Quantifying Frequency and Variety of Activities in Older Adults: Relationships with Physical and Cognitive Performance

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ABSTRACT

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(Under the direction of Dr. Carol Giuliani)

Activity provides a protective effect against cognitive and physical decline in older adults. Recent literature suggests that for older adults, variety and frequency of activity may be more important to this protective effect than intensity level. Although the ideal amount, type, and intensity of activity for preventing decline has not been determined, current tools for measuring activity are inadequate. A review of current activity measures used for older adults revealed that there is no reliable and valid tool to quantify variety or frequency of participation in different types of activities. Using a cross sectional design, I developed, tested and validated the Variety of Activity Questionnaire (VAQ) to measure frequency and variety in social, cognitive, physical, and exercise activity domains, and examined associations among frequency and variety with physical and cognitive function. Questionnaires were collected from 196 community dwelling older adults (range: 70 – 99 years, mean: 78.7 years) in North Carolina. Exploratory factor analysis evaluated the underlying structure of the VAQ. An ICC was used to assess test-retest reliability for the outcomes of total activity (TA) and variety of activity (VA) on a subset of 30 participants and construct validity on a different subset of 53 participants. Physical and cognitive performance measures were assessed on 95 participants. Regression analyses identified demographic and performance measures significantly associated with TA and VA. The VAQ demonstrated acceptable test-retest reliability [ICC 2,1 = .69 (TA), .72 (VA)] and validity [ICC 2,1 = .57(TA), .71(VA)]. The VAQ failed to factor; therefore, the structure and components of the VAQ were not modified. A mobility measure and marital status were significant predictors of VA, and a dynamic balance measure was a significant predictor of TA. Measures of attention and processing speed were significantly related to both VA and TA, but had stronger associations with VA. Variety of activity appears to have stronger associations with physical and cognitive performance than TA, suggesting that variety of activity may be important for function. The VAQ has potential as a tool for researchers and clinicians and warrants continued study. Future intervention studies will clarify the relationship between variety of activity and function.

DEDICATION

All we have to decide is what to do with the time that we are given.
-- Gandalf,

Graduate school was a catalyst for change. During my time at UNC I got married, purchased a house, and had a child. In short, I evolved to my next stage of life. I dedicate this work to my husband, Brian for all of his love, patience, support, and extreme silliness, and to my daughter, Emlyn, whose laughter, smiles, and 3 am wake up calls got me to the finish line. These two people have helped me to achieve balance and happiness in my life and realize the goal of completing graduate school. More importantly, they have made my life full of love, laughter and adventure.

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CHAPTER I

INTRODUCTION

The Problem

In 2004, 36.5 million Americans were aged 65 and over, comprising 12% of the population. In the next 25 years, the number of older adults is expected to double, comprising over 25% of the total United States population.[1] This demographic shift has created research imperatives to keep older adults independent in the community as long as possible. One growing area of research is exploring the protective effect of activity against physical and cognitive declines and risk of falls. Participation in cognitive and social activities has a protective effect against mild cognitive impairment, depression and dementia.[2-7] Regular engagement in physical or exercise activities is associated with decreased cognitive impairment, decreased incidence of dementia, and maintenance of physical function and mobility.[8-12] These findings suggest that staying active and engaged can provide some protection against the physical and cognitive declines associated with aging. This is important because physical and cognitive declines contribute to a loss of independence,[13,14] increased risk of falls,[15-17] increased hospitalizations, [18,19] morbidity and mortality in older adults.[20] Although the evidence is fairly strong that activity is a contributing factor to maintaining independence, several questions remain unanswered regarding the type, amount, duration, and frequency of activity needed to achieve these protective effects. One of the problems in the literature is that activity is not always well defined, and methods of measuring activity differ across areas of research, making comparisons among studies difficult. The cognitive and social activity literatures both support that number of activities is related to decreased incidence of dementia.[2, 3, 5-7] In the physical activity literature, activity is typically quantified by amount (hours per week), or intensity (calories burned or metabolic equivalent units), as opposed to variety; however, there is some evidence that the total number of physical and exercise activities has a greater effect than total amount or intensity of activity on the relative risk of dementia.[21]

Variety of activity is a concept that is relatively unexplored, but may be an important factor for maintaining cognitive and physical function. It is possible that participating in a variety of certain types of activity may be necessary for improved functional outcomes and falls prevention. In one of the few studies to explore the concept of variety of activity, Podewils et al. reported that variety of exercise activity appears to be protective of cognitive decline.[21] Results of intervention studies also suggest that variety may be important for decreasing falls. Studies that have incorporated a variety of activities in the intervention have reported significant reductions in falls rates [22-24] and improved performance on daily tasks.[25] An interesting caveat was that the interventions with greater variety did not significantly improve intrinsic risk factors associated with falls such as leg strength, walking speed, or balance skills.[22, 24, 26] This suggests variety may affect different mechanisms than the specific risk factors associated with falls.

How might participating in a greater variety of activities maintain or improve physical and cognitive function? The International Classification of Function, Disability and Health (ICF) provides a theoretical framework to explain how participating in a variety of activities may affect function.[27] (Figure 1.1) In the ICF model, activity is central, affecting body functions and structure, participation, and health conditions (disability, falls). Likewise, environment and personal factors affect activity. It may be that increasing the variety of activity results in interacting with a greater number and types of environments, in turn affecting a greater number of body systems. The exposure to increased numbers of activities and environments may positively influence health condition and overall function.

A review of current activity measures used for older adults revealed that we do not have a reliable and valid tool to quantify participation in different types of activities. Several self-report questionnaires have been used to quantify participation in either social,[28] cognitive,[29] physical,[30] and exercise activities[31] domains; however no questionnaire measures all four of these domains. Interestingly, there are numerous activity questionnaires available, however very few of these questionnaires have published reliability and validity [3, 32] or use activity items appropriate for an older adult population.[33]

Rationale and Significance

The purpose of this project was to develop, test and validate a brief tool called the Variety of Activity Questionnaire (VAQ) to measure frequency and variety of activity in social, cognitive, physical activity, and exercise domains. The VAQ should provide a valuable research tool for identifying the relationships among physical and cognitive function, variety of activity and total amount of activity. The questionnaire might also be valuable for assessing changes in activity during aging or as the result of interventions. Clinicians as well as researchers might benefit from using the VAQ to quantify activity, identify individuals at risk of low activity, and develop individualized interventions based on client responses.

The VAQ was developed with the goals of simplicity, brevity, and applicability to individuals 70 years and older. Activities included in the questionnaire are those identified with high participation rates for older adults. Initially the VAQ was developed and tested, and then cross-sectional relationships were examined among frequency and variety of activity and physical and cognitive function. Future research will use longitudinal and intervention studies to explore the responsiveness of the VAQ and the role of variety of activity interventions to reduce functional decline, decrease falls risk and promote independence.

Specific Aims

The specific aims of this project were:

1) To develop a self-report measure called the Variety of Activity Questionnaire, to quantify the frequency and variety of activities in cognitive, social, physical activity, and exercise domains during an average week of an older adult.
2) To describe the relationships between physical performance measured by walking speed, chair rise time, static balance and dynamic balance assessments and frequency and variety of activity quantified by the VAQ.
3) To examine the relationship between performance on cognitive measures of attention and processing speed and frequency and variety of activity quantified by the VAQ.

Research Questions

This is a manuscript-style dissertation composed of three studies. Results of each study are presented in the respective manuscript complete with tables, figures, and references. The first paper discusses the reliability and validity of the VAQ questionnaire.

The second paper examines associations between performance of mobility and balance assessments and frequency and variety of activity. The third paper examines associations between performance of cognitive measures of attention and processing speed and frequency and variety of activity. Chapter III is a synthesis of the dissertation projects. Additional information and analyses are contained in the appendices. The following research questions were addressed in this dissertation.

Manuscript 1: Is the VAQ a reliable and valid self-report measure of weekly participation in cognitive, social, physical and exercise activities?

Research Questions:

1. Are the activities for each domain correctly categorized?

   Hypothesis: Very few activities belong to one domain. For example, social activities often incorporate physical components. The domains may be re-structured after exploratory factor analysis.

2. Is the VAQ a reliable measure?

   Hypothesis: The VAQ will demonstrate moderate test-retest reliability when administered a second time after a period of seven days.

3. Is the VAQ a valid measure?

   Hypothesis: The VAQ will demonstrate moderate concurrent validity with daily activity logs.

Manuscript 2: What are the associations between physical performance and frequency and variety of activity?

Research Question

1. Do older adults who perform well on assessments of mobility and balance engage in a greater frequency or variety of activities than those who do not perform as well?

   Hypothesis 1: Older adults who perform better on assessments of mobility and balance will engage in a greater frequency of activities.

   Hypothesis 2: Older adults who perform better on assessments of mobility will engage in a greater variety of activities.

   Hypothesis 3: Mobility and balance measures will have stronger associations with variety of activity than frequency of activity.

Manuscript 3: What are associations between performance on cognitive measures of attention and processing speed and frequency and variety of activity?

Research Questions

1. Do older adults who perform well on a cognitive measure of attention and processing speed engage in a greater frequency or variety of activities than those who do not perform well?

   Hypothesis 1: Older adults who perform better on a cognitive measure of attention and processing speed will engage in a greater frequency of activities.

   Hypothesis 2: Older adults who perform better on a cognitive measure of attention and processing speed will engage in a greater variety of activities.

   Hypothesis 3: Attention and processing speed measures will have stronger associations with variety than frequency of activities.

2. Do older adults who perform well on a divided attention task engage in a greater frequency or variety of activities than those who do not perform well?

    Hypothesis 1: Older adults who perform better on a divided attention task will engage in a greater frequency of activities.

    Hypothesis 2: Older adults who will perform better on a divided attention task will engage in a greater variety of activities.

    Hypothesis 3: Performance on a divided attention task will have stronger associations with variety than frequency of activity.

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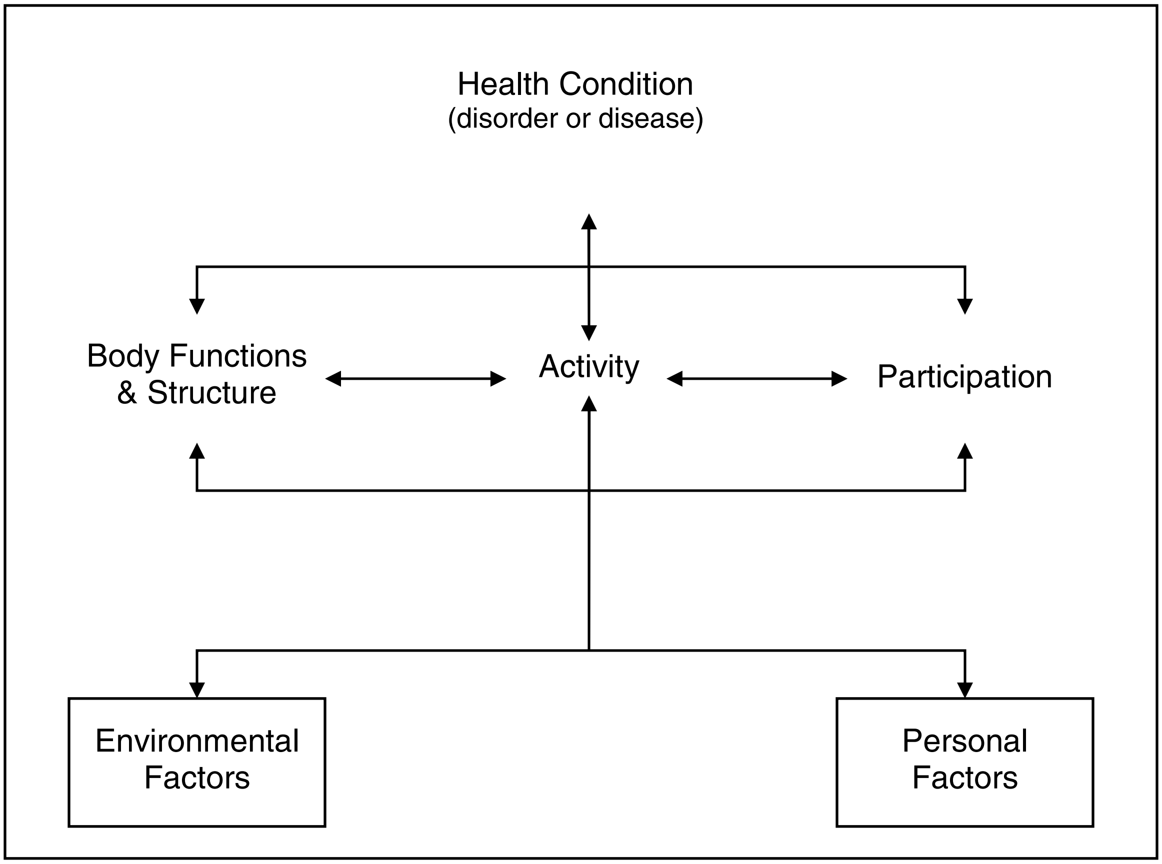

Figure 1.1. International Classification of Function, Disability and Health (ICF): Proposed mechanism of variety. Reprinted from *International Classification of Functioning, Disability and Health: ICF*. Geneva, Switzerland: World Health Organization; 2001 with permission of the World Health Organization.

OPERATIONAL DEFINITIONS

Cognitive Activities: Activities that require analytical skills, decision making and/or memory.

Community Dwelling Older Adults: Adults over the age of 70 who are living independently in the community. They do not require full time in-home assistance or care.

Continuing Care Retirement Community (CCRC): A private residence for older adults that offers several levels of care; older adults who are fully independent in these residences may use the facilities for meals and housecleaning; however they are equivalent in function to a community dwelling older adult.

Exercise: Planned, structured, and repetitive bodily movement for a period of time with the purpose of improving or maintaining a component of physical fitness; e.g. swimming, aerobics, walking.

Functional Strength Training: Strength training using activities necessary for daily life; e.g. getting up from a chair, standing on one foot, turning in a circle.

Physical Activity: Any bodily movement produced by skeletal muscles resulting in increased energy expenditure; e.g. cleaning house, gardening, climbing stairs.

Social Activities: Activities that require interaction with other people or groups of people such as going to church, talking on the phone, attending discussion groups.

Traditional Strength Training: Structured strength training protocols with progression of exercises based on percentages of the maximum amount an individual can lift.

CHAPTER II

MANUSCRIPT 1

Development of a Tool to Quantify the Frequency and Variety of Activity for Older Adults: The Variety of Activity Questionnaire

INTRODUCTION

In the last century, the older adult population in the United States increased from 4.1% to 12.0%.[1] That number is expected to double in the next 30 years, with projections of individuals 65 and older comprising 25% of the population.[2] This unprecedented growth of the aging population has created research imperatives to determine key factors for maintaining an independent and mobile older adult population. One important area of research is describing the protective mechanism of activity or an active lifestyle against physical and cognitive decline in older adults.

Researchers studying older adults reported that increased activity levels appear to provide a protective effect against cognitive and physical decline. Increased participation rates in cognitive and social activities have been associated with decreased incidence of cognitive decline and dementia.[3-8] Increased participation in physical activities and exercise has also been associated with decreased incidence of cognitive decline and dementia,[9-11] as well as maintained physical function.[12, 13]

Longitudinal studies reported significant associations between number of cognitive and social activities and decreased incidence of depression and dementia.[3-7] Older adults with high participation rates in cognitive activities such as reading books, listening to music, or playing board games exhibit less decline on measures of memory and processing speed[3] and a decreased incidence of mild cognitive impairment[14] and Alzheimer's disease[4] than adults with low participation rates in these activities. The number of cognitive activities appears to be an important component of this effect, with an increase in participation in one activity per week resulting in a 19% decrease in incidence of cognitive decline,[3] and a 13% decrease in the risk of dementia.[4]

A similar protective effect was reported in studies assessing participation in social activities such as visiting with friends and family, going to church and talking on the phone.[5, 7, 15] The type of social contact (attending an event versus talking on the phone) did not appear to be a critical factor; rather, the overall number of weekly social activities was associated with decreased incidence of dementia in community dwelling older adults.[7]

Studies assessing older adults' participation in physical and exercise activities reported protective effects against both physical[12, 13] and cognitive decline.[9, 10, 11] Older adults who were physically active exhibited less functional decline[12] and reduced all-cause mortality.[13] Increased levels of physical activity were associated with less difficulty in performing activities of daily living,[16] and improved performance on physical measures,[17, 18] which are predictive of functional decline, morbidity and mortality.[19] Longitudinal studies reported that greater levels of physical activity at baseline were associated with decreased levels of cognitive impairment and incidence of dementia.[9, 10, 20] Number of physical activities as well as total amount may be an important component of this outcome. A retrospective study assessing number and intensity of activities in middle age reported that diversity of activities had a stronger association with decreased incidence of Alzheimer's disease.[8] A longitudinal study comparing associations between total number of exercise activities and amount of activity for the outcome of dementia provides further evidence for number or variety of activities.[21] Individuals in this study who engaged in four or more activities per week had a lower relative risk of dementia (.51, 95% C.I. 0.33 - 0.79) compared with individuals who participated in less than four activities. The protective effect for variety was significant and stronger than the highest quartile of weekly caloric expenditure (relative risk: 0.85, 95% C.I. 0.61, 1.19).[21]

There is considerable controversy in the activity literature about the nature and extent of this protective effect. Some researchers argued that older adults with greater cognitive abilities participate in more activities; therefore it is not activity level, but pre-existing cognitive abilities protecting against decline.[22, 23] Other researchers question the associations between physical activity and cognitive decline, suggesting that other factors, like education levels or participation in cognitive activities, are contributing to the protective effect.[4, 14, 24] Sturman reported the protective effect afforded by physical activity against cognitive decline was no longer significant after controlling for cognitive activities.[24] Verghese compared the effects of participating in physical activity to cognitive activities and reported only participation in cognitive activities provided protection against cognitive decline.[4]

Several questions exist concerning the amount, type, and intensity of activity required to achieve this protective effect. However, the literature generally supports the idea that participating in cognitive, social, and physical activities may be important to healthy aging, and variety may be an important way to quantify activity participation. Developing a tool to measure an older adult's participation in these activities would be useful for both researchers and clinicians.

Currently, there is no standardized questionnaire that captures the variety or frequency of participation in social, cognitive, physical, and exercise activities for older adults. One difficulty interpreting results in the literature is that researchers have used several different questionnaires to record activity levels, some of which have reported reliability and validity, and some of which do not. The number and type of activities chosen varies widely among questionnaires, and the intervals for measuring activity participation (times per week, month, or year) is not standardized among studies (Table 1.1).

Many activity questionnaires have been developed, but few quantify participation rates in the four domains of activities. Some investigators assessed participation in combinations of activity domains such as cognitive and physical,[4] or social and physical.[15] Two studies combined all four domains,[23, 25] however, the limited number and appropriateness of items per category used in these studies may not accurately capture activity rates for older adults. For example, Aartsen assessed participation in social, cognitive, and physical activities, but several activities included in the questionnaire, such as attending a neighborhood meeting or going to the zoo[22] are activities with low participation rates for older adults.[26] In an attempt to define participation in several types of activities, Newson created a "general lifestyle activity" composite score to examine activity level as a predictor of cognition and cognitive change over a six year period. The measure assessed participation rates in physical and social activities; however it does not include exercise activities,[25] which may be important for physical and cognitive function. Verghese also created an activity index that included ten physical activities and six cognitively demanding activities, but did not include social activities.[4]

Although there are several standardized physical activity questionnaires these tools have methodological problems for use with older adults and do not assess participation in cognitive or social activities. Many questionnaires were originally designed for the 55 plus age group and have decreased applicability and validity for use in individuals over the age of 65.[27, 28] Older adults often participate in low intensity activities, which results in low validity values when measured by accelerometer or self-report.[29-31] Several studies use metabolic equivalent units (METS) or caloric expenditure to quantify physical activity.[28, 31, 32] METS may not be an accurate indicator of activity levels in older adults because the standardized MET values were calculated using younger adults as subjects.[33]

A final problem in the activity literature is a lack of a standardized time frame for questionnaires. Researchers reported participation in activities using frequencies that range from times per week,[4, 28, 32, 34] per month,[3] within a 3 month period,[25] to frequencies per year.[3, 23] The recall bias inherent in self report of activities for a three month to one year period brings the results of these studies into question.[29, 35] Most studies in the physical activity literature use a one week interval to quantify activity levels and minimize recall bias.[28, 32, 34] The questionnaire developed for the present study used an interval of one week to capture participation in usual activities.

These methodological differences among studies make comparisons difficult, and indicate that current measures do not have adequate reliability and validity for quantifying activity levels in older adults. A review of the literature failed to identify a questionnaire that quantifies variety of activity, even though the literature suggests that variety of activity in addition to intensity and duration may be an important outcome measure for older adults.

Frequency and variety of activity in multiple domains could be important indicators of an older adult's current activity level and provide insight on future function. Developing, testing and validating an activity tool that is appropriate for older adults, simple to administer, brief, and assesses participation in social, cognitive, physical activity and exercise domains would be a valuable contribution to this area of research. Such an activity survey using a standardized time frame of one week would also be valuable to clinicians. Results of the questionnaire could identify patients at risk for low activity, document current activity levels, and provide a platform to dialogue about ways to increase the numbers and types of activities.

The purpose of this study was to develop a brief questionnaire for older adults that captures weekly participation in cognitive, social, physical, and exercise activities. Specifically, our aims were to develop a Variety of Activity Questionnaire (VAQ) and assess feasibility, reliability and validity as a self-report measure of weekly participation in four activity domains. We achieved these aims by using exploratory factor analysis to determine if the items would factor into proposed domains, a test-retest reliability measure to compare stability of responses after one week, and a concurrent validity measure to determine if the VAQ was accurately capturing activity participation in a usual week for an older adult.

