**NE\_TEMP 1939 PROPOSAL**

**TITLE: IMPROVING THE HEALTHSPAN OF AGING ADULTS THROUGH DIET AND PHYSICAL ACTIVITY**

**ISSUES AND JUSTIFICATION**

As the population of aging adults continues to grow, better understanding of effective strategies aimed toward improving the health span is needed. Aging is a multifaceted area of study that is continually exploring how to promote health and well-being throughout the lifespan. An integrative, interdisciplinary approach toward healthy aging from the metabolic level to translational science is imperative as aging is influenced by our genetics, metabolic processes, environment, and lifestyle practices. In doing so, it is likely we will improve the healthspan (part of a person’s life during which they are generally in good health) of aging adults.

**The need, as indicated by stakeholders**

Older adults.Aging adults face numerous barriers towards achieving optimal health and wellness including chronic disease, nutritional risk, food insecurity and functional impairments. The United States (U.S.) population is experiencing a shift in demographics. Adults aged 60 years and older have become the largest growing age group. It is estimated that around 1 in 7 Americans classify as an older adult, with about 20.4% age 60 years and older and 14.5% age 65 years and older 59.There is also a steady increase of older adults identifying as persons of color. The number of persons of color age 60 years and older increased 23% from 2006 to 2016 and is projected to increase to around 21.1 million 1. Based on these demographics, nutrition, physical activity and biomarker research for aging adults must include a diverse sample. A multistate approach is one strategy in which to achieve this.

Poverty. Poverty affects many older adults. In 2016, 14.5% of older adults were living below the poverty level per the Supplemental Poverty Measure 1. An additional 4.9% were found to be “near-poor” (ACL USDHHS, 2018). Of this proportion of older adults living below the poverty line, roughly half were persons of color 1. Older women are also more likely to be classified as living in a state of poverty, at 10.6% compared to 7.6% among older men 1. Consequently, limited income adversely affects the nutrition intake of older adults 30.

Food insecurity. Food insecurity and hunger can have profound impacts on nutritional status and health-related quality of life (QOL). Although food insecurity and hunger are often used interchangeably, the two are different degrees of the same indicators. Food insecurity is characterized by having inconsistent access and uncertainty in obtaining food, putting individuals at higher risk for malnutrition, chronic disease, and low QOL 24. The threat of food insecurity and hunger among older adults is rapidly increasing with about 15.8 % 60 being food insecure and 14.7% facing the threat of hunger 71. Older adults at greatest risk include those with a low income, those under the age of 70 years, being a person of color, and residing in the southern states 71. Food insecurity is correlated with lower energy and nutrient intakes, worse health outcomes, increased risk of early mortality and increased health care expenditures 7, 8, 71. Food insecurity and hunger affect more aging women than aging men 71. In addition, food insecurity is associated with higher likelihood of having limitations performing activities of daily living (ADLs) 72. Furthermore, older adults who were facing the threat of hunger are 30% more likely to report at least one ADL limitation 71.

Nutritional Risk. Nutritional risk increases with age due to a variety of factors such as decreased appetite, chewing and swallowing difficulties, physical limitations, limited income, reduced social interaction, and chronic disease. Nutritional risk encompasses both ends of the health spectrum, undernutrition and overnutrition, with each having equally detrimental health consequences. The prevalence of malnutrition among older adults is problematic, since a nutrient-poor diet is related to morbidity and mortality, physical impairments, functional disability and a greater frequency of admittance into hospitals and other long-term care facilities 21. The USDA NE-1439 Multistate Project “Changing the Health Trajectory for Older Adults through Effective Diet and Activity Modifications” team has conducted various studies examining the dietary practices of older adults. A three-state study revealed that 80.1% of older adults electing to take part in community nutrition programs were classified as “at nutritional risk” or “at possible nutritional risk” 39. Poor diets can have a profound effect on cell physiology altering inflammatory markers and oxidative stress, which contribute to telomere erosion and cellular senescence. Our work demonstrates the need for better understanding of the bidirectional relationships of the nutritional status of aging and the impact of nutritional status on health outcomes. An interdisciplinary approach would enable researchers to examine these issues at the cellular, individual and societal levels.

Dietary Intakes. A primary factor affecting the nutritional status of older adults is inadequate food and nutrient intakes. MyPlate recommendations suggest adults over age 50 years consume 1½ to 2 cups of fruits, 2 to 2½ cups of vegetables, 5 to 6 ounce-equivalents of grains, 5 to 5½ ounce-equivalents of protein and 3 cups of dairy daily 61. However, based on the Healthy Eating Index, only 18% of adults age 60+ years meet grain recommendations, 32% meet recommendations for vegetables, 34% meet total fat recommendations and between 23-27% consume the recommended amount of meat, dairy and fruit 18. Inadequate food intakes and aging can affect micronutrient status. For example, it is estimated that selenium status in 10% of Americans aged 40 or older is sub-optimal. These levels of marginal deficiency increase the susceptibility to many age-related degeneration later in life. High dietary selenium intake has also been reported to increase muscle protein levels by 10-14% in adult pigs 70. Inversely, whether or not a high protein diet affects body selenium status among aging adults is unknown.

As people age, blood levels of the cardioprotective fatty acid, linoleate (18:2n6) decreases. The decrease of blood levels of linoleic status parallels the loss of skeletal and cardiac muscle function and lean mass 30. In addition, diminished linoleate status in older individuals coincides with diminished mitochondrial function in skeletal muscle that accompanies aging 12, 50. Physical activity and a balanced diet may prevent muscle atrophy by targeting mitochondria 44.

 A dietary intake frequency assessment conducted by the NE-1439 multistate team revealed the majority of community residing older adults surveyed were consuming low intake frequencies of protein-rich foods, produce and whole grains 39. In addition to examining whole food consumption among aging adults, the NE-1439 team is exploring specific nutrients including selenium and fatty acids.

Physical Activity. Physical activity is a key modifiable behavior that can attenuate chronic disease risk and improve physical functioning in older adults 49. It also builds “physical reserves” so that if physical function declines resulting from illness or injury occur, individuals with greater physical reserves would be less likely to fall below the threshold for disability 55. Thus, physical activity is a key component of healthy aging. Unfortunately, the vast majority of older adults are not engaging in the recommended levels of physical activity 49.

Sarcopenia. Adults can experience a 3 to 8% decline in muscle mass per decade beginning in the their 40s and 50s 47; and muscle mass traditionally declines 30% to 50% between the ages of 40 and 80 years 14. For this project, we use the Foundation for the National Institutes of Health Sarcopenia Project (FNIH-SP) definition that uses lean mass (absolute or relative to body mass) and physical function cut points to define sarcopenia 57. The cut points have been shown to be independent predictors of incident mobility impairment in men and women 43. Sarcopenia-related health care costs are substantial, with estimates ranging from $11.8 to $26.2 billion 32. A 10% reduction in sarcopenia prevalence could save upward of $1.1 billion annually in the US 32. Nearly half (46.6%) of these savings would occur if 10% of those with severe sarcopenia were able to improve to a moderate level of sarcopenia while the remaining 56.4% would occur if 10% of those classified with “moderate sarcopenia” moved to “normal” 32. If sarcopenia were to be eradicated, about 26% of disability cases would be eliminated 32.

