombe, 2008; Tanaka & Seals, 2003, 2008).

Research on some aspects of health suggests the risk of certain chronic diseases (e.g., chronic chest pain, asthma, heart attack and diabetes) is lower for older athletes who participated in Master Sport (Kettunen, Kujala, Kaprio, & Sarna, 2006). However, Masters Athletes also report a higher likelihood for injury, although the type of injury sustained seems to depend on the activity. For instance, runners above the age of 45 reported significantly greater rates of shoulder and Achilles tendinopathy or rupture, compared to weightlifters and soccer players who reported greater rates of lower-back injury (Kettunen et al., 2006). In contrast, Masters football players predominantly reported muscle and/or tendon strain in the lower body as the most common site of injury (Walsh et al., 2013). Older Masters track and field athletes are also at a greater risk of injury in comparison to younger athletes (Opar et al., 2015). While these results provide some information on the health status of older athletes, to the best of our knowledge no study has explored the prevalence of injury in older Masters Athletes in comparison to non-athletes. This may be valuable since the inherent risk of injury associated with sport has been related with developing a chronic disease later on in life. For example, due to continual sport participation, individuals who experienced overuse injuries resulting in microtrauma may accelerate the risk of developing chronic diseases such as osteoarthritis (Saxon, Finch & Bass, 1999). Similarly, underlying conditions such as osteoporosis as well as repetitive motions when exercising are reported as the common risk factors for severe injury (e.g., fracture, dislocation or crushing injury) in women aged 65 and above (Jones & Turner, 2005).

While Masters Athletes have been proposed as models of successful aging, participation in sport represents only one of the many types of active engagement older adults may experience. Besides sport, other forms of engagement may also benefit older adults in maintaining components of successful aging (e.g., cognitive function). Given that the number of older adults with dementia is expected to rise by 66% over the next 15 years (Canadian Medical Association, 2016), it is important to compare the benefits of sport involvement to other forms of engagement. Evidently, individuals with optimal cognitive function are also associated with a decreased risk for functional disability, as well as lower demands for health care (Kelly et al., 2014).

Previous research on cognitive engagement has extensively focused on how participation in this activity affects mental and/or cognitive health. For instance, older adults who participate in common information-processing activities (i.e., reading newspapers, playing cards, checkers, crosswords or other puzzles) are at a reduced risk for dementia, specifically Alzheimer's Disease (Scarmeas, Levy, Tang, Manly & Stern, 2001; Wilson et al., 2002). In addition, longitudinal studies have explored significant positive associations between cognitively engaging activities across the lifespan and level of cognitive performance (Hertzog, Kramer, Wilson, &

Lindenberger, 2009). Coincidentally, by participating in mentally stimulating activities, many older adults help to dispel the negative stereotypes (e.g., senile, forgetful or confused) associated with aging and cognitive decline.

Interest and involvement in sport (and other forms of physical activity) are complex phenomena and, as a result, it is important to recognize that declines in cognitive function may be associated with an inability to initiate sport or other forms of engagement. Effective brain function is crucial in managing general activities of daily living (ADLs) such as taking medical prescriptions, appointments, driving, or completing household chores (Weir, Meisner & Baker, 2010). A decline in cognitive function can be a significant contributor to a loss of physical independence and inability to complete ADLs. Older adults who are unable to complete their ADLs may also be less likely to take up competitive hobbies since they can require commuting to various locations, as well as an optimal physical and cognitive function. Interestingly, impaired cognitive function has also been related to prevalence of chronic diseases such as coronary heart disease, atherosclerosis, and chronic obstructive pulmonary disease (Moss, Franks, Briggs, Kennedy, & Scholey, 2005; Ylikoski et al., 2000). Additionally, longitudinal research in this area has supported a significant relationship between hypertension and cognitive performance (Sands & Meredith, 1992). Findings from these studies highlight the importance of examining health outcomes associated with sport and cognitive engagement. Progression in this area will advance our understanding on how sport and cognitive activity affect health and function of older adults.

Thesis Objective

Modifiable lifestyle factors (e.g., cognitive and physical engagement) may have several associated health benefits for older adults. As such, the purpose of this thesis was to compare the health outcomes of physical and cognitive engagement in relation to Masters Athletes, in older adults aged 50 and above. Specifically, the study examined the rate of physical injuries and prevalence of chronic diseases reported by Masters Athletes and chess players, in comparison to normative data from the Canadian population.

CHAPTER TWO

Manuscript

Masters or pawns? Examining injury and chronic disease among older athletes and chess players.

Shruti Patelia, Rachael C. Stone, Rona El-Bakri and Joseph R. Baker

Note: All references are provided at the end of the thesis

Abstract

Masters Athletes have been proposed as the ideal model of successful aging; however, little is known about the physical health of older athletes. Similarly, given the importance of cognitive engagement to successful aging, it is surprising that no study has investigated the physical health of older adults involved in cognitive activities. To this end, the current study aimed to compare the rates of physical injury and prevalence of chronic disease among Masters Athletes and chess players compared to moderately-active adults and inactive adults aged 50 and above. Masters Athletes and chess players were recruited from various Master track and field and chess competitions within the province of Ontario and profiles of injury and disease were compared to population norms (for moderately active and inactive older adults) drawn from the Canadian Community Health Survey (CCHS). Masters Athletes had a significantly higher rate of injury and the lowest prevalence of chronic disease, compared to all other activity groups. In contrast, chess players reported a lower rate of injury compared to Masters Athletes as well as a lower prevalence of chronic diseases compared to the moderately active and inactive groups. The normative groups reported the lowest rate of injury but an increased prevalence of chronic diseases compared to Masters Athletes and chess players. Findings highlight the importance of expanding the notion of successful aging to other activities, since participating in chess was associated with a lower prevalence of chronic disease and lower risk of injury.

Introduction

Older adults aged 65 and above are now outnumbering those below the ages of 14 years, due to consistent increases in human lifespan and decreases in fertility rates (CIHI, 2011; Canadian Medical Association, 2016; Statistics Canada, 2015). In conjunction with this trend, the majority of older adults have an increased likelihood of living longer with multiple comorbidities (e.g., arthritis, high blood pressure, injury) that can require continual financial and medical care. Unfortunately, the current health care was designed to provide acute, episodic care for a relatively young population, however; with approximately 75 – 80% of older adults reporting prevalence of one or more chronic diseases, the Canadian health care system will likely struggle in managing the complex health care needs of this rising population (CIHI, 2011; Canadian Medical Association, 2016). Furthermore, older adults with cost-related barriers may skip medical treatments because they cannot afford the expenditure, which amount to approximately $2000 per a year on chronic disease management (Canadian Medical Association, 2016; Hennessy et al., 2016). As a result, ignoring medical treatments or services can increase the likelihood of serious consequences such as mortality, use of emergency care and in-patient services (Hennessy et al., 2016)

In contrast, participating in modifiable lifestyle factors (e.g., nutritious diet, physical and cognitive engagement) may be a feasible option to manage or mitigate some health related issues among older adults. As such, in an effort to improve the current health and wellness of older adults, many government strategies (CIHI, 2011; Canadian Medical Association, 2016; Health Canada, 2002) endorse the concept of healthy aging or its related terms - positive aging, active aging, and most prominently, *successful aging* (Rowe & Kahn, 1987, 1997). According to Rowe and Kahn’s (1987, 1997) model, successfully aging adults (i) avoid disease and disability, (ii) maintain a high cognitive and physical function, and (iii) are actively engaged with life.