METHODS

Study Participants

This was a cross sectional study. Eligible participants were 70 years or older and living independently in the community or in continuing care retirement communities (CCRC). Participants were excluded if they had significant cognitive decline (score of six or seven on the Short Portable Mental Status Questionnaire depending on level of education),[36] had a diagnosis of a progressive neurological disorder, were in the latter stages of terminal disease, unable to read, write, or speak English, or walk independently with or without an assistive device. Additionally, people were excluded if they experienced a major health event (e.g., stroke, orthopedic surgery, or hospitalization) within the last six months.

Participants were recruited from senior centers, churches, and CCRCs in central North Carolina. The study was promoted through community presentations, newsletters and flyers, and at senior health fairs. The study was approved by the University of North

Carolina at Chapel Hill Institutional Review Board, and all participants provided informed consent. Two hundred and eighteen participants were screened for eligibility requirements and 199 individuals met the criteria and participated in the study.

Procedure

All testing occurred at the recruitment site. Participants completed questionnaires for demographic and health information and the Variety of Activity Questionnaire (VAQ). The testing session took approximately 15 minutes.

Tool Development – The Variety of Activity Questionnaire

The VAQ was designed as a brief measure to capture participation in the four domains of activity (cognitive, social, physical, and exercise). These domains of activity have been identified as important factors that protect against cognitive decline and maintain functional mobility.[3-7, 9-13, 37]

Domain Specific Activities: Cognitive – Activities for the cognitive domain were based on work by Wilson[26] and Ambrose.[38] Wilson rated cognitive complexity of seven cognitive tasks and surveyed participation in each task in a cohort of 6,162 adults over 75 years of age living in the greater Chicago area.[26] Ambrose completed a similar survey on 73 frail older adults living in New York.[38] All surveys included items asking about reading newspapers or books, playing board games or puzzles, and watching television. Ambrose included playing music, writing, attending lectures and participating in group discussions. The cognitive section of the VAQ consisted of eight items.

Domain Specific Activities: Social – Activities chosen for the social domain were used in previous studies assessing the relationship between participation in social activities and incidence of dementia, depression, and successful aging.[5-7, 15] Key activities in this domain include social engagement with friends or family, social participation by attending church or club activities, and volunteerism. The social section of the questionnaire consisted of eight items.

Domain Specific Activities: Physical Activity – Physical activity and exercise were separated into two domains. Physical activity is defined as "any bodily movement produced by skeletal muscles resulting in increased energy expenditure" and exercise is defined as "planned, structured, and repetitive bodily movement for a period of time with the purpose of improving or maintaining a component of physical fitness".[39] Older adults tend to participate more in physical activity as opposed to structured exercise.[38, 40] Recent studies suggest that physical activity is associated with reduced risk of functional impairment, morbidity and mortality,[13, 41] and appears to be a key component of healthy aging. The nine physical activity items included in the VAQ were based on published studies of physical activity patterns in older adults.[38, 40]

Domain Specific Activities: Exercise – The exercise domain assessed participation rates in age appropriate exercise activities. Exercise appears to provide a protective effect against physical and cognitive decline. Older adults who participate in exercise interventions three times a week report improved physical function,[42] endurance,[43] and balance.[44] Researchers conducting longitudinal studies have reported that participation in exercise activities three or more days a week is associated with a protective effect against cognitive decline.[10, 45-47] Older adults with higher levels of fitness have decreased atrophy of grey matter as measured by MRI,[11] and decreased choice reaction times.[48] The eleven exercise items were selected from standardized physical activity and exercise questionnaires for older adults.[28, 34, 49]

Pilot Testing – The questionnaire was piloted on two samples of older adults to confirm that the items included in the questionnaire had adequate participation rates. The first pilot study surveyed the exercise activity participation rates of 128 older adults living in a CCRC in western North Carolina. The second pilot study surveyed social and physical activity participation rates in 23 community dwelling adults in rural central North Carolina. Activities with participation rates of 20% or higher were included in the VAQ.

Thirty-seven activities were selected based on published questionnaires,[28, 34, 50] research results,[7, 26, 38] and pilot data. A preliminary version of the VAQ was given to three expert researchers in geriatrics, five geriatric clinical specialists and four older adults to obtain feedback based on content, clarity of questions, and inclusiveness of activities. The 37 items were judged by this group to be representative of activities common to older adults, and no items were removed from the questionnaire. Suggestions to improve content included incorporating computer based activities for two cognitive domain items: playing games and writing, and to include a write in category of "other" for each domain. Suggestions to improve clarity included adding examples of activities for items of light and heavy housework and team games. The current version of the questionnaire includes 37 activity items and takes approximately five minutes to complete.

Administration – The administration protocol was based on pilot testing and recommendations from an expert in the field of measurement development (M.R.Lynn, personal communication, July 6, 2005). Participants were told the following: "We will now fill out a questionnaire asking about the activities you do in a usual week. The questions ask how many times in a usual week you participate in different activities for your mind, for your body and social activities". Participants were shown a series of four calendars that illustrated participation in an activity daily (6-7 times/week), often (2-5 times/week), once a week, or 1-2 times a month. Participants were told: “I will read you an activity, and I want you to mark on the questionnaire how many times in a usual week you do that activity. Do you do the activity daily (the appropriate calendar was indicated for each frequency of activity), often, once a week or 1-2 times a month. If you do not do that activity, just say never.” The questionnaire was given to the participant and the researcher read each activity item. Participants checked the box that described the frequency of their participation in the activity. The researcher provided any necessary clarification to improve accuracy such as alerting the participant if they skipped an item.

Scoring – The VAQ was designed to generate two different scores. The first scoring method assessed total weekly activity (TA) and was based on the work of Verghese.[4] Participants received a score for each activity based on the frequency of activity as follows: activities done “daily” were scored a 7, “often” a 4, “once a week” a 1, “one to two times a month” a .5, and “never” a zero. Frequency scores were summed to create a TA score which ranged from 0 to 259. The second scoring method assessed variety of activity (VA). Subjects received a point for each activity in which they participated, and all points were summed to create a VA score which ranged from 0 - 37.

To conduct reliability and validity tests for the VAQ, additional testing sessions were scheduled with volunteer subgroups of participants. Upon completing the first testing, we asked if participants were willing to either retake the VAQ after a one week period to assess the stability of the instrument, or to complete a 7-day activity log to be used in validity assessment.

Thirty participants were recruited to retake the VAQ and 55 were recruited to complete the activity log. The test-retest sample was either scheduled for a follow-up visit or called on the phone to complete the second administration of the VAQ. Individuals contacted by phone had a copy of the VAQ for their reference, and the researcher read each activity and asked if they did the activity: daily, often, once a week, 1-2 times a month or never. The participant provided verbal responses to the researcher about frequency of the activity. When the repeat administration was conducted in person, the administration was exactly the same as the first test. Fifteen repeat administrations were done by phone and 15 were conducted in person. The retests were scored in the same way as the original VAQ.

The participants recruited to complete the activity log were given a packet of seven VAQs labeled for each day of the week and a postage paid return envelope. They were instructed to check off any activity done at the end of each day, and mail the questionnaires to the researcher after the seventh day. The daily logs were scored so that participants received a point for each activity done on each day. All points were summed for the specific activity for the week, and then the activity was categorized into daily, often, or once a week based on the number of points.

Analyses

Data were analyzed using SPSS software, version 14.0 (SPSS Inc., Chicago, IL). Descriptive statistics were used to describe the demographics as well as total activity and variety of activity. Frequency tables and descriptive measures were generated for each category of activity.

Variety of Activity Questionnaire – Exploration of Activity Domains

Activities with very low or very high participation rates were eliminated from the final version of the questionnaire. Exploratory factor analysis (EFA) was used to evaluate the underlying structure of the VAQ. A principal component analysis with a varimax rotation was employed based on the assumption that we had a large number of items we believed would reduce to a small number of factors,[51] and that the factors produced would not be strongly correlated with one another.[51]

Reliability and Concurrent Validity

A two-way mixed model (ICC 2,1) estimated the test-retest reliability for the outcomes of total activity (TA) and variety of activity (VA) between the first and second administrations of the VAQ (n = 30). To provide an estimate of concurrent validity, 55 participants completed the VAQ, and then kept records of their activity for seven days using the daily activity log. Self-report of activity for a 7-day period has been used as a validation method in several physical activity questionnaires[30, 52, 53] The daily activity logs were summed to generate a TA and VA score for the week, and a two-way mixed model (ICC 2,1) measured the association between scores on the VAQ and scores calculated from the 7-day activity log.

RESULTS

Subjects

From September 2005 to May 2006, 199 community dwelling older adults were recruited from central North Carolina to participate in the study. During data entry, it was discovered that 3 questionnaires were missing a section of the VAQ, and 2 questionnaires were missing data on the 7-day activity log; these subjects were dropped from the analyses. Exploratory factor analysis was performed on 196 subjects, test-retest reliability on 30 subjects (15 in person, 15 by phone), and concurrent validity on 53 subjects. On average subjects were 78.7 years old (*SD* = 6.3), 79% were female, 28% were African American, 70% White, and 2% Other. The majority of subjects (74%) walked without an assistive device, and had an average of three health conditions. Education levels varied among subjects; 42% had a high school education or less, and 24% had graduate degrees (Table 1.2).

Frequency of Activities

Participation rates of each activity are shown in Table 1.3. Activities with the highest daily participation rates in the cognitive domain were reading (86% daily), playing an instrument, listening to music and singing (45% daily); in the social domain, talking on the phone (75% daily) and visiting with friends or relatives (23% daily); in the physical activity domain, light housework and meal preparation both have daily rates of 76%; and in the exercise domain 25% had a daily home exercise routine and 24% walk daily. The physical activity domain had the highest overall daily participation rate, and the exercise domain had the lowest overall daily participation rate.

Exploratory Factor Analyses

The EFA was run with the 14 factors indicated by the scree plot. The Kaiser-Meyer-Olkin (KMO) test was used to assess sampling adequacy, and Bartlett's Test assessed sphericity. The KMO value of .58 was considered unacceptable for factor analysis.[54] Each factor was composed of one to three items with factor loadings from .41 - .87. Reliability estimates were poor with coefficient alphas for 12 of the 14 factors of less than .53,[55] providing evidence that the data were not amenable to EFA. Rescoring the VAQ on standard

0 – 4 scale instead of a 0 - 7 scale (0, .5, 4, 7) did not improve the factor structure. We decided that the VAQ is either not amenable to EFA or is in a preliminary phase of development. Factor analysis was not used to determine if an item should remain in the questionnaire.

The participation rates of each item were further analyzed to determine if the item was of value to the questionnaire or inconsequential. If all participants did the activity or very few did the activity, the item was not contributing discerning information to the VAQ scores. Items that had high (≥ 85% daily) or low (< 85% never participated or less than one time a week) were dropped from the questionnaire. "Reading" was the only item dropped due to high participation rates (85% daily) The following activities were dropped due to low participation rates: take day or overnight trips (95% did 1x/month or never), hiking (89% never), golf (98% never), and team games (85% never). Subsequent reliability analyses were conducted on items remaining in the VAQ.

Reliability

A two-way mixed effects model (ICC 2,1) demonstrated a one week test-retest reliability of .69 for TA and .72 for VA. The people effects were considered random and the measures effects were fixed. (Table 1.4)

Concurrent Validity

A two-way mixed effects ICC model assessed the concurrent validity of the VAQ with the 7-day activity log (n = 53). The strength of agreement between what participants recall that they do in a usual week and what they recorded in a daily log (7 days) was .57 for TA and .71 for VA (ICC 2,1). (Table 1.4)

DISCUSSION

The purpose of this project was to develop a self-report measure designed to quantify the frequency and variety of activities in cognitive, social, physical activity and exercise domains during an average week of an older adult (VAQ). Developing a standardized measure to quantify participation in these activities should provide the methodology for studying relationships between participation in these activities and physical and cognitive function. The questionnaire items were developed, piloted, and given to experts in the field for feedback. The current version of the VAQ shows promise as a brief measure with acceptable psychometrics. The VAQ has higher reliability and validity values in comparison to other validated activity questionnaires,[56] suggesting it is an adequate tool to measure activity levels in older adults. The VAQ requires further study with a larger number of participants to test if an underlying factor structure exists.

The VAQ was administered to 196 individuals from a wide range of educational backgrounds, including a few individuals who did not complete grade school. All participants were able to complete the VAQ, either independently or with minimal assistance from the researcher. Average completion time of the questionnaire was five minutes, suggesting the VAQ places minimal burden on the participants. Census data supports that the sample was representative of the population of central North Carolina regarding race, gender, health conditions, and falls prevalence.[57-59]

The activities included in the VAQ appear to be appropriate for this population. Four activities were removed from the questionnaire due to low participation rates. These activities were more complex, and potentially posed a higher financial burden than other activities, which may explain the low participation rates. For example, taking a trip or going hiking requires planning, transportation and possibly hotel costs. Playing games (e.g., tennis or golf) involves coordinating with a group of people, purchasing equipment, and paying court or green fees. Although our sample had low participation rates in these activities, other groups of seniors may show different participation patterns. Reading was the only activity removed from the VAQ due to high participation rates. Other studies identified reading as a cognitive activity[3, 4] associated with a protective effect against cognitive decline. However with 86% of the population reading daily, and 95% of the population reading books, newspapers, or magazines often to daily, we concluded this item does not seem to discriminate differences in activity levels. Nonetheless, participation in this activity may be important to measure in older adults.[3, 4, 60]

Activity patterns generated from the VAQ were as we expected, with the highest participation rates in activities that are necessary for daily function (cooking, cleaning, talking on phone). The cognitive activity patterns of our sample were similar to older adults from urban areas who reported high participation rates in reading and writing.[26, 38] Our sample differed with lower participation rates in playing board games, which may be associated with community and regional differences in activities available at senior centers and churches. The seniors who attend centers often participate in the activities provided, and this might be an ideal environment to promote participation in cognitive activities.

Approximately one-fourth of our sample participated in some form of home exercise daily, which suggests that the majority of our sample is relatively sedentary. More importantly, 80% of our sample indicated that they never participated in any form of strength training. Leg muscles experience preferential atrophy in older adults,[61] and weak leg strength is a risk factor for falls,[62] functional decline[63] and poor mobility.[64] Older adults should be educated regarding the benefits of strength training for maintaining function and mobility, and having more strength training programs available in the community would help to prevent functional decline.

We reported good reliability and concurrent validity values for our questionnaire, especially in comparison to other tools in the literature. Validation studies of other self reported physical activity questionnaires reported low but acceptable reliabilities of .26 - .52.[33, 53] Because we were comparing a measure of activities recalled for a usual or typical week to activities recorded in a daily log, we believe the VAQ has acceptable stability and is an adequate measure of weekly activities.

The good test-retest reliability and validity values supports the use of the VAQ as a clinical tool. The VAQ takes approximately five minutes to complete and provides the clinician with valuable information about the type and frequency of activities that can be used to plan intervention, record change, and provide counseling. Low activity levels may identify people at risk for functional and cognitive decline, and may prompt counseling about the need for and value of activity. A dialogue in this area may reveal reasons for low activity levels and insight to issues not evident from a standard assessment. Self-report of current activity levels provides information about activity preferences, availability and access, needed supports, and barriers that will help to develop an exercise or activity program that may have better client acceptance, adherence and compliance. For example, a person who does not enjoy group activities might not follow through with a recommendation to join an exercise class at the senior center, but might have greater success for increasing activity with an individualized home exercise program. The VAQ can be used as a health promotion tool by providing an opportunity to educate older patients on the benefits of remaining or increasing participation in cognitive, social, physical and exercise activities.

The VAQ has promise as a tool to measure participation frequency and variety in cognitive, social, physical, and exercise activities. Quantifying participation in these areas may be an important component of health and wellness assessments in older adults. Our results suggest that the VAQ has acceptable retest reliability and concurrent validity. The questionnaire is brief, easy to understand, and produces a measure of total activity and variety of activity scores, both of which are easy to interpret and quantify for research studies and for clinical practice.

Limitations

The main limitation to this study was sample size. Our projected sample of 199 was smaller than desired for EFA. A larger sample might help clarify if the EFA would work for this questionnaire. Only 21% of the sample was male; according to the 2001 Census data, men compromise 40% of the population aged 75 to 84, indicating that men were under-sampled for this study.[2] A final limitation of the study was that the sample of volunteers recruited for this study from senior centers, continuing care retirement communities (CCRCs), and churches may not represent the general population. However, the demographics of our sample indicate we recruited an adequate representation of older adults in central North Carolina.[57] Future studies should focus on including recruitment of individuals from a larger geographical region to enhance the universality of the tool.

CONCLUSIONS

Preliminary development of the VAQ suggests that it is a reliable and valid measure that may have utility as a tool for researchers wanting to measure activity in older adults. As a clinical tool the VAQ provides insight on a patient's current activity levels and information to develop interventions. In the community, the VAQ may provide information on activity patterns for older adults that can be used to develop and modify programming to promote health and wellness. Future studies will focus on increasing the sample size and the heterogeneity of the sample to further refine the tool and continue exploring the value of amount, variety, and type of activity associated with maintaining function in older adults.

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Table 1.1 Comparison of Activity Instruments for Older Adults *

* For review of physical activity questionnaires, please refer to Jorstad-Stein, 2005

Citation	Domains	Instrument	Reliability Validity	Frequency of Activity	Applicable to older adults	Additional Concerns
Verghese, 2003	Physical Cognitive	Index cognitive (6) exercise (10)	None	Times per week and month	Yes – participation rates of 73 older adults	1) Based on activities of urban dwelling 2) No social or physical activities
Menec, 2003	Social Cognitive Physical	"Every Day" Activities 18 activities in 3 categories: Social (10) Solitary (4) Work (4)	None	Times per week	Yes – participation rates in each activity measured	1) No exercise 2) Only 2 physical activities
Hultsch, 1999	Cognitive Social Physical Exercise	"Activity Lifestyle" 70 activities in 6 categories Physical (4) Self-maintenance (6) Social (7) Hobbies/home maintenance (12) Passive information processing (8) Novel information processing (27)	6 year stability = .57 - .63	Daily to yearly scored on 0 -9 point scale	Designed for middle aged and older, low participation rates for some items	1) Exercise items may not be applicable to older adults (jogging, etc) 2) Recall issues for yearly participation in activities
Aartsen, 2002	Social Cognitive Physical	"Everyday Activities" 8 activities in 3 categories: Social (3) Experiential (4) Developmental (1)	None	No time frame reported	Items selected based on participation rates of older adults	Items groups into categories by research team. Time frame for social activities is yes/no Time frame for other activities is not clear (0 – never do the activity, 7 = every day) No explanation for the scale
Newson2005	Social Cognitive Physical	Adelaide Activities Profile- 21 activities in 4 categories Household Maintenance (7) Domestic Chores (8) Social activities (4) Service to others (5)	Factor α .51-.80 Reproducibility: .94 PCA: 43.5% of variance	3 month period Scored on 0 -4 point scale	Yes	No exercise activities Developed for Australians, may have limited applicability for Americans Time scale is not explained
Wilson, 1999, 2002	Cognitive Physical	Index 7 cognitive activities 11 exercise activities adapted from the 1985 Health Interview Survey	None	For cognitive: 5 point scale - daily to yearly Exercise: Number of times and average duration of activity during last 2 weeks	Cognitive activities: Participation rates of 6.162 older adults Exercise: Adapted information for use with older persons, no further explanation	Participation scale difficult to understand Exercise activities may not be appropriate for older adults Recall of length and intensity

Table 1.2. Participant Demographics (n=196)

Variables	**Mean (*SD*)**
Age	78.7 (6.3)
BMI	25.9 (5.0)
Number of Health Conditions	2.7 (1.6)
	Percentage of Subjects
Gender (female)	79
Race	
Black	28
Asian	1
White (non-Hispanic)	70
White (Hispanic)	1
Marital Status	
Married	35
Widowed	45
Divorced	10
Single	3
Other	7
Education	
Less than high school	16
High School/GED	26
Associate Degree	16
Bachelor's Degree	18
Graduate Degree	24
Assistive Device	
Never	74
Rarely	7
Some of the time	7
Most of the time	5
All of the time	7
Number of Falls in Past Year	
0	67
1	21
2	5
3	3
4	3
>4	1