Lifestyle practices of older adults, in particular obesity, physical inactivity and poor nutritional intake, increase sarcopenia risk 22. This provides a unique challenge when designing community-based physical activity and nutrition programs. An effective sarcopenia prevention/treatment program must increase physical activity and promote healthy eating while preventing an energy-deficit that promotes weight loss, which can adversely affect sarcopenia 22. Establishing successful interventions that preserve and/or improve lean mass and physical function is crucial. There has been a significant effort to determine the most effective and efficacious interventions for treating sarcopenia and its associated symptoms 10; however, many efforts are not easily transferable to the community setting. A study conducted as part of the NE-1439 project demonstrated that a 12-week periodized resistance training intervention strategy was effective in retaining appendicular lean muscle mass and improving muscle strength in women ages 65-84 years 53. The renewal project will further develop this work into a larger scale, multistate intervention.

**Importance of Work**

A project renewal will provide the opportunity to expand on the work completed thus far by the members of the USDA NE-1439 Multistate Project “Changing the Health Trajectory for Older Adults through Effective Diet and Activity Modifications” from 2014 to the present. Through our collaborative efforts, we identified community supports for produce consumption among older adults 33 and the nutritional deficiencies placing aging adults at increased nutritional and sarcopenia risk 39. For example, we found that dietary selenium insufficiency induces age-related diabetes-like symptoms in association with accelerated telomere shortening 67, 69. Other dietary interventions, such as fortifying diets with high quality oils rich in linoleic acid appear to impact skeletal muscle mass 46. Additionally, we identified exercise modalities that offer promise in lowering sarcopenia risk and severity 53 and that nutritional risk is associated with shorter telomeres, a biological marker of aging 40. Further work can build on these findings to ascertain if shortened telomeres and the corresponding increase in cellular senescence are contributing factors in sarcopenia.

Building on these efforts, the renewal project will focus on **two objectives**: (1) to conduct multidimensional assessment of diet, physical activity and related factors affecting aging adults and (2) to develop, implement and evaluate interventions that improve health and well-being in aging adults in urban and rural environments. Given the diversity of the current team, which includes experts from metabolic nutrition to Extension and Outreach researchers, our team is well positioned to address the health and well-being of community-residing older adults from the laboratory to community. This provides a unique opportunity to work from the metabolic level to translational science.

We will also expand our reach to include those age 40 years and older. This expansion of age inclusion is based our present work that has illustrated the need to start interventions earlier than age 60 when applicable 17, 45, 53.

**The technical feasibility of the research.**

Our team has a long-standing interest and strong research record in the areas of aging, nutrition, exercise/physical activity, physiology and health promotion. Each has extensive experience in one of the five areas: metabolic nutrition, nutrition and/or physical activity interventions, qualitative research, nutritional science, and cell physiology. The proposed research is strengthened by our interdisciplinary approach that embodies translational research taking it from the lab to the community. The project team has a successful work history, including project development, data collection, evaluation, and dissemination.

**The advantages for doing the work as a multistate effort.**

This multistate aspect will provide the opportunity for team members to reach a diverse group of aging adults from around the United States. The multistate and institutional aspect allows us to collect data in a range of socioeconomic and ethnically diverse populations and across rural, suburban and urban geographical areas. This multistate group currently covers the northeast, mid-Atlantic, Southern, and upper Midwest regions of the country. Second, the multistate nature of the project, which entails the utilization of standardized assessment tools used by all researchers, lends itself to the establishment of a large data set from which additional analyses can be conducted. Additionally, the collaborative nature of the proposed work will allow a better utilization of research funding on larger-scale, multi-purpose, comprehensive projects that embodies translational research (lab to community).

**Anticipated Impacts**

The proposed multistate research team will train undergraduate and graduate students in qualitative research (e.g., conducting focus groups, analyzing focus group transcripts), quantitative research (e.g., data collection, data analysis), professional and scientific writing, laboratory skills, anthropometric measures, nutritional status assessment, dietary intake assessment, and physical function. The team will submit collaborative grant applications to external funding organizations and publish research findings in joint publications. The work conducted through our independent and collaborative efforts will (1) provide a better understanding of nutrition and physical activity needs of at-risk aging adults, (2) develop and implement effective strategies to address these needs, and (3) identify biomarkers related to the health of aging adults. Overall, these combined efforts will improve understanding of the dietary intakes, physical function, QOL and food security, lower sarcopenia risk, and reduce age-related diseases such as type 2 diabetes.

**RELATED CURRENT AND RELEVANT WORK**

 Related multistate projects. A recent Current Research Information System (CRIS) search of multistate research projects was conducted using the key words: human, aging, nutrition, exercise, physical activity, obesity, and sarcopenia. This search revealed this proposed renewal project is unique. Other multistate initiatives address in some aspect nutrition, physical activity, exercise, obesity and sarcopenia, but the focus on aging and older adults is not replicated with other multistate projects. Furthermore, there are no known groups working at the intersection of these important topics whose members represent such a diverse range of disciplines and skills and continued support of these efforts is perhaps more important than ever before as the population of the US is continuing to age.

 Accomplishments under current project. A strength of the NE-1439: Changing the Health Trajectory for Older Adults through Effective Diet and Activity Modifications multistate project is that the current team is comprised of molecular biologists, nutritional scientists, sociologists, anthropologists, registered dietitian nutritionists, exercise physiologists, and Extension researchers. Having a broad interdisciplinary team provides an opportunity for innovative collaborative translational work. Translational research is key to fundable, comprehensive nutritional research.

Our work since October 2014 has focused on three research areas including molecular and mechanistic understanding of age-related diseases, environmental assessment, and lifestyle needs assessments and interventions. Collectively, we have secured more than $750,000 in funding, published 39 peer-reviewed manuscripts (4 joint publications), trained 66 undergraduate students, 50 graduate students, and 2 post-doctoral research associates, and developed various Extension resources, including a four-module Extension healthy aging curriculum (For more information, <https://www.nimss.org/meetings/project/15898>).

Given the diversity of the work being completed, the resulting projects have been a blend of individual state projects and collaborative multistate efforts. For example, Dr. Belden adapted a PCR-based telomere length assay (a marker for cellular aging) similar to the one used in the NHANES national survey 11. This initial project involved only Rutgers University (Rutgers) students and faculty. Following this assay adaption, Dr. Ventura-Marra (West Virginia University [WVU]) collaborated with Dr. Belden to perform a telomere assessment as a biological marker of cellular aging as part of a diet and cardiovascular risk assessment study. This collaborative effort provided Dr. Ventura-Marra with the opportunity to report include objective data on cellular aging to support the efficacy of a lifestyle intervention and allowed Dr. Belden to use the developed assay in a real-world application 40. The proposed renewal project is anticipated to expand on this type of collaboration. In addition to their individual foundation experiments, the molecular biologists and nutritional scientists will be involved with select intervention studies to help assess programming impacts by performing comprehensive dietary analyses.

