THE STUDY ON GLOBAL AGEING AND ADULT HEALTH (SAGE): DEPRESSION AND BODY COMPOSITION AMONG AGING POPULATIONS

by

WILLIAM JOHN OLSON

A THESIS

Presented to the Department of Biology
and the Robert D. Clark Honors College
in partial fulfillment of the requirements for the degree of
Bachelor of Science

June 2014

An Abstract of the Thesis of

William Olson for the degree of Bachelor of Sciences
in the Department of Biology to be taken June 2014

Title: The Study on global AGEing and adult health (SAGE): Depression and Body Composition among Aging Populations

Approved: _____

Josh Snodgrass

Chronic disorders affecting the mind and the body are particularly common among older adults, presenting a major health challenge to healthcare providers around the world. However, the effects of aging on chronic mental disorders remains poorly characterized. The goal of the Study on global AGEing and adult health (SAGE) is to develop a more complete understanding of the process of aging and how it affects health in general. The current study used Wave 1 data from SAGE, a longitudinal study organized by the World Health Organization (WHO), which collects nationally representative samples of older adults (>50 years old) in six middle income countries (China, Ghana, India, Mexico, Russian Federation, and South Africa), to examine relationships among body mass index (BMI), waist circumference (WC), and depression (with diagnosis based on a symptom-based algorithm). Previous research has documented complex associations between depression and body composition; in some studies, depression increases risk for being underweight, while in other studies it has been linked to obesity. However, the links between depression and body composition remain relatively unexplored among older adults and, additionally, no studies have systematically examined this relationship in non-Western countries. Results indicate substantial differences in depression prevalence by gender and country, ranging from 1.6% (men in China) to 22.9% (women in Mexico). Variation by gender and country was also evident in prevalence of obesity (from 1.3% among Indian men to 51.0% in South African women) and underweight (0.5% in Mexican women to 40.0% in Indian

men). Multiple regression analyses were used with weighted population samples to examine the relationship between body composition measures and depression classification while controlling for key covariates such as age, smoking, drinking, marital status, and income. Among older South African women, depression was positively associated with BMI ($p=0.003$). Otherwise, the lack of a significant relationship between depression and body composition variables in the individual SAGE countries suggests that depression is not a major driver of body composition among older adults.

Acknowledgments

I would like to thank Professor Snodgrass and other names thereafter, for helping me to fully examine the specific topic and consider the various perspectives and contexts related to this subject matter. I would like to thank my committee, Josh Snodgrass, Theresa Gildner, and Matthew Sandler for their time and support. I would like to thank all of the members of the Snodgrass lab who aided me in my research, particularly Melissa Liebert for her work with the statistical analysis. We thank all participants in the study, study PIs and teams, and Paul Kowal, Somnath Chatterji, and Nirmala Naidoo. Additionally, I would like to thank the Department of Anthropology of University of Oregon for their financial support, in the form of a Williams Fund Undergraduate Research Award. A version of this paper was presented in poster form at the Human Biology Association meeting at Calgary in April of 2014, where it was awarded the Spielvogel award for outstanding presentation by an undergraduate student. SAGE was supported by NIH NIA Interagency Agreement YA1323-08-CN-0020, the NIH grant R01-AG034479, and the University of Oregon.

The creators of this template (CHC Librarian Miriam Rigby & CHC Academic & Thesis Coordinator Miriam Jordan) would like to thank Reed College for providing their Thesis Template for the inspiration of many elements of this template.

Table of Contents

List of Figures

Background Information

Depression, as defined by the World Health Organization, is a common mental disorder, characterized by sadness, loss of interest or pleasure, feelings of guilt or low self-worth, disturbed sleep or appetite, feelings of tiredness, and poor concentration (WHO 2012). It is a complex condition that is caused by a mixture of social, psychological, and biological influences (WHO 2012).The effects of depression vary widely, ranging from minor insomnia and a lack of motivation to suicidal thoughts and actions (NIMH 2012). Many treatments are available for those suffering from depression, ranging from traditional therapy and pharmaceuticals to alternative approaches such as acupuncture or exercise and nutrition plans (Khan 2012). However, the efficacy of individual treatments varies greatly from case to case, and there is no "one size fits all" cure for the condition. Indeed, some recent surveys even suggest that most treatment options, including traditional and alternative ones, are statistically no different in their expected outcome on a population scale (Khan 2012). Only through combinatorial treatments are significant improvements observed (Khan 2012). Treatment, however, remains heavily underutilized, with the WHO estimating that roughly half of all depressed individuals worldwide are not treated for their condition (WHO 2012).

Depression can be particularly devastating among older adults, as they are faced with numerous risk factors that increase their likelihood of developing the condition (NAMI 2009). As of 2009, 6.5 out of 35 million adults in the United States aged 65 and older suffered from depression (NAMI 2009). Additionally, a 2008 study by the Center for Disease Control found that Major Depression prevalence increased with age up to

those 65 years and older (CDC 2010). This increased risk is due to a number of factors, including physical ones, such as increased frailty, mental ones, such as decreased perceived health, and social ones, such as societal disconnect (Djernes 2006). Additionally, older populations are more likely to not seek depression treatment or diagnosis due to a lack of information about the disease (NAMI 2009). Many assume that common depression symptoms, such as fatigue, memory loss, or loss of appetite are simply a natural part of the aging process, or are misattributed to some other condition, such as Alzheimer's (NAMI 2009). The accumulation of these risk factors in older adults has led to an increase in depression on a global scale as the population of the world has gotten older (Marcus 2012).