Currently, there is considerable evidence of the benefits of maintaining an active lifestyle irrespective of age (Ashe, Miller, Eng, & Noreau, 2008; Bassuk & Manson, 2005), although studies on older adults have predominantly focused on activities with low to moderate exercise intensity (i.e., walking, dancing, fitness classes; Dionigi, Baker & Horton, 2011). As a result, we have little information on the health outcomes associated with older adults who regularly participate in more intensive activities such as organized sport (Baker, Fraser-Thomas, Dionigi, & Horton, 2010; Dionigi, 2006, 2008). However, the growing number of baby boomers competing in sport has recently caught the attention of many researchers. Since its formation in 1975, the number of competitors in the World Masters Athletics Championship has more than quadrupled from 1400 to 4800 competitors in 2011 (World Masters Athletics, 2017). Similarly, participation in the World Masters Games has also increased from 8305 competitors in 1985 to 15,394 in 2013. In Canada, a 2 to 3-fold increase was observed in the number of sport participants aged 55 and above (Mckean, Manson, & Stanish, 2006). As the proportion of older Canadians continues to rise, the number of participants who can compete in sport at more advanced ages will also almost certainly rise. This proliferation has motivated researchers to increase their understanding of *Masters Athletes,* defined as individuals generally above the age of 35 who continually maintain a high intensity of exercise by competing in Master sport (Weir, Baker & Horton, 2010). Additionally, despite having little information on the health and functional benefits of competitive sport (Dionigi, Baker & Horton, 2011; Heo et al., 2013), some researchers have proposed Masters Athletes as the ideal model of successful aging (Hawkins, Wiswell & Marcell, 2003).

A large body of empirical evidence with this group has focused on areas such as maintaining performance despite declines in physical function or modulating the factors responsible for age-related decline (Maharam, Bauman, Kalman, Skolnik & Perle, 2012; Reaburn & Dascombe, 2008; Tanaka & Seal, 2003, 2008). Interestingly, the few studies that have explored the health and functioning of older athletes, suggested continual participation in Master Sport was associated with lower risk of certain chronic diseases (e.g., chronic chest pain, asthma, heart attack and diabetes; Kettunen, Kujala, Kaprio, & Sarna, 2006). However, no study has explored the prevalence of injury in older Masters Athletes in comparison to non-athletes. This could be important, since regular sport participation can accelerate the onset of conditions such as osteoarthritis as a result of overuse injuries, whereas some chronic diseases (e.g., osteoporosis) can increase the risk of severe injury (Jones & Turner, 2005; Kettunen et al., 2006; Saxon, Finch & Bass, 1999). In addition, since Rowe and Kahn's model of successful aging stresses the importance of avoiding disease and disability (e.g., avoiding injury), exploring rates of injury within Masters Athletes is necessary before concluding they are the gold standard for successful aging.

Importantly, despite increased attention on the need for sport and exercise in older adults, most are inactive (Grant, 2001). In Canada, for example, from 2007 to 2011 only 11% of adults aged 60 to 70 reported meeting the Canadian physical activity guidelines in conjunction with a high total sedentary time (i.e., 10 hours and 8 minutes/per day; Statistics Canada, 2015). From a health promotion standpoint, advocating sport as a preventive health strategy may be problematic, particularly for individuals who have internalized the pervasive old age stereotypes in North American society and may be likely to avoid participation in competitive sport (Baker, Fraser-Thomas, Dionigi, & Horton, 2009). Furthermore, physical impairments, debilitating chronic diseases and/or socio-demographic barriers can limit participation in sport.

Moreover, sport is extolled as a key activity for promoting successful aging in older adults, but it represents only one of the many types of active engagement they may experience. Additionally, other types of activities may be equally (or more) beneficial for maintaining other components of successful aging. For example, a 66% rise in older adults with dementia is expected to occur over the next 15 years (Canadian Medical Association, 2016). According to much of the research literature, cognitive engagement has many associated mental health benefits (e.g., improvement of memory or delaying Alzheimer's Disease) and can be useful for maintaining cognitive performance (Reingold, Charness Pomplun, & Stampe, 2001). In contrast, several studies (Moss et al., 2005; Sands & Meredith, 1992; Ylikoski et al., 2000) have found older adults with chronic diseases (e.g., hypertension, heart disease, chronic obstructive pulmonary disorder) to score significantly lower on cognitive performance tasks (e.g., block design, object assembly, word recall, visuospatial tests) compared to older adults without chronic diseases.

Interestingly, none of the studies of Masters Athletes has considered them relative to other forms of engagement. To this end, we compared older adults who participated in competitive sport with similar aged older adults who were active competitors in chess. This activity was chosen because of its popularity amongst older adults, objective performance measure (i.e., Elo score), and the intense practice required to become an expert competitive participant (Salthouse, 2006). This allows for an intriguing comparison between older adults who are highly physically active with those who are highly cognitively active. Moreover, exploring competitive chess may increase our understanding on the health outcomes associated thoseolder adults who are actively engaged in a sedentary activity outside of sport. In this study, the rate of physical injuries and prevalence of chronic diseases reported by Master Athletes and active chess players were compared to normative data from the Canadian Community Health Survey (CCHS) for older adults aged 50 and above. Based on limited past research, we expect Master Athletes would have the highest rates of injury but the lowest prevalence of chronic disease due to their continual participation in vigorous activity. Conversely, inactive adults are expected to have lowest rate of injury and increased chronic diseases, due to their inactive lifestyle.

Methods

Participants

Masters Athletes and competitive chess players were recruited voluntarily from local track and field Master sport events or chess competitions organized by the Chess Federation of Canada. Sampling was limited to track and field events and chess competitions to decrease the variability between different physical or cognitive activities. In addition, electronic versions of the questionnaires were distributed by email to registered Canadian Masters Athletes and chess players. A total of 146 Masters Athletes completed the survey, of which, 108 were aged 50 or above and completed the injury and chronic disease sections relevant for this investigation. Similarly, from a total of 68 chess players, 50 were aged 50 and above and were included in the current analysis. Informed consent was obtained from all participants prior to completing the survey and this project received institutional ethics approval.

Normative data. The *Canadian Community Health Survey* (CCHS) cycle 4.1 provided the normative data for this study (N= 131,486; Statistics Canada, 2007). Participants included in the CCHS questionnaire range from ages 12 years and above who are residing in 10 provinces and 3 territories. Participants are excluded if they (1) live on reserves and Aboriginal settlements in the provinces, (2) full-time members of the Canadian Forces and (3) the institutionalized population and persons living in the Quebec health regions of Région du Nunavik and Région des Terres-Cries-de-la-Baie-James. These exclusions in total represent less than 3% of the target population (Health Canada, 2006). After providing consent, Canadians voluntarily responded to the CCHS questionnaire via telephone through a computer-assisted interview.