Another example of a project that started as a one-state effort but expanded to include three other states is our produce consumption environmental assessment study. Dr. Cohen (University of Massachusetts at Amherst [UMass]) began work on creating a theory-based produce access questionnaire. In order to ensure the applicability of the tool to different populations, Dr. Cohen worked with NE:1439 team members (Iowa State University [ISU], New York University [NYU], and WVU) to complete formative online focus groups as well as pilot-test the resulting environmental assessment tool (ISU and University of Illinois-Urbana Champaign [UIUC]). These multistate collaborations resulted in ascertaining the priorities for health eating in older adults in diverse communities 33 and used the resulting survey tool to determine the perceived environmental supports for produce consumption among older adults 34. As a result, our team has a better understanding of the produce access issues facing older adults. We learned how to use technology to conduct qualitative research across state lines, and now have a tool that can be used by other team members. Further, the inclusion of sociologists and anthropologists on our team in recent years has enabled our environmental and intervention work to look more holistically at the health and well-being of older adults. We anticipate expanding on this work by including more quality of life assessment tools during our studies.

Multistate research projects offer many benefits including working across state lines to evaluate the efficacy and impact of lifestyle interventions among diverse audiences. However, a challenge is that in order for an intervention to be effective it must be focused on the needs and preferences of the target audience. This means the approach utilized by each state may need to differ. In order to be more collaborative while respecting the unique needs of residents from each state, we began using common assessment tools across studies. This has allowed for the merging of data to perform cross-sectional studies. For example, many states were implementing various community-based nutrition education programs designed to meet the needs of our stakeholders. Although we were not evaluating the same intervention across states, each state had asked the same sociodemographic questions and used the same nutritional risk assessment tool. Team members from three states, New Hampshire (no longer with the project), Rhode Island and Iowa, created a multistate database with sociodemographic data and the nutritional risk assessment data to identify the nutritional risk factors of community-residing older adults. This study revealed most community-residing older adults were at nutritional risk and that their intake frequencies of protein-rich foods was low (MacNab et al., 2018). Given the success of this project, this approach will be expanded for this proposed renewal project with all states choosing from the same assessment measures as appropriate for their studies.

Furthermore, three current team members are Extension state specialists (ISU, Mississippi State University [MSU], and UICU). Having Extension Specialists on the NE-1439 team, has allowed for the development of community-based materials and interventions based on the formative work completed through the NE-1439 project. For example, the Stay Independent—a healthy aging series (<https://www.extension.iastate.edu/humansciences/stay-independent>) was developed based on the nutritional risk assessments by MacNab and others 39. It is now a statewide program in Iowa. For the proposed renewal project, we aim to pilot test community-based interventions through Extension as well as develop Extension publications and products that are informed through our collaborative research efforts. Doing so, increases the likelihood of this multistate project having national implications, as Extension is available in all states.

The work accomplished over the past few years through the NE-1439 multistate project has identified sarcopenia as a focus of our future interdisciplinary work. Helping adults age in place is a critical public health issue as the number of adults turning age 65+ grows rapidly. Long-term care spending reached $210.9 billion in 2011 in the United States (US) 20 and can comprise a major expense for older adults. A major threat to adults being able to age in place is sarcopenia. Sarcopenia is an often undiagnosed, chronic disease affecting older adults that has dire consequences both financially and physically 32. The renewal project provides the opportunity for team members to focus on sarcopenia prevention applying a translational approach that is inclusive of molecular, community and environmental areas. This is innovative in the area of sarcopenia research. While sarcopenia will be a disease endpoint of focus, we will also continue to emphasize ways that the work we do has applications for the general aging process and for other health conditions.

**OBJECTIVES**

The long-term goal of the proposed renewal project is to promote the independence and well-being of community-residing aging adults (ages 40 years and older). We aim to achieve this long-term goal by achieving the following research objectives:

* **Objective 1:** To conduct multidimensional assessments of diet, physical activity and related factors affecting aging adults.
* **Objective 2:**  To develop, implement and evaluate interventions that preserve or improve health in aging adults living in rural and urban environments.

Completing research studies under these objectives over the proposed five-year period (2019 through 2024) is expected to provide us with a more thorough understanding of: (1) the issues impacting the health and well-being of adults age 40 years and older; (2) how diet and exercise/physical activty factors influence the body at the molecular and cellular level; and (3) intervention strategies resulting in behavior changes as well as the development of interventions that are deliverable at the community-level nationally.

**METHODS**

Team members are expected to participate in at least one of the two overarching research objectives. The interdisciplinary composition of our team necessitates individual-level research as well as integrative, collaborative projects. The proposed activities will contribute toward the long-term goal of promoting the independence and well-being of community-residing aging adults (ages 40 years and older) while enabling researchers to maintain autonomy over their research experiments. For example, many of the laboratory-based projects will take place at the one of three universities (MSU, Ohio State University [OSU], and Rutgers); however, the formative work being completed in the areas of lipidomics (OSU), selenium (MSU) and telomere length (Rutgers, MSU) will inform our intervention strategies. It is also anticipated that some of our lifestyle intervention researchers will work with our molecular biologists and nutritional scientists to conduct specialized laboratory tests in addition to the traditional blood tests when examining the impact of dietary and physical activity programming. Finally, establishing one standardized set of inclusion criteria for human subjects conducted as part of this project is not feasible given the anticipated blend of individual-level and collaborative research as well as target behaviors. Therefore, the recruitment strategies utilized may vary by study (Appendix A).

**Objective 1: To conduct multidimensional assessments of diet, physical activity and related factors affecting aging adults.** These multidimensional assessments will explore molecular, community, and individual factors thus providing a comprehensive assessment. This approach will entail three overarching areas.