Table 1.3. Participation Rates in Activities

Daily	%	Often	%	Once a Week	%	Never	%
Read	86	Gather with People	45	Church/Temple	44	Golf	98
Light Housework	76	Going Shopping	45	Heavy Housework	35	Hike	88
Meal Prep	76	Walk for Exercise	37	Club/Social Meetings	21	Team games	85
Phone	75	Visit/Visited	33	Visit/Visited	20	Swim/Water Aerobics	80
Music	45	Conditioning Exercise	21	Group Activities	20	Lift weights	80
Climb Stairs	33	Cog games	20	Going Shopping	20	Bicycle	75
Walk for Errands	29	Church/Temple	20	Group Talks	19	Childcare/Caregiving	74
Puzzles	27	Group Activities	20	Write	16	Dancing	74
Home Exercise	25	Gardening/Yardwork	20	Movies/Videos	15	Work/Volun, active	69
Going Shopping	24	Phone	19	Cog games	13	Conditioning Exercise	68
Walk for Exercise	24	Write	18	Attend Lecture	13	Gentle Exercise	63
Write	23	Group Talks	18	Work/Volun, sedentary	13	Trips	60
Visit/Visited	23	Heavy Housework	18	Gather with People	13	Work/Volun, sedentary	59
Gather with People	18	Climb Stairs	18	Music	12	Arts&Crafts	52
Arts&Crafts	13	Home Exercise	17	Arts&Crafts	11	Gardening/Yardwork	48
Gardening/Yardwork	12	Walk for Errands	16	Walk for Exercise	11	Cog games	47
Cog games	9	Gentle Exercise	16	Walk for Errands	10	Movies/Videos	46
Heavy Housework	9	Club/Social Meetings	15	Dancing	10	Attend Lecture	44
Gentle Exercise	7	Bicycle	15	Home Exercise	10	Puzzles	43
Work/Volun, active	6	Music	14	Climb Stairs	9	Home Exercise	42
Childcare/Caregiving	6	Puzzles	14	Gardening/Yardwork	9	Walk for Errands	41
Group Talks	5	Attend Lecture	14	Gentle Exercise	9	Climb Stairs	33
Church/Temple	4	Meal Prep	14	Work/Volun, active	8	Group Talks	31
Work/Volun, sedentary	4	Swim/Water Aerobics	14	Light Housework	8	Club/Social Meetings	31
Lift weights	3	Lift weights	13	Puzzles	7	Group Activities	31
Movies/Videos	2	Work/Volun, sedentary	12	Conditioning Exercise	5	Write	28
Club/Social Meetings	2	Arts&Crafts	10	Phone	4	Heavy Housework	26
Group Activities	2	Light Housework	10	Childcare/Caregiving	4	Church/Temple	25
Dancing	2	Read	9	Bicycle	4	Walk for Exercise	25
Bicycle	2	Movies/Videos	9	Team games	4	Music	24
Conditioning Exercise	2	Work/Volun, active	7	Trips	3	Gather with People	13
Trips	1	Childcare/Caregiving	7	Meal Prep	3	Meal Prep	6
Hike	1	Dancing	7	Swim/Water Aerobics	3	Visit/Visited	5
Attend Lecture	0	Team games	7	Read	2.5	Light Housework	5
Swim/Water Aerobics	0	Hike	5	Hike	2	Going Shopping	4
Team games	0	Trips	1	Lift weights	2	Read	2.5
Golf	0	Golf	1	Golf	0	Phone	2

Table 1.4. Reliability and Validity for Total Activity and Variety of Activity

	T1 Mean (95% CI)	T2 Mean (95% CI) n=30	T3 Mean 95% CI n = 53	Reliability ICC	Validity ICC
Total Activity					
n = 30	71.4 (64.5-78.4)	73.3 (65.8 – 80.8)		**0.69**	
n = 53	92.5 (80.9 – 104.1)		89.6 (72.8 – 106.4)		**0.57**
n = 196	77.6 (74.4-80.8)				
Variety of Activity					
n = 30	18.5 (16.7 – 20.3)	20.6 (18.8-22.3)		**0.72**	
n = 53	20.7 (19.5 – 22.0)		17.4 (16.3-18.5)		
n = 196	20.8 (20.0 – 21.5				**0.71**

CHAPTER II

MANUSCRIPT 2

Measures of Mobility and Balance:

Associations with Frequency and Variety of Activity

INTRODUCTION

There is growing evidence of the importance of physical activity and an active lifestyle for maintaining independent function in older adults. Although "activity" is often poorly defined and difficult to measure, participation in social, cognitive, and physical activities have been associated with decreased disability,[1, 2] cognitive decline,[3-7] and incidence of dementia.[8-11]

The number of social contacts one makes per week (talking on the phone, going to church, or attending a meeting) is related to improved well being,[1] and decreased incidence of depression[1, 12] and dementia.[5, 12] Individuals who engage in a greater number of cognitive activities experience less cognitive decline and dementia than their peers.[3, 8, 9, 13] This relationship remains even when cognitive activities are studied in conjunction with physical activities.[8, 9] Verghese reported that number of cognitive activities provided a protective effect against mild cognitive impairment and dementia.[8, 9]

Increased levels of physical activity and exercise have been associated with improved physical function,[2, 14] increased balance confidence,[2, 14, 15] maintaining independence in activities of daily living,[16] and providing a protective effect against all-cause mortality.[17, 18] It appears that older adults with the highest activity levels experience the greatest protective effects;[2, 7] however individuals who engage even in minimal amount of physical activity most days of the week perform significantly better on physical assessments then their sedentary peers.[2]

Overall the evidence for activity is compelling but several questions remain unanswered regarding the type, amount, duration, and frequency of activity needed to achieve these protective effects. Methods of measuring activity differ across areas of research making comparisons among studies difficult. Some researchers have quantified the weekly number or amount of activities for an individual, and reported that number or variety of activities had stronger associations with decreased cognitive decline than total activity levels.[8, 9, 13, 19] Researchers typically quantified amount of physical activity in kilocalories per week or distance walked, and typically did not assess number or variety of activity in relationship to outcome measures. Podewils, however, compared variety of exercise activities to total amount of activity and reported that variety of exercise activities was associated with a lower relative risk of vascular dementia and Alzheimer's disease than amount of activity quantified in kilocalories per week .[20]

Variety of activity is a concept that is relatively unexplored and may be an important factor to measure for maintaining function. Interventions incorporating a variety of activities compared with traditional training interventions demonstrated greater reductions in falls rates [21-24] and improved performance on daily tasks.[25] If participating in different activities (variety) is important for maintaining or improving physical and cognitive function, what mechanisms might be responsible? The International Classification of Function, Disability and Health (ICF) provides a theoretical framework for the mechanism of variety (Figure 1).[26] In this framework, activity is central, affecting body functions and structure, participation, and health conditions (disability falls). Likewise, environment and personal factors affect activity. It may be that increasing the variety of activity results in interacting with a greater number of environments, affecting a greater number of body functions, thus reducing the effects of the health condition, and ultimately improving overall function.

To explore the association of variety and frequency of activity to function, we developed a brief Variety of Activity Questionnaire (VAQ) (Manuscript one of the dissertation). The VAQ consists of 33 items that measures participation in cognitive, social, physical and exercise activities specific to older adults. We were interested in exploring how frequency and variety of activity were related to physical performance. In older adults, performance of physical assessments such as walking or rising from a chair is predictive of functional decline[27, 28] and increased morbidity and mortality.[29] Physical performance measures are reliable and valid indicators of physical function, but are they related to activity? Could they be used to identify individuals who might benefit from increasing number or amount of activity? Individuals that perform well on physical assessments should have the mobility skills to engage in several different types of activities. We wanted to test this assumption and to determine if specific physical performance tests had stronger relationships to frequency or variety of activity.

The purpose of this study was to determine the associations among mobility and balance performance measures and weekly total activity and variety of activity. Secondarily we explored differences in associations for performance measures of balance and mobility with different categories of activity measures.

METHODS

Study Participants

This cross sectional study included participants 70 years or older and living independently in the community or in continuing care retirement communities (CCRC). Participants were excluded if they had significant cognitive decline (score of six or seven on the Short Portable Mental Status Questionnaire depending on level of education),[30] had a diagnosis of a progressive neurological disorder, were in the latter stages of terminal disease, unable to read, write, or speak English, or walk independently with or without an assistive device. Additionally, they were excluded if they had a major health event (e.g., stroke, orthopedic surgery, or hospitalization) within the last six months.

Participants were recruited from senior centers, churches, and CCRCs in central North Carolina. The study was approved by the University of North Carolina at Chapel Hill Institutional Review Board, and all participants provided informed consent. Prior to participating in the physical performance testing, individuals completed a health status screen to identify symptoms or signs contraindicative of testing, such as experiencing new onset of pain, dizziness, or problems with blood pressure. Ninety-five participants volunteered and were eligible for the study.

Measurements

All testing occurred at the recruitment sites in a quiet, private area. Participants first completed a demographic questionnaire, self-report of height and weight, health and falls history, and the Variety of Activity Questionnaire (VAQ). Falls information was recorded as an additional descriptive measure for our sample. Falls were recorded if the participant stated they had experienced a fall in the last 12 months and could describe when and where they fell. Participants also completed physical performance assessments including: two trials of walking 20 feet at their self-selected walking speed (WALK), a timed chair rise task (TCR), a static balance assessment (Tandem Stance Test –TST), and two dynamic balance assessments, the Four Square Step Test (FSST) and the 360º Turn test (360º turn). Total testing time took approximately 45 minutes. At the end of the testing session, participants were given feedback on their performance and provided with an individualized home exercise program to improve balance and strength.

Activity Assessment

The Variety of Activity Questionnaire (VAQ) quantifies total activity levels (TA) and the variety of activity (VA) for a typical week. The VAQ is a 33 item questionnaire assessing older adult's weekly participation in social, cognitive, physical, and exercise activities. Compared to other activity questionnaires, the VAQ has good stability (ICC 2,1 = .69)[31] and validity (ICC 2,1 = .61).[32] The development of this questionnaire was described in manuscript 1 of this dissertation document. The VAQ was designed to generate two different scores. The first scoring method assessed total weekly activity (TA) and was based on the work of Verghese.[9] Participants received a score for each activity based on the frequency of activity as follows: activities done "daily" were scored a 7, "often" a 4, "once a week" a 1, "one to two times a month" a .5, and "never" a zero. Frequency scores were summed to create a TA score which ranged from 0 to 231. The second scoring method assessed variety of activity (VA). Subjects received a point for each activity they participated in, and all points were summed to create a VA score which ranged from 0 to 33.

Mobility Assessments

Walking Speed – Walking speed measured in meters per second is a robust indicator of functional status and predictor of functional decline, morbidity, and mortality.[29] Individuals who walk less than 1.0 meter per second are at increased risk of functional decline,[33] fear of falling,[34, 35] and falls;[36] have decreased muscle strength,[37] and poor self-perception of physical function.[38] A minimum distance of four meters with one meter acceleration and deceleration zones is required for a reliable and valid measure of walking speed.[39]

This study measured self-selected walking speed over a distance of 20 feet, with a five foot acceleration and deceleration zone. Participants were instructed to walk at their "normal" pace along a straight path, free from obstacles or distractions. Participants started at the acceleration zone (five feet before the start line), timing began when the first foot crossed the start line and stopped when the foot crossed the finish line. Participants completed two walking trials, and average walking speed was calculated in meters per second.[33,40]

Timed Chair Rise (TCR) – The TCR is a performance measure of functional mobility requiring strength, balance, and sensorimotor skills.[41] The ability to rise from a chair without using one's arms is a valid predictor of functional decline, with times greater than 13.6 seconds associated with increased risk of nursing home admission, morbidity and mortality.[40] The TCR is frequently used as a proxy measure for lower extremity strength; however, studies suggest that leg strength accounts for only 48% of the variance, and other factors, such as vision, proprioception, balance, and balance confidence are integral components of this task.[41, 42]

The TCR was conducted using a protocol developed by Guralnik et al,[40] requiring participants to rise from a standard height chair with arms folded across chest. The tester demonstrated the task and participants were instructed to stand one time. Those who could successfully rise one time were instructed to stand up and sit down five times as quickly as possible. Timing began with the word "go" and stopped when the subject reached the standing position for the fifth time. Participants who could not complete five chair rises were given a score of zero and these scores were not included in analyses.

Balance Assessments

Tandem Stance (TST) – The TST is a measure of static balance, associated with falls [43] and functional decline.[40] The TST is a novel task for most older adults[44] requiring lower extremity strength and lateral stability, both of which are associated with risk of falls.[43] Standard protocols time individuals holding the tandem position (heel-toe) for 10 or 30 second durations.[27, 40] Previous work with a sample population of 195 residents of a continuing care retirement community showed that 86% of the residents who could hold the position for a minimum of 10 seconds also had the ability to hold the position for 30 seconds.[45] Based on these data, and to decrease participant burden, the 10 second version of the TST was used. The tester demonstrated the full tandem position (front heel touching back toe), and then assisted the participants in assuming the position. Participants were allowed to support themselves while assuming the tandem-stance position and timing began when they let go of the support. Timing ended when the participants took a step or successfully held the position for 10 seconds.[40] One trial was performed for this task, and if a participant could not assume the position, their score was not included in the analyses.

The Timed 360° Turn (360º turn) – The 360º turn is a reliable and valid measure of dynamic balance used in standardized physical performance assessments.[27, 46, 47] The ability to maintain one's balance while turning is necessary for many activities of daily living. Difficulty turning has been associated with an increase in the number[48, 49] and severity of falls.[50] Individuals who take more than four seconds to complete the turn are at a greater risk of functional decline.[46, 51] This study used the timed 360° turn protocol described by Gill.[52] Participants were asked to turn in a circle in the direction of their choice as quickly as possible. Participants performed two trials, and the average time used for analysis.

The Four Square Step Test (FSST) – The FSST is a relatively new assessment of dynamic balance requiring weight shift, stepping, and directional change.[53] The test has excellent interrater reliability (ICC 2,1 = .99) and retest reliability (ICC 2,1= .98).[53] A time of $\geq$ 15 seconds to complete the task is a sensitive (85%) and specific (88%) measure that identifies community dwelling individuals who have experienced at least one fall.[53] This study used the protocol developed by Dite et al.[53] Four canes were laid on the ground to form four squares. Participants started in square one facing square two. Participants stepped forward into square two, sideways to square three, backwards to square four, sideways into one, and then reversed the sequence - sideways into four, forward, sideways, and backwards (Figure 2).

First the investigator demonstrated the proper stepping sequence. Then participants were allowed one practice trial, and the completion time was recorded for the two subsequent trials. Scores were based on total time to complete the sequence, and the best time was selected for analyses. Participants were required to make contact with both feet in the floor of each quadrant, to not step on the canes, and to remain facing forward during the entire sequence. Mis-trials occurred if the subject could not complete the sequence, lost their balance or stepped on a cane. One mis-trial was allowed. Participants who had more than one mis-trial or could not follow the sequence received a score of zero for the test and were not included in the FSST analyses.

Analyses

Data were analyzed using SPSS software, version 14.0 (SPSS Inc., Chicago, IL). Descriptive statistics generated for 95 subjects included demographics, BMI, level of education, health conditions, number of falls for a one year period, and TA and VA values.

The following descriptive statistics were generated for the balance and mobility measures: walking speed in meters/second (m/s), time to complete five chair rises, time to maintain the TST position, average 360º turn time, and best FSST time.

Pearson product moment correlations were used to examine associations among all continuous demographic, balance and mobility variables, and to identify collinearity among performance variables. Spearman's ordinal rho was used to assess correlations between categorical or dichotomous demographic data (sex, race, education, marital status) and balance and mobility measures. For the correlation and multiple regression analyses, education was coded as high school (including less than high school) or college, and marital status was coded as married or single. Single included widowed, divorced, and never married. Multiple regression analyses were used to identify significant predictors of TA and VA using demographic and performance measures as independent variables.

RESULTS

Subjects

From September 2005 to May 2006, 95 community dwelling older adults were recruited from central North Carolina to participate in the study. On average subjects were 78.5 years of age (SD = 5.6), 77% were female, and 25% were African American (Table 2.1). Education levels varied among subjects; 32% had a high school education or less, and 35% had graduate degrees. The majority of subjects (73%) walked without an assistive device, and 32% reported at least one fall in the previous year. For the Variety of Activity Questionnaire (VAQ) mean total activity (TA) was 71.8 (*SD* = 21.4) and variety of activity (VA) was 18.8 (*SD* = 4.3).

Performance on balance and mobility measures demonstrated a range of functional abilities. Approximately half of our sample (47%) walked slower than 1.0 m/s (range .39 – 1.92), and 44% of the sample took longer than 13.6 seconds to complete five chair rises (range 6.1 – 55.3) (Table 2.1). Five participants could not complete the five repetitions of the TCR and their scores for this test were excluded from analyses. The scores of the two participants who could not assume the tandem stance position and the one participant who refused to try were not included in analyses. The FSST was challenging for participants. Three individuals were unable to follow the step sequence directions, two individuals were too unsteady or lost their balance while doing the task, and one individual refused to perform the task. The scores for these participants were not included in the analyses. Of the participants who did not complete these assessments, only one was unable to do any of the three tasks (TST, TCR, and FSST).

Associations Among Variables

All balance and mobility variables were significantly and moderately associated with each other, with the strongest associations between Walk and 360º turn (r = .63), and FSST and 360º turn (r = .69). Measures of total activity (TA) and variety of activity (VA) had significant but weak associations with all balance and mobility variables (r = .22 - .38), with stronger associations for VA than for TA. Marital status was the only demographic variable associated with TA or VA (Spearman's rho = .21, .32, respectively) (Table 2.2).

Multiple Regression

Multiple regression models identified significant predictors for the outcomes of TA and VA based on the demographic variables of age, sex, race, education, and marital status and balance and mobility variables of TST, 360º, FSST, TCR, and Walk. The demographic variables of BMI and number of health conditions were not used in the full model because they were not correlated with TA or VA, and the number of predictor variables needed to be limited due to a sample size of 95. In the regression model for TA, FSST was the only significant predictor ($p < .01$) and the model accounted for 10% of the variance. In the regression model for VA, TCR and martial status were both significant predictors ($p < .05$), and the model accounted for 22% of the variance (Table 2.3). The statistical test for tolerance indicated that collinearity was not present among the variables in the model.[54] Studentized deleted residuals confirmed that all regression assumptions were met and the deleted residuals had approximately normal distributions for each model.[55]

We were also interested in determining how performance on mobility assessments was related to participation in different types of activities. Several studies reported strong associations between participation in physical and exercise activities and physical performance measures;[2, 14, 15] however, little is known about the relationship between participation in cognitive and social activities and physical performance measures. What is known is that cognition is an important component of several mobility assessments.[41, 44, 56, 57] For example, walking has been defined as a task with high attention demands for older adults,[57] and poor performance on assessments of executive function has been correlated with slower walking speeds.[56] Similar findings have been reported for performance of the TCR[41] and TST.[44]

We wanted to determine the associations between mobility and balance assessments and participation in physical and exercise activities, and cognitive and social activities. For these secondary analyses, items on the VAQ were separated into two categories: Cognitive and social activities (COG/SOC), and physical and exercise activities (PA/EX). Multiple regression analyses identified significant demographic (age, sex, race, education, and marital status) and balance and mobility (TST, 360º, FSST, TCR, and WALK) variables for the outcomes of Total COG/SOC, Total PA/EX, Variety COG/SOC, and Variety PA/EX. The 360º turn was the only significant predictor for Total PA/EX, explaining 9% of the variation of the model. No model predicted total COG/SOC. The variables of TCR and TST were the only significant predictors of Variety PA/EX, explaining 20% of the variance, and TCR and marital status were the only significant predictors of Variety COG/SOC, explaining 17% of the variance (Table 2.3).

DISCUSSION

The purpose of this paper was to determine the associations among balance and mobility measures and frequency or variety of activities. Results from analyses indicate that performance of a dynamic balance measure, the Four Square Step Test (FSST) was a significant predictor of total activity (TA), whereas mobility measured by the Timed Chair Rise (TCR) and marital status were significant predictors of variety of activity (VA).

The FSST is a new clinical tool developed to assess dynamic balance in older adults and to identify fallers.[53] Participants in this study had similar FSST scores as those published by Dite et al.[53] Of the balance and mobility assessments used in this study, the FSST has the greatest physical and cognitive complexity. Successful performance of the FSST physically requires negotiating obstacles and remaining upright through several changes of direction, and cognitively requires sequencing and memory skills.[53]

The inclusion of the FSST and the exclusion of walking speed in the model was a surprising finding of this study. Because walking speed is a reliable and valid indicator of current and future mobility[58] and general function,[29] we anticipated it would be significantly associated with TA. Total Activity is a sum not just of physical and exercise activities, but also cognitive and social activities. Several of the cognitive and social activities also have a physical activity component. It may be that walking speed is too simple of a measure to capture the complexity of activity inherent in the TA measure.

The FSST had stronger correlations with the TCR and the balance tests than with walking speed, which indicates that the FSST requires components of strength, balance, and mobility. Because the FSST requires a complex interaction of multiple systems it seems reasonable that it is associated with total amount of participation in different activities. The fact that the FSST was associated with TA levels indicates that it may provide a good overall indication of the abilities required for activity of older adults.

Only TCR and marital status were significant predictors for VA. The TCR requires leg strength, balance, sensorimotor skills, and executive function skills.[41] Leg strength is the primary component of the TCR,[59] and is necessary for successfully rising from a chair[60] and walking to and from activities,[61] as well as for performing physical activities such as cleaning the house and gardening.[62, 63] For a group of independent community dwelling older adults, decreased leg strength may be a critical factor that limits participation in variety of activities more than balance ability. Getting to an upright position for balancing and walking first requires the functional strength necessary for getting out of a chair or bed. If leg strength is a limiting factor for activity levels in community dwelling older adults, then appropriate strength training should improve physical function and mobility.[64-66]

Marital status was the only demographic variable associated with VA, and Variety COG/SOC. Marital status has a positive effect on longevity,[67] though the mechanism of this effect has yet to be elucidated.[68] Marriage may provide greater opportunities for participation through companionship (having someone to do something with) or through motivation. Several husbands interviewed stated, "I do *that activity* because my wife makes me", and a few wives stated "I can't drive, so my husband takes me shopping/to the senior center etc." Approximately 30% of adults over the age of 65 live alone.[69] Living alone could mean that you have higher physical activity levels because you perform all housework and meal preparation; however, increased physical work may not compensate for the increased variety of cognitive and social activities that marriage provides. Remaining engaged socially is an important component to protect against physical and cognitive decline.[1, 5] Older single people may need extra support and encouragement to engage in activities with other people in the neighborhood, senior center, club, church, etc. to increase their variety of weekly activities.

To better understand the differences between VA and TA, we compared the associations among VA and TA and demographic and physical performance variables. The correlation analyses indicated that VA and TA were associated with balance and mobility though VA had stronger associations, and VA was associated with demographic variables. This supports the notion that VA may provide additional and potentially different information than TA.

It is interesting that the balance and mobility assessments identified as significant predictors for activity were those that provided a greater challenge to participants, incorporated components of strength, balance, and mobility, and were related to falls risk.[28, 51, 53] Results from this study indicate that balance and mobility were associated with activity levels, and explained a greater amount of variance in variety of activity than total activity levels. Though a small percentage of the variance in the models was explained by the performance measures, these results lend support for use of the Variety of Activity Questionnaire (VAQ) to measure both TA and VA.