Due to the complexity of comparing a recruited sample with a normative dataset, two separate data sets were organized in the Statistical Package for Social Sciences (SPSS, v24). Since many sections within the CCHS were optional, the overall sample was first restricted to those who completed the injury and chronic disease portion, as well as those who were “moderately active” or “inactive” older adults. Respondents who were considered “active”, had missing information or were below the age of 50 were removed. As a result, participants who provided complete sets of data and were aged 50 and above were included in this study. A sub-sample of 1609 moderately active, 2679 inactive older adults, 108 Masters Athletes and 50 chess players were used for the first part of the investigation. A second sub-sample was created from the first dataset by case-matching Masters Athletes from the moderately active and inactive older adults used in Phase 1. As a result, this sub-sample consisted of 108 moderately active and 108 inactive older adults, and was used for the second part of the analyses. All datasets had consistent information from Masters Athletes and chess players.

Measures

Outcome variables

The present study focused on two main outcome variables: 1) occurrence of injury and 2) chronic disease in the past 12 months.

Injuries. Prevalence of an injury was measured using the following questions from the CCHS 4.1: *In the past 12 months, did you experience an injury?* If participants answered “yes” to this question, they were requested to provide whether they sustained “one”, “two”, “three to five”, or “six or more injuries”. Participants were coded based on the number of injuries they experienced.

Chronic disease. Chronic disease was examined using the following question: *In the past 12 months, were you diagnosed by a health professional with a type of chronic disease?* Participants responded to the following options for chronic diseases: (1) Asthma, (2) Arthritis (3) Back problems, (4) High blood pressure, (5) Migraine headaches, (6) Chronic bronchitis, (7) Emphysema, (8) Chronic obstructive pulmonary disease (COPD), (9) Diabetes, (10) Heart disease, (11) Cancer, (12) Intestinal or stomach ulcers, (13) Stroke, (14) Urinary incontinence, and (15) Bowel disorder (Crohn’s Disease, ulcerative colitis, Irritable Bowel Syndrome or bowel incontinence). In order to analyze chronic disease as a single variable, all fifteen chronic diseases questions were combined into a total score, where a score of 30 (i.e., sum of all “no = 2”) would equal to “no chronic disease”, 29 = “one chronic disease”, 28 = “two chronic diseases” and so on. As a result, by using the sum of “yes = 1” and “no = 2”, respondents were coded as prevalent with either zero, one, two, three, or four or more chronic diseases.

Predictor Variable

Physical activity index. The CCHS 4.1 includes a *physical activity index* based on reported leisure time physical activities during the past 3 months, representing the average daily energy expended (EE)[1]. Accordingly, participants are categorized as moderately activity when their physical activity index is between 1.5 to <3 kcal/kg/d and inactive adults if their value is

[1] EE (energy expenditure) = Frequency of the activity x Duration of activity (hours) x MET value (kcal.kg.hr) / 365 days

lower than 1.5 kcal/kg/d. This project used this categorization to identify the moderately active and inactive groups. The active group (i.e., >2.9 kcal/kg/d) was removed from the dataset to ensure high levels of physical activity and exercise are not confounded with Masters Athletes who are vigorously active within sport. Similarly, chess players who expended >2.9 kcal/kg/d were removed from the dataset. This step ensured that respondents who maintain a high physical activity level by participating in various sports are removed.

Covariates

In line with previous research, this study accounted for possible socio-demographic variables that may pose as confounders such as sex, marital status, income, education, and age (Moreira, Mazzardo, Vagetti, De Oliveira & De Campos, 2015). Respondents specified if they were “male” or “female” and whether they were “married or in a domestic partnership”, “divorced/widowed/separated” or “single/never married”. For income, participants specified if they had a household income of “≤ $60,000”, “$60,000 - $79,999” or “≥ $80,000”. Participants also specified their highest level of education as either “less than secondary”, “secondary graduate”, “other post-secondary graduate” or “post-secondary graduate”. Lastly, respondents answered whether they were between ages “50 – 59 years”, “60 – 69 years”, “70 – 79 years” or “80 and above”.

Analyses

The vastly different sample sizes in each group presented some statistical concerns for our analyses. Therefore, we considered a multi-pronged approach to exploring these data. First, preliminary analyses were conducted to understand differences in injury and chronic disease prevalence between groups with various activity levels. Results from these preliminary analyses suggested Masters Athletes were not normally distributed in their demographics in comparison to moderately active and inactive older adults. Because of the departures from normality, Kruskal-Wallis non-parametric tests were performed to compare the four groups. Separate analyses on both injuries and chronic disease outcomes indicated that at least one sample stochastically dominated another sample, which justified further non-parametric and parametric exploratory analyses.

In order to further understand where this stochastic dominance occurred, an analysis of covariance (ANCOVA) was conducted for injuries and chronic diseases, with age, sex, marital status, income and education as covariates. The Bonferroni post hoc tests (alpha adjusted to $p \leq 0.0125$) available in the ANCOVA analyses allowed for the identification of between group differences. Results from this analysis suggested moderately active and inactive older adults were significantly different than Masters Athletes in age, sex, education and income[2]. As a result, the final phase involved a case-match selection for a random selection of moderately active (n=108) and inactive (n=108) older adults[3]. Since income, education and sex are known to be closely related (Statistics Canada, 2016), we case matched with one of these covariates (i.e., income) as well as with age. As expected, this resulted in all covariates having non significant p-values. This final phase was performed to eliminate the potential confounders and gain coherence between groups in the final analyses. Examining these non-parametric, parametric and case-matched analyses would allow us to determine whether the pattern of results converges on a conclusion and thereby increase the validity of our final results.

[2] Masters athletes were predominantly males aged 50-59 years, with a post secondary graduate degree and a total household income of $80,000 or more

[3] Because chess players had a smaller sample size than the Masters Athletes and were not significantly different in demographics from this group, they were not case-matched.

Results

Phase I: Activity groups prior to case-matching

Descriptives. A greater proportion of Masters Athletes were males, aged 50 to 59 years, with a total household income of $80,000 or more and post secondary graduates. Similarly, an increased number of chess players reported a total household income of $80,000 and were between the ages of 50 to 59 years; however, in comparison to all other subsets 100% of chess players were males. For the prevalence of an injury, 12.2% from the total sample (N = 4446) sustained an injury in the past 12 months, while 87.8% reported no injury. Among the injured older adults, Masters Athletes indicated sustaining the highest number of injuries (65.7%), compared to moderately active (11.4%), inactive (10.3%) and chess players (24%). Regarding chronic disease prevalence, of the 76.6% who experienced some type of chronic disease in the past 12 months, 75.9% were moderately active and 80.6% were inactive older adults. In contrast, 89.8% of Masters Athletes and 70% of chess players reported no chronic disease. Descriptive statistics for the activity groups are presented in Table (1.1).