* AREA 1 involves performing molecular assessments on aging adults as a means to better inform participants’ activities and diet choices. Diet and exercise ultimately affect physiology on the molecular and cellular level and specific biomarkers are often the best predictors of whether certain diet and exercise modifications are beneficial. To accomplish Area 1, routine assessments of telomere length (Leukocyte Telomere Length [LTL] assay) will be coupled with assays that monitor markers of inflammation (CRP, Fibrinogen, IL-6, and TNFγ). The purpose of these assays will help predict the best diet and activity interventions for the participants and educate them on best practices to increase health span and independent living. In particular, Wu and others 67, have reported dietary selenium deficiency shortens telomere length in the highly proliferative colonocytes and accelerates incidence of such age-related symptoms of telomere-humanized mice. This provides an opportunity to assess whether telomere length is associated with blood selenium status in aging adults. Muscle mass will be estimated using bioelectrical impedance or skin fold and circumference measurements. Muscle function will be measured using grip strength, a criterion of the FNIH definition of sarcopenia 57 will be used to assess muscle function 9, 66. Peripheral blood lymphocytes collected at the same time as plasma for markers of inflammation and telomere length (above) will be analyzed for mitochondrial enzyme activity (e.g., citrate synthase activity 54. Targeted lipidomics of mitochondrial fractions from peripheral blood lymphocytes will identify mitochondrial phospholipids that are modified by dietary lipids 35.
* AREA 2 includes conducting needs and preference assessments to determine aging adults’ perceptions and recommendations for community environmental supports for a food secure, culturally appropriate and healthy eating environments. Improving the general health, functionality and the quality of life (QOL) of aging adults is a Healthy People 2020 goal 19, 64. In order to achieve this, social determinants of health (circumstances in the environment in which people are born, live, learn, work, worship and age) must be considered. The purpose of these studies is to identify the most important and modifiable enablers and behavioral of healthy eating among aging adults. To accomplish this, mixed methodology approaches will be used, including both qualitative and quantitative methods such as focus groups and consumer surveys. Qualitative methodology is an effective way to engage groups of people in a conversation about topics in which there are gaps in the literature and results can be useful as formative data to create surveys. We anticipate that focus groups would include six to eight people and do as many as needed to reach a saturation point in the data. Saturation occurs when further data collection does not provide new knowledge. Open-ended questions will be used and questions will be developed to answer gaps in the literature review. All focus group discussions will be transcribed verbatim and will be analyzed using standard focus group protocols. Themes will then be identified from the most prevalent codes found amongst the transcriptions. Expanding on the NE-1439 produce access questionnaire project additional consumer surveys will be developed using literature reviews, formative data from focus group discussions, or from community service providers or community members in the rural and urban regions of the participating states. These surveys will highlight the most important and modifiable community settings to improve food access and dietary behaviors in older adults. Surveys will be pretested for clarity and reliability and then administered to consumers receiving services through home-delivered meal programs (e.g., Meals on Wheels), congregate meal sites, food pantries, senior centers, and other community centers serving older adults in participating states. Surveys will identify older adults’ use of community supports for healthy eating, identify the types of supports used, identify where seniors access their foods and if they are food secure, and provide recommendations for improvement to foster healthy eating in older adults.
* AREA 3 entails determining, examining and understanding cultural, personal and accessibility barriers to dietary intakes and physical activity by aging adults. The purpose of these studies is to identify the geographic locations, cultural, and personal characteristics, and attitudes and beliefs that influence dietary behaviors (e.g., the purchase, preparation, and consumption of various foods) and physical activity patterns. Based on these findings, we will propose and implement sustainable methods to eliminate identified barriers, including nutrition education and physical activity interventions. Quantitative and qualitative data will be collected on aging adults. Quantitative data such as demographics, dietary intake, physical activity, food security and food access will be collected using standardized, validated assessment tools across states (See “Survey Tools Description” section). The methods for qualitative data collection will be focus groups and personal interviews as described above in Area 2. The information obtained through these studies will be shared with team members during the team’s general meetings and the annual meetings. The findings will be used to inform the studies being conducted under Objective 2.

**Objective 2: To develop, implement, and evaluate interventions that improve health in aging adults living in rural and urban environments.** The growth of the current team (13 states) has resulted in a more diverse make-up of states. This diversity includes population density (urban versus rural). Of the 11 states focused on community-based research, four (36.4%) have rural state populations of 20% and higher 63. Rural-residing older adults have worse physical health, decreased socialization, and a lower health-related quality of life than their urban-residing counterparts do 4, 31. The proposed renewal project will begin to examine programs relevance toward both rural and urban environments.

* Area 1 necessitates conducting qualitative and quantitative research examining nutrition- and physical activity related patterns and predictors of healthy aging. The purpose is to identify individual, family, clinical, community and health services nutrition- and physical activity-related factors for successful aging. All states implementing human studies will use the same assessment tools as applicable to the respective studies. These common assessment tools reflect the core variables being addressed across all human studies in this multistate project. These survey tools will collect the same: sociodemographic information, examine nutritional risk and dietary composition, food security, QOL, physical function, and physical activity. A common data set will be created to store data from all needs assessment and intervention studies conducted as part of this project. This large data set will be used to conduct modeling studies examining predictors of successful aging as well as cross-sectional data analyses to explore risk factors across states.
* Area 2 will involve developing theory-based nutrition and physical activity interventions based on identified needs and preferences. These interventions may focus on a variety of issues affecting aging adults such as weight loss, arthritis reduction, general health, and food security. Expanding on the work completed as part of the NE-1439 project we will further develop a sarcopenia prevention program. A variety of methods will be utilized depending on the type of study being implemented. These methods may include community-based assessments and/or interventions (e.g., Extension-delivered), clinical trials, and epidemiological studies. The key predictors and outcome measures include anthropometric, biochemical, clinical, dietary, physical activity, socioeconomic, and environmental factors according to the study design. For example, the loss of muscle in sarcopenia driven by cellular senescence and the major driver of cellular senescence is telomere shortening. When telomeres become too short, cells enter a state where they are incapable of driving and enter a dormant state. In addition, chronic inflammation has been proposed to be a major contributor to sarcopenia so following markers of inflammation will serve as a predictor of muscle loss. To address this, key markers of inflammation such as IL-6, and TNFγ and DNA repair such as OGG1 will be assessed in blood serum. Results from these biochemical analyses will complement and strengthen this area of research. Elevated inflammation, as indicated by plasma levels of TNFγ and IL-6, are highly associated with muscle loss. The Belury research group (OSU) will assess the association of dietary intake of fatty acids with inflammation and muscle function, mass and mitochondrial capacity, in collaboration with Drs. Belden (Rutgers) and Cheng (MSU).
* Area 3 is the development and testing of a theory-based, community-implemented, exercise and nutrition program (lifeSPAN [Sarcopenia Prevention through Activity and Nutrition] Program) capable of reducing the risk of and/or severity of sarcopenia among women ages 40-75 years. The long-term goal of the lifeSPAN Program is to promote the independence and well-being of community-residing aging and older women through an integrative, community-based exercise and nutrition intervention. ThelifeSPAN program utilizes an interdisciplinary approach, applies sustainable lifestyle intervention approaches, and is designed for community-delivery through Extension. The lifeSPAN Program will include creating an exercise DVD that emphasizes resistance training (based on work completed by URI as part of the NE-1439 project) and a nutrition curriculum that promotes protein intake through whole foods (based on MacNab study 39). The key indicators may include physical function (grip strength, four-meter gait speed test, chair stand tests, isometric leg extensor strength),body composition (multi-frequency bioelectrical impedance analysis (MFBIA), height and weight), nutrition and food measures (multiple 24-hour recalls, nutritional risk and dietary intake frequencies, complete blood counts, serum selenium levels), and markers of inflammation. The intervention will be pilot-tested in a variety of community settings. Data analysis will be undertaken using general linear models methods, focused on testing for differences between Control and Treatment groups and controlling for relevant demographic and structural covariates. The lifeSPAN program will be implemented in both urban and rural areas.