A factor found in several studies to be associated with depression is body composition, which is defined as the relative amounts of fat, bone, muscle, and other organs and tissues that make up the human body (Mezuk 2012). It is generally reported as a series of percentages representing the amount of each tissue, but in population research most often it is used to refer to an individual's body type, whether they are underweight, normal, overweight, or obese (WHO 2000). A recent trend of increased prevalence rates of obesity in all age groups has emerged globally, having large effects on the health of the world population as a whole (Flegal 2012; Dinsa 2012).

Body composition irregularities among older adults' presents with its own set of issues, as being underweight or overweight can cause very different problems. For example, while overweight older adults are more prone to heart conditions and joint related issues, underweight patients often suffer from an increased degree of frailty (Mezuk 2012). The impact of body composition on the health of older adults can often

be compounded by their frequently poor diets. Whether due to a psychological or physical condition, older adults regularly have incomplete diets, which neglect important nutritional requirements (Hickson, 2006). Imbalanced diets can lead to unhealthy body types, and can further be a risk factor for various physiological and mental conditions (Hickson, 2006). As the population of the world ages it has become increasingly important to understand the impact of body composition on the multitude of conditions that negatively affect the health of older adults, while also examining what factors related to aging may contribute to an unhealthy body composition.

Literature Review

Research into the possible link between depression and body composition among older adults has been remarkably limited. Examinations of the two variables at a population level are abundant, although the body composition portion of the studies often focuses solely on obesity, and relatively few studies examine a link between the two. Of the studies that do examine a link between depression and body composition relatively few target older adults, instead focusing on adolescents (Goodman 2002; Franko 2005). Recent findings have demonstrated a significant relationship between adolescent depression in American teens and obesity in young adulthood (Goodman 2002; Franko 2005). This trend has been shown to transcend race and gender, providing a powerful predictive tool for the association between depression and body composition in adolescents and young adults (Goodman 2002 and Franko 2005). After excluding these youth-focused studies there are very few research inquiries that deal with the chosen topic directly. However, of those studies that focus on older adults, the results are intriguing yet contradictory. In the article by Mezuk and colleagues (2012), the researchers concluded that there was a link between low levels of central body fat and lean mass and depression in older females, but not in males. This stands in contrast to a paper by Li et al., published in 2004, which documented a statistically significant negative association between BMI and depression in the both male and female older adults. Additionally, a study published by Peltzer and Phaswana-Mafuya in 2013, which used preliminary data from the SAGE project in South Africa, showed no significant correlation between obesity and depression among older populations. Mezuk and colleagues (2012) worked with older clinical patients in Baltimore Maryland, Li et al.

(2004) worked with older Chinese adults from Hong Kong, while Peltzer and Phaswana-Mafuya (2013) worked among South Africans. All of these studies provide valuable information about their respective communities, although further research is needed to not only attempt to reproduce their results, but also to examine how the consistency of their findings differs with age from within the large category of older adults (>50 years old). None of these works, however, examine their hypotheses on a global scale, and indeed only the South African study is nationally representative (Peltzer and Phaswana-Mafuya, 2013). Herein lies the importance of the present study, which investigates possible links between body composition and depression among older adults in six different nations, which together comprised roughly 42% of the world's population in 2012. Any findings, whether positive or negative, could allow health officials to make informed decisions regarding the health of their aging populations not only in the SAGE countries, but also on a global scale for other middle income nations.

Research Questions and Hypothesis

The present study examines associations between body composition and depression among older adults. I hypothesize that significant associations will be observed, both in men and women, and that moreover these relationships will not be the same between the examined nations. I expect to see diverse associations in the different populations examined due to a multitude of factors, including diet, healthcare access, and societal pressures regarding body composition or depression. In order to test the hypothesis two specific objectives were developed:

1. To document the prevalence of depression and variance in body composition among older adults in each nation.
2. To examine whether depression is significantly linked to body composition among older adults.

Materials and Methods

The Study on global AGEing and adult health (SAGE)

SAGE, the Study on global AGEing and adult health, is a multinational research program organized by the World Health Organization (WHO) (Kowal et al. 2012). The study focuses on the health of adults fifty years and older, including a small group of younger adults aged 18-49 for comparative purposes (Kowal et al. 2012). In total six middle-income countries are examined at a national level, including China, Ghana, India, Mexico, Russian Federation, and South Africa (Kowal et al. 2012). Together, these studies provide not only geographic diversity, but also represent a range of economic development levels. The present study used data collected by the SAGE surveyors on body mass index, waist circumference, and depression.