Variety of activity is relatively nascent in the aging literature, but appears to be an important component of successful aging. In the falls prevention literature, interventions that incorporate a variety of activities such as walking in different environments, a daily exercise program, and attending a class report a greater reduction in falls over a longer period[21, 23, 24] than studies utilizing a specific set of exercises 2-3 times a week.[70-72] A paradox of these studies is that the interventions that successfully reduce falls do not always improve falls risk factors such as walking speed, leg strength, or balance performance.[21, 23, 24] These results support the notion that variety of activity may be an important component of interventions because it trains multiple systems in a variety of contexts as illustrated by the ICF model. This differs from interventions based on the specificity of practice hypothesis. This hypothesis states that to improve performance of a certain skill, you need to practice that specific skill.[73] Placed in the ICF framework, the specificity of practice hypothesis shifts the emphasis from activity to body functions and structures, which may limit the overall effect on the health condition. Individuals who engage in a greater variety of activities are directly affecting all components of the framework, which may be having a greater ultimate effect on function.

The purpose of the secondary analyses was to answer the question: “How is performance on balance and mobility assessments associated with participation in physical and exercise activities compared with cognitive and social activities?” An interesting finding was that dynamic balance measured by the FSST was associated with Total PA/EX, and static balance measured by the TST was associated with Variety PA/EX. These findings seem reasonable because having adequate dynamic and static balance is a necessary component for participating in several different types of physical and exercise activities. Similar to the outcome of VA, the TCR was significantly associated with participation in Variety of COG/SOC, potentially for the same reason that leg strength is a key requirement for the mobility necessary to participate in several different types of activities. There was no significant model for Total COG/SOC, indicating that physical performance measures alone are not associated with total cognitive and social activities.

One overall finding from these analyses is the importance of balance and mobility to variety of activities. The TCR traditionally has been used to identify individuals at risk of decline or falls, but results from this study indicate it also is an important component of activity participation, and should be assessed in older adults.

Limitations

The findings in this study are based on the VAQ which quantifies frequency and variety of activity in older adults and is in the preliminary phase of development. The results reported support our hypothesis that balance and mobility are associated with TA and VA; however the R^2 values were lower than expected. Once the tool is finalized, we anticipate further clarification of these relationships. Though our sample size (N = 95) was smaller than might be desired, it was a representative racial sample of older adults from North Carolina.[74] Men were under-sampled for this study, and future studies should focus on increasing the percentage of men recruited. The cross-sectional nature of this study limits any cause and effect conclusions that we can draw from these results.

CONCLUSIONS

Remaining active and engaged in cognitive, social, physical and exercise activities is an important component of healthy aging. Total activity and variety of activity are associated with physical performance measures that require strength, balance, and mobility. The results of this study suggest that engaging in a variety of activities may be associated with maintaining physical function in older adults. A surprising finding of this study was the importance of chair rise and marital status to variety of activities. Older adults should be educated about the role of leg strength for maintaining activity levels. Variety of activity could be an important factor in protecting against physical decline, and may have value as a health promotion tool for older adults. We recommend future intervention studies to clarify the relationships between TA, VA and physical performance measures.

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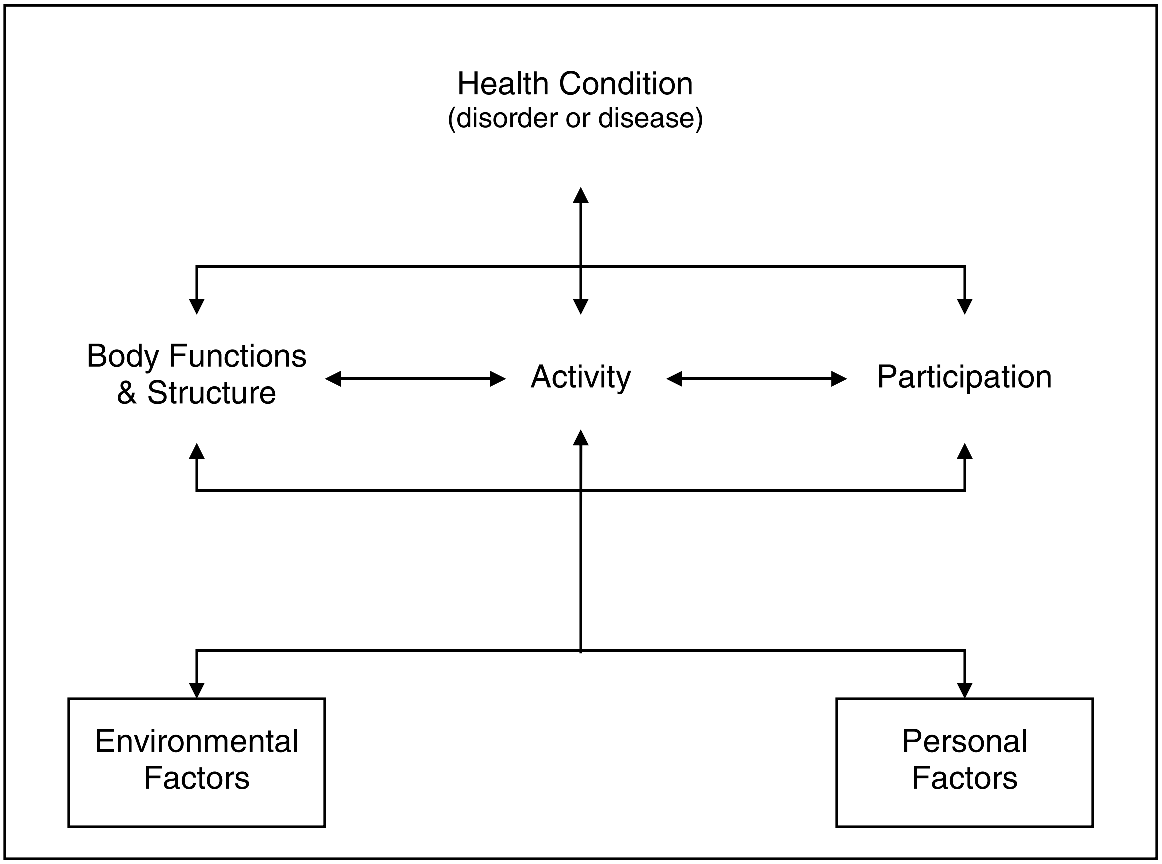

Figure 2.1. International Classification of Function, Disability and Health (ICF): Proposed mechanism of variety. Reprinted from *International Classification of Functioning, Disability and Health: ICF*. Geneva, Switzerland: World Health Organization; 2001 with permission of the World Health Organization.

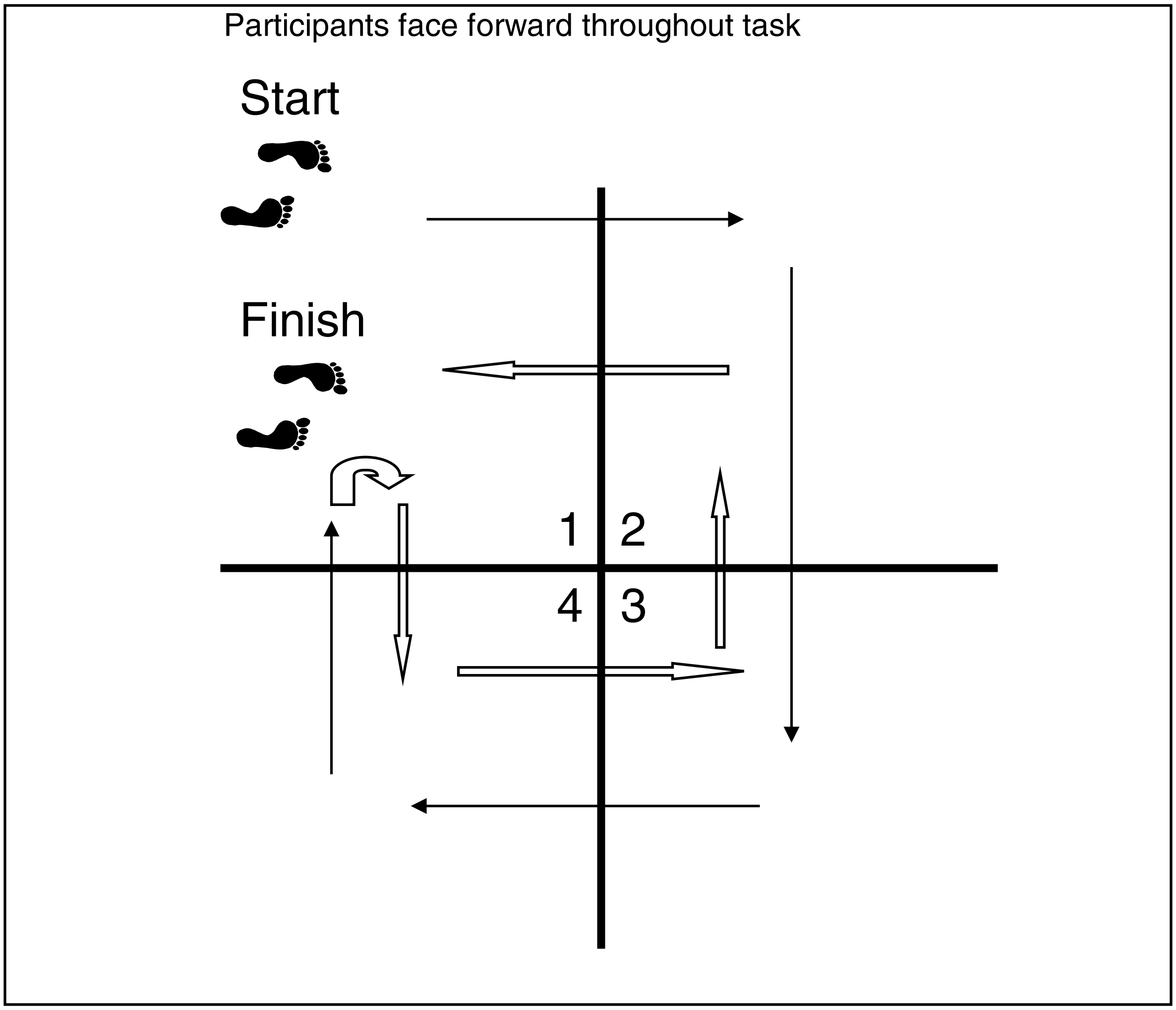

Figure 2.2 Sequence for Four Square Step Test

Table 2.1 Participant Demographics (n = 95)

Variables	**Mean (*SD*)**
Age	78.5 (5.6)
BMI	25.5 (4.9)
Number of Health Conditions	2.7 (1.6)
Total Activity	71.9 (21.4)
Variety of Activity	18.9 (4.3)
	Percentage of Subjects
Gender (female)	77
Race	
Black	25.0
White (non-Hispanic)	75.0
White (Hispanic)/Asian	0.0
Marital Status	
Married	36
Single	
Widowed	39
Divorced	11
Other	14
Education	
High School	
Less than high school	19
High School/GED	11
College	
Associate Degree	14
Bachelor's Degree	23
Graduate Degree	33
Assistive Device	
Never	73
Rarely	9
Some of the time	9
Most of the time	3
All of the time	4
Number of Falls in Past Year	
1	22
2	6
3	2
4	2
Performance Variables (n=95) **Times associated with decline**	**Mean (*SD*)**
Walking Speed (meters/second) (n=95) < 1.0 m/s	1.06 (.29)
Timed Chair Rise (n = 90) > 13.6 seconds	14.1 (6.3)
Tandem Stance Test (n = 92) < 10 seconds	7.7 (3.5)
Timed 360º Turn (n=95) > 4 seconds	2.94 (1.27)
Four Square Step Test (n = 89) > 15 seconds	11.5 (3.5)

Table 2.2 Correlations among demographic, performance, and activity level variables

	Sex	Race	BMI	Health Cond	Marital Status	Educ	Total Activity	Variety of Activity	Walk Speed	Timed Chair Rise	Tandem Stance Test	360º Turn	Four Square Step Test
Age	.01	-.16	.32**	-.04	.02	.17	.02	-.12	-.25*	.02	.31**	.33**	.26*
Sex†		.03	.10	.26*	.25*	-.07	-.04	-.08	-.30**	.18	-.12	.24*	.15
Race†			.26*	-.07	-.28**	-.58**	-.12	-.27**	-.24*	.34**	-.11	.15	.23*
BMI				.17	-.11	-.28**	-.11	-.15	-.23*	.24*	-.04	.10	.18
Health Conditions					-.10	-.17	-.03	-.14	-.28**	.12	-.11	.24*	.23*
Marital Status†						.34**	.22*	.32**	.39**	-.33**	.29**	-.36**	.24*
Education†							.13	.28**	.31**	-.31**	.22*	-.24*	-.32**
Total Activity								.72**	.27**	-.25*	.15	-.25*	-.33**
Variety of Activity									.40**	-.38**	.29**	-.35**	-.37**
Walking Speed (meters/second)										-.54**	.41**	-.63**	-.61**
Timed Chair Rise (seconds)											-.34**	.53**	.59**
Tandem Stance Test (seconds)												-.37**	-.47**
360º Turn (seconds)													.69**
Four Square Step Test (seconds)													

*Significant at $p < .05$
**Significant at $p < .001$
†Spearman's rho used for non-parametric variables – sex, race, marital status, education

Table 2.3 Regression Models
Demographics: Age, sex, race, education, marital status

Outcome	Predictors	Model	Beta	R^2
Total Activity	Demographics Walk Timed Chair Rise Tandem Stance 360 Turn Four Square Step	Four Square Step	-.31	.10
Variety of Activity	Demographics Walk Timed Chair Rise Tandem Stance 360 Turn Four Square Step	Marital Status Timed Chair Rise	.21 -.37	.22
Total Activity (COG/SOC)	Demographics Walk Timed Chair Rise Tandem Stance 360 Turn Four Square Step	No Model		
Total Activity (PA/EX)	Demographics Walk Timed Chair Rise Tandem Stance 360 Turn Four Square Step	360 Turn	-.30	.09
Variety of Activity (COG/SOC)	Demographics Walk Timed Chair Rise Tandem Stance 360 Turn Four Square Step	Marital Status Timed Chair Rise	.28 -.23	.17
Variety of Activity (PA/EX)	Demographics Walk Timed Chair Rise Tandem Stance 360 Turn Four Square Step	Timed Chair Rise Tandem Stance	-.32 .25	.20

CHAPTER II

MANUSCRIPT 3

Performance on Assessments of Attention and Processing Speed: Relationships to Frequency and Variety of Activity

INTRODUCTION

With projections of 71.5 million Americans being at least 65 years of age by 2030,[1] identifying factors that may prevent or postpone cognitive decline has become a research priority. A growing area of interest is the effects of activity and an active lifestyle on health status in older adults. In particular, several studies have explored participation in activity as providing a protective effect against cognitive decline and dementia.[2-10] Although the direction and extent of this effect is the subject of much debate, it appears that participation in activity is an important factor in maintaining health and function. The interest in activity and cognition is meaningful beyond the focus on dementia. Cognitive ability is important for maintaining independent function[11] and has been associated with balance impairment and falls risk.[12, 13] Understanding the amount, type, and intensity of activities that affect cognition is essential for developing successful interventions to maintain or delay cognitive and functional decline in older adults.

Older adults who participate in cognitive activities such as reading, writing, playing board games and crossword puzzles show decreased cognitive decline.[3, 5, 14] Researchers report that increasing participation by one cognitive activity one day a week resulted in a 13% reduction in the risk of cognitive impairment and dementia.[3, 5] Participating in cognitively stimulating activities also is associated with better performance of complex cognitive tasks.[15] Several researchers, however, question the direction of these relationships based on cross sectional data. It may be that individuals with high cognitive abilities participate in more cognitively challenging activities,[16, 17] or it is possible that participation in cognitive activities protects an individual against cognitive decline.[2] The few intervention studies that examined the effect of cognitive training on cognitive abilities reported that cognitive abilities improved in the domains trained, but this improvement did not necessarily affect other areas of cognitive function.[18-20]

Active engagement in social activities such as visiting with friends and family, going to church and talking on the phone has been associated with improved measures of well being, decreased incidence of depression and cognitive decline in older adults.[6, 21, 22] This relationship remains significant when controlling for confounding factors of age, baseline cognitive function, and education.[21] Type of social contact (attending an event versus talking on the phone) does not appear to be the critical factor; rather the overall number of weekly social activities was associated with protection from dementia.[22] Other studies, however, reported that participation in social activities was not protective against cognitive decline.[16, 17] In a six-year longitudinal study of healthy older adults, Aartsen found no significant associations between participation in activities such as going to church and attending neighborhood meetings and performance on assessments of fluid intelligence and processing speed.[17] These results seem contradictory; however, these studies used different outcome measures of cognition, and different definitions of social activities. Some of the divergent results in this field of study are due to methodological differences such as definitions of constructs, choice of measurement, and the population studied.

Researchers examining the effects of physical activity levels on cognition decline have demonstrated that physical activity facilitates the maintenance of cognitive function and protects against cognitive decline.[10, 23-26] Longitudinal studies suggest that participating in physical activity and exercise three or more days a week provides a strong protective effect against cognitive decline and dementia.[8, 10, 24, 27] Podewils followed 3,608 individuals for an average of 5.4 years and compared the number of activities and intensity of activity as measured by total caloric expenditure and subsequent risk of dementia.[28] The number of physical activities people reported during a two-week baseline period was inversely associated with dementia risk, loss of independence in activities of daily living, and depression. Compared to caloric expenditure, the number of physical activities had a significant and lower relative risk for developing Alzheimer's disease and vascular dementia.[28] This study is one of the first to quantify number of activities, and to use number versus amount to describe activity levels in older adults.

Other researchers reported that physical activity alone does not provide a protective effect against cognitive decline. Sturman followed 4,055 older men for six years and annually assessed performance on four cognitive measures, recorded the number of hours exercising per week, and rated frequency of participation in seven cognitively stimulating activities. The results indicated that the amount of exercise was associated with a slower rate of decline in cognitive performance; however, when the model was adjusted for participation in cognitive activities, physical activity was no longer significant.[29] Researchers studied participation in cognitive activities in conjunction with physical activities and reported only cognitive activities provided a significant protective effect against dementia and cognitive impairment.[3, 5, 14, 30] However, the populations sampled for all of these studies were largely sedentary, with 48% reporting walking only three times a week, and only 6% reporting participation in a weekly exercise class.[3, 5, 14, 30 29] One plausible hypothesis for these divergent findings is that individuals who engage in physical activities may also engage in a high level of cognitive activities, which can confound any protective effect afforded by physical activity level.

Although the relationship between participation in different types of activities and protection against cognitive decline is not clear, it appears that remaining active and engaged is important for healthy aging.[31] We do not know how much and which type of activities one should do; however, the research suggests that number as well as amount of activities may be an important variable.

What is there about activity that may be important for cognitive function? From cognitive intervention studies, it appears that practicing specific cognitive abilities preserves specific cognitive functions and supports a specificity of practice hypothesis.[18-20] It is possible that by participating in different types of activities challenges a broader scope of cognitive processes supporting a variable practice hypothesis for learning.[32] Inherent in participating in a greater number of activities is an increase in the opportunity to practice skills in different environments, which is a key tenant of the variability of practice hypothesis. Although there is little empirical evidence of cortical changes associated with variable practice, animal studies examining the effects of enriched environments report increased synaptic efficacy, synaptogenesis, and increased dendrite morphology.[33-35] This effect has been demonstrated in both young and older animals.[34, 36] When learning occurs in the brain, researchers studying both animals and humans report an increase in synaptic connections between neurons,[37, 38] and short and long term changes in the motor cortex in response to the new skill.[39] We believe that similar to enriched environments "variety" may be facilitating learning by providing more and different opportunities to practice skills, making variety a stronger factor associated with preserving cognitive function than frequency of activity.

To study the relationship between types, frequency and variety of activity we developed a brief Variety of Activity Questionnaire (VAQ). The VAQ consists of 33 items measuring participation in cognitive, social, physical and exercise activities specific to older adults. The VAQ was described in manuscript 1 of this dissertation, and has good reliability (ICC 2,1 .69) and validity (ICC 2,1 .61) for measuring participation in activities in the four categories of activity. The VAQ produces a total activity measure that is the sum frequency of all activities reported during the week (TA), and a variety of activity measure (VA) which is the total number of different activities done in one week.

The purpose of this study was to compare the strength of relationships between cognitive performance and total activity level (TA), and cognitive performance and variety of activity (VA) as recorded by the VAQ. We were particularly interested in cognitive processes of attention and processing speed because of their direct and indirect relationships with daily function and falls risk. Declines in cognitive processing speed have been associated with the loss of ability to perform instrumental activities of daily living.[40, 41] Decreased reaction times have been associated with increased falls risk,[42] and poor cognitive performance has been associated with increased rate and risk of falls in older adults.[13] This evidence suggests that maintaining attention and processing speed abilities is important for keeping older adults independent in the community. I wanted to know if older adults who perform well on cognitive measures of attention and processing speed engage in a greater TA or VA than those who do not perform as well. I hypothesized that older adults who performed well on these cognitive measures would have higher VA scores and that this relationship would be similar but weaker for TA.

METHODS

Study Participants

This was a cross sectional study of community dwelling older adults. Participants were 70 years or older, English speaking and able to walk independently with or without an assistive device. Participants were excluded if they had significant cognitive decline (score of 6 or 7 depending on education level on the Short Portable Mental Status Questionnaire),[43] a diagnosed progressive neurological disorder or terminal disease, or had a major health event (e.g., stroke, orthopedic surgery, or hospitalization) within the last 6 months.