**Survey Tool Descriptions**

*Sociodemographic Attributes*

 We will use the demographic questions collected as part of the Performance Outcome Measurement Project (POMP) 2. The demographics modules includes 10 questions related to gender, race, age, marital status, and include. These questions utilize standard wording used with national surveys, which will allow for better comparison to national findings.

*Nutritional Risk and Dietary Intake Frequency Assessment:*

The Dietary Screening Tool (DST) is a validated tool to assess nutritional risk in middle-aged and older adults based on frequency of intakes of fruits, vegetables, dietary fiber, lean protein, added fat, sugars and sweets, dairy, and processed meats. The DST has 25 food and behavior specific questions, which can be completed by individuals in less than 10 minutes and scored by clinicians in less than 5 minutes 5, 6. The maximum score of 100 points is divided into 7 diet component categories (added fats, sugar, and sweets; whole fruit and juice; vegetables; total and whole grains; lean protein; dairy; and processed meat). A higher score is desirable as it indicates lower nutritional risk (“nutritional risk” [<60 points], “possible nutritional risk” [60-75 points], and “not at risk” [>75 points]) (Bailey, 2009). As part of the NE-1439 project, Dr. Ventura-Marra validated the DST for use among middle-adults adults (45 to 64 year olds) 41; thus expanding its use among all aging adults.

*Food Security*

Food insecurity is associated with poverty, lower nutrient intakes, increased likelihood of poor or fair health, being a person of color, activities of daily living (ADLs) limitations, and poor chronic disease management 3, 26, 37, 38, 56, 58, 72. Per the USDA Economic Research Service, nearly all the states in the renewal project where community-based research will occur (10 out of 11) has a food insecurity rate of 10 % and higher 63. The renewal project will collect food security data. To lower participant burden, researchers will be encouraged to use either the “Six-Item Short Form” 62 or the two-question option 25. The “Six-Item Short Form” quickly assesses food insecurity among older adults 62. A two-question subset from this short form has a sensitivity of 96% and higher and a specificity of 79% and higher 25.

*Quality of Life (QOL)*

We will assess QOL using one of the following tools: Satisfaction with Life Scale (SWLS) 15, food satisfaction will be measured using the Satisfaction With Food-Related Life (SWFL) scale 24, or the deJong Gieveld 6-item loneliness scale 13. The validated SWLS is a measure of subjective well-being. It is a 5-item 7-point Likert scale questionnaire used as measure of global cognitive judgments of satisfaction with one’s life 15. The SWFL scale is comprised of five questions on a 6-point Likert scale centered on food and meals 24. The loneliness scale is comprised of six questions and assesses emotional loneliness and social loneliness 13.

*Physical Activity*

The validated Yale Physical Activity Survey (YPAS) estimates caloric expenditure of habitual physical activity, including exercise activities, chores, and leisure activities in older adults 16, 68. It is valid and reliable when used with adults aged 60-86 years. Since there are no questions regarding specific exercises such as resistance training, we will ask a few additional questions regarding whether they have recently engaged in resistance training or other exercises including recent frequency, duration, and intensity.

*Physical Function*

Physical function will be assessed using at least one of the following tests: static handgrip strength 36, 42, 48, 52 the Short Physical Performance Battery Protocol (SPPB) 27, 28, and a 400-meter walk test 51, 65.

Static handgrip strength is a simple, safe, reliable and valid predictor of total body strength, physical functioning, and future disability and will be done using a hand-grip dynamometer (Jaymar Hydraulic Dynamometer, J.A. Preston, Corp., Jackson, MS) 36, 42, 48, 52. Participants will perform the grip strength test in a seated position using their dominant arm with the elbow flexed at a 90-degree angle. They will be instructed using standardized oral encouragement to squeeze the dynamometer with as much force as possible and highest force attained will be recorded. Three trials separated by a 1-minute rest period will be done and the highest force will be used.

The SPPB includes three balance tests, a gait speed test and a chair stand test 27, 28. Walking speed will be measured by requesting the participant to walk at their normal pace over a 4m distance. Time in seconds to complete the full course will be recorded. Two attempts will be done, and the faster of the two times will be used. A 46-cm high straight-back chair will be used to complete the repeated chair stand test, and participants will be instructed to stand up from the chair once without using their arms for assistance. If a participant is able to complete one chair stand, he/she will be asked to stand up and sit back down five times as quickly as possible, and the time to complete one series of five chair stands will be recorded.Participants will be instructed to sustain balance in three different positions distinguished by sequential narrowing of the base of support. Position one will begin with feet together (i.e. side by side); position two will consist of the heel of one foot next to the big toe of the other foot (i.e. semi-tandem); the last position will have the heel of one foot in front of and touching the toes of the other foot (i.e. tandem). For all three positions, participants will be timed for a maximum of 10 seconds, and scores will be summed for the measure of balance for a range of 0 to 30 seconds. Scores from 0 (inability to complete the test) to 4 (highest possible score) will be assigned to each of the three performance measures based on standard cut-points. A summary score ranging from 0 (lowest) to 12 (highest) will be calculated by adding walking speed, chair stands, and balance scores.

We will also use the 400-m walk test 51, 65. This test is a predictor of subsequent mortality in older adults. On a track (or measured corridor) each participant will be instructed to walk the track in a continuous loop as quickly as possible at a pace that can be maintained. Standardized oral encouragement will be given, as well as feedback regarding the number of laps remaining.

**MEASUREMENT OF PROGRESS AND RESULTS**

**Outputs**

* Development of Manual of Operations that includes all common validated tools that will be used for multistate research efforts. This manual will help ensure common research protocols are followed by all states.
* A comprehensive database of needs assessment and intervention data will be developed to allow for multistate cross-sectional data analysis and comprehensive assessment of lifestyle inventions for community-residing aging adults.
* Results from these studies will be used to provide recommendations to appropriate agencies regarding implementation of methods to improve availability and accessibility of healthful foods and physical activity for older adults.
* Continued statistical exploration of the associations among the following age-related health factors: dietary and physical activity behaviors, quality of life, socioeconomic status, race, etc.
* Molecular data of telomere length and markers of inflammation correlated with specific dietary and activity interventions.
* Using cross-sectional and longitudinal approaches, we will measure the association of dietary fat quality with changes of muscle function, mass and mitochondrial capacity. Results will be used to design intervention studies to test dietary oils (doses and types) to attend the loss of muscle mass and function in older people.