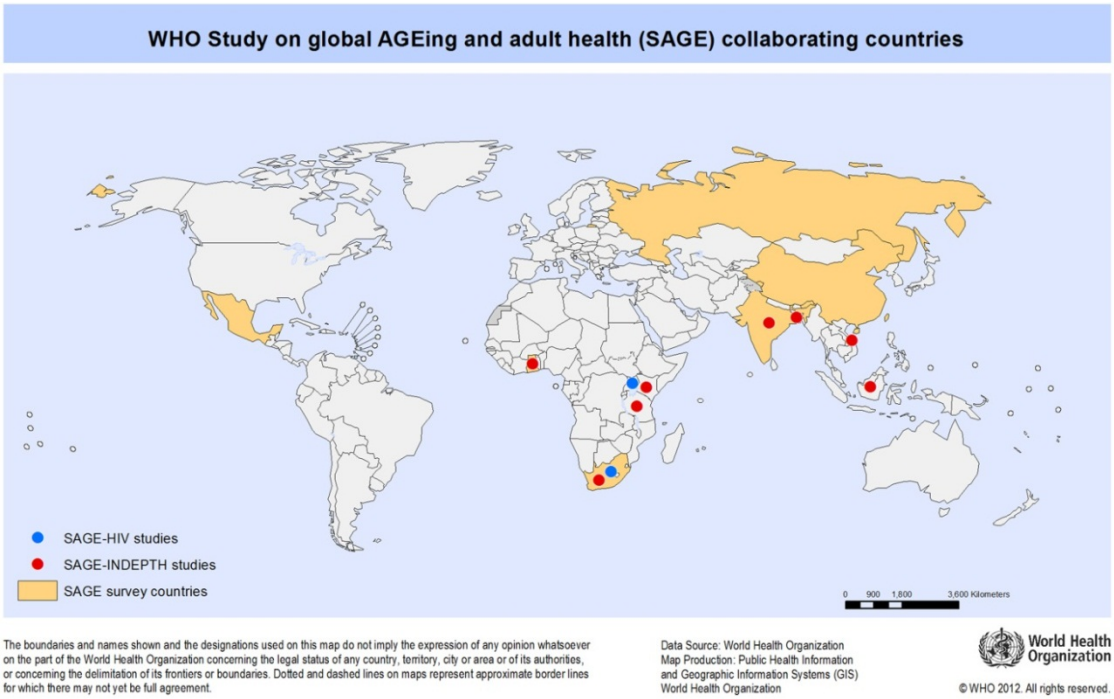

Figure 1: Sage study map, nationally representative studies are in yellow while local non-nationally representative studies are show by red and blue dots. (Map provided by the WHO http://www.who.int/healthinfo/sage/sage_001.jpg?ua=1)

The population of the world is aging at a rapid rate; since 1950 the average age of the world's population has risen 4 years from 28 to 32 years old, and is projected to continue to increase (United Nations 2012). A United Nations 2012 prediction puts the average age of the world at roughly 42 years of age by 2100. This growth is unparalleled, and will have profound implications on many facets of human life, including healthcare. Additionally, SAGE was designed so as to have results that are comparable to ongoing studies in high-income nations including the US Health and Retirement Study (HRS) and the Collaborative Research on Ageing in Europe (COURAGE) (Kowal et al. 2012). This will allow for a results based comparison between many high and middle income nations on the nature of aging and health. The all-encompassing nature of this change is what SAGE seeks to address. The SAGE data

set is proportional to population size, with over 42,400 participants and over 8,000 questions and measurements assessed for each participant (Kowal et al. 2012). Additionally, while the effect of aging on health has been studied extensively in high income countries, there has been a dearth of work on the relationship in middle income nations. These categories are defined by the World Bank according to 2012 GNI per capita, calculated using the World Bank Atlas method (World Bank 2012). The groups are: low income, $1,035 or less; lower middle income, $1,036 - $4,085; upper middle income, $4,086 - $12,615; and high income, $12,616 or more." (World Bank 2012) SAGE seeks to address this problem by working in high-middle and low-middle income nations. The six countries in question provide the economic and geographic diversity which has been lacking from prior large scale aging studies.

Figure 2: A SAGE participant and surveyor in China filling out the survey. Photo courtesy of Paul Kowal.

In order to understand how the relationship between health and aging changes over time and facilitate the identification of causal relationships, SAGE was designed as a longitudinal study. The first wave of data collection occurred in 2007-2010 (Wave 1), the second is currently underway 2013-2014 (Wave 2), and a third wave is planned for 2015-2016 (WAVE 3) (Kowal et al. 2012). 8,000 participants from Wave 1 also engaged in the 2004-2005 World Health Survey (Wave 0), which measured the same variables as used in SAGE. The study itself is being conducted by locally trained SAGE surveyors, who administer the SAGE Questionnaire in person and collect household surveys from the participants (Kowal et al. 2012). The participants were selected so as to provide a random, nationally representative data set, and were categorized as either a young control group (18-49 years of age) or older adults (50+ years of age) (Kowal et al. 2012).

Figure 3: SAGE participant and surveyor measuring blood pressure in South Africa. Photo courtesy of Paul Kowal.

Body Composition; Body Mass Index (BMI) and Waist Circumference (WC)

Body composition, for this study's purposes, is a range of weight classes defined by the WHO and measured by BMI and WC. The major groups are: Underweight (BMI<18.50), Normal Range (BMI 18.50-24.99), Overweight (BMI>25.00), and Obese (BMI>30.00) (WHO 2000). An individual's BMI is calculated by dividing their weight, in kilograms, by their height, in meters, squared (BMI = kg/m^2). BMI alone, however, is not a completely accurate measure of body composition, as it does not account for fat localization and is only an estimate of adipose tissue mass (Mezuk 2012). Therefore, in order to more accurately determine individual's weight classes, the current study additionally incorporated waist circumference (WC) into the process for assigning individuals body composition classifications, so as to examine central adiposity. Waist circumference (WC) values were interpreted based on WHO categories: normal (<94

cm) and increased risk (≥94 cm) for males, and normal (<80 cm) and increased risk (≥80 cm) for females (IDF, 2006).