Participants were recruited from senior centers, churches, and continuing care retirement communities (CCRCs) in central North Carolina. The study was advertised through community presentations, newsletters and flyers. All participants provided informed consent approved by the University of North Carolina at Chapel Hill Institutional Review Board. Prior to participating in the performance testing, individuals completed a health status screen to identify current symptoms or signs that might indicate precautions for testing, such as experiencing new onset of pain, dizziness, or problems with blood pressure. Ninety-five participants volunteered and were eligible for the study.

Measurements

All testing occurred at the recruitment sites in a quiet area. Participants completed the demographic information form, a health and falls history, the Variety of Activity Questionnaire (VAQ) and cognitive assessments. Falls were recorded if the participant stated they had experienced a fall in the last 12 months and could describe when and where they fell. To examine the relationships between activity and attention and processing speed, we administered the VAQ and two cognitive assessments, the Symbol Digit Modality test

(SDMT) [44] and a dual task assessment (walking and reciting words).[45] We included a dual task paradigm because performing a cognitive task, such as talking or mental calculations while walking requires additional attentional resources.[46-48] These skills are necessary for navigating real life situations in the community such as walking with friends or shopping. Furthermore, reduced capacity in dual task conditions has been associated with balance difficulty and fall risk.[47, 49, 50]

Activity Assessment

The VAQ is a 33-item measurement tool that assesses participants total activity levels (TA) and the variety of activity (VA) for a typical week. Participants TA score is based on self-report of frequency of activity. Participation in an activity daily scored 7, often (2 – 5 times a week) scored 4, once a week scored 1, and 1-2 times a month scored .5 (possible range 0 – 231). The VA score is the sum number of different activities an individual participated in during a typical week (possible range 0 - 33).

Cognitive Assessment

The SDMT is a brief test assessing complex scanning, visual processing,[51] information processing speed,[52] and shifting of attention.[53] The test was administered in the oral form using a standard protocol that required directed pairing of digits (1-9) with a set of symbols shown at the top of the test form. The test consists of eight rows each with 15 symbols. Each participant was instructed to match numbers to symbols using the symbol digit key at the top of the test form. The first ten symbols in the first row were practice items and the timed test started on the eleventh symbol. The total number of correct matches in 90 seconds was recorded.[44]

Dual Task Assessment

Older adults show greater decrements in physical performance compared with younger adults when performing a cognitive task during a balance or walking task (dual task).[54, 55] Performance of a dual task is measured by the motor (e.g. walking speed) or cognitive "cost" of the task, which is the difference in the task performance between the single and dual task conditions.[56] Increased dual task cost of motor and cognitive performance has been associated with decreased function and increased risk of falls.[47, 50, 57-59]

Key to the dual task paradigm is choosing the appropriate cognitive task. Tasks of varying complexity have different effects on walking parameters. For example, Beauchet reported greater changes in walking parameters when performing a counting backwards task as opposed to a word generation task.[60] Inherent to the complexity of the task is the cognitive ability of the individual performing the task. For example, an individual with a high school education may have a greater challenge with a complex math task than one with a college education. This difference may manifest as greater decrements of performance, making it difficult to interpret the outcomes of the dual task correctly. The cognitive task chosen should pose a similar level of challenge for all participants and be understood by those from a variety of backgrounds. To choose a cognitive task that was appropriate for older adults of diverse educational levels and feasible to use during walking, we compared administration and performance of three separate cognitive tasks based on a testing protocol developed by Verghese.[50]

Verghese studied the effect of a simple task (reciting the alphabet, ABC) and a complex cognitive task (reciting the alphabet skipping every other letter, ACE) on the time to walk 40 feet in a sample of community dwelling older adults (mean age = 79.4). Verghese reported that times of > 20 seconds for the ABC task or > 33 seconds for the ACE task were sensitive (46%, 39%) and specific (89%, 96% respectively) tools to identify fallers.[50]

The majority of English speaking adults are familiar with reciting the alphabet. For this reason, we chose to use the walking and talking tasks used by Verghese (ABC, ACE),[50] and we added a counting task (every other number, ODD) for comparison purposes. We were interested in how the dual task condition affected walking speed, and how the dual task conditions affected performance on the cognitive tasks. The dual task costs for walking and cognitive performance were compared across the three cognitive tasks. We wanted to use task performance data to determine which cognitive task would be the most appropriate to assess for our sample.

Protocol for the dual task paradigm – All participants completed the dual tasks in the same order. The single motor task (walking) was measured as the time to walk 20 feet, turn, and return (40 feet total).[50] Participants were instructed to walk at their usual pace, and timing started as the first foot crossed the start line and stopped as the first foot crossed the finish line. To insure safety, participants were guarded during all walking tasks. For the single cognitive task, participants were asked to recite ABC, ACE and ODD while standing. The total time to recite each task and the total number of errors was recorded. If participants could not successfully finish the single cognitive task (e.g., stopped recitation before reaching the final letter/number or stated, "I can't do that" and were unwilling to try) they were not assessed on dual task performance.

After the single task testing, participants completed two dual task trials for each condition: walking (40 feet) and reciting ABC, walking and reciting ACE, and walking while counting (ODD). Participants were told to perform each trial at their regular walking pace, and instructed to repeat the verbal task if they ran out of letters or numbers before finishing the walking course. The time to complete the task, total number of letters/numbers recited and total numbers of errors were recorded for each trial. Participants were given rest breaks as needed.

Analyses

Data were analyzed using SPSS software, version 14.0 (SPSS Inc., Chicago, IL). Descriptive statistics were generated for 95 subjects including demographics, level of education, health conditions, number of falls for a one-year period, total activity (TA) and variety of activity (VA). Level of education was coded as either high school education or less or college. Marital status was coded as either married or single. The following descriptive statistics were generated for the single task condition: walking speed, time to complete each verbal task, and number of errors for the verbal tasks. The following descriptive statistics were generated for the dual task conditions: walking speed, number of letters/numbers recited, and number of errors.

The changes in motor and cognitive performance between the single task and dual task were defined as dual task costs. For this study, the relative changes in walking speed was defined as the motor cost (Walk).[56, 57] Cognitive costs were defined as the change in accuracy of letters/numbers (Accuracy) and in the change in relative rate of letters/numbers (Rate cost).[57, 61] An additional measure of cognitive performance was a comparison of the rate of letters/numbers spoken per second (L/S) between the two conditions.[61, 62]

The dual task costs were calculated for motor and cognitive performance using the following formulas:

Motor Cost

- *Relative change in walking speed = (single task walk time – dual task walk time)/single task walk time (Walk)*

Cognitive Costs

- *Accuracy cost = Single Task [(total number of letters – total number of errors)/ total number of letters] – Dual Task [(total number of letters – total number of errors)/ total number of letters] (Accuracy)*
- *Rate for each condition = total number of correct letters / task time (L/S)*
- *Rate cost = (single task rate – dual task rate)/single task rate (Rate cost)*

Task feasibility was determined by counting the number of participants who could successfully complete the single and dual task, and by the cost of motor and cognitive performance. The mean relative change in performance was used to quantify dual task cost for motor, accuracy, and rate cost. Paired samples t-tests were used to compare L/S between the single and dual task conditions. Results of the task feasibility analysis were used to choose a cognitive task for subsequent analyses that the majority of participants could perform, was economical, showed significant decrements in performance, and was simple to interpret.

Once the appropriate dual task cognitive measure was chosen, Pearson's correlation coefficients were used to assess relationships among performance variables. Regression analyses included demographic variables and performance of attention and processing speed (SDMT and Dual Task) to identify significant predictors of TA or VA. A final model assessed the relative contributions of both the SDMT and dual task performance as significant predictors of TA and VA

RESULTS

Subjects

Ninety-five community dwelling older adults were recruited from central North Carolina to participate in the study. On average subjects were 78.5 years old (SD = 5.6), 79% were female, and 25% were African American (Table 1). The sample represented a range of educational levels with 32% completing grade or high school, and 35% obtaining a masters degree or higher. The majority of subjects (75%) stated they never used an assistive device, and 35% reported at least one fall in the previous year. Mean self-selected walking speed was .96 m/s (SD = .24), with 39% walking at 1.0 m/s or faster, and 4% walking at .6 m/s or slower. Most participants (87%) completed the SDMT test. Participants who required reading glasses and had not brought them to the testing session were not assessed (n =3) and participants who refused to be tested after the protocol was explained were not assessed (n = 3). The mean number of correct responses for the SDMT was 35.4 (SD = 11.0).

Dual Task Performance

Task Feasibility

All participants were able to perform the single walking task. For the single cognitive tasks, 96% of subjects could complete the ABC, 83% ACE, and 88% ODD. Individuals either refused (n = 2) or were unable to finish the single tasks because the task was too challenging (n = 15) and one individual had a stutter that severely affected performance of the dual task. Individuals were grouped into categories based on education levels to determine if years of schooling were related to task performance. Twenty-eight subjects had a high school education or less (HS), and 67 had some college education (COL). The HS group had lower completion rates for both single and dual task conditions, with only 60% able to complete the ACE in the dual task condition (Table 3.2).

Motor Cost

Walking time slowed for all three dual task conditions. The motor cost increased concordantly with task difficulty with a cost of 11% for the ABC, 35% for ODD, and 54% for the ACE task. (Table 3.2).

Cognitive Cost

To determine cognitive cost, change in Accuracy and Rate cost were compared between the single task and dual task conditions. Based on large confidence intervals which crosses zero, Accuracy was an imprecise and insignificant measure of cost for ABC and ODD, and Rate cost was an imprecise and insignificant measure for ACE and ODD. Mean Accuracy for ACE decreased 7.6% (95% C.I. 3.7 - 11.5), and mean Rate cost for ABC decreased 23% (95% C.I .17 - .29). The rate of letter generation per second (L/S) between single and dual task was significantly different for ABC and ACE ($p < .01$), but not for ODD ($p < .07$) (Table 3.2).

Correlations Among Cognitive Variables and Activity

Pearson correlation coefficients were significant between SDMT and VA ($r = .38$), and between L/S and TA ($r = .24$) and VA ($r = .38$). There were no significant correlations among dual task motor costs and performance on the SDMT. There were weak but significant correlations among Accuracy cost for the ACE and ODD tasks and SDMT ($r=.23$, $.25$), and between Rate cost for ABC and SDMT ($r = -.23$). A significant correlation was reported for Rate cost of ACE and SDMT; however, the direction of this correlation indicated that worse performance of ACE was correlated with higher SDMT scores. The strongest correlations were between SDMT and L/S for all three dual task conditions (ABC $r = .57$, ACE $r = .54$, ODD $r = .62$ $p < .01$) (Table 3.3).

Regression Analyses

The ABC task was chosen as the task with greatest feasibility because it had the highest successful completion rate and demonstrated significant decrements in motor and cognitive performance. For regression analyses, the variables of motor cost (Walk) and L/S were used in the model. Accuracy and Rate cost were either imprecise or difficult to interpret and not included in subsequent analyses.

Regression models identified significant predictors for the outcomes of TA and VA based on the performance of the SDMT and demographic variables (age, sex, BMI, number of health conditions, race, education, and marital status). For TA, SDMT was the only significant predictor ($p < .03$) and the model accounted for 6% of the variance. For VA, SDMT and martial status were both significant predictors ($p < .01$), and the model accounted for 21% of the variance (Table 5).

The models identifying significant predictors for the outcomes of TA and VA based on dual task performance (Walk and L/S) and demographic variables had similar results. For TA, L/S was the only significant predictor ($p < .01$), explaining 19% of the model; For VA, L/S and marital status ($p < .01$) explained 27% of the variance (Table 5).

When all cognitive predictors were put in the model (SDMT, Walk, L/S), L/S was the only significant predictor of TA and VA ($p < .01$), accounting for 18% and 27% of the respective models. Studentized deleted residuals confirmed that all regression assumptions were met and the deleted residuals had approximately normal distributions for each model.[63]

To further explore relationships between performance of measures of attention and processing speed and participation in activities with a cognitive focus versus activities with a physical focus, the VA and TA scores from the VAQ were re-calculated into two outcome measures. A few researchers report that participation in cognitive activities has a stronger protective effect against cognitive decline than participation in physical activities,[3] or that participation in cognitive activities confounds the effect of physical activities.[29] We were interested in determining if differences existed in predictor variables for two different outcome measures, one that combined the Cognitive + Social (COG/SOC) activities, and one that combined Physical + Exercise (PA/EX) activities. Several of the cognitive and social activities have components of both domains such as playing bridge, attending a bible study, or volunteer work, making it difficult to define purely cognitive or social activities. Other researchers have combined participation in cognitive and social activities as an outcome measure,[6, 64] as opposed to creating two separate measures. The categories of physical activity and exercise are similarly related, and activities from both domains have been combined in several physical activity questionnaires.[65, 66] Stepwise regression analyses determined if differences existed between participation rates in COG/SOC and PA/EX and demographic variables (age, sex, BMI, number of health conditions, race, education, and marital status). All models showed much stronger relationships between measures of attention and processing speed for COG/SOC activities (R^2 =6% for TA, 22% for VA) than for PA/EX activities (no model for TA, R^2 = 7% for VA) (Table 5).

DISCUSSION

The purpose of this paper was to determine the associations between assessments of attention and processing speed and weekly total activity levels (TA) and variety of activity (VA). Results suggest the cognitive measures of SDMT and the dual task measure of L/S appear to be significant predictors of VA and TA levels for this group of older adults. These cognitive measures also account for a significant amount of variance in the model for VA. Marital status was the only significant demographic variable, positively affecting the outcome of VA.

Our initial hypothesis for this study, older adults who perform well on measures of attention and processing speed will engage in a greater variety of activities than those who do not perform as well is supported by our findings. The cognitive measures of SDMT and L/S explained a greater amount of variance in the VA ($R^2 = .21, .27$) than TA score ($R^2 = .06, .19$). These results support the notion that the number of activities a person does per week may be an important factor in protecting against cognitive decline, lending scientific credibility to the adage "Variety is the spice of life".[3, 14, 28] Researchers from different disciplines suggested that variety may be more important than total activity for both cognitive and physical function. Wilson reported that number of leisure activities was more protective against cognitive decline and dementia than total hours of activity,[14] and Podewils reported similar findings for number of physical and exercise activities as opposed to total caloric expenditure.[28] Research in falls prevention has demonstrated that interventions incorporating a variety of activities, requiring participants do something different each day, from a 10 minute home exercise program to attending a 60 minute class, report significantly greater reductions in falls[67-69] than interventions that used a prescribed amount of exercise during a standard time period.[70, 71]

The concept of number or variety of activities as a component of healthy aging is nascent in the literature. The novel findings from this study adds support to the hypothesis that variety of activities is important for protecting and maintaining cognitive function in older adults.[3, 5] The mechanism of variety is not clear at this time; however, both theoretical constructs of variability of practice and cognitive reserve may provide insight for this process. Variability of practice proposes that performing a skill or activity under variable conditions results in improved learning, retention, and transfer of that skill.[32] Older adults tested on retention of a novel motor task perform significantly better when the task is practiced under highly variable conditions.[72, 73] Individuals who engage in a greater number of activities are potentially introducing a greater amount of variability into their environment, facilitating the learning of different cognitive and motor skills to successfully perform and adapt the activity in different environments. Theoretically, this process could be facilitating synaptogenesis resulting in increased number and density of connections among neurons in the brain,[37, 38] potentially resulting in maintenance or improvement of cognitive performance.

The physiologic changes in the brain that occur with learning lend credence to the cognitive reserve hypothesis. Cognitive reserve has several definitions, one of which is the capacity to function beyond what is needed for daily functioning.[74] It may be that individuals who engage in a greater number of activities are creating a greater capacity to function in more environments. This active learning could be contributing to their cognitive reserve, resulting in the protective effect against cognitive decline reported in the studies by Wilson and Verghese.[3, 14]

In the secondary analysis that explored relationships between cognitive performance and participation in the different types of activities (COG/SOC and PA/EX), cognitive performance was clearly a stronger predictor of the number of COG/SOC than PA/EX activities. Participation in physical and exercise activities has been shown to be protective of cognitive decline;[10, 23-26] however, researchers have questioned if other activities are important to this process.[3, 29] This study showed no significant relationships between performance on cognitive measures of attention and processing speed and total PA/EX activity levels, and only a small percent of the variance was explained for variety (number) of PA/EX activities. Several longitudinal studies showed that participation in cognitive activities, not physical activity, was protective against cognitive decline and dementia;[2, 3, 5] however, these studies had limited definitions of physical activity and included limited information regarding frequency and variety of activities.[2, 3, 5] Our study included 16 physical activity and exercise items and still found stronger relationships with cognition and social activities, suggesting that participating in cognitive and social activities may be an important factor in addition to physical and exercise activities for cognitive performance in older adults.

For our sample population, the only demographic variable that was a significant predictor of TA or VA was marital status. The fact that age, sex, race, and education were not significant predictors of activity levels for this group of older adults is intriguing. Our sample was only 23% male and 25% African American that may explain why sex and race were not significant. However, age and education had normal distributions, and still were not significant predictors, suggesting that these variables may not be as important to overall activity levels.

Marital status has a positive effect on longevity,[75] though the mechanism of this effect has yet to be elucidated.[76] Marriage may provide greater opportunities for participation through companionship (having someone to do something with) or through motivation. Several husbands interviewed stated, "I do that activity because my wife makes me", and a few wives stated "I can't drive, so my husband takes me shopping/to the senior center etc." Approximately 30% of adults over the age of 65 live alone.[77] Living alone may result in higher physical activity levels because you have to do all the housework and meal preparation; however, this may not compensate for the increased variety of activities that marriage provides. Older single people may need extra support and encouragement to engage in activities with other people in the neighborhood, senior center, club, or church to increase their weekly activities.

Our results and those of others support the notion that participation in a variety of activities may be important for healthy aging. However, the cross sectional nature of this study does not clarify if adults who perform better on cognitive tests engage in more activities or if adults who engage in more activities do better on cognitive assessments. The fact that both a measure of attention and processing speed and a dual task measure were significant predictors of VA suggests that the relationship of variety of activity to healthy aging merits conducting longitudinal and intervention studies to determine if individuals who perform better on cognitive assessments participate in more activities, or if participation in activities is protective against cognitive decline.

Dual Task Measure

A component of this study was to determine which cognitive task was the most appropriate for our sample in the dual task condition. We assessed the costs of relative change in walking speed, change in accuracy, change in rate, and letters spoken per second (L/S) for each dual task condition. The motor cost for the three dual task conditions increased concordantly with task difficulty (ABC, ODD, ACE), regardless of education levels. To determine which cognitive task was the most feasible, we compared cognitive costs for Accuracy and Rate cost between conditions. We found neither Accuracy nor Rate cost were precise or meaningful values for the three dual task conditions. For Accuracy, performance actually improved for the dual task ABC condition, probably due to participant's speaking slower and increased concentration than when doing the rote single task. A similar phenomenon occurred with the ODD task. For ACE, Accuracy changed meaningfully for the group; however, we observed that several individuals were challenged by this task and made several mistakes resulting in a wide distribution of scores. Because only 60% of the HS group was able to complete the ACE, it may not be an appropriate task for a representative sample of the older adult population. The Rate cost measure for the ACE and ODD task had similar problems with precision. Rate cost for ABC was a precise measure; however, we determined that a change in Rate cost was difficult to measure and meaningfully interpret. We were interested in using a cognitive measure that could be performed successfully by a representative sample of the population, so we investigated the utility of a simple measure of L/S as opposed to a change score.

When we compared L/S between single and dual tasks conditions, we found significant differences, with the greatest changes for the ABC task ($p < .01$). We also found strong correlations between dual task L/S and SDMT performance ($r = .57$). The correlations between the SDMT and Accuracy and Rate cost were weak and not significant for the three conditions. This finding suggests that L/S may better represent aspects of processing speed than change scores. Other researchers have used speech rate as a measure of cognitive performance in dual task conditions,[61, 62] and reported significant slowing under dual task conditions. Williams compared speech rates for younger and older adults performing a walking while talking task, and found that older adults significantly slowed the words per minute generated and had different talking strategies than younger adults.[61] Williams also reported that the word per minute measure was positively associated with processing speed in her study sample.[61] Because the cognitive aspect of dual task performance is often difficult to quantify, we suggest that using L/S as an outcome measure has potential as a clinical tool. L/S was simple to measure, had utility for a diverse sample of older adults, and was correlated with assessments of attention and processing speed.

Limitations

The findings in this study were based on the VAQ which quantifies frequency and variety of activity in older adults, and is in the preliminary phase of development. The results reported indicate that relationships between cognitive measures and TA and VA were in the direction that we hypothesized; however the R^2 values were lower than expected. Once the tool is finalized, we anticipate further clarification of these relationships. This study included a relatively small (N = 95) sample of older adults from central North Carolina[78] and may have regional bias, suggesting these results cannot be applied to other populations of older adults in the United States. Future studies should focus on recruiting a larger sample size from diverse regions. Because the cross-sectional design of this study limits the conclusions that we can draw from these results, we recommend future longitudinal studies to clarify the direction of the relationships between VA and cognitive performance. A final limitation is the use of letters/second (L/S) as a dual task cognitive measure. Change in cognitive performance is often reported as a performance cost measure in dual task data,[56] but we did not anticipate that both accuracy and rate cost measures of performance would be imprecise. For this diverse sample, cognitive cost was not a useful outcome measure; therefore we explored the utility of L/S to measure cognitive performance under dual task conditions. Though L/S is not a "cost" of dual task performance as it has been defined in the literature,[56] it appears to be associated with processing speed and may be an appropriate dual task performance measure for future studies.