Non-parametric tests. The Kruskal-Wallis tests indicated a statistically significant difference in the number of injuries experienced between various physical activity groups, $X^2(3) = 337.85$, $p<0.001$ and in the prevalence of chronic disease between the groups, $X^2(3) = 258.36$, $p<0.00$, respectively.

Parametric tests: Injury. Table 1.2 reveals the individual mean values from an analysis of covariance (ANCOVA) between groups, with age, sex, marital status, education and income as covariates suggested incidence of injury was higher in Masters Athletes compared to chess players and the normative groups. According to the *post hoc* comparisons (alpha adjusted to $p\leq0.0125$), there were no significant differences between the number of injuries sustained by older adults and covariates such as age F(1, 0.002) = 0.011, p = 0.918, sex F(1, 0.138) = 0.682, p =0.409, marital status F(1, 1.06) = 5.21, p = 0.022, or income F(1, 0.365) = 1.80, p = 0.180. In contrast, the number of reported injuries were statistically significant with physical activity groups F(3, 40.14) = 197.84, p<0.0125, $\eta^{"}$= 0.12 as well as with education F(1, 1.602) = 7.90, p<0.0125, $\eta^{"}$= 0.002. Pairwise comparisons between incidence of injury and activity groups indicated that both Masters Athletes and chess players were significantly different (p<0.0125) from each other, as well as from moderately active (p<0.0125) and inactive (p<0.0125) participants. Conversely, there was no significant difference between moderately active (p=1.00) and inactive older adults (p=1.00).

Parametric tests: Chronic disease. Individual mean values from an analysis of covariance (ANCOVA) with age, sex, marital status, education and income as covariates suggested the prevalence of chronic diseases was lowest in Masters Athletes compared to the moderately active, inactive, and chess players (Table 1.2).

Results from the *post hoc* tests indicated no main effects from covariates such as marital status, F(1, 6.26) = 2.65, p= 0.103, or education, F(1, 9.57) = 4.06, p = 0.044 on the prevalence of chronic disease. However, significant effects were found for age F(1, 358.02) = 151.69, p<0.0125, sex F(1, 56,19) = 23.81, p<0.0125, and income F(1,158.88) = 67.32, p<0.0125. As expected, there were statistically significant differences between the activity groups on the prevalence of chronic disease, F(3, 91.97) = 38.97, p<0.0125, $\eta^{"}$= 0.026. In addition, moderately active and inactive older adults were significantly different from all groups (p<0.0125).

Table 1.1

Descriptive statistics for all variables in the study sample (n=4446)

Variable	Physical Activity Groups				
	Masters Athletes (n=108)	Moderately Active (n=1609)	Inactive (n=2679)	Chess (n=50)	**Total**
Age					
50 - 59 years	49 (45.4%)	604 (37.5%)	944 (35.2%)	20 (40.0%)	36.4%
60 - 69 years	33 (30.6%)	542 (39.9%)	766 (28.6%)	17 (34.0%)	30.5%
70 - 80 years	19 (17.6%)	306 (19.0%)	576 (21.5%)	8 (16.0%)	20.4%
80 and above	7 (6.5%)	157 (9.8%)	393 (14.7%)	5 (10.0%)	12.6%
Sex					
Male	68 (63.0%)	691 (42.9%)	1140 (42.6%)	50 (100%)	43.8%
Female	40 (37.0%)	981 (57.1%)	1539 (57.4%)	0 (0%)	56.2%
Marital status					
Married and domestic partnership	57 (52.8%)	947 (58.9%)	1410 (52.6%)	30 (60.0%)	55.0%
Divorced/Widowed/Separated	16 (14.8%)	520 (32.3%)	1018 (38.0%)	11 (22.0%)	35.2%
Single/ Never married	35 (32.4%)	142 (8.8%)	251 (9.4%)	9 (18.0%)	9.8%
Income					
< $60,000	20 (18.5%)	1011 (62.8%)	1941 (72.5%)	22 (44.0%)	67.3%
$60,000 - $79,999	10 (9.3)	208 (12.9%)	302 (11.3%)	4 (8.0%)	11.8%
$80,000 or more	78 (72.2%)	360 (24.2%)	436 (16.3%)	24 (48.0%)	20.9%
Highest level of Education					
< Than Secondary	5 (4.6%)	324 (20.1%)	745 (27.8%)	3 (6.0%)	24.2%
Secondary graduate	5 (4.6%)	260 (16.2%)	460 (17.2%)	5 (10.0%)	16.4%
Other post-secondary	13 (12.0%)	123 (7.6%)	203 (7.6%)	14 (28.0%)	7.9%
Post-secondary graduate	85 (78.7%)	902 (56.1%)	1271 (47.4%)	28 (56.0%)	51.4%
Injury					
Yes	71 (65.7%)	183 (11.4%)	275 (10.3%)	12 (24.0%)	12.2%
No	37 (34.3%)	1426 (88.6%)	2404 (89.7%)	38 (76.0%)	87.8%
Chronic Disease					
Yes	11 (10.2%)	1221 (75.9%)	2160 (80.6%)	15 (30.0%)	76.6%
No	97(89.8%)	388 (24.1%)	519 (19.4%)	35 (70.0%)	23.4%

Table 1.2

ANCOVA for the difference in injury and chronic between various physical activity level before case matching.

Self reported Injury	**n**	**Mean (SD)**	**Significant post-hoc tests**
(A) Masters Athletes	108	1.23 (1.21)	AxB*, AxC*, AxD*
(B) Moderately Active	1609	0.14 (0.42)	BxA*, BxD*
(C) Inactive	2679	0.12 (0.38)	CxA*, CxD*
(D) Chess	50	0.58 (1.18)	DxA*, DxB*, DxC*
Self reported chronic disease			
(A) Masters Athletes	108	0.13 (0.43)	AxB*, AxC*
(B) Moderately Active	1609	1.68 (1.51)	BxA*, BxC*, BxD*
(C) Inactive	2679	2.03 (1.70)	CxA*, CxB*, CxD*
(D) Chess	50	0.48 (0.84)	DxB*, DxC*

Note. Bonferroni adjusted $p \leq 0.0125$
Age, sex, income and education were significantly different between groups ($p \leq 0.0125$)
SD= Standard deviation
n = number of participants

Phase II: Case-matched activity groups

Table 1.3 provides an overview of all the variables in the final case-matched analysis with a subsample of n=374 participants.

Nonparametric tests. According to the mean scores from the Kruskal-Wallis tests, Masters Athletes stochastically dominated all activity groups in number of injuries reported $X^2(3) = 98.92$, p<0.001. Whereas, a separate analysis for chronic diseases revealed the inactive group to stochastically dominate all other activity groups, $X^2(3) = 91.26$, p<0.001.

Parametric tests: Injury. Table 1.4 provides an overview of mean values from the analysis of covariance (ANCOVA) between groups, with age, sex, marital status, education and income as covariates. In congruence with results prior to case matching, the incidence of injury was higher in Masters Athlete in comparison to chess players and normative activity groups. Since activity groups were matched on certain covariates (i.e., income and age), *post hoc* tests indicated only the differences in type of activity as statistically significant $F(3, 23.36) = 35.57$, $p < 0.0125$, $\eta^{''} = 0.21$.