Height and weight were directly measured by the SAGE surveyors using a scale and a measuring tape. Likewise, waist circumference was measured via a measuring tape around the waist using a standard approach. Previous research that examined associations between body composition and depression have used dual-energy X-ray absorptiometry (DEXA) to measure an individual's fat and lean mass (Mezuk 2012). DEXA, as the name suggests, makes use of two X-ray beams of different energy levels to measure the absorptivity of a patient's bones and soft tissue. This absorptivity can then be used to calculate the proportion of different kinds of mass (e.g., bones, central lean, central fat, etc.) in the body. While this method does appear to have advantages in its ability to accurately measure body composition, the combined BMI-WC method gives allows an adequate estimation of body composition for use in population-level epidemiological research (Goulding, 1996). Furthermore, the costs and logistical issues associated with using DEXA on large scale data collection surveys, particularly in less developed nations, make its use problematic. While both BMI and WC can be calculated using a scale and measuring tape, DEXA requires a specialized and expensive instrument, which is not portable and, additionally, exposes participants to radiation (Mezuk 2012).

In the present study, body composition was analyzed as a categorical variable, wherein participants were sorted into one of four categories depending on their body composition: underweight, normal, overweight, or obese. While treating body composition as a continuous variable might lend additional insight, as it more

accurately represents an individual's physical state, large scale public health studies typically investigate body composition via BMI and/or WC categories (WHO 2000 and Dinsa 2012). Thus, while some of the data is lost by assigning individuals to categories, the results gain a degree of practicality and ease of application as far as public health is concerned.

Additionally, the study used modified BMI cutoffs for India and China, as recommended by the WHO, because the relationships among BMI, body fat percentage, and health risks are different for Asian populations (WHO 2000). The alternate cut offs are as follows; underweight (<18.5 kg/m^2), normal (18.5-22.9 kg/m^2), increased risk (23.0-27.5 kg/m^2), and higher high risk (≥27.5 kg/m^2) (IDF 2006). Modified WC cut-offs were also used for China and India; however, these revised categories only adjust the risk classifications for males: normal (<90 cm) and increased risk (≥90 cm) (IDF, 2006).

Depression Measurement and Quantification

SAGE collected, via interview, a wide spectrum of data on both physical and mental health, including a series of questions regarding depression. The survey determined whether or not individuals had ever been diagnosed with depression and also inquired about a number of common symptoms of depression such as fatigue, lack of sleep, and loss of appetite (Appendix 1). These questions were based on the World Mental Health Survey version of the Composite International Diagnostic Interview and the diagnosis of depression based on the International Classification of Diseases (10th revision) Diagnostic Criteria for Research. The answers provided for the mental health

questions can be used as input for a depression algorithm, which defines individuals as having experienced Major Depression (MD), or not (Peltzer 2013).

While other categories of depression exist, such as subsyndromal or situational depression, this study did not consider these within the analysis. Major Depression is one of the most common clinically diagnosed forms of depression, and also has the greatest long term effect on an individual's life (NIMH 2012). The National Institute of Mental Health describes the symptoms for Major Depression as severe symptoms that interfere with your ability to work, sleep, study, eat, and enjoy life. An episode may occur only once in a person's lifetime, but more often, a person has several episodes (NIMH 2012). This analysis was therefore limited to those who have recently been Majorly Depressed or not, so as to avoid including those in the "Depressed" category who may be less affected by the disease and would therefore be less likely to have an altered body composition. Additionally, if multiple depressive conditions were included into the "Depressed" category the results would be unable to discern if any one type of depression was driving or hiding a relationship between depression and body composition.

Countries, Participants, and Sampling Design

In order to ensure a nationally representative dataset, SAGE uses multistage cluster sampling strategies that sorted individuals into either "50+" households or "18-49" clusters depending on their age, before randomly selecting clusters (Kowal et al. 2012). Only one 18-49 year old per household was asked to participate, whereas all members of 50+ households were invited. Sample sets were then weighted by household and individual to ensure an even sampling strategy. Given that the

questionnaire and data collection take several hours, participants were compensated for their time (Kowal et al. 2012).

SAGE was approved by the WHO Ethical Review Committee and each partner organization within the study obtained ethical clearance from their respective institutions (Kowal et al. 2012). All participants gave informed consent to take place in the study.

Statistical Analysis

The analysis made use of analysis of variance (ANOVA), chi square tests, and regression model tests, all conducted in the statistical program SPSS 20.0. ANOVA is a system of statistical models that examines the means of several data sets and determines where the variance between the averages may have originated. This partitioning of variance in turn ensures that any observed trends will not originate due to confounding variables. Chi square tests and regression models enabled the analysis to take observed variance and determine the relationships between the chosen variables of body composition and depression. The subject pool was restricted to those aged 50 or older. Weighted prevalence estimates were calculated for depression classification (presence or absence), BMI categories (underweight, normal, overweight/increased risk, obese/higher high risk), and WC categories (normal, increased risk) by gender.

The analysis controlled for several common variables known to be associated with depression, including smoking, drinking, gender, and marital status (Dinsa 2012). These controls further ensured that any significant relationships observed were not due to a confounding variable. Each of the control variables was measured via self-reporting as part of the SAGE individual questionnaire (see Appendix Figures 3 and 4).