CONCLUSIONS

Performance of measures of attention and processing speed appears to be associated with the frequency and variety of activities an individual does in a given week. Variety of activity may be an important factor for maintaining cognitive performance in older adults. Marital status also appears to influence the variety of activities in which older adults participate. Clinicians should provide additional counseling to older adults who live alone to insure they are staying active and engaged socially and cognitively as well as physically. Including an assessment of social, cognitive, physical, and exercise activities in a clinical evaluation may be a critical component of a wellness evaluation for older adults.

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Table 3.1 Participant Demographics (N = 95)

Variables	**Subjects Mean (SD)**
Age (mean number of years)	78.5 (5.6)
BMI	25.5 (4.9)
Number of Health Conditions	2.8 (1.6)
Symbol Digit Modality Test (N = 89) Age based normative value = 32.7 (10.2)	35.4 (11.0)
Walking Speed (meters/seconds)	1.1 (.29)
Total Activity	71.4 (21.1)
Variety of Activity	18.8 (4.4)
	Percentage of Subjects
Gender % (female)	77
Race %	
Black	25.0
White (non-Hispanic)	75.0
Asian/White (Hispanic)	0.0
Marital Status %	
Married	36
Single	
Widowed	39
Divorced	11
Other	14
Education %	
High School	
Less than high school	19
High School/GED	11
College	
Associate Degree	14
Bachelor's Degree	23
Graduate Degree	33
Assistive Device %	
Never	73
Rarely	9
Some of the time	9
Most of the time	3
All of the time	4
Number of Falls in Past Year	
1	22
2	6
3	2
4	2

Table 3.2 Dual Task Performance

Test	Mean Task Time (Seconds)	Relative Mean % Decrease in Walking (95% C.I.)	Mean % Change in Accuracy (95% C.I.)	Relative Mean% Decrease in Rate (95% C.I.)
Single Task				
Walk	13.6 (3.8)			
ABC	8.1 (4.4)			
ACE	21.2 (9.4)			
ODD	18.6 (8.6)			
Dual Task				
ABC	15.0 (4.3)	11% (08 – 15)	-1.29 (-2.50 – -0.04)	23% (17 – 29)
ACE	20.1 (7.5)	54% (44 – 64)	7.66 (3.70 – 11.5)	3.6% (-5 – 12.7)
ODD	17.9 (7.0)	35% (26 – 43)	1.32 (-0.39 – 2.7)	2.6% (-3.3 – 8.6)

Letter Rate	Letters/Second Mean (95% C.I.)	t –test (p)
Single Task		
ABC	3.70 (3.40 - 4.00)	
ACE	0.65 (0.59 - 0.70)	
ODD	0.97 (0.88 - 1.10)	
Dual Task		
ABC	2.60 (2.40 - 2.80)	10.2 (p < .01)
ACE	0.59 (0.54 - 0.63)	-17.9 (p < .01)
ODD	0.94 (0.87 - 1.00)	1.8 (p < .07)

Table 3.3 Correlations Among Cognitive Variables and Activity

	SDMT	Total Activity	Variety of Activity	Walk ABC	Walk ACE	Walk ODD	Accuracy ABC	Accuracy ACE	Accuracy Odd	RR ABC	RR ACE	RR ODD	L/S ABC	L/S ACE	L/S ODD
Symbol Digit Modality Test (# Correct)	1	.24*	.38**	.02	-.15	-.14	-.07	.23*	-.25*	-.23*	.23*	.13	.57**	.54**	.62**
Total Activity		1	.72**	.07	.05	-.01	-.17	-.06	-.06	.01	-.09	.04	.44**	.30**	.19
Variety of Activity			1	.08	.13	.10	-.12	-.01	-.14	-.10	.03	.22*	.47**	.33*	.29**
Walk ABC				1	.42**	.54**	.03	-.18	.02	-.15	-.11	.11	.03	-.02	-.01
Walk ACE					1	.64**	.06	-.11	.02	.03	.16	.10	.03	-.41**	-.15
Walk ODD						1	.02	-.12	-.02	-.01	.11	.13	.02	-.24*	-.29**
Accuracy ABC							1	.06	.09	.07	-.02	.09	.09	-.12	-.06
Accuracy Ace								1	.12	-.03	.65**	.12	.06	-.09	.25*
Accuracy ODD									1	.15	-.04	.22*	-.09	.08	-.23
RR ABC										1	-.07	.25*	-.40*	-.04	-.17
RR Ace											1	.18	.14	-.12	.16
RR ODD												1	.03	.28*	.09
L/S ABC													1	.28*	.50*
L/S ACE														1	.48*
L/S Odd															1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 3.4 Regression Analyses
Demographic Variables = age, sex, race, education, marital status, number of health conditions, BMI

Outcome	Predictors	Model	Beta	R^2
Total Activity	Demographics SDMT	SDMT	.24*	.06
Variety of Activity	Demographics SDMT	Marital Status SDMT	.33 .27	.21
Total Activity	Demographics Walk ABC L/S ABC	L/S ABC	.44	.19
Variety of Activity	Demographics Walk ABC L/S ABC	Marital Status L/S ABC	.24 .41	.27
Total Activity	Demographics SDMT Walk ABC L/S ABC	L/S ABC	.42	.17
Variety of Activity	Demographics SDMT Walk ABC L/S ABC	Marital Status L/S ABC	.26 .41	.28

***p < .05, for all other β values p < .01**

Table 3.5: Secondary Regression Analyses: Total Activity and Variety of Activity separated into two outcomes: 1) cognitive and social activities (COG/SOC) and 2) physical and exercise activities (PA/EX)

Outcome	Predictors	Model	Beta*	R^2
Total Activity (COG/SOC)	**Demographics SDMT**	**SDMT**	**.26**	**.06**
Variety of Activity (COG/SOC)	**Demographics SDMT**	**Marital Status SDMT**	**.33 .28**	**.22**
Total Activity (PA/EX)	**Demographics SDMT**	**No Model**		
Variety of Activity (PA/EX)	**Demographics SDMT**	**Education**	**.25**	**.07**
Total Activity (COG/SOC)	**Demographics SDMT Walk ABC L/S ABC**	**L/S ABC**	**.37**	**.13**
Variety of Activity (COG/SOC)	**Demographics SDMT Walk ABC L/S ABC**	**Marital Status L/S ABC**	**.26 .37**	**.23**
Total Activity (PA/EX)	**Demographics SDMT Walk ABC L/S ABC**	**L/S ABC**	**.29**	**.08**
Variety of Activity (PA/EX)	**Demographics SDMT Walk ABC L/S ABC**	**L/S ABC**	**.09**	**.09**

*All β significant at $p < .01$

CHAPTER III

SYNTHESIS

What did I find … The development of the Variety of Activity Questionnaire

The results indicate the Variety of Activity Questionnaire (VAQ) is a reliable and valid measure of activity in adults 70 years and older. As mentioned in manuscript one, the tools designed to measure activity levels in older adults have low reported reliabilities and validities. The VAQ has comparable and often better psychometrics in comparison to the validated tools reported in the literature.[1-3]

Based on the literature, I hypothesized the factor analysis would identify underlying constructs based on the primary component of the activity. For example, I predicted a social/ physical factor may have included going to church or meetings, doing volunteer work, or attending group exercise classes. I rejected this hypothesis based on the failure of the VAQ to factor. The tool was tested on 196 individuals, which was an appropriate sample size based on research literature.[4] Though my sample was composed of individuals from diverse socio-economic backgrounds, my recruitment methods may have contributed to low variability of activities. For example, if I recruited 20 people from the same senior center, those 20 people probably all did similar activities. It is possible that as I continue testing the tool, a larger sample with greater variability will result in successful factoring. However, other tools in the literature report poor outcomes for factor analysis,[2, 3] indicating there is a high probability that the tool will not be amenable to factor analysis. Even though at face value activities appear to combine components, the results do not support an underlying factor structure. At this point, I believe activities should be categorized based on their primary component. For example, attending church is primarily a social activity, and should be categorized as such.

The results from regression analyses support that cognitive and physical performance was associated with total activity (TA) and variety of activity (VA); however, all models explained a larger portion of the variance for variety of activity. One reason for this finding could be the differences in distribution between TA and VA; however residual analysis indicated that both distributions were approximately normal. A second reason for this finding supports our hypothesis that participating in a variety of activities may be important to protect against the declines in physical and cognitive function associated with aging. Variety of activity has been identified as an important factor in cognitive and social activities, but it has not been studied in association with physical and exercise activity. We suggest that variety and frequency of activity should be assessed in older adults and may provide important insights for independent function. I chose to use the International Classification of Function, Disability and Health (ICF) model as a theoretical framework to explain how variety of activity may improve function.[5] The revised ICF model shown in Figure 3.1 is an illustration of how variety may work to improve function. Based on my results, I believe that individuals who engage in a greater number of activities are interacting with a greater number of environments. This in turn is having an effect on body functions and structures and participation, which may provide a protective effect against the health condition on overall function.

The VAQ is the first tool to assess activity levels in multiple domains that has adequate reliability and validity. One interesting finding was that the associations reported for variety and performance measures were not domain specific. For example, a participant could have a high variety score that reflects participation in social and cognitive activities, yet the physical performance variables were also positively associated. Secondary analyses on both physical performance and cognitive performance measures were conducted to better understand the relationship of activities in the different domains to physical and cognitive performance.

Findings from the secondary analyses clarified that participation in physical and exercise activities have stronger associations with physical performance measures, and participation in cognitive and social activities has stronger associations with cognitive measures. These findings lend partial support to the specificity of practice hypothesis, and also may provide additional evidence that activities are domain specific. One model that differed in these secondary analyses was for the outcome of variety of cognitive and social activities. The physical performance measures explained almost as much of the variance for this outcome as for variety of physical activity and exercise, providing additional support for our hypothesis that participating in a greater number of activities, regardless of type of activity, may be important to protect against cognitive decline.

The inspiration for the VAQ came from the wealth of information linking increased physical activity levels to improved functional outcomes, and the frustration with the lack of reliable and valid tools available to measure activity levels in older adults. We originally planned to develop a questionnaire for physical activity and exercise, but after reviewing the literature realized that including participation in cognitive and social activities would provide additional information for researchers and clinicians. The VAQ is a simple and brief assessment that can be used in future research projects to quantify and describe activity patterns for individuals or groups. Clinically, the VAQ can be used as a health promotion tool to educate and encourage patients to stay cognitively, socially and physically active. This topical message is already being used by organizations such as the Alzheimer's Association in their "Maintain Your Brain" public awareness campaign, which encourages individuals to use their minds, remain socially engaged, and stay physically active in order to reduce the risk of Alzheimer's and other dementias.

What did I learn … Limitations/Strengths/Weaknesses

The major limitation of the study was our sample size. Though we projected a sample size of 200 would be adequate for factor analysis, the Kaiser-Meyer-Olkin test indicated we may not have an adequately sized sample for factoring.[6] This sampling issue may have stemmed from a lack of variability in our study participants as previously mentioned. In addition, a portion of participants were recruited from Continuing Care Retirement Communities. These individuals were predominately well educated (90% had graduate degrees) and were generally more uniform in their activities. For example, if you live in a CCRC you are not responsible for heavy housework and you have access to group dining. This may have decreased the variability of the sample, which could have contributed to the failure in factor analysis. Conversely, 43% of the sample was high school educated or less, so it is difficult to say that the sample lacked variability. If the sample size had been larger (N = 300 - 400) we would have a much better sense if the tool was amenable to factoring.

A second weakness in the tool development was the method for test-retest reliability. Some participants who volunteered to retake the VAQ lived 60 to 90 miles from the researcher, making it necessary to conduct the second administration of the VAQ by phone. We did not anticipate this situation and did not pilot test a telephone administration of the VAQ. Half the retests were done in person and half over the phone. Even though a t-test comparison of the means indicated no statistical differences between the two methods, future studies should validate administration of the questionnaire by phone.

The dual task assessment provided a formidable challenge for both researchers and participants. We did not anticipate the cognitive challenge that the ACE task would pose to some participants, especially those who had not completed high school. Performance of this task made us acutely aware how important it is that the dual task matches the cognitive abilities of the participant. One problem with the dual task administration was measurement of the single task. We anticipated that participants would be able to complete the cognitive task during the time it took for the walking task, so we tested people while reciting the entire alphabet or counting to 30 for the single task condition. During the testing, 27% of participants (N = 16) were not able to complete the entire alphabet or to count to 30 during the dual task, making it difficult to compare dual task performance to single task performance. In future studies, single task performance will be based on the number of letters spoken during a specified time (rate of letter response) as opposed to the time to complete the single task.

This study has several strengths. Our sample was representative of North Carolina's demographics, and 30% of our sample was African American. We developed successful partnerships with senior centers and churches in Lee, Harnett, Chatham and Durham counties to recruit participants. The strategy of organizing a healthy aging presentation at the centers, and then setting up an information table worked well to recruit individuals from diverse backgrounds. As an additional service, we committed to return to several centers and CCRCs to present the results of this study.

We recruited a greater number of participants than we projected for the physical and cognitive performance assessments. We had anticipated recruiting 80 subjects, and 95 subjects volunteered for these assessments, adding additional strength to our analyses and conclusions.

A final strength is the quality of the VAQ. Participants had minimal difficulty answering the questions and the items chosen seemed to be appropriate for this population of older adults. Frequency and variety appear to be reliable and valid outcome measures, even for low intensity activities. Finally, the VAQ is brief and placed minimal burden on participants, yet appeared to accurately capture participation rates in several different types of activities. Senior center directors and clinicians have indicated interest in using the VAQ either as a program evaluation or clinical assessment tool.

Where do I go from here … Future Directions

I found significant associations between physical and cognitive performance measures and variety of activity. The next step is to collect VAQ data on one to two hundred more subjects and determine if the VAQ is amenable to factor analysis. If the KMO values and scree plots indicate factoring is reasonable, then we will proceed accordingly. If the KMO values do not change, then we will not attempt further factoring. After the factoring question has been answered, there are several options for the VAQ.

In a recent review of physical activity questionnaires, Jorstad-Stein suggested that no physical activity measure currently is appropriate for use in intervention studies to measure an older adult's change in activity levels. The ideal measure is described as sensitive to change in populations with low activity levels, brief, cost effective, and self-administered.[7]

The VAQ meets several of these criteria. Our next step is to test the responsiveness of the VAQ to changes in activity, and to assess the reliability and validity of the VAQ when self administered.

If the VAQ is a sensitive measure of change, then an intervention study could be developed to determine if increasing variety is associated with significant improvements in physical and cognitive outcomes. A secondary study would be determining if increasing variety in a specific domain significantly changes physical and cognitive outcomes.

Another option is to complete an additional validation study using Step Activity Monitors (SAM) to determine associations between variety of activity and total number of steps taken during a one week period. The SAM has the highest reliability and validity values for populations with low activity levels.[8] It would be interesting to see if greater variety is associated with greater overall activity.

An eventual goal is to introduce the VAQ as a health promotion tool to clinicians and a program evaluation tool for senior center directors. Clinicians currently using the VAQ remark on the additional information it provides about older patients and its utility for intervention planning. Senior centers could also use the VAQ to describe the activity patterns in their seniors and plan appropriate programming, and could use the VAQ as an outcome measure to show changes in activity levels as a result of program participation.

The inclusion and exclusion of items in the VAQ may need to be revisited depending upon the use of the tool. We excluded activities with high or low participation rates because we believed these items did not discriminate between activity levels of the participants. If the tool is being used clinically or to describe activity patterns, the four items dropped from the VAQ should be included. If the VAQ is being used in a different region, all items should be included to capture activity in other seniors who play more golf or team games than the seniors in our study. Finally, there was an "other" category of activity in the questionnaire for individuals to fill in. The care of pets was often written in the "other" category, usually in the social domain. Participants identified the care of pets in the same category as providing childcare or being a care giver. Future studies will determine if this item should be incorporated into the VAQ.

For a tool developed from my frustration with a lack of available measures, the VAQ meets several criteria as an acceptable measure of activity, and shows promise as a useful measure in several different settings. Future studies will expand that utility to other populations and settings.

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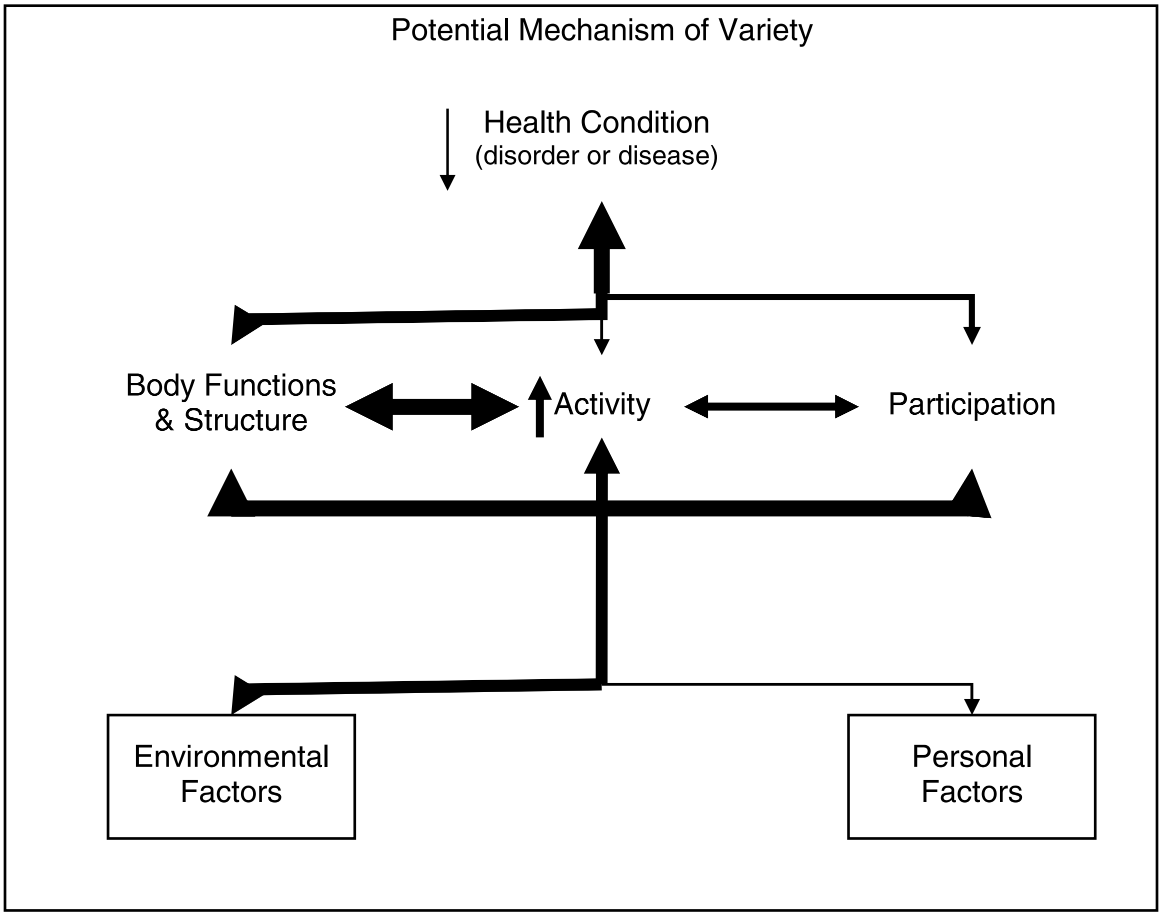

Figure 3.1.1 The ICF framework :How participating in a variety of activities may contribute to maintaining physical and cognitive function

Appendix A

LITERATURE REVIEW

Maintaining independence and preventing falls are serious health concerns for older adults. Regular physical activity appears to be an important component of a healthy lifestyle for older adults, which is associated with increased longevity, reduced depression, reduced pain from arthritis, a reduced risk of falls and fractures, and an increased ability to maintain functional independence.[1, 2] The benefits of maintaining an active lifestyle has become a growing area of research because the effects appear wide ranging. Although the cause of falls and functional decline are complex, this literature review will focus on aspects of falls risk that may be associated with activity and active life style. There is strong evidence of the health benefit of physical activity and there is less but intriguing evidence of benefits of social and cognitive activity. The driving hypothesis for this thesis is that several domains of activity and active lifestyle contribute to reduced falls risk and increased independence in older adults.

The International Classification of Functioning, Disability and Health (ICF) model provides a potential theoretical model for this mechanism[3] (Figure 1). The ICF framework proposes activity and function are interdependent, and a dynamic interaction exists between health conditions (defined at disease, disorder, aging, injury or trauma), activity (the execution of a task or action by an individual), body functions and structure, participation (involvement in life situations), environmental factors (physical, social, and attitudinal environment) and personal factors (age, sex, etc). Activity is central to all other elements in the ICF. Increasing or decreasing activity is directly related to health condition and the contextual factors of participation, body functions and structure. It is possible that by increasing the numbers of activities, many factors in the ICF model are affected, which may result in greater net changes to the entire system.

The falls prevention literature may provide support for this proposed mechanism of activity. Falls research has focused on identifying extrinsic and intrinsic risk factors associated with falls, and assessing the efficacy of interventions targeting these risk factors. Traditional exercise interventions targeting these specific impairments report improvements; however they do not consistently report significant reductions in falls rates. [4-6] Falls prevention programs that used multi-component interventions that incorporated a greater variety of activities including strength, static and dynamic balance, endurance and flexibility training in different environments (e.g. in a class, the community, the home) seem to be more effective than the traditional exercise interventions in reducing falls; however, they often report no significant changes in the impairments associated with falls,[7-9] which questions the mechanism of these interventions.

Using the ICF as a theoretical framework, I propose that the variety of activity inherent in the multi-component balance interventions results in increased exposure to different environmental factors, increased participation levels, and improved body function, resulting in better overall function and fewer falls.