**Outcomes or Projected Impacts**

* Improved understanding of the nutrition and physical activity practices of community-residing adults ages 40 years and older influencing their chronic disease status.
* Reduced chronic disease incidence and/or severity as indicated through self-report, validated survey outcomes related to the targeted chronic disease and/or blood values.
* Reduced nutritional risk and improved dietary intake frequencies as measured by the DST among those participating in nutrition-focused interventions
* Increased physical activity participation among aging adults and increased physical function among those attending exercise, physical activity and/or sarcopenia interventions.
* Reduced food insecurity among those with limited incomes
* Enhanced healthspan as assessed by reduced chronic disease risk factors, increased QOL, and/or physical function.
* Study participants will gain knowledge regarding recommended nutrition and physical activity behaviors.
* Optimized healthspan through nutrition and physical activities that are cost-effective and achievable for aging or older adults.
* Study participants will implement dietary and other lifestyle goals that will attenuate muscle loss.

**Milestones**

* **Year 1:**
	+ Develop operations manual for common survey tools.
	+ Develop SPSS-base codebooks for each of the common research tools.
	+ Prepare manuscripts and grant submissions for studies.
* **Years 1-2:**
	+ Create lifeSPAN curriculum and prepare related grant applications.
	+ Optimize laboratory procedures for blood collection and preparation of peripheral blood lymphocytes at multiple sites.
	+ Prepare manuscripts and grant submissions for studies.
* **Years 2-3:**
	+ Pilot-test lifeSPAN program.
	+ Collect survey data from across states.
	+ Examine telomere length and markers of inflammation for selected studies.
	+ Quantify association of dietary fat intake with mitochondrial capacity and muscle health.
	+ Prepare manuscripts and grant submissions for studies.
* **Years 4-5:**
	+ Conduct cross-sectional data analysis using multistate dataset.
	+ Examine telomere length and markers of inflammation for selected studies.
	+ Prepare manuscripts and grant submissions for studies.

**OUTREACH PLAN**

We plan to disseminate the work accomplished through this multistate project at multiple levels. We will create and distribute education materials and programs for community-level implementation, ideally through Extension but may also include Area Agencies on Aging and public health departments. Joint publications related to our research findings will be prepared and submitted to peer-reviewed journals. We will continue to do oral and poster presentations at local, regional and national professional meetings such as Experimental Biology, American College of Sports Medicine, the American Society for Nutrition annual meeting, Food and Nutrition Conference and Expo, the Society of Nutrition Education and Behavior annual meeting, and the annual National Health Outreach Conference (Extension).

**ORGANIZATION AND GOVERNANCE**

Currently an Executive Committee (chair, chair-elect, past-chair, secretary, and member-at-large) and a Regional Administrative Advisor has the administrative oversight and organization for the multistate group. All positions are elected to three-year terms by team members during the annual meeting. The term begins October 1 of each respective year. The Chair is responsible for setting the meetings, developing and posting agendas, and facilitating the meetings. The Chair also oversees the completion of the annual reports and project-related revisions. The chair-elect completes the duties in the absence of the chair. The secretary maintains the minutes and sends to the Chair to post on the multistate website. The member-at-large attends the executive committee meetings and performs other duties as assigned by the Chair. The multi-state members meet on a regular basis (every other month) via online meetings and annually face-to-fact at a date and place that is selected by the entire group.

The NE-1439 Multistate group is in the process of developing and adopting a policy and procedures manual that will guide the functioning of the group. The maximum size of the multistate group will be 25 members. Members will be expected to actively participate in, collaborate, and contribute to the multistate research and administrative activities. Members who choose not to actively participate will be asked to resign from the group. Active participation is defined as participating in at least 50% of online meetings and contributing to the collaborative research and administrative activities. Consideration for termination of group membership due to inactive status will be presented on agenda and discussed by full group membership followed by a vote by the full membership at the next group meeting (face-to-face or online). A protocol will be established for accepting new members. It is anticipated that new members will be voted upon by the current members and should have applicable expertise that strengthens the group research, at least one chapter of dissertation published, and able to obtain independent funding for participation. The best time to join the group will be during the renewal process. Candidates must submit CV and documentation of how their skills meet the group research needs to the Chair. The group will review and vote upon the respective candidates.