Additionally, all analysis was separated by gender, as is seen in most depression studies due to the different ways the disease affects men and women (WHO 2012).

Results

Objective One

Objective 1 examined how prevalent the conditions of depression, underweight, and overweight are in older populations separated by gender and country. The unweighted numbers of participants, separated by gender and country, are available in Figure 4. As was predicted, a great degree of variation was observed in the frequency of each condition both between countries and between gender. Depression was found to be most common in Mexican females, affecting 22.9 percent of the population, while it was found least often in Chinese males, of which only 1.6 percent were affected (Figure 5). Variation by gender and country was also evident in prevalence of obesity, ranging from 1.3% among males in India to 51.0% in South African females, and in underweight, varying from 0.5% in Mexican men to 40.0% in Indian men (Figure 5).

Country	Sex	Participants
China	Male	6887
	Female	7924
Ghana	Male	2696
	Female	2412
India	Male	4349
	Female	6881
Mexico	Male	1047
	Female	1687
Russian Federation	Male	1548
	Female	2802
South Africa	Male	1796
	Female	2427

Figure 4: Unweighted sample sizes by country and gender.

Country	Sex	Depressed	Obese	Underweight
China	Male	1.6%	3.3%	4.2%
	Female	2.5%	7.9%	4.3%
Ghana	Male	7.1%	6.3%	15.2%
	Female	11.6%	13.9%	15.3%
India	Male	17.9%	1.3%	40.0%
	Female	21.4%	3.2%	37.8%
Mexico	Male	4.7%	21.7%	0.5%
	Female	22.9%	34.5%	0.7%
Russian Federation	Male	3.5%	27.8%	1.1%
	Female	9.6%	41.8%	1.0%
South Africa	Male	4.8%	37.3%	4.4%
	Female	5.3%	51.0%	2.5%

Figure 5: The prevalence of Depression, obesity, and underweight by country and gender. The highest and lowest values in each category are highlighted red and blue respectively.

Objective Two

Objective two sought to demonstrate that depression is significantly linked to body composition among older adults. Populations were separated by gender and, in some cases, country. They were analyzed via multiple regression analysis. The hypothesis was mostly unsupported by the results, as can be seen in Figure 6. With all countries combined depression was negatively related to BMI levels in males with a β coefficient of -2.536 and a significance of 0.018. This means that males across all countries were significantly more likely to have a lower BMI when depressed ($p<0.05$). Additionally, depression in South African females was positively associated with BMI with a β coefficient of 3.035 and a significance of 0.003, indicating that South African females are significantly more likely to possess an increased BMI when depressed ($p<0.05$). However, depression was not significantly associated with BMI for the majority of examined populations and did not associate significantly with waist circumference in any population ($p>0.05$). Thus, while there are certain exceptions, it would appear that body composition in adults is not a significant predictor of depression in older adults from middle income countries.

Population	Sex	B co-efficient	Significance
All Males	-	-2.536	0.018
All Females	-	0.922	0.357
China	Male	-0.555	0.579
	Female	-0.48	0.633
Ghana	Male	-0.674	0.5
	Female	-0.941	0.349
India	Male	-1.878	0.061
	Female	0.761	0.45
Mexico	Male	-0.644	0.52
	Female	-0.475	0.636
Russian Federation	Male	-0.884	0.377
	Female	-0.757	0.45
South Africa	Male	0.481	0.631
	Female	3.035	0.003

Figure 6: Association and significance results from multiple regression analysis examining the relationship between depression and BMI. Significant relationships are highlighted yellow. ($p<0.05$)

Discussion

This study examined the relationship between depression and body composition among older adults in six middle income nations. Specifically, the study made use of data from the Study on global AGEing and adult health (SAGE). Older adults are a segment of the population where depression is thought to be highly prevalent, yet there is comparatively little data available about the condition in poorer nations. Furthermore, the possible association between depression and body composition has been relatively unexplored among older adults, particularly outside of high income nations. The proposed relationship was examined via two objectives.

Objective One

Objective one examined how prevalent depression, underweight, and overweight are in the older populations. A wide range of values was observed in each category, with high levels of variation by country and gender. Depression peaked in Mexican females at 22.9%, and was least prevalent in Chinese males with only 1.6% afflicted. Body composition also displayed great variation with obesity prevalence ranging from 1.3% in Indian males to 51.0% in South African females, while underweight varied from 0.5% in Mexican men to 40.0% in Indian men. The obesity prevalence data demonstrate a wide range of values which overlap with values from wealthy nations such as the United States, where 36.6% of older males and 42.3% of older females are classified as obese (CDC 2008). The underweight values for the United States would likewise be included within the range demonstrated by SAGE participants, with 2.2% of older females and 1.0% of older males found to be underweight (CDC 2008). Likewise, the distribution of depression prevalence in the examined nations would encompass US

values, with 3.7% of older females and 3.8% of older males exhibiting Major Depression (CDC 2008). This inclusion of US values within the range of examined nations demonstrates that, although national income certainly influences the prevalence of depression, obesity, and underweight, it is not the sole definitive factor. It is likely that many other factors, such as cultural views on body type or levels of education about depression, also significantly influence the prevalence values.