Table 1.3

Descriptive statistics for all variables in the study sample (n=374)

Variable	Masters Athletes (n=108)	Moderately Active (n=108)	Inactive (n=108)	Chess (n=50)	**Total**
	Physical Activity Groups				
Age					
50 - 59 years	49 (45.4%)	49 (45.4%)	49 (45.4%)	20 (40.0%)	44.7%
60 - 69 years	33 (30.6%)	33 (30.6%)	33 (30.6%)	17 (34.0%)	31.0%
70 - 80 years	19 (17.6%)	19 (17.6%)	19 (17.6%)	8 (16.0%)	17.4%
80 and above	7 (6.5%)	7 (6.5%)	7 (6.5%)	5 (10.0%)	7.0%
Sex					
Male	68 (63.0%)	64 (59.3%)	62 (57.4%)	50 (100%)	65.2%
Female	40 (37.0%)	44 (40.7%)	46 (42.6%)	0 (0%)	34.8%
Marital status					
Married and domestic partnership	57 (52.8%)	81 (75.0%)	80 (74.1%)	30 (60.0%)	66.3%
Divorced/Widowed/Separated	16 (14.8%)	20 (18.5%)	21 (19.4%)	11 (22.0%)	18.2%
Single/ Never married	35 (32.4%)	7 (6.5%)	7 (6.5%)	9 (18.0%)	15.5%
Income					
< $60,000	20 (18.5%)	20 (18.5%)	20 (18.5%)	22 (44.0%)	21.9%
$60,000 - $79,999	10 (9.3)	10 (9.3)	10 (9.3)	4 (8.0%)	9.1%
$80,000 or more	78 (72.2%)	78 (72.2%)	78 (72.2%)	24 (48.0%)	69.0%
Highest level of Education					
< Than Secondary	5 (4.6%)	12 (11.1%)	16 (14.8%)	3 (6.0%)	9.6%
Secondary graduate	5 (4.6%)	18 (16.7%)	24 (22.2%)	5 (10.0%)	13.9%
Other post-secondary	13 (12.0%)	7 (6.5%)	5 (4.6%)	14 (28.0%)	10.4%
Post-secondary graduate	85 (78.7%)	71 (65.7%)	63 (58.3%)	28 (56.0%)	66.0%
Injury					
Yes	71 (65.7%)	16 (14.8%)	14 (13.0%)	12 (24.0%)	30.2%
No	37 (34.3%)	92 (85.2%)	94 (87.0%)	38 (76.0%)	69.8%
Chronic Disease					
Yes	11 (10.2%)	69 (63.9%)	70 (64.8%)	15 (30.0%)	44.1%
No	97 (89.8%)	39 (36.1%)	38 (35.2%)	35 (70.0%)	55.9%

Table 1.4

ANCOVA for the difference in injury and chronic between various physical activity level after case matching.

Self reported Injury	**n**	**Mean (SD)**	**Significant post-hoc tests**
(A) Masters Athletes	108	1.23 (1.21)	AxB*, AxC*, AxD*
(B) Moderately Active	108	0.17 (0.42)	BxA*
(C) Inactive	108	0.16 (0.46)	CxA*
(D) Chess	50	0.58 (1.18)	DxA*
Self reported chronic disease			
(A) Masters Athletes	108	0.13 (0.43)	AxB*, AxC*
(B) Moderately Active	108	1.31 (1.35)	BxA*, BxD*
(C) Inactive	108	1.33 (1.43)	CxA*, CxD*
(D) Chess	50	0.48 (0.84)	DxB*, DxC*

Note. Bonferroni adjusted $p \leq 0.0125$
All covariates were not significantly different ($p \geq 0.0125$) after case-matching.
SD= Standard deviation
n = number of participants

Additionally, pairwise analysis suggested Masters Athletes were significantly different than all groups, while no significant difference was found between inactive, moderately active and chess groups for incidence of injury.

Parametric tests: Chronic disease. Significant differences were found between the activity groups for the prevalence of chronic diseases F(3, 35.69) = 30.29, p<0.001, $\eta^{''}$= 0.20. There was no significant difference (p=0.937) between Masters Athletes and chess players, however this may be a gradient effect due to a smaller sample size. In contrast, the normative groups were significantly different (p<0.0001) from both Masters Athletes and chess players.

Discussion

Advancing age is a unique constraint on health and function. It acts as both a risk factor for many health outcomes *and* a barrier to participation in physical or cognitive activities as well as other preventive behaviours (i.e., medical physical examinations; Meisner & Baker, 2013). With this in mind, the current study compared injury and chronic disease rates among groups of older adults who maintained competitive involvement in a physically or cognitively challenging activity – namely, Masters Athletes and chess players. These values where then compared to normative data from moderately active and inactive older adults.

As expected and in congruence with past research (Hootman, Macera, Ainsworth, Addy, Martin, & Blair, 2001; McKean, Manson & Stanish, 2006; Moreira, Mazzardo, Vagetti, De Oliveira & De Campos, 2016), Masters Athletes experienced significantly higher rate of injuries compared to all activity groups in the study. Results from this study also reinforce findings from previous literature suggesting that risk of injury can be higher in vigorous forms of physical activity such as competitive sport (Hootman, et al., 2001; Kettunen et al., 2006).

Masters Athletes also reported a significantly lower prevalence of chronic diseases compared to moderately active, inactive and chess players. This finding is supported by literature (Batista & Soares, 2014; Kettunen et al., 2006) suggesting that athletes have a significantly lower prevalence of some chronic diseases (e.g., high blood pressure) compared to non-athletes or insufficient physical activity groups. Furthermore, athletes may also practice other lifestyle behaviors such as eating a healthy diet or limiting alcohol intake and cigarette smoking to a greater extent than the ‘average’ older adult (Batista & Soares, 2014). Furthermore, athletes may also practice other positive lifestyle behaviours such as limiting sedentary time, which has been recognized as an independent contributor for the decline in physical health (Dogra & Stathokostas, 2012). As a result, increased participation in these various positive lifestyle behaviors may have improved the health outcomes of athletes; however, this does not explain why chess players also reported low prevalence of chronic disease compared to the normative groups.

It is possible that competitive cognitive engagement may be associated with a similar effect on mitigating chronic diseases as sport participation. For instance, maintaining cognitive function by playing chess could be closely associated with other positive health behaviours such as seeking medical examinations and having positive expectations regarding aging (ERA), which may decrease the risks of disease and disability over time (Meisner & Baker, 2013). Whereas, avoiding chess in conjunction with the presence of some chronic diseases (e.g., chronic kidney disease, heart disease, hypertension, COPD) may hinder cognitive performance (Moss et al., 2005; Sands & Meredith, 1992; Ylikoski et al., 2000) as well as increase the risk of developing dementia including Alzheimer's Disease (Yaffe et al., 2010).