**References**

1. Administration for Community Living, U.S. Department of Health and Human Services. *2017 Profile of Older Americans.* Published April 2018. Retrieved from: <https://www.acl.gov/sites/default/files/Aging%20and%20Disability%20in%20America/2017OlderAmericansProfile.pdf>.
2. Administration for Community Living, U.S. Department of Health and Human Services. *Performance Outcome Measurement Project (POMP).* Published December 2018. Retrieved from: https://acl.gov/programs/pomp
3. An R. Association of home-delivered meals on daily energy and nutrient intakes: findings from the National Health and Nutrition Examination Surveys. *J Nutr Gerontol Geriatr.* 2015;34(2):263-272. doi:10.1080/21551197.2015.1031604.
4. Baerenholdt M, Yan G, Hinton I, Rose K, Mattos M. Quality of life in rural and urban adults 65 years and older: Findings from the national health and nutrition examination survey. *Journal of* *Rural Health.* 2012; 28(4), 339-347.
5. Bailey RL, Miller PE, Mitchell DC, et al. Dietary screening tool identifies nutritional risk in older adults. *Am J Clin Nutr.* 2009;90(1)177-183. doi:10.3945/ajcn.2008.27268.
6. Bailey RL, Mitchell DC, Miller CK, et al. A dietary screening questionnaire identifies dietary patterns in older adults. *J Nutr.* 2007;137(2):421-426.
7. Berkowitz SA. *Food Insecurity, Malnutrition, and the Health of Older Adults: Testimony for the United States Senate Special Committee on Aging.* Published July 2017. Retrieved from: <https://www.aging.senate.gov/imo/media/doc/SCA_Berkowitz_7_12_17.pdf>.
8. Berkowitz SA, Basu S, Meigs JB, Seligman HK. Food Insecurity and Health Care Expenditures in the United States, 2011-2013. *Health Serv Res.* 2018;53(3):1600-1620. doi: 10.1111/1475-6773.12730.
9. Brown DJ, McMillan DC and Milroy R. "The correlation between fatigue, physical function, the systemic inflammatory response, and psychological distress in patients with advanced lung cancer." *Cancer*. 2005;103(2):377-382.
10. Burton LA, Sumukadas D. Optimal management of sarcopenia. *Clinical Interventions in Aging*. 2010;5:217-228.
11. Cawthon RM. Telomere measurement by quantitative PCR. *Nucleic Acids Res.* 2002;30:e47.
12. Conley K, Jubrias SA, Esselman PE (2000). Oxidative capacity and ageing in human muscle. *J Physiol*. 2002;526:201-210.
13. deJong Gierveld J., van Tilburg T. 6-Item Scale for Overall, Emotional, and Social Loneliness: Confirmatory Tests on Survey Data. *Research on Aging.* 2006;28(5):582-598.
14. Denison HJ, Cooper C, Sayer AA, Robinson SM. Prevention and optimal management of sarcopenia: a review of combined exercise and nutrition interventions to improve muscle outcomes in older people. *Clinical Interventions in Aging*. 2015;10: 859-869.
15. Diener E, Emmons RA, Larsen RJ, Griffin S. The Satisfaction with Life Scale. *Journal of Personality Assessment*. 1985;49:71-75.
16. Dipietro L, Caspersen CJ, Ostfeld AM, Nadel ER. A survey to assessing physical activity among older adults. *Med Sci Sports Exerc.* 1993;25:628-642.
17. Drazba M, Morris A, Marra M. Sarcopenia Assessment in a Middle-aged Appalachian Population. *The* *Journal of Frailty and Aging*  2018;7(S1):125.
18. Ervin BR. Healthy eating index scores among adults, 60 years of age and over, by sociodemographic and health characteristics: United States, 1999-2002. Published May 2008. Retrieved from: <http://www.cdc.gov/nchs/data/ad/ad395.pdf>
19. Federal Interagency Forum on Aging-Related Statistics. Older Americans 2016: key indicators of well-being. Washington, DC: U.S. Government Printing Office. Published August 2016. Retrieved from: <https://agingstats.gov/docs/LatestReport/Older-Americans-2016-Key-Indicators-of-WellBeing.pdf>.
20. Freundlich N. Long-term care: What are the issues? Published February 2014. Retrieved from: https://www.rwjf.org/en/library/research/2014/02/long-term-care--what-are-the-issues-.html
21. Furman EF. Undernutrition in older adults across the continuum of care: nutritional assessment, barriers, and interventions. *Journal of Gerontological Nursing*. 2006;*32(1):*22-27.
22. Goisser S, Kemmler W, Porzel S, Volkert D, Sieber CC, Bollheimer Lc, Freiberger E. Sarcopenic obesity and complex interventions with nutrition and exercise in community-dwelling older persons—a narrative review. *Clinical Interventions in Aging*. 2015;10:1267-1282.
23. Gregory CA Coleman-Jensen A. *Food insecurity, chronic disease, and health among working-age adults*. U.S. Department of Agriculture, Economic Research Service, ERR-235. Published July 2017. Retrieved from: https://nopren.org/wp-content/uploads/2017/08/ERS-Report-Food-Insecurity-Chronic-Disease-and-Health-Among-Working-Age-Adults.pdf
24. Grunert K., Dean D, Raats M., Nielsen N, Lumbers M. A measure of satisfaction with food-related life. Appetite. 2007;49:486-493.
25. Gundersen C, Engelhard EE, Crumbaugh AS, Seligman HK. Brief assessment of food insecurity accurately identifies high-risk US adults. *Public Health Nutr.* 2017;20(8):1367-1371. doi: 10.1017/S1368980017000180
26. Gundersen C, Ziliak JP. Food insecurity and health outcomes. *Health Affairs.* 2015;34(11):1830-1839. doi:10.1377/hlthaff.2015.0645.
27. Guralnik JM, Ferrucci L, Pieper CF, Leveille SG, Markides KS, Ostir GV et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *J Gerontol A Biol Sci Med Sci*. 2000;55:M221–M231
28. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol*. 1994;49:M85–M94
29. Guthrie JF, Lin BH. Overview of the diets of lower- and higher-income elderly and their food assistance options. *J Nutr Educ & Behav.* 2002;34(1):S31-S41.
30. Harris WS, Pottala JV, Varvel SA, Borowski JJ, Ward JN, McConnell JP. Prostaglandins. *Leukot Essent Fatty Acids*. 2013 Apr;88(4):257-63.
31. Hawton A, Green C, Dickens AP, Richards SH, Taylor RS, Edwards R, Campbell JL. The impact of social isolation on the health status and health-related quality of life of older people. *Quality of Life Research*. 2010;20(1):57-67.
32. Janssen I, Shepard DS, Katzmarzyk PT, Roubenoff R. The healthcare costs of sarcopenia in the United States. *J. Am Geriatr Soc.* 2004;52:80-85.
33. Jiang Q, Cohen N, Marra M, Woolf K, Gilbride J, Francis S. (2017). Priorities for health eating in older adults in diverse communities. *J Nutr Gerontol and Geriatr;*2017;36:*75-91.* Doi: 10.1080/21551197.2017.1365039
34. Jiang Q, Francis SL, Chapman-Novakofski KM, Carbone ET, Cohen N. Perceived environmental supports for fruit and vegetable consumption among older adults in the US. Manuscript in preparation.
35. Kim J, Hoppel CL. Comprehensive approach to the quantitative analysis of mitochondrial phospholipids by HPLC-MS. *J Chromatogr B Analyt Technol Biomed Life Sci.* 2013;226:497-509.
36. Laukkanen P, Heikkinen E, Kauppinen M. Muscle strength and mobility as predictors of survival in 75-84-year-old people. *Age Ageing*. 1995;24: 468-473.
37. Lee JS, Johnson MA, Brown A. Older Americans Act Nutrition Program improves participants' food security in Georgia. *J Nutr Gerontol Geriatr.* 2011;30(2):122-139. doi:10.1080/21551197.2011.566526.
38. Lee JS. Food insecurity and healthcare costs: research strategies using local, state, and national data sources for older adults. *Adv Nutr.* 2013;4(1):42-50. doi:10.3945/an.112.003194.