Objective Two

Objective two analyzed the proposed relationship between depression and body composition among older adults. Populations were separated by gender and, in some cases, country. They were analyzed via multiple regression analysis, and it was found that only two populations (all males combined and South African females) had a significant relationship ($p<0.05$) between depression and BMI, while no populations exhibited a significant relationship between depression and waist circumference. South African females demonstrated a significant ($p=0.03$) positive relationship between depression and BMI (beta coefficient of 3.035), indicating that depressed older females are significantly more likely to have an increased BMI. When all males were analyzed a significant negative (beta coefficient of -2.536 and $p=0.018$) association between depression and body composition was found. However, this finding was not reproduced in any individual country when the data set was separated by country. This finding, therefore, was not viewed as particularly important, given that it was not reproduced in any male population, although Indian males demonstrate the a significant trend ($p=0.061$, beta coefficient of -1.878).

Conclusions

The present study concluded that depression, obesity, and underweight are all present in older populations at a wide range of frequencies. This variation may be due to a number of factors, ranging from diet to social pressures concerning weight or mental health. The hypothesized link between depression and body composition among the older adults was largely unsupported by the data. With the exception of South African women, the lack of a significant relationship between depression and body composition variables in the individual SAGE countries suggests that depression is not a major driver of body composition among older adults. The association between depression and body composition observed when all men are combined across countries is not considered significant, as the result was not reproduced on an individual country level.

The results can be interpreted in several ways. Firstly, the scope of our study only considered the clinical condition Major Depression, as opposed to more moderate forms of depression such as subsyndromal depression. This may have affected our results significantly, as it is unknown if any specific form of depression has a significant relationship with body composition. Additionally the results were not divided by age class, but the present study instead analyzed all adults over 50 as one group. Separation of participants into age cohorts (e.g., 50-59, 60-69, 70-79, 80+ years old) may yield further insights into whether or not depression is a significant driver of body composition at a particular age. The results observed in South African women can be also be interpreted in several ways. South African women have the highest prevalence of obesity among all measured populations, which may indicate that there exists less societal pressure on older females to maintain a low BMI, resulting in unusual dietary

patterns. Additionally, South Africa's culture has heavy western European influences, due to recent colonization, which may have influenced the perceptions of depression or body composition in a way not seen in other participating countries.

Within the study there were several limitations that are important to acknowledge. First, the nature and societal pressures of depression make its prevalence problematic to quantify. While this is true of any survey that examines depression, it is nevertheless important to note the inherent difficulty in measuring depression at a population level when so much social stigma and misinformation about the disease exists. Additionally, although the current study is large and nationally representative, it sacrifices rich ethnographic data that are often collected in anthropological studies.

While the results of the present study indicate that Major Depression is not a significant determinant of body composition among the elderly in these middle income countries that is not to say that this is the final word on the subject. While there may not be an immediate way to address the weaknesses of the study, the strength can be improved by utilizing further data sets. SAGE is a longitudinal study, meaning that data will eventually be available on the mental state and body composition of the same individuals over the course of the three waves of the study (2007-2010 wave 1, 2013-2014 wave 2, and 2015-2016 wave 3). When these data are available in three years' time it will be possible to observe how an individual's affliction with depression affects their body composition over time, which is a very powerful and direct form of analysis.

Appendix

Question No.	Question	Guide for completion
Q4040	Have you ever been diagnosed with depression?	• Identify individuals with a diagnosed case of depression (mood disorder). • Although depression is common, it often goes undetected because it may be attributed to a person's physical, social or economic difficulties. • Treatments for depression can include medication and talking to a therapist or other health care professional (counselling).

Question No.	Question	Guide for completion
Q4046	Was this period [of sadness/loss of interest/low energy] most of the day, nearly every day?	Emphasize the symptoms of low mood/interest/ energy being present for most of the day (not just one or two hours), and occurring nearly every day (not just one or two days) over an extended period.
Q4047	During this period, did you lose your appetite?	Determine whether the respondent had the symptom of much smaller appetite than usual, often accompanied by weight loss.
Q4048	Did you notice any slowing down in your thinking?	"Slowing down" means thoughts that are coming much slower than usual. The person needs more time to think, make decisions, making up his/her mind and reacting to events.
Q4049	Did you notice any problems falling asleep?	Problems "falling asleep" refer to inability to sleep or to get to sleep.
Q4050	Did you notice any problems waking up too early?	"Waking up too early" means a change from the normal sleep patterns – waking up earlier than wanted by the respondent or typical for the person.
Q4051	During this period, did you have any difficulties concentrating; for example, listening to others, working, watching TV, listening to the radio?	"Difficulties in concentrating" means not following the content of a conversation or work, or having to ask people to repeat themselves because the mind wanders.
Q4052	Did you notice any slowing down in your moving around?	"Slowing down in moving around" means movements or walking that is much slower than usual. The person needs more time to move or walk and react to events.
Q4053	During this period, did you feel anxious and worried most days?	"Anxious and worried" means feelings of anxiety or worrying about things on most days (not just one or two days).
Q4054	During this period, were you so restless or jittery nearly every day that you paced up and down and couldn't sit still?	"Restless or jittery" usually means physical things such as pacing or repetitive walking patterns or movements, but could be a feeling inside.
Q4055	During this period, did you feel negative about yourself or like you had lost confidence?	This is a change from normal levels of outlook and confidence.
Q4056	Did you frequently feel hopeless - that there was no way to improve things?	"Hopeless" means the feeling or belief that there seems to be no possibility of comfort or success – that things are certain to fail.