The purpose of this dissertation was to explore this proposed relationship between activity levels and function as it relates to falls risk factors. First, we developed a tool to quantify variety and frequency of participation in activities for four domains. Then we assessed relationships between variety and frequency of self-report activity and performance on physical and cognitive assessments. In this literature review I will discuss the epidemiology of falls, measurements of fall risk factors, evidence for interventions to reduce risks, the role of daily activity to reduce falls rates, and tools developed to quantify activity. The review concludes with a discussion of the hypothesized protective role of variety of activity as related to risk factors for falls and functional decline.

A.1 Epidemiology Of Falls

A fall is a seminal event for an older adult, and can contribute to disability, morbidity and mortality. One third of individuals over the age of 65 will experience a fall this year,[10] and 20 - 30% of these falls will result in moderate to severe injuries.[11] Falls become a greater health risk with age, as an 85 year old man is ten times more likely to die from a fall then a 65 year old man.[11] Those who survive a fall may sustain a hip or wrist fracture, resulting in decreased mobility and loss of function.[11] Individuals who fall once are at greater risk for future falls,[12] increased fear of falling,[13] and subsequent restriction in activities,[14] all of which can contribute to a loss of independence and longer recovery times after a disabling event.[15,16] Falls are a significant economic burden for the healthcare system. The average cost for a hospital admission due to a fall is $19,440 with estimates of total American health care dollars spent on falls at 43.8 billion dollars by 2020.[17]

A.2 What Are The Major Risk Factors For Falls?

Several intrinsic and extrinsic factors are associated with falls risk. Intrinsic factors which cannot be modified include age greater than 80 years, visual changes including poor depth perception and contrast sensitivity, female gender, and presence of chronic health conditions.[18-20] Modifiable intrinsic factors include muscle weakness, poor gait, and balance deficits.[18-20] It is unclear if the intrinsic risk factor of cognitive decline is able to be modified,[21-23] however research suggests that participation in physical and cognitive activities may be protective against cognitive decline and dementia.[24-29] Extrinsic risk factors associated with falls include polypharmacy[12] and environmental risk factors such as poor lighting, clutter on floors, and throw rugs.[30] This review will focus on modifiable intrinsic risk factors.

A.3 What Instruments Are Used To Measure Intrinsic Risk Factors?

Conducting meaningful research depends on the development of reliable and valid screening batteries to identify individuals with modifiable intrinsic risk factors. In the past decade, several physical and cognitive performance batteries were developed and tested to identify specific impairments contributing to falls risk in older adults. Researchers have identified key physical assessments such as walking speed, getting up from a chair, standing in different balance positions, and cognitive assessments of attention and processing speed which are reliable and valid indicators of functional decline and potential falls risk.[19, 31-37]

Walking speed is a sensitive tool to identify individuals at risk for falls and functional decline.[31, 37] Walking slower than 1.0 meters/second over a distance of four meters is a reliable and valid indicator of functional decline, morbidity, and mortality.[31, 37 38] Individuals who walk slower than .8 meters/second are at increased risk of falls,[39] fear of falling,[40, 41] and have decreased confidence in one's own physical abilities.[42]

The timed chair rise is a measure of leg strength, balance, and proprioceptive function.[43] Two versions of this task are used to identify at risk individuals. The version used in the Established Populations for Epidemiologic Studies of the Elderly (EPESE) studies requires an individual to stand up and sit down five times without upper body assistance.[44] Performance is measured by total time to complete five repetitions. Times of greater than 13.6 seconds are associated with increased falls risk, morbidity and mortality.[31] A second version measures the number of chair rises performed in 30 seconds, and is strongly correlated with lower extremity strength as assessed by the leg press (r =.71).[45]

Three simple clinical assessments of balance predictive of falls in older adults are the tandem stance test (TST), the timed 360° turn, and the four square step test (FSST). The TST requires participants to hold a heel-toe position from ten to thirty seconds.[46, 47] Individuals who cannot maintain balance in this position or cannot hold the position for at least ten seconds are at risk of falls, morbidity, and mortality.[31, 46, 48] The timed 360° turn test records the total time for an individual to turn in a circle. Times greater than 3.8 seconds are associated with loss of independent function[49] and falls.[50] The FSST requires individuals to complete a series of steps and direction changes within a circumscribed area.[51] Four canes are laid on the ground creating four boxes. Individuals step forwards, sideways, backwards, sideways and reverse this sequence to return to the start. The test includes one practice and two timed trials, with the best time used to identify fallers. The test has high retest reliability (ICC=.98). The time of > 15 seconds to complete the sequence is sensitive (85%) and specific (88%) to identify individuals who have experienced at least one fall.[51]

Two other valid and reliable clinical measures frequently used to assess balance and falls risk are the Berg Balance Scale[46] and the Timed Up and Go.[52] The Berg Balance Scale (Berg) is a fourteen item balance performance scale with a maximum score of 56. Each item is rated on a scale of 1- 4 based on quality of performance or time to complete the task.[46] Examples of items on the Berg include single leg stance, arising from a chair without using the hands, and picking up an object from the floor. Although the Berg Scale is a good indicator of fall risk it takes 10-15 minutes to administer, and some items are rated subjectively on performance. The “Timed Up and Go” test times individuals as they stand up from a chair, walk three meters, turn, and return to sitting.[52] When 14 seconds is used as a cut off, this test is sensitive (87%) and specific (87%) to identify elderly individuals with a history of falls.[53] This test is an excellent clinical screening tool to identify individuals at risk of falls, though it does not identify specific deficits in balance.

Cognitive impairment and slowed reaction times are well documented risk factors for falls.[12, 19, 54] Tests designed to assess executive function, processing speed and the ability to divide attention may identify an at risk individual.[19, 33, 36, 55, 56] The ability to maintain one's balance requires integrating information from appropriate sensory input, choosing the correct musculoskeletal response, and executing that response within the appropriate time frame. Studies have shown older adults require more processing time when they switch from one cognitive task to another,[57] and are challenged when they need to inhibit irrelevant information.[58] Slow information processing and difficulty switching attention may be contributing factors to the increase in falls seen in older adults.[32, 33, 59]

Several assessments have been developed to measure processing speed and executive function including the Trail Making Tests A and B, and the Symbol Digit Modality Test (SDMT). Though there are many tests of executive function and processing time, these two tests were selected because they have good psychometric properties, require minimal training, can be conducted easily in the field, and are time efficient. The Trails test is a pen and paper test requiring individuals to connect sequential numbers and then alternating numbers and letters.[60] The test is sensitive to cognitive decline,[61] and assesses visual search, sequencing, and motor speed.[61] This test has normative data based on age and education level.[62]

The SDMT consists of pairing symbols to numbers and assesses executive function, processing speed, and the ability to switch attention.[63] The test can be administered in written or oral version, and has normative data for education and age for older adults to age 90.[63, 64] The oral version is valid for those with less than eight years of education.[63] Performance of this test is based on the number of correct pairs completed in 90 seconds and scores are categorized as normal (at or above mean for age group), low (one standard deviation below mean), moderately low (1.5 standard deviations) and very low (2 standard deviations).[63] For the oral version, the mean scores and standard deviations for ages 65 – 75 are 42.05 (11.26),[63] ages 75 - 80 are 32.75 (10.16), and ages 80 - 90 are 28.84 (8.93).[64]

An area of emerging research merging cognition and mobility is the ability to divide one's attention between two tasks, such as walking while talking.[65] Many community based mobility activities are dual task in nature: people perform mental while shopping, converse with companions while walking, and carry bags while walking and talking. If individuals have a difficult time dividing attention between situations, they may not be able to attend to the environment and balancing, and put themselves at risk for a fall. Measuring performance of a dual task can provide insight to falls risk and function in community dwelling older adults.[66-68]

In the dual task paradigm, the performance of a primary physical task such as maintaining balance or walking is assessed while simultaneously conducting a secondary task such as talking, counting, or carrying an item.[69] Walking performance alone in older adults requires more attentional resources than younger adults, and is associated with executive function. [70, 71] When older adults perform a secondary task while walking, such as talking or subtracting numbers, they tend to have larger decrements in performance of primary tasks than middle aged or young adults.[66, 72, 73] These decrements in performance are even greater in older adults with mobility or strength impairments. [56, 68]

Several dual task assessments with different degrees of cognitive difficulty have been developed for older adults. The "Stops Walking While Talking" test is highly predictive of falls in institutionalized elders.[65] This test may not be a sensitive measure for identifying falls risk in higher functioning individuals.[74] More complex secondary tasks have been developed for community dwelling older adults such as saying the alphabet skipping every other letter,[55] carrying an item,[53, 67] or counting backwards using serial sevens.[75] Several studies have compared older adults performance of these complex tasks to young adults and report compromised parameters of gait such as slowed speed,[55, 76] and increased variability of stride length[77] and stride time.[76] These measures have all been associated with increased falls risk in older adults.[41, 78, 79] Verghese compared walking speed performance of 60 non-demented older adults (mean age 79.6 years) while reciting the alphabet and reciting the alphabet skipping every other letter. He reported that walking slower than one standard deviation on both tasks is a sensitive and highly specific tool to identify fallers.[55] Toulotte performed a similar study comparing differences in walking speed between fallers and non-fallers while performing a secondary manual task of carrying a cup of water. Fallers exhibited greater deficits in walking including significantly slower speed and greater variability in the dual task condition.[67]

To summarize, there are several reliable and valid assessments to determine if an individual is at risk of a fall based on walking speed, leg strength, balance and cognitive abilities. The instruments developed are brief, functional, and easy to use in research and clinical settings. This study will include assessments of walking speed, chair rise, the tandem stance test, the timed 360º turn, the Four Square Step test, the Symbol Digit Modality Test, and a dual task assessment.

A.4 What Is The Evidence For Interventions To Modify Intrinsic Fall Risk Factors?

The intrinsic risk factors of muscle weakness, gait and balance deficits can improve with appropriate interventions. Older adults can increase muscle mass and muscle strength,[80] improve walking speed with exercise training,[5, 81, 82] and improve scores on balance assessments.[83] The research on the effectiveness of interventions to improve cognition in older adults is nascent. Studies have shown short term improvements in reaction times to auditory and visual stimuli with cognitive training.[84, 85] Other studies have assessed improvements in memory and processing speed after a 10 week intervention; However, these improvements did not transfer to performance of any other cognitive tasks.[21, 22] More research has been conducted using prospective studies to determine if cognition is protected or improved in individuals reporting high participation rates in social, cognitive and physical activities.[24, 29, 86] The following section will review current evidence for modification or prevention of each risk factor.

Risk Factor: Muscle Weakness

As lower extremity strength is a primary risk factor for falls,[87] researchers have reported the effects of "traditional" strength training on falls reduction.[6, 88, 89] Based on the American College of Sports Medicine (ACSM) guidelines, these protocols incorporated weight training exercises with specified progressions based on percentage of maximum effort and numbers of repetitions and sets. Frequency of these interventions was two to three times a week with durations from twelve weeks to six months. Studies of strength training interventions for older adults reported significantly increased lower extremity muscle strength,[80, 88, 90] improved physical function,[91, 92] and endurance.[5, 91] The results of strength training interventions to improve balance performance and decrease falls risk are not as straightforward. Two researchers used traditional strength training interventions to improve performance of balance measures and reported no significant changes in community dwelling individuals.[5, 81] Conversely, other researchers studying effects of this type of intervention report decreased postural sway[93] and improved functional balance ability[94]. Liu-Ambrose compared measures of postural stability and numbers of falls between community dwelling women participating in a 12 week traditional strength training program compared to individuals in a flexibility training program. She reported significant improvements in postural sway for the strength training group, however there were no differences in the numbers of falls between groups.[6]

The effect of strength training protocols incorporating functional exercises using body weight or elastic resistance bands as opposed to traditional strength training on balance performance and falls risk is difficult to interpret. Studies using these interventions were of variable duration, from eight weeks to one year, and the progression of exercises was based on number of repetitions and sets of exercises instead of percentage of maximum weight. Morgan examined the effect of an eight-week strength training program on low functioning older adults using body weight as resistance, and found the twice weekly intervention resulted in no significant improvements in strength or difference in falls rate between exercise and control groups.[95] Jette studied the effects of a 6 month home based intervention using resistance bands, and reported the thrice weekly intervention resulted in small but significant increases in leg muscle strength (6% – 12%) and improved performance of a balance assessment.[96] To summarize, lower extremity weakness can be improved by high to moderate intensity strength training interventions, and specific strength training interventions may improve falls risk factors; however, the research to date has not clearly demonstrated a relationship between strength training interventions and a significant decrease in falls rates.

Risk Factor: Gait Speed and Instability

Walking speed is a good overall indicator of functional ability,[31] and is a common outcome measurement in physical activity and exercise interventions. Interventions focused on walking report improvements in walking speed, distance, and endurance.[5, 81, 82, 88] Macrae studied residents of a nursing home who participated in a walking intervention and reported significant improvements in endurance and distance walked, but no change in walking speed.[82] A few studies have focused on walking interventions and balance measures.[90, 97] Simons reported improved lower extremity strength and performance on an agility test in elderly community dwelling individuals who participated in a twice a week walking intervention for 16 weeks.[90] Paillard reported improved dynamic balance ability after a 12 week brisk walking intervention.[97] No falls related outcomes were reported for either studies, and the literature has not clarified the relationship between walking interventions and falls reduction in older adults.

Risk Factor: Balance

Balance training interventions range from laboratory based computerized balance training to participation in Tai Chi, and from structured balance classes to home based exercises. Results of these studies show improved balance and balance confidence, but not always a decrease in falls. Balance interventions incorporating functional exercises such as standing on one leg, reaching in all directions and tandem stance do not appear to be effective.[4, 6, 83, 95] These interventions occurred one to three times a week, for eight weeks to six months, and did not report significant reduction in falls rates.[4, 6, 83, 95]

Wolfson compared individuals participating in one of three protocols for a twelve-week intervention: computerized balance training, strength training, and Tai Chi.[98] Balance training consisted of moving the individual's base of support to a computer target that changed position and speed. Individuals also practiced different tasks using altered visual, foot, and surface conditions. The Tai Chi group and the strength training group both met three times a week. Individuals in the Tai Chi group showed a greater improvement on balance assessments and falls risk factors than those in the strength or computerized balance training group. Interestingly, there were no significant improvement in balance outcomes for the strength training group.[81] The outcome of falls were not reported for this study.[81]

A seminal study assessing the effect of Tai Chi on falls rate reported a significant reduction in falls.[99] Participants attended two 60 minute classes a week, and were encouraged to practice an additional 15 minutes, twice a day.[99] Though falls rate was reduced for this sample, there were no significant improvements in lower leg strength or walking speed. A similar reduction in falls rate was demonstrated in a study of 130 sedentary community dwelling older adults participating in tai chi three times a week.[100] This study did not report on strength or gait measures.[100] Transitionally frail individuals who participated in a twice a week tai chi intervention did not experience a significant decrease in falls after a 6 month intervention.[101] This negative result may be due to the initial frail condition of the subjects, or because the intervention did not incorporate daily practice, which may have been an important component of Tai Chi interventions reporting significant reductions in falls.[99 100]

Balance appears to improve with the functional exercises incorporated in a Tai Chi class; however, other functional balance interventions have not yielded similar results.[4, 6, 83, 95] What might account for the disparity of effects between these two types of balance interventions? An answer may be found in the design of the interventions used in Tai Chi and successful multi-component functional balance interventions. These studies incorporated a variety of training methods (standing in different poses, doing different exercises in different environments), have a higher frequency of participation (the intervention takes place daily or almost daily) and report a significant decrease in the rate of falls. We will now discuss the results of multi-component balance programs which conventional wisdom that training to improve specific risk factors will decrease falls.

Interventions that utilized a traditional exercise class format: sixty minutes, two to three times a week, for eight to twelve weeks with aerobic, strength, balance, and flexibility components improved strength, endurance, and performance on functional measures; however, these interventions did not appear effective at reducing the number of falls.[4, 6, 83, 93, 95] In contrast, interventions incorporating components of balance, mobility, and strength, requiring daily participation in walking or functional balance exercises do significantly decrease the numbers of falls, even for individuals classified as high risk or frail.[7-9, 102] These interventions used daily exercise alternating between strength and balance exercises one day, and walking the other day. A few programs included structured exercise classes once a week or once every other week.[7, 9] Participants in these interventions did not show significant improvements in the risk factors of lower extremity strength or balance, however they reported significant, (45-50% compared to controls) long term (over two years) reductions in falls.[7, 9, 103]

Three multi component exercise interventions report significant, long-term reductions in falls rates. Women, aged 80 and older, who participated in a six month home exercise program of strengthening and balance exercises three times a week, and a walking program three times a week experienced a protective effect against falls for over two years.[103] Two additional studies that included weekly participation in a one hour exercise class consisting of aerobic, strength, balance, and flexibility components, and completion of a daily home exercise program of walking, strength, and balance exercises reported similar decreases in falls rates.[7, 9] Incorporating a structured exercise class does not appear to significantly enhance the intervention, but it may facilitate compliance and adherence. Helbostad et al compared two groups of frail elders, one group completed four strength and balance exercises twice a day and another group attended training classes twice a week in addition to a daily home exercise program.[104] Both groups reduced rate of falls; however no significant differences existed between groups in the physical performance measures, suggesting the organized class did not significantly improve performance.[104]

Multi-component daily interventions do not significantly improve leg strength and physical performance. Individuals in the intervention groups showed some improvements on balance measures[9, 99, 103] but no significant differences in measures of leg strength, gait speed, or endurance.[7, 9, 99, 103] These data pose an interesting question: if the intrinsic risk factors for falls are not changing, and individuals are not improving in functional performance measures, then what mechanism is contributing to their decrease in falls?

A common trend across effective interventions is daily activity in addition to traditional exercise. The daily activity takes place in the home or outside as a walking program. These exercise programs usually use resistance bands or light weights and are of low to moderate intensity levels. The exercises are modified and slowly progressed at regular intervals, and a walking component is incorporated into the intervention. The home exercise component provides opportunities for activity in different environments. The walking component is usually done outside, for twenty to thirty minutes every other day, and exposes the older adult to a variety of environments to negotiate. *It may be that the daily participation in an activity, physical interaction with the environment, and participation in a variety of activities are the mechanisms contributing to improving balance and decreasing falls.*

Risk Factor: Cognition

Exploring methods for improving cognitive performance in the elderly is a nascent area of research. Most evidence of improved cognitive performance associated with physical activity is based on studies measuring changes in reaction time. Reaction time is a measure of processing speed[105] that has been associated with increased falls risk.[106] Improvements in choice reaction times in healthy older adults have been reported in aerobic[107, 108] and balance exercise interventions.[7] Rogers reported improved step reaction times with a three-week program that trained older adults to initiate a step at an auditory stimulus.[85] These studies reported reaction times improved in the laboratory setting, however they did not report on other aspects of cognition, nor did they determine if these are long term changes.[107, 108 85] Two aerobic intervention studies reported significantly decreased choice reaction times to visual stimuli in the intervention compared to the control group after a 6 month aerobic training intervention.[84, 109] These studies did not address the questions of type, duration or intensity of exercise needed to achieve or maintain these improvements.

Other researchers studied the effects of cognitive interventions to improve memory, reasoning, and processing speed.[21, 22] These studies showed that areas of cognitive ability can be improved in older adults; however these improvements are specific to the cognitive function trained (i.e., memory, processing speed), and were not associated with improvements in other cognitive areas or in everyday function. [21, 22]

Research in this area has primarily focused on the identification of factors that protect against cognitive decline and dementia. As cognitive decline is a risk factor for falls,[12, 32] protecting against decline could be an important component of falls reduction. Several studies identified regular participation in social, cognitive, and physical activities as protective factors against cognitive decline.

Social activity. Results of longitudinal studies suggest that socially active individuals who report several weekly contacts with friends, family and the community are less likely to develop depression and cognitive decline than those with limited social interactions and smaller social networks.[86, 110] This relationship remains significant when controlling for confounding factors of age, baseline cognitive function, and education.[86] Type of social contact (attending an event versus talking on the phone) does not appear to be the critical factor in this protective effect, rather the overall number of weekly social activities is associated with protection from dementia.[110]

Other studies have suggested that participation in social activities may not be protective against cognitive decline.[111, 112] In a six year longitudinal study of healthy older adults, Aartsen found no significant associations between participation in activities of going to church and attending neighborhood meetings and performance on assessments of fluid intelligence and processing speed. These results conflict with findings of other studies,[86, 110] however Aartsen used three community based activities as a social measure which may not have adequately quantified the amount of social interactions for her participants.[111] Additional work using standardized categories of social activity needs to be done in order to clarify this relationship.

Cognitive activity. Individuals who engage in cognitively stimulating activities appear to experience similar protective effects against cognitive decline. Longitudinal studies report strong associations between frequency of participation in cognitively stimulating activities (reading newspaper, listening to radio, reading books, crossword puzzles, playing an instrument) and decreased incidence of dementia.[29, 113, 114] These studies controlled for baseline cognition, education, and other known confounding factors. Verghese studied 488 individuals for a 21 year period and reported participation in several different types of cognitive activities appeared to provide the greatest protection, with an increase of one cognitive activity one day a week resulted in a 7% reduction in the risk of cognitive impairment[115] and dementia.[29]

When cognitive activities are studied in conjunction with physical activities, cognitive activities appear to have a stronger association with decreased dementia and cognitive impairment.[29, 115, 116] However, the populations sampled for these studies were largely sedentary, with 48% reporting walking at least three times a week, and only 6% reporting participation in an exercise class.