39. MacNab L, Francis SL, Lofgren I, Violette C, Shelley MC, Xu F, Delmonico M. Factors influencing dietary intake frequencies and nutritional risk among community-residing older adults. *J of Nutr Gerontol Geriatr. 2018;* doi: [10.1080/21551197.2018.1524809](https://doi.org/10.1080/21551197.2018.1524809)
40. Marra MV, Drazba M, Holásková I, and Belden WJ. Nutrition Risk, but Not Diet Quality, is Associated with Leukocyte Telomere in a Middle-aged Appalachian Population. In review.
41. Marra MV, Thuppal SV, Johnson E, Bailey R. Validation of a Dietary Screening Tool in a Middle-aged Appalachian Population. *Nutrients.*2018;10(3):E345.doi: 10.3390/nu10030345.
42. Mathiowetz V, Kashman N, Volland N, Weber K, Dowe M, Rogers S. Grip and pinch strength: normative data for adults. *Arch Phys Med Rehabil*.1985;66:69-74
43. McLean RR et al. Criteria for clinically relevant weakness and low lean mass and their longitudinal association with incident mobility impairment and mortality: the foundation for the National Institutes of Health (FNIH) sarcopenia project. *J Gerontol A Biol Sci Med Sci.* 2014 May;69(5):576-83.
44. Menshikova E, Ritov VB, Fairfull L, Ferrell RE, Kelley DE, Goodpaster BH. Effects of exercise on mitochondrial content and function in aging human skeletal muscle. *J Gerontol A Biol Sci Med Sci*. 2006;61(6): 534-540.
45. Morris A, Drazba MA, Delmonico M, Marra, MV. Assessing Sarcopenia Risk Using Established Metrics in Obese Middle-Aged and Older Men. *J Frailty Aging*. 2018;7(S1):162.
46. Norris LE, Collene AL, Asp ML, Hsu JC, Liu LF, Richardson JR, Li D, Bell D, Osei K, Jackson RD, Belury MA. *Am J Clin Nutr.* 2009 Sep;90(3):468-76.
47. Paddon-Jones D, Leidy H. Dietary protein and muscle in older persons. *Curre Opin Clin Nutr Meab Care*. 2014 January;17(1):5-11. Doi: 10.1097/MCO.0000000000000011.
48. Rantanen T, Guralnik JM, Foley D, Masaki K, Leveille S, Curb JD, White L. Midlife hand grip strength as a predictor of old age disability. *JAMA*. 1999;281: 558-560.
49. Rosenberg D, Depp C, Vahia I, Reichstadt J, Palmer B, Kerr J, et al. Exergames for subsyndromal depression in older adults: a pilot study of a novel intervention. *American Journal of Geriatric Psychiatry.* 2010;18:221-226. doi:10.1097/JGP.0b013e3181c534b5
50. Short K, Bigelow ML, Kahl J, Singh R, Coenen-Schimke J, Raghavakaimal S, Nair KS. Decline in skeletal muscle mitochondrial function with aging in humans. *Proceedings of the National Academy of Sciences of the United States of America.* 2005;102: 5618-5623.
51. Simonsick EM, Montgomery PS, Newman AB, Bauer DC, Harris T. Measuring Fitness in healthy older adults: the Health ABC Long Distance Corridor Walk. *J Am Geriatr Soc*. 2001;49:1544–1548
52. Skelton DA, McLaughlin AW. Training functional ability in old age. *Physiotherapy*. 1996;82:159-167
53. Slezak SG, Renna EN, Mahoney KB, Lofgren IE, Xu F, Delmonico MJ, Hatfield DL. Effects of Periodized Resistance Training on Sarcopenia Classification in Older Inactive Women. *Medicine & Science in Sports & Exercise*. 2017;49(5S):543.
54. Srere P. Citrate synthase. *Methods in Enzymology*. 1969;3: 3-5.
55. Stewart AL. Conceptual challenges in linking physical activity and disability research. *Am J Prev Med*. 2003;25(suppl):137-140.
56. Strickhouser S, Wright JD, Donley AM. Food insecurity among older adults. AARP website. Published 2014. Retrieved from: <http://www.aarp.org/content/dam/aarp/aarp_foundation/2015-PDFs/AF-Food-Insecurity-2015Update-Final-Report.pdf>.
57. Studenski S, Peters KW, Alley DE, Cawthon PM, McLean RR, Harris TB, Ferrucci L, Guralnik JM, Fragala MS, Kenny AM, Kiel DP, Kritchevsky SB, Shardell MD, Dam TT, Vassileva MT. The FNIH sarcopenia project: rationale, study description, conference recommendations, and final estimates. *J Gerontol A Biol Sci*. 2014;69(5): 547-558.
58. Thomas KS. Outcomes matter: the need for improved data collection and measurement in our nation's home-delivered meals programs. *J Nutr Gerontol Geriatr*. 2015;34(2):85-89. doi:10.1080/21551197.2015.1031591.
59. U.S. Census Bureau. *2012-2016 American Community Survey 5-Year Estimates*. Retrieved fromhttps://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk. Accessed on December 26, 2018
60. United Health Foundation. *America’s health rankings senior report*. Retrieved from: <https://www.americashealthrankings.org/learn/reports/2017-senior-report/executive-summary>. Accessed on December 26, 2018.
61. United States Department of Agriculture. *MyPlate food groups.* Updated December 2018. Retrieved from <http://www.choosemyplate.gov/food-groups/>
62. United States Department of Agriculture, Economic Research Service. U.S. Household Food Security Survey Module: Six-Item Short Form. Published September 2012. Retrieved from: <https://www.ers.usda.gov/media/8282/short2012.pdf>
63. United States Department of Agriculture, Economic Research Service. State Fact Sheets. Updated November 2018. Retrieved from: <https://www.ers.usda.gov/data-products/state-fact-sheets/>
64. US Department of Health and Human Services, Office of Disease Prevention and Health Promotion. Older adults: overview. Healthy People 2020 website. Updated December 2018. Retrieved from: <https://www.healthypeople.gov/2020/topics-objectives/topic/older-adults>.
65. Vestergaard S, Patel KV, Bandinelli S, Ferrucci L, Guralnik JM. Characteristics of 400-meter walk test performance and subsequent mortality in older adults. *Rejuvenation Res*. 2009;12: 177-184.
66. Vestergaard S., Nayfield SC, Patel KV, Eldadah B, Cesari M, Ferrucci L, Ceresini G, Guralnik JM. Fatigue in a representative population of older persons and its association with functional impairment, functional limitation, and disability. *J Gerontol A Biol Sci Med Sci*. 2009;64(1): 76-81.
67. Wu RT, Cao L, Mattson E, Witwer KW, Cao J, Zeng H, He X, Combs GF Jr, Cheng WH. Opposing impacts on healthspan and longevity by limiting dietary selenium in telomere dysfunctional mice. *Aging Cell*. 2017 Feb;16(1):125-135. doi: 10.1111/acel.12529.
68. Young DR, Jess SH, Appel LJ. A comparison of the Yale Physical Activity Survey with other physical activity measures. *Med Sci Sports Exerc*. 2001;33:955-961.
69. Zhang L, Zeng H, Cheng WH. Beneficial and paradoxical roles of selenium at nutritional levels of intake in healthspan and longevity. *Free Radic Biol Med.* 2018 Nov 1;127:3-13. doi: 10.1016/j.freeradbiomed.2018.05.067.
70. Zhao Z, Barcus M, Kim J, Lum KL, Mills C1, and Lei XG. High dietary selenium intake alters lipid metabolism and protein synthesis in liver and muscle of pigs. *J. Nutr.* 2016;146:1625-33. doi: 10.3945/jn.116.229955.
71. Ziliak JP, Gundersen C. *The state of senior hunger in America 2015: an annual report.* National Foundation to End Senior Hunger, Feeding America. Published August 2017. Retrieved from: <http://www.feedingamerica.org/research/senior-hunger-research/state-of-senior-hunger-2015.pdf>.
72. Ziliak JP, Gundersen C, Haist M. The causes, consequences, and future of senior hunger in America. special report by the University of Kentucky Center for Poverty Research for the Meals on Wheels Association of America Foundation. Published 2008.