Question No.	Question	Guide for completion
Q4057	During this period, did your interest in sex decrease?	This refers to a change from the respondent's normal level of interest in sex or intimate relations.
Q4058	Did you think of death or wish you were dead?	This is a difficult question but is meant to determine if the person thinks about death in general, his or her own death or have feelings that they wish they were dead.
Q4059	During this period, did you ever try to end your life?	This question is likely to be a sensitive question, but it is a very important question to have answered. You may need to give the person extra time to answer or note any difficulties in responding.

Appendix Figure 1: Tables of depression questions asked by SAGE surveyors

I would now like to measure how tall you are. To measure your height I need you to please take off your shoes. Put your feet and heels close together, stand straight and look forward standing with your back, head and heels touching the wall. Look straight ahead.		
Q2506	*Measured height in centimetres*	☐☐☐.☐ centimetres *997 Refused* *998 Not able*
Now we want to measure your weight - could you please keep your shoes off and step on this scale. We will also measure your waist and hips using a tape measure.		
Q2507	*Measured weight In kilograms*	☐☐☐.☐ kilograms *997 Refused* *998 Not able*
Q2508	*Waist circumference INTERVIEWER: identify the top of the hip bone - and make sure the tape measure is parallel to the floor all the way around the body*	☐☐☐.☐ centimetres *997 Refused* *998 Not able*
Q2509	*Hip circumference INTERVIEWER: measure at the midpoint of the hips - and make sure the tape measure is parallel to the floor all the way around the body*	☐☐☐.☐ centimetres *997 Refused* *998 Not able*

Appendix Figure 2: Tables of height and weight measurement techniques used by SAGE surveyors

Q1012	What is your current marital status?	1 NEVER MARRIED ..... →	Q1015
		2 CURRENTLY MARRIED ..... →	Q1014
		3 COHABITING ..... →	Q1014
		4 SEPARATED/DIVORCED ..... →	Q1013
		5 WIDOWED ..... →	Q1013
Q1013	For how many years have you been separated, divorced or widowed? *INTERVIEWER: if less than 1 year, enter "00"*	☐☐ NUMBER OF YEARS ..... →	Q1015
		-8 *DON'T KNOW* ..... →	Q1015
Q1014	For how many years have you been married or living together? *INTERVIEWER: if less than 1 year, enter "00"*	☐☐ NUMBER OF YEARS	
		-8 *DON'T KNOW*	

Appendix Figure 3: Questions for determining marital status asked by the SAGE surveyors

Q3001	Have you ever smoked tobacco or used smokeless tobacco?	1 YES 2 NO ……➔	Q3007
Q3002	Do you currently use (smoke, sniff or chew) any tobacco products such as cigarettes, cigars, pipes, chewing tobacco or snuff?	1 YES, DAILY 2 YES, BUT NOT DAILY ……➔ 3 NO, NOT AT ALL ……➔	 Q3005 Q3005
Q3003	For how long have you been smoking or using tobacco daily? *INTERVIEWER: If less than one month – enter "00" for years and "00" for months.*	☐☐ YEARS ☐☐ MONTHS -8 DON'T KNOW	
Q3004	On average, how many of the following products do you smoke or use each day?	*Include number below:*	
	Q3004a. Manufactured cigarettes	☐☐	
	Q3004b. Hand-rolled cigarettes	☐☐	
	Q3004c. Pipefuls of tobacco	☐☐	
	Q3004d. Cigars, cheroots, cigarillos, bidis	☐☐	
	Q3004e. Smokeless tobacco	☐☐☐ GRAMS/DAY	
	Q3004f. Other, specify:	☐☐ ……➔	Q3007
Q3005	In the past, did you ever smoke tobacco or use smokeless tobacco daily?	1 Yes 2 No ……➔	 Q3007
Q3006	How old were you when you stopped smoking or using tobacco daily?	☐☐ YEARS OF AGE ……➔ -8 DON'T KNOW ……➔	Q3007 Q3006a

	Q3006a. How long ago did you stop smoking or using tobacco daily? *INTERVIEWER: If less than one month – enter "00" for months.*	☐☐ YEARS AGO ☐☐ MONTHS AGO -8 *DON'T KNOW*

ALCOHOL *(show Alcohol card to respondent - see Appendix A3000B)*

Q3007	Have you ever consumed a drink that contains alcohol (such as beer, wine, spirits, etc.)?	1 YES 2 NO, NEVER ..... ➔	Q3012
Q3008	Have you consumed alcohol in the last 30 days?	1 YES 2 NO ..... ➔	Q3010
Q3009	During the past 7 days, how many drinks of any alcoholic beverage did you have each day? *USE SHOWCARD Appendix A3000B.*	*INTERVIEWER: Want respondent to tell you the number of "standard" drinks. By standard drink - refer to Appendix. Include number below:*	
	Q3009a. Monday	☐☐	
	Q3009b. Tuesday	☐☐	
	Q3009c. Wednesday	☐☐	
	Q3009d. Thursday	☐☐	
	Q3009e. Friday	☐☐	
	Q3009f. Saturday	☐☐	
	Q3009g. Sunday	☐☐	
Q3010	In the last 12 months, how frequently [on how many days] on average have you had at least one alcoholic drink?	1 LESS THAN ONCE A MONTH 2 ONE TO THREE DAYS PER MONTH 3 ONE TO FOUR DAYS PER WEEK 4 FIVE OR MORE DAYS PER WEEK	
Q3011	In the last 12 months, on the days you drank alcoholic beverages, how many drinks did you have on average?	☐☐ DRINKS -8 *DON'T KNOW*	

Appendix Figure 4: Smoking and Alcohol use questions from the SAGE questionnaire

Bibliography

Center for Disease Control and Prevention (CDC). 2010. “Current Depression Among Adults --- United States, 2006 and 2008” Morbidity and Mortality Weekly Report (MMWR). Gerogia: Center for Disease Control and Prevention.