It is possible the brain activity during chess stimulates biopsychosocial elements of health that have implications for the physical health of older adults. Although this has yet to be explored empirically, this hypothesis acknowledges the complex and unified relationship between the mind and body, where declines in either cognitive or physical health can become a risk factor for future physical health outcomes (i.e., chronic diseases). While these results are intriguing, future research is required to confirm whether playing chess provides a protective mechanism for chronic diseases. Furthermore, future work is needed to determine whether these differences are due to participation in the activity itself (e.g., competition in a cognitively or physically challenging task) or to variables that might be related to these relatively unique groups (e.g., greater involvement in preventive health activities). These studies will extend our knowledge of the level and type of activity required to optimize health and function, as well as confirm whether participation in an intense cognitive activity alone can mitigate chronic disease amongst older adults.

Results also indicated chess players to initially experience significantly more injuries than moderately active and inactive older adults, although the differences between these groups disappeared after the case-matching. This disparity may be a result of case-matching the sub-sample of moderately active and inactive groups to reflect participants who were predominantly male, affluent, with higher education, and within a younger age group (i.e., 50 to 59 years). Prior research indicates older adults with a low household income, education, and/or females generally report higher inactivity levels (Gilmour, 2007; Health Canada, 2002; Statistics Canada 2015, 2016). Therefore, the case-matching may have removed important variance responsible for the difference in the number of injuries sustained by these key populations.

Similarly, the discrepancies between chronic diseases reported by the normative groups in the initial analyses compared to after case matching could have resulted from the removal of these particular at-risk groups (i.e., low household income, education, and females). Given that moderate activity has been associated with attenuating many chronic diseases (Ashe et al., 2009; Bassuk & Manson, 2005; Meisner, Dogra, Logan, Baker, & Weir, 2010) creating a more homogenous sub-sample may have concealed the effects of socio demographic factors on the physical health of moderately active and inactive older adults.

Interestingly, given that chess players reported lower incident of injuries than Masters Athletes as well as a lower prevalence of chronic diseases compared to moderately active and inactive groups, it begs the question 'why is the gold standard for successful aging only associated with those who participate in Master sport?' as suggested by Hawkins et al. (2003). Results from this study imply this label could be expanded to other types of activities besides competitive sport. Moreover, our lack of understanding regarding the consequences of competitive sport (Dionigi, Horton, & Baker, 2016; El-Bakri, Stone, Patelia, & Baker, 2017; Gayman, Fraser-Thomas, Dionigi, Horton, & Baker, 2016), further justifies the need to refrain from labeling Masters Athletes as the ideal model for successful aging, at least until further work has been conducted. Importantly, these results suggest older adults may have other options, such as competitive chess, to gain similar health benefits to sport participation. Moreover, it is possible older adults who participate in a variety of activities (e.g., chess *and* sport) may gain a greater combination of physical and cognitive health benefits. For that reason, advocating programs designed to cognitively and physically engage the older adult population may be a profitable response from both a health and an economic standpoint.

Limitations

While this study had many strengths, including the use of a nationally representative dataset to generate normative data for group-based comparisons, as well as two unique activity groups (i.e., athletes and chess players), there were some limitations. For instance, the majority of the athlete and chess player data were collected within the province of Ontario and our samples were limited to track and field and chess. As such, generalizations to other provinces or countries outside of Canada should be made with caution. Second, using a cross-sectional study design limits us from concluding that participation in chess or Masters sport has a causal effect on the physical health of older adults, since other genetic or environmental factors may be involved. Further, the data from our chess players should not be generalized to female chess players, since all of the chess participants in this study were males. In addition, it is important to acknowledge biases that may have affected participants' recall, question interpretation, and/or social desirability when collecting health-related information in a survey. Although not a limitation, this study did not compare ‘active’ older adults (i.e., the most active group in the CCHS) with Masters Athletes due to concerns about overlap between these groups. As a result, this limits what we can say about the value of high levels of sport participation compared to high levels of exercise. Finally, our analyses may also have been limited by the difficultly of capturing the nuances of socioeconomic status and its influence on the health of older adults, especially between the chess and athlete participants which seem to be privileged groups compared to the normative data.

Conclusion

Regular participation in an array of physical, cognitive and social activities has a multitude of health benefits for older adults. Results from the present study suggest older adults who are competitively active within sport or chess are able to mitigate their prevalence of chronic diseases compared to moderately active and inactive older adults. Interestingly, cognitive engagement was associated with a lower prevalence of injury. As a result, chess competition may provide a reasonable way to maintain both cognitive function and physical health, although the precise mechanism of these effects are not clear. Overall, the findings from the present study have implications for promoting both physically- and cognitively-engaging leisure activities for aging cohorts and provide several intriguing areas of futureresearch.

CHAPTER THREE

General Discussion

Project Summary

The current study was part of a larger project aimed at broadening our understanding of whether Masters Athletes represent the ideal model of *successful aging* (Geard, Reaburn, Rebar & Dionigi, 2016; Hawkins et al., 2003) by examining the individual components of Rowe and Kahn's (1987; 1997) model: (i) avoidance of disease and disability, (ii) maintenance of high cognitive and physical function, and (iii) active engagement with life. In an attempt to understand the first component from this theory (i.e., avoidance of disease and disability), this thesis aimed to investigate rates of injury and prevalence of chronic disease among older athletes and chess players in comparison to normative data using the Canadian Community Health Survey.

Regardless of age, sport participation has been advocated as a vehicle to maintain optimal physical health. However, the value of sport compared to other forms of activity, such as the cognitively engaging activity like chess, is not known. Prior research would clearly suggest Masters Athletes as physically healthier than chess players as well as the general population of older adults. Interestingly, findings from this study indicate the relationships between competitive sport involvement and multifaceted health outcomes in older adults is more complicated than previously assumed. Compared to all other groups in this study, competitive track and field athletes had the lowest prevalence of chronic disease, but increased rates of injury. In contrast, chess players experienced a lower rate of injury compared to Masters Athletes as well as a lower prevalence of chronic diseases compared to moderately active and inactive groups. These findings were consistent in both the Phase 1 and Phase 2 of the analyses.

Relative to the general population, results from the normative dataset indicated both moderately active and inactive older adults experienced a lower rate of injury but had the highest prevalence of chronic diseases compared to Masters Athletes. In Phase 1 of the analyses, inactive older adults had the highest prevalence of chronic diseases compared to all other subsets in the study, but these differences disappeared in Phase 2 possibly due to the case-matching, which may have masked the nuances between moderately active and inactive older adults. A similar finding occurred for the relationships between chess players and the normative groups on rates of injuries, which was significant in Phase 1 but disappeared after the case-matching. Collectively, these results highlight the impact socio-demographic factors may have on physical health of older persons.

Practical Implications

Although we cannot make any causal inferences regarding how involvement in different forms of activity affect the health of older adults, findings from this study may still have several practical implications for older adults trying to manage chronic diseases. The direct implications from this study are outlined below.