Physical activity and exercise. Researchers reported that regular participation in physical activity and exercise (participation in three or more days a week) is protective against cognitive decline.[24, 117-119] Women aged seventy and over who walk an average of one mile a day are 13% less likely than sedentary women to experience cognitive decline as measured by a three point decrease in Mini Mental Status Exam (MMSE) score.[24] Results from a two year study of 1,164 older adults demonstrated that individuals who exercised at least 30 minutes three times a week experienced a stronger protective effect against cognitive decline than their sedentary peers.[117] Older adults with higher levels of fitness have decreased atrophy of grey matter as measured by MRI,[120] and decreased reaction times to conflicting stimuli.[84]

Podewils addressed the question of type of exercise, frequency and intensity of activity in a study of 3,608 individuals asked to record frequency of participation in 15 different activities over a two-week period.[26] Total caloric expenditure and number of activities were the primary activity measures. Participants were followed for development of dementia an average of 5.4 years (range .03 – 8.4 years). The number of physical activities people reported during the two weeks was inversely associated with dementia risk, loss of independence in activities of daily living, and depression. Compared to caloric expenditure, the number of physical activities had a lower relative risk of Alzheimer's disease or vascular dementia.[26] This study is one of the first to assess variety of activity and compare it to caloric expenditure in older adults. Podewils's results support findings from a retrospective study that suggest diversity of physical activity in middle age is has a greater protective against subsequent development of Alzheimer's disease than intensity of activity.[121] Both studies suggest it may not be intensity of exercise, but variety of activities that provides the greatest protection against cognitive decline.

A confounding factor that is not reported in several of these longitudinal studies is level of participation in cognitive activities. This information is an important component for describing the relationship between activity and cognitive decline. It may be that older adults who engage in high levels of physical activity also participate in intellectually challenging activities, which provides this protective effect. Sturman followed 4,055 older men for six years and annually assessed cognitive performance on four cognitive measures, recorded the number of hours exercising per week, and rated frequency of participation in seven cognitively stimulating activities. The results indicated that the amount of exercise was associated with a slower rate of decline in cognitive performance, however, when the model was adjusted for participation in cognitive activities, physical activity was no longer significant.[27]

The studies discussed show conflicting associations between participation in social, cognitive, and physical activities and protection against aspects of cognitive decline. One reason for this conflict is a lack of a standardized reliable and valid measure to quantify physical, social, and cognitive activity in older adults. The tools that assess participation in social and cognitive activities measure different aspects of activity, and have no reported reliability or validity. The tools used to assess participation in physical activities and exercise rely on subject's ability to quantify distances, (i.e., the number of city blocks walked daily, or to judge intensity of effort, are two self reported measures that have questionable validity in older adults.[122, 123] In addition to these methodological limitations, several studies utilize the Mini-Mental Status Exam (MMSE) to quantify cognitive decline. The MMSE is a cognitive screen for moderate to severe dementia,[124, 125] and is not a sensitive measure of cognitive function or changes in cognition,[125, 126] suggesting that these studies may not be measuring important aspects of cognitive function.

The studies reviewed measured participation in specific types of activities – social, cognitive, and physical, which questions the confounding influence of participation in other activities on reported study outcomes. The next section will review available tools to assess participation rates in multiple activity domains (social, cognitive, leisure), and will provide a review of the physical activity questionnaire literature for older adults.

A.5 Do We Have Adequate Measurements For Activity?

Several self-report tools developed for social, cognitive, physical activity, and exercise research quantify participation rates in activities. The tools used in social and cognitive research have no published validity or reliability; however, they have been used in studies reporting significant associations between participation in activities and cognitive decline. The physical activity literature reports reliability and validity for several questionnaires; however methodological problems limit the application of these measures for older adults. A few researchers developed questionnaires which assess participation in both social and physical activities, but none attempt to include the scope of cognitive, social, physical and exercise activity. Some studies include physical activity and exercise into a single category of activity. Because the health benefits of regular exercise seem to be stronger than that of daily physical activity, measuring these activities separately within the same tool will provide a better understanding of how each type of activity affects function, falls, and quality of life.

Activity Measurements

Activity is typically measured by recording the frequency of participation during a week, month, or other specified time period. The next questionnaires reviewed record participation in a combination of social, cognitive, or leisure activities. Methodological concerns with these tools include applicability of items chosen, reliability, and validity.

Social activities are based on the definition of social engagement that includes maintenance of social connections and participation in social activities.[127] Indexes of social activity include common activities proposed by Hultsch and modified by Glass: number of social contacts with friends and family, attending the theater/concerts/restaurants, traveling, participating in organization meetings, and attending church.[127, 128] A recent survey assessing participation in activities by urban dwelling older adults confirmed high participation rates in these activities.[129] Neither Hultsch or Glass report reliability nor validity values for their indexes.

Cognitive activity indexes are based on a series of activities studied by Wilson who sampled 5000 community dwelling older adults in Chicago.[113] Subjects reported frequency of activity in seven areas of cognitive activities, and were followed for subsequent incidence of dementia for ten years. Activities were rated simple to complex by a panel of experts. The activities with greatest participation rates were watching television, reading the newspaper, reading a book, and the activity with the lowest rate was visiting a museum.[113] Though watching television was the most often sited activity, it was the only activity with no protective effect against dementia.[114, 130] Several other researchers used variations of Wilson's activities without comment on reliability or validity of this index.[29, 131]

Many studies assessing participation in cognitive activities also assess components of leisure activities. Verghese expanded his index to include leisure and cognitively demanding leisure activities (cognitive activities requiring interaction with other people).[29] To date, no studies have been published assessing the reliability of these measures or the validity of these tools as an accurate measure of frequency of participation in cognitive or social activities.

Lennartsson studied how group social activities versus solitary social activities related to morbidity in 465 Swedish adults.[132] He developed a 10 item questionnaire with 5 social items, 4 cognitive items and one physical item. A factor analysis determined these items constituted four factors.[132] One problem with this study was the items chosen were redundant, for example one item was visiting friends and another item was to be visited by friends.[132]

Newson created a "general activity" measure composed of household maintenance, domestic chores, social and service activities, and reported that overall activity levels were predictive of cognitive outcome measures. The questionnaire produced a score based on how often the subject participates in the activity in a 3-month period.[133] This scale was a reliable and valid measure for use with community dwelling older adults. The activities chosen did not include exercise activities, which may be an important component for adequate protection against decline. The activity score generated by the questionnaire was difficult to translate into a meaningful guideline of weekly activity to achieve this protective effect.

Hultsch studied 250 individuals for six years and reported on the relationships between participation in "active lifestyle," which was a composite of physical, social, and self maintenance activities, information processing activities (e.g., learning a new language, playing bridge), and performance on several cognitive measures. He reported that level of participation in information processing activities was highly correlated with cognitive performance, and a change in participation in these activities was associated with a change in performance. The six year stability of these items was quite high (r = .60), however activity participation was recorded as daily to yearly, making it difficult to translate results into a meaningful amount of activity.[112]

Aartsen studied 2,000 older adults for 6 years and reported on the relationship between participation in three types of “everyday” activities on cognitive function. The original 23 activities on the questionnaire were chosen by a group of experts, and activities with low participation rates were excluded in the final analysis. There were no reliability or validity measures reported for the questionnaire. Everyday activities were categorized into social, developmental (cognitively demanding), and experiential (relaxing/satisfying). The time frame for participation ranged from daily to weekly for some items, and number of times in the last six months for other items. Aartsen did not include physical activities in her questionnaire. Based on the results, she reported a significant relationship between participation in the developmental activities and information processing speed, but not between participation levels and cognitive function.[111]

In the activity literature, few researchers report on the development, reliability, or validity of their questionnaires, making it difficult to compare studies and interpret results. The physical activity literature does include psychometric information, however methodological issues still exist in regards to measuring physical activity in older adults.

Physical Activity Questionnaires

Measuring physical activity in older adults is a unique challenge. Older adults may have diminished recall and they may have physical and cognitive limitations affecting abilities to complete an extensive questionnaire. Several tools have adequate reliability and validity; however, they have methodological problems that challenge universal utility. One problem is the units used to quantify physical activity. Some questionnaires use metabolic equivalents (METS) to determine total daily and weekly caloric expenditure.[134, 135] METS are the approximate energy cost for different physical activities, based on a young to middle aged population.[136] These MET values for physical activities may not accurately reflect energy expenditure for older adults. Multiple co-morbidities could result in a higher MET value for an activity, or the opposite could occur when individuals move slower and have a lower MET for an activity.[134] Other instruments, such as the Physical Activity Scale for the Elderly (PASE) and the Modified Baecke, quantify physical activity in units specific to the questionnaire, which raises the question of how the units actually translate into total energy expenditure.[137, 138]

In addition to the limitations in quantifying physical activity, the lack of validity for older populations (over 75 years) is also a concern. Many of these tools were originally designed for assessing physical activity in the 55 plus age group, and have decreased validity for use in individuals over the age of 75.[134, 135] In a comparison of three self-report questionnaires, Harada found lower correlations between activity questionnaire results and activity measured by accelerometer in adults 75 years old compared to adults 65 years old for the Community Healthy Activities Model Program for Seniors (CHAMPS), and the Yale Physical Activity Survey (YPAS). The PASE maintained strong correlations values for all age groups, but validity was significantly lower for women than men.[139] The PASE is a reliable questionnaire, developed and validated for use with older adults.[140] However, the PASE is biased towards higher functioning people. Activities of more sedentary, low functioning individuals are not adequately assessed, and these individuals often score a 0 on this questionnaire.[141] The PASE was developed and tested in Amherst, Massachusetts, and several of the items on the questionnaire are biased to that region of the country (e.g. shoveling snow, ice skating).[137, 140]

Questionnaire length may create additional problems for older adults. Fatigue and loss of interest are common complaints when an individual completes a 60 to 70 item questionnaire, especially when activities are not applicable, such as rollerblading or recreational sports.[134] Surveys of older adults in urban and suburban areas have identified activities with high participation rates by older adults.[129, 142] These studies report a relatively brief list of activities that includes items such as walking, housework, cooking, and participation in exercise classes, suggesting that activity surveys need not be extensive or burdensome to capture a valid activity profile

Recall becomes a problem if a questionnaire requires self assessment of city blocks or miles walked per day, intensity of activity, or estimation of hours per day or week a person did the activity. For older age groups, the length of the recall period can significantly bias the estimation of activity levels in older adults.[122, 123, 143]

A simple, efficient tool to assess physical activity in older adults has not been developed. Although many good measures quantify intensity and amount of physical activity, it may be that frequency of participation in activity is also an important variable. In a study using the CHAMPS to quantify behavioral change after a physical activity intervention, frequency of activity was a more sensitive measure of change in activity behavior than intensity of activity. (M Morey, personal communication, April 2005) Pilot work in a group of community dwelling older adults (n = 71, mean age 83) found frequency of activity had stronger and significant correlations with chair rise performance and gait speed than intensity of activity.[144]

Studies assessing relationships between participation in physical activities and cognitive decline report that physical activity is associated with decreased risk of dementia, similar to results of studies from the social and cognitive literature.[24, 26, 145] Frequency of activity and variety of activity in multiple domains could be important activity variables for understanding the effects of programs that decrease falls risk and disability. Developing, testing and validating a tool that is simple to administer, brief, and assesses frequency and variety in social, cognitive, physical activity and exercise domains, would be a valuable contribution to this area of research.

A.6 How Might Variety of Activity Influence Function, Balance, and Falls Risk?

Variety of activity is a relatively new concept in the geriatric literature. Although several researchers identified associations between activity variety and protection against cognitive decline,[26, 29, 146, 147] no one has examined the relationship of variety of activity to function and falls risk factors. De Vreede compared the ability to perform daily tasks between individuals in a traditional strength training program to those in a functional exercise program that varied aspects of the exercises daily, and found those in the varying exercise program performed significantly better on the daily tasks.[148] Results from this study and others assessing effects of frequency and variety of activities on function provide the initial stages for understanding the relationship between activity levels and physical performance.

From the dementia literature, it appears that activity variety may be an important construct in successful aging. From the balance literature, daily participation in exercise and walking program is an important component of a falls reduction program. However, the results of studies using structured exercise for improving physical function, balance, and reducing falls have been mixed. These interventions may improve muscle strength, endurance, and balance but do not necessarily reduce falls. The relationship between exercise and falls reduction is not as clear as the effect of exercise on the individual fall risk factors. These somewhat discrepant findings may be related to complexity of balance control and falls.

Maintaining one's balance requires attention to the environment, integration of sensory input from the visual, proprioceptive, and vestibular systems, choosing the appropriate muscular action, and effectively executing that action. An intervention focusing on strength or endurance alone may not incorporate enough input from other senses to significantly improve balance responses. Likewise, an intervention that occurs two to three times a week may not have an adequate frequency to affect balance abilities. Studies that incorporate different daily activities such as walking or task training routines, have reported significant decreases in self report of falls, suggesting that daily activity may play an important role in improving balance ability and decreasing falls risk. Although several studies show a positive relationship between daily activity and decreased falls, the underlying mechanisms of this relationship have not been explored. Could participation in daily exercise that alternates between walking and exercises be an important source of variety of activity? Could this variety be protective against loss of balance skills and increased falls?

This proposed project will study the effect of real life practice of a variety of daily activities that occurs in different environments and its relationship to physical function, balance, and cognition. The activities older adults do such as walking while talking to friends, carrying groceries up and down stairs, and trying to remember shopping items involve aspects of cognition, socialization, and physical activities. I hypothesize that daily physical activity and participation in wide variety of activities contributes to maintaining or improving falls risk factors and attentional abilities required for balance in older adults. This effect on attentional systems may be an important link for understanding the effects of successful fall reduction programs.

Developing, testing, and validating a tool to measure variety of activity in multiple domains, and determining the relationship between variety of activity and physical function, balance, and cognition will provide an important contribution to our understanding of factors that contribute to falls risk, and may provide insight into development of appropriate interventions for successful aging.

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APPENDIX B1

Additional Results Paper 1

Table B1.1. Total variance explained by exploratory factor analysis

Total Variance Explained

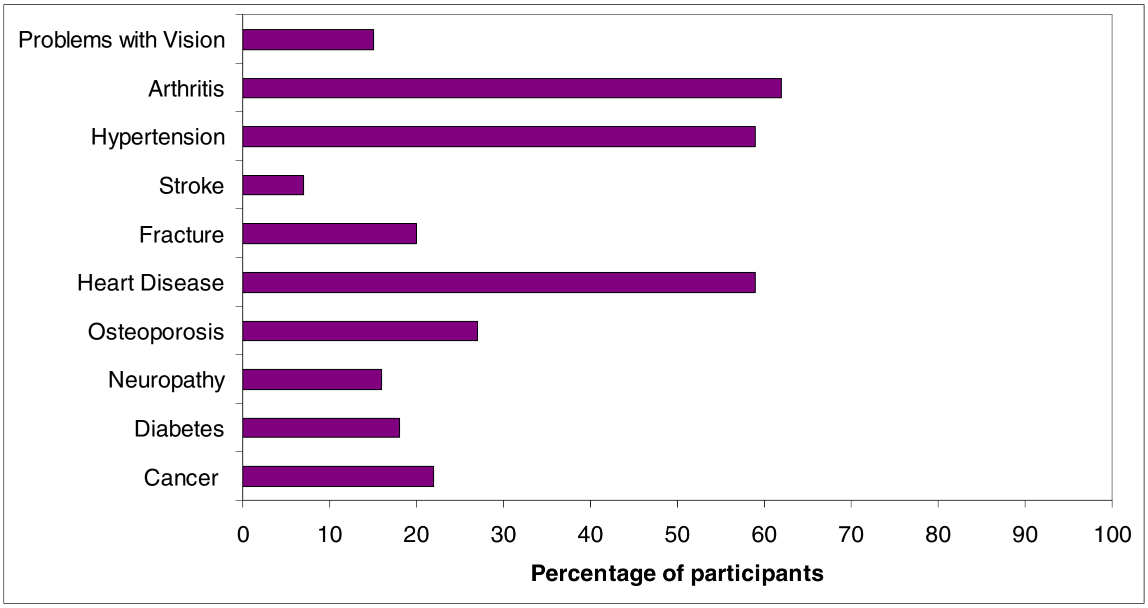
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.584	9.686	9.686	3.584	9.686	9.686	2.122	5.736	5.736
2	2.281	6.165	15.852	2.281	6.165	15.852	1.960	5.296	11.032
3	2.137	5.774	21.626	2.137	5.774	21.626	1.874	5.064	16.096
4	1.813	4.900	26.526	1.813	4.900	26.526	1.728	4.671	20.767
5	1.755	4.744	31.270	1.755	4.744	31.270	1.626	4.396	25.163
6	1.661	4.489	35.760	1.661	4.489	35.760	1.605	4.338	29.501
7	1.527	4.126	39.886	1.527	4.126	39.886	1.596	4.315	33.815
8	1.365	3.689	43.575	1.365	3.689	43.575	1.596	4.314	38.129
9	1.298	3.509	47.084	1.298	3.509	47.084	1.592	4.302	42.431
10	1.246	3.368	50.452	1.246	3.368	50.452	1.548	4.184	46.615
11	1.161	3.139	53.591	1.161	3.139	53.591	1.542	4.166	50.781
12	1.146	3.098	56.689	1.146	3.098	56.689	1.471	3.977	54.758
13	1.108	2.995	59.685	1.108	2.995	59.685	1.444	3.903	58.661
14	1.033	2.792	62.477	1.033	2.792	62.477	1.412	3.816	62.477

Table B1.2. Principal component analysis with varimax rotation

	Component													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Meeting or organizations	.81													
Club,organization, activities	.77													
Light Housework	α=.67	.87												
Prepare Meals		.76												
Climb flight of stairs		α= .69	.73											
Shopping/errands			.56											
Swim/Water Aerobics			.49											
Walk for errands			.41											
Attendreligious services			α=.45	.69										
Visit/visitedby friends				.63										
Provide childcare/caregiving				α=.33										
Talk on the phone														
Paid/volunteer (sitting)					.76									
Paid/volunteer (standing)					.78									
Walk for Exercise					α= .53	.73								
Hike						.68								
Movies, watch videos						α= .35	.77							
Attend lecture, play, concert														
ConditioningGroup Exercise								.66						
GentleGroup Exercise								.62						
Day or overnight trips								α= .35						
Playboard,card, games									.73					
Crossword									.63					
Bicycle/Stationary Bike									α= .35	.82				
Lift Weights										.53				
Read newspapers/books										α= .52				
Arts andcrafts projects											.73			
Gardening/yard work											.69			
Team Gamess											α=.42			
Dancing												.76		
Group discussions														
Golf													.64	
Play/listen to music, sing													-.59	
Gather with people														
Home Exercise														.70
Write stories, cards, letters														
Heavy Housework									-					

Factor loadings less than .3 are suppressed

Table B1.3 Health conditions for sample



APPENDIX B2

How many times during a usual week do you do the following?	**Daily (6-7 times /week)**	**Often (2-5 times /week)**	**Once a week**	**1-2 times/ month**	**Never**
Play board, card or computer games, dominoes or other similar games					
Read newspapers/magazines/books (Does not include reading the mail)					
Attend club, organization, or social meetings					
Light Housework (e.g. dishes, laundry, dusting)					
Walk for exercise					

Figure B2.1 Example of Variety of Activity Questionnaire

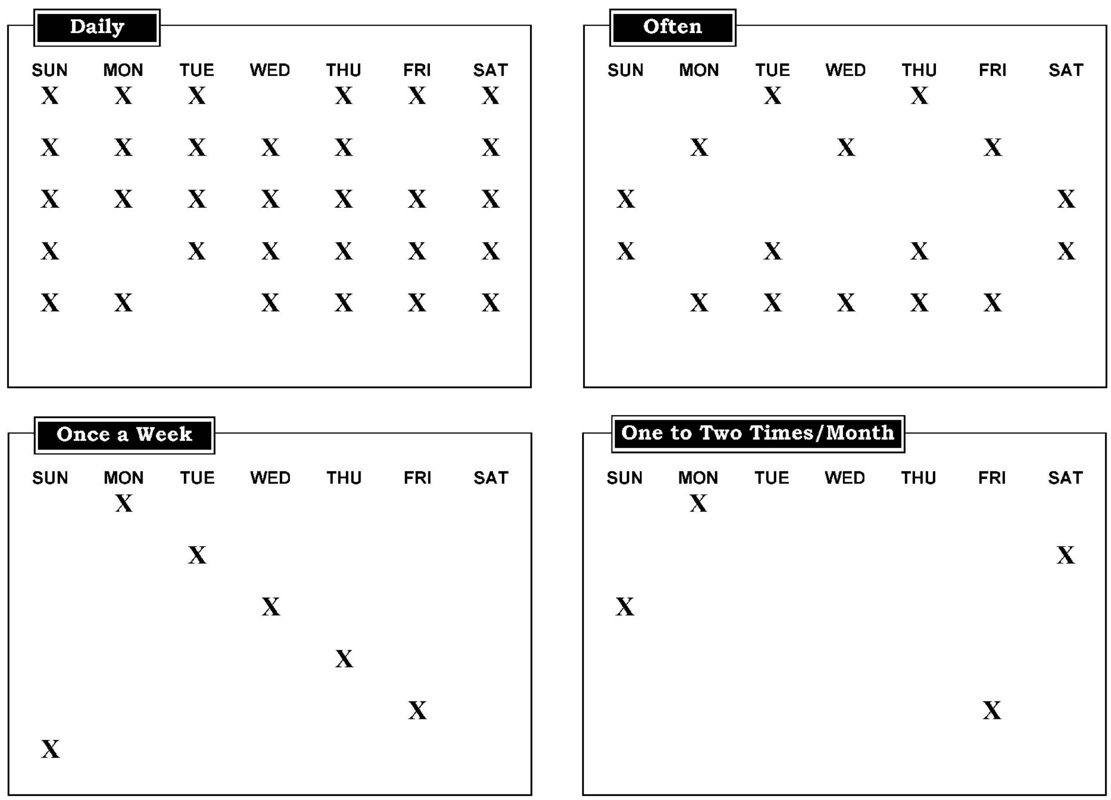


Figure B2.2 Example of activity frequency calendar