CDC (Center for Disease Control and Prevention).”2007-2008 National Health and Nutrition Examination Survey Examination Data” NHANES (National Health and Nutrition Examination Survey). 2008. Atlanta: Center for Disease Control and Prevention

Dinsa, G.D. Goryakin Y. Fumagalli E. and Suhrcke M. “Obesity and Socioeconomic Status in Developing Countries: A Systematic Review” Obesity Reviews. Volume 13. 2012. 1067-1079. This one has all the confounding variables

Djernes J.K. “Prevalence and Predictors of Depression in Populations of Elderly: A Review” Acta Pyschiatrica Scandinavica. Volume 113. 2006. 372-387.

Flegal, K.M. Carroll, M.D. Kit, B.K. and Ogden, C.L. “Prevalence of Obesity and Trends in the Distribution of Body Mass Index among US Adults, 1999-2010” Journal of the American Medical Association. Volume 307. 2012. 491-497.

Franko, D.L. Striegel-Moore, R.H. Thompson, D. Schreiber, G.B. and Daniels, S.R. “Does Adolescent Depression Predict Obesity in Black and White Young Adult Women?” Physiological Medicine. Volume 35. 2005. 1505-1513.

Goodman, E. and Whitaker, R.C. “A Prospective Study of the Role of Depression in the Development and Persistence of Adolescent Obesity” Journal of the American Academy of Pediatrics. Volume 11. 2002. 497-504.

Goulding, A. Gold, E. Cannan, R. Taylor, R.W. Williams, S. and Lewis-Barned, N.J. “DEXA Supports the Use of BMI as a Measure of Fatness in Young Girls” International Journal of Obesity and Related Metabolic Disorders. Volume 20. 1996. 1014-1021.

Hickson, M. “Malnutrition and Ageing” Postgraduate Medical Journal. Voume 82. 2006. 2-8.

IDF (International Diabetes Foundation). “The IDF Consensus Worlwide Definition of the Metabolic Syndrome” IDF Task Force on Epidemiology and Prevention. 2006. Brussels: International Diabetes Foundation.

Khan, A. Faucett, J. Lichtenberg, P. Kirsch, I. and Brown, W.A. “A Systematic Review of Comparative Efficacy of Treatments and Controls for Depression” PLOS one. 2012.

Kowal, P. Chatterji, S. Naidoo, N. Biritwun, R. Fan, W. Lopez Ridaura, R. Maximova, T. Arokiasamy, P. Phaswana-Mufuya, N. Williams, S. Snodgrass, J.J. Minicuci, N. D'Este, C. Peltzer, K. Boerma, J.T. and SAGE Collaborators. "Data Resource Profile: The World Health Organization Study on global AGEing and adult health (SAGE)" International Journal of Epidemiology. Volume 41. 2012. 1639-1649.

Li, Z.B. Ho, S.Y. Chan, W.M. Ho, K.S. Li, M.P. Leung, G.M. and Lam, T.H. "Obesity and Depressive Symptoms in Chinese older adults" International Journal of Geriatric Psychiatry. Volume 19. 2004. 68-74.

Marcus, M. Yasamy, M.T. Ommeren M.V. and Chishol, D. "Depression; A Global Public Health Concern" WHO Department of Mental Health and Substance Abuse.. 2012. Geneve: World Health Organization.

Mezuk, B. Golden, S.H. Eaton, W.W. and Lee, H.B. "Depression and Body Composition among Older Adults" Aging Mental Health. Volume 16. 2012. 167-172.

National Alliance on Mental Illness (NAMI). 2009. "Depression in Older Persons Fact Sheet" NAMI Fact Sheet series. Virginia: National Alliance on Mental Illness.

NIMH (National Institute of Mental Health). "What is Depression?" 2012. Available from: URL http://www.nimh.nih.gov/health/topics/depression/index.shtml?utm_source=BrainLine.orgutm_medium=Twitter (Accessed May 2013)

Peltzer, K. and Phaswana-Mafuya, N. "Depression and Associated Factors in Older Adults in South Africa" Global Health Action. Volume 6. 2013.

The World Bank. 2012. Classification of economies. Available from: URL http://data.worldbank.org/about/country-classifications (accessed May 2014)

United Nations. "World Population Prospects; the 2012 Revision" Department of Economic and Social Affairs Population Division. 2012. New York: United Nations.

United States Census Bureau. 2010. World Population Country Rankings. Available from: URL http://www.census.gov/population/international/data/countryrank/rank.php (accessed May 2014)

WHO (World Health Organization). "Obesity: preventing and managing the global epidemic" WHO Technical Report Series No. 894. 2000. Geneva: World Health Organization.

WHO (World Health Organization). “Depression” WHO Fact Sheet Series No. 369. 2012. Geneva: World Health Organization.