Emphasis on modifiable lifestyle factors. Although a consistent decline does occur for some physical and cognitive capabilities with advancing age, results from this study highlight the critical role of modifiable lifestyle factors (i.e., engagement in physical and cognitive activities). In this investigation, older adults engaged in competitive sport or chess had a lower prevalence of chronic diseases compared to those who were moderately active or inactive. Additionally, a sedentary lifestyle may be an independent contributor for the decline in physical health, which may decrease the likelihood of aging successfully (Dogra & Stathokostas, 2012). Focusing on modifiable lifestyle factors such as sport engagement has been found to have positive implications to mitigate chronic disease among older adults (Kettunen et al., 2006). Additionally, results from this study suggest competitive chess may be associated with a decrease in the prevalence of chronic diseases.

Recognizing physical activity barriers. Factors that may be difficult to modify such as a person's sex or socioeconomic status can facilitate or impede participation in competitive activities. For instance, older adults who may not be able afford recreational hobbies or are societally discouraged, may be less likely to initiate participation. These variables may affect participation in healthy behaviors and hence have a crucial effect on the health outcomes of older adults. Our results suggest males who are affluent, educated and/or between the ages 50 to 59 years may be more likely to participate in competitive sport and chess, and, as a result, they have significantly different physical health outcomes than older adults outside of these categories. It is therefore important to promote, encourage and fund programs for these overlooked groups of older adults. This may translate to greater participation in competitive activities by the general population.

Questioning the ideal model for successful aging. Thus far, Masters Athletes have been the only group of older adults labeled as the models for successful aging, largely due to their capacity to maintain their physical capabilities through competitive sport. According to our results, competitive track and field seems to be related with mitigating chronic disease; however, the increased rate of injury may cause many older adults to avoid (or withdraw from) competitive track and field. As a result, it is imperative that researchers expand and deconstruct the current model of successful aging prior to identifying Masters Athletes as the gold standard for aging. Exploring other successfully aging adults and deconstructing the notion itself, may lead to enhanced understanding on the health outcomes associated with competitive activities outside of sport. Furthermore, older adults who are physically unable to participate in competitive sport, will be provided with more alternative recreational activities/hobbies to manage or improve their current health status. It is also critical to note the domain of sport is broad, with track and field representing only a small element of the skills, capacities and demands required for participation. Therefore, it is necessary to explore older adults in different sports (recreational, competitive or team sport) to create an inclusive model of successful aging as well as understand health from multiple dimensions.

Future directions

Preliminary findings from this study provide several recommendations to advance research on this cohort. While the results on chronic disease prevalence for sport and chess participation seem promising, it is important to not misinterpret these findings as causal. Longitudinal studies are required to address the following question: 'Are older adults without chronic diseases participating in competitive sport and chess or is participation itself providing a protective mechanism to mitigate chronic diseases?'. Similarly, the increased rate of injury among Masters Athletes should also be explored, especially if the rationale to improve the health of the general population relies on positioning Masters Athletes as role models. Additionally, fear of injury has been raised as a primary concern and a limiting factor for older adults to participate in sport or any other physical activities (King, Rejeski, & Buchner, 1998; Lees, Clark, Nigg & Newman, 2005). It is therefore necessary to understand the factors that can prevent injury from limiting or ending participation within Masters sport, prior to promoting competitive sport for the general public. Moreover, future studies should explore the types and severity of injuries experienced across various Master sports, in order to better understand the extent to which a high rate of injury is a concern for this population.

On a more positive note, because competitive chess was associated with a lower prevalence of chronic disease and a lower rate of injury compared to population norms, it is recommended that investigators begin exploring other activities (cognitive or otherwise) that may provide similar health outcomes among older adults. Exploration in this area mayultimately expand the model of ‘successful aging’ to include individuals who were previously overlooked. Furthermore, studies should investigate whether similar health outcomes can be attained from recreational engagement or if this notion is exclusive to competitiveactivity.

Importantly, older adults with debilitating chronic diseases may find it challenging to participate in competitive sport, and organizing a minimal risk activity such as competitive chess in retirement and/or nursing homes may have positive physical and cognitive health implications. Especially since a number of these older adults may be diagnosed with Alzheimer’s disease and/or debilitating chronic diseases. Finally, considering the expenses required for treating injuries and chronic diseases, healthcare professionals and public policy developers should take interest in funding preventative measures, (i.e., older adult activity programs) as well as negating the stigmas of old age when promoting cognitive and physical engagement for older adults.

Concluding remarks

This thesis provides a different perspective on the ideal model for successful aging. Masters Athletes who are generally placed on the pedestal as successful agers, reported the lowest prevalence of chronic diseases and the highest rate of injuries compared to the other subsets in this study. Interestingly chess players also reported lower prevalence of chronic diseases compared to moderately active and inactive older adults. While these results do not imply chess is *better* than sport for optimizing aging, they provide several intriguing areas for further research to determine the ideal model of successful aging.

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Appendix A: Non-parametric tests performed for rate of injury and prevalence of chronic diseases (*N = 4446)*

Kruskal Wallis Tests measuring rate of injury

Ranks			
	Physical activity index	N	Mean Rank
Number of injuries	MASTERS ATHLETES	108	3473.05
	MODERATE ACTIVE	1609	2204.41
	INACTIVE	2679	2179.04
	CHESS PLAYERS	50	2521.18
	Total	4446	

Test Statistics[a,b]	
	Number of injuries
Chi-Square	337.848
df	3
Asymp. Sig.	.000
a. Kruskal Wallis Test	
b. Grouping Variable: Physical activity index	

Kruskal Wallis Tests measuring prevalence of chronic disease

Ranks			
	Physical activity index	N	Mean Rank
Chronic disease prevalence	MASTERS ATHLETES	108	659.54
	MODERATE ACTIVE	1609	2124.68
	INACTIVE	2679	2368.16
	CHESS PLAYERS	50	1030.75
	Total	4446	

Test Statistics[a,b]	
	Chronic disease prevalence
Chi-Square	258.361
df	3
Asymp. Sig.	.000
a. Kruskal Wallis Test	
b. Grouping Variable: Physical activity index	

Appendix B: ANCOVA test for differences between mean values for all variables prior to case-matching

Descriptive Statistics			
Dependent Variable: Number of injuries			
Physical activity index	Mean	Std. Deviation	N
MASTERS ATHLETES	1.23	1.212	108
MODERATE ACTIVE	.14	.420	1609
INACTIVE	.12	.384	2679
CHESS PLAYERS	.58	1.180	50
Total	.16	.484	4446

Tests of Between-Subjects Effects								
Dependent Variable: Total Number of Injuries								
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	141.474[a]	8	17.684	87.153	.000	.136	697.222	1.000
Intercept	7.548	1	7.548	37.198	.000	.008	37.198	1.000
DHHGAGE	.002	1	.002	.011	.918	.000	.011	.013
DHH_SEX	.138	1	.138	.682	.409	.000	.682	.048
Marital status	1.057	1	1.057	5.211	.022	.001	5.211	.415
EDUDR04	1.602	1	1.602	7.897	.005	.002	7.897	.622
Income	.365	1	.365	1.800	.180	.000	1.800	.124
PACDPAI	120.431	3	40.144	197.839	.000	.118	593.518	1.000
Error	900.315	4437	.203					
Total	1152.000	4446						
Corrected Total	1041.789	4445						
a. R Squared = .136 (Adjusted R Squared = .134)								
b. Computed using alpha = .0125								

Appendix B: Continued

Descriptive Statistics			
Dependent Variable: Chronic disease prevalence			
Physical activity index	Mean	Std. Deviation	N
MASTERS ATHLETES	.13	.434	108
MODERATE ACTIVE	1.68	1.506	1609
INACTIVE	2.03	1.702	2679
CHESS PLAYERS	.48	.839	50
Total	1.84	1.643	4446

Tests of Between-Subjects Effects								
Dependent Variable: Chronic Disease Score								
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	1526.741[a]	8	190.843	80.861	.000	.127	646.885	1.000
Intercept	7.457	1	7.457	3.160	.076	.001	3.160	.236
DHHGAGE	358.019	1	358.019	151.694	.000	.033	151.694	1.000
DHH_SEX	56.190	1	56.190	23.808	.000	.005	23.808	.991
Marital status	6.259	1	6.259	2.652	.103	.001	2.652	.192
EDUDR04	9.572	1	9.572	4.056	.044	.001	4.056	.314
Income	158.884	1	158.884	67.320	.000	.015	67.320	1.000
PACDPAI	275.915	3	91.972	38.969	.000	.026	116.906	1.000
Error	10471.952	4437	2.360					
Total	27034.000	4446						
Corrected Total	11998.693	4445						
a. R Squared = .127 (Adjusted R Squared = .126)								
b. Computed using alpha = .0125								

Appendix C: ANCOVA test for differences between mean values for all variables after to case-matching

Descriptive Statistics			
Dependent Variable: Number of injuries			
Physical activity index	Mean	Std. Deviation	N
MASTERS ATHLETES	1.23	1.212	108
MODERATE ACTIVE	.17	.421	108
INACTIVE	.16	.457	108
CHESS PLAYERS	.58	1.180	50
Total	.53	.968	374

Tests of Between-Subjects Effects								
Dependent Variable: Number of injuries								
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	88.182[a]	9	9.798	13.662	.000	.253	122.959	1.000
Intercept	.002	1	.002	.002	.961	.000	.002	.013
AGErecoded	.347	1	.347	.483	.487	.001	.483	.036
DHHGAGE	.333	1	.333	.465	.496	.001	.465	.035
DHH_SEX	3.279	1	3.279	4.572	.033	.012	4.572	.356
Marital status	.001	1	.001	.001	.974	.000	.001	.013
EDUDR04	.127	1	.127	.177	.674	.000	.177	.021
Income	1.096	1	1.096	1.528	.217	.004	1.528	.103
PACDPAI	70.087	3	23.362	32.576	.000	.212	97.727	1.000
Error	261.050	364	.717					
Total	453.000	374						
Corrected Total	349.233	373						
a. R Squared = .253 (Adjusted R Squared = .234)								
b. Computed using alpha = .0125								

Appendix C: Continued

Descriptive Statistics			
Dependent Variable: Chronic disease prevalence			
Physical activity index	Mean	Std. Deviation	N
MASTERS ATHLETES	.13	.434	108
MODERATE ACTIVE	1.31	1.350	108
INACTIVE	1.33	1.434	108
CHESS PLAYERS	.48	.839	50
Total	.86	1.247	374

Tests of Between-Subjects Effects								
Dependent Variable: Chronic disease prevalence								
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	151.111[a]	9	16.790	14.248	.000	.261	128.235	1.000
Intercept	.183	1	.183	.155	.694	.000	.155	.020
AGErecoded	.072	1	.072	.061	.805	.000	.061	.015
DHHGAGE	2.725	1	2.725	2.313	.129	.006	2.313	.163
DHH_SEX	.489	1	.489	.415	.520	.001	.415	.033
Marital status	.420	1	.420	.356	.551	.001	.356	.029
EDUDR04	.434	1	.434	.368	.544	.001	.368	.030
Income	4.231	1	4.231	3.590	.059	.010	3.590	.271
PACDPAI	107.080	3	35.693	30.290	.000	.200	90.870	1.000
Error	428.934	364	1.178					
Total	859.000	374						
Corrected Total	580.045	373						
a. R Squared = .261 (Adjusted R Squared = .242)								
b. Computed using alpha = .0125								

Appendix D: Pairwise comparisons between activity groups for rate of injury *(N=374)*

Pairwise Comparisons

Dependent Variable: Number of injury

(I) Physical activity index	(J) Physical activity index	Mean Difference (I-J)	Std. Error	Sig.[b]	98.75% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
MASTERS ATHLETES	MODERATE ACTIVE	1.058*	.121	.000	.683	1.432
	INACTIVE	1.051*	.122	.000	.673	1.429
	CHESS PLAYERS	.703*	.156	.000	.220	1.185
MODERATE ACTIVE	MASTERS ATHLETES	-1.058*	.121	.000	-1.432	-.683
	INACTIVE	-.007	.116	1.000	-.367	.353
	CHESS PLAYERS	-.355	.154	.132	-.833	.123
INACTIVE	MASTERS ATHLETES	-1.051*	.122	.000	-1.429	-.673
	MODERATE ACTIVE	.007	.116	1.000	-.353	.367
	CHESS PLAYERS	-.348	.157	.163	-.835	.138
CHESS PLAYERS	MASTERS ATHLETES	-.703*	.156	.000	-1.185	-.220
	MODERATE ACTIVE	.355	.154	.132	-.123	.833
	INACTIVE	.348	.157	.163	-.138	.835

Based on estimated marginal means

*. The mean difference is significant at the .0125 level.

b. Adjustment for multiple comparisons: Bonferroni.

Appendix E: Pairwise comparisons between activity groups for prevalence of chronic disease *(N=374)*

Pairwise Comparisons

Dependent Variable: Chronic disease prevalence

(I) Physical activity index	(J) Physical activity index	Mean Difference (I-J)	Std. Error	Sig.[b]	98.75% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
MASTERS ATHLETES	MODERATE ACTIVE	-1.234*	.155	.000	-1.715	-.754
	INACTIVE	-1.247*	.156	.000	-1.731	-.762
	CHESS PLAYERS	-.284	.200	.937	-.903	.335
MODERATE ACTIVE	MASTERS ATHLETES	1.234*	.155	.000	.754	1.715
	INACTIVE	-.012	.149	1.000	-.474	.449
	CHESS PLAYERS	.951*	.198	.000	.338	1.564
INACTIVE	MASTERS ATHLETES	1.247*	.156	.000	.762	1.731
	MODERATE ACTIVE	.012	.149	1.000	-.449	.474
	CHESS PLAYERS	.963*	.201	.000	.339	1.587
CHESS PLAYERS	MASTERS ATHLETES	.284	.200	.937	-.335	.903
	MODERATE ACTIVE	-.951*	.198	.000	-1.564	-.338
	INACTIVE	-.963*	.201	.000	-1.587	-.339

Based on estimated marginal means

*. The mean difference is significant at the .0125 level.

b. Adjustment for multiple comparisons: Bonferroni.