Testing a Model of Knowledge and Lifestyle Variables
Associated with Cognitive Health among Older Adults

BY

CATHERINE J. O’BRIEN
BEd, University of Wisconsin, Madison, 1993
MA, University of California, San Diego, 2000
MPH, San Diego State University, 2005

THESIS
Submitted as partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Public Health Sciences
in the Graduate College of the
University of Illinois at Chicago, 2014

Chicago, Illinois

Defense Committee:
Susan Hughes, Chair and Advisor
Sally Freels, Biostatistics
Thomas Prohaska, George Mason University
Amy Eisenstein, Northwestern University
David Lindeman, Center for Technology and Aging
This thesis is dedicated to my parents, George and Carol Knorr, without whom it would have never been possible.
ACKNOWLEDGEMENTS

I would like to thank my thesis committee, Drs. Susan Hughes, Thomas Prohaska, Amy Eisenstein, Sally Freels, and David Lindeman, each of whom supported me in so many ways, sharing their time, expertise, and kind advice throughout my program. I am especially thankful to Dr. Susan Hughes who helped me to move forward with my thesis topic and guide me through the many steps it took to bring my dissertation to fruition. I would also like to thank Dr. Prohaska for his encouragement and mentorship during the early years of my graduate program.

My colleagues at Mather LifeWays deserve special thanks for providing ideas and suggestions on the various challenges I encountered as well as offering a kind ear in discussing the ups and downs of the dissertation process. Finally, I would like to thank my family, especially my daughter Keely, for providing the additional inspiration to make it happen.

CJO
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. INTRODUCTION</td>
<td></td>
</tr>
<tr>
<td>A. Background and Significance</td>
<td>1</td>
</tr>
<tr>
<td>B. Study Purpose</td>
<td>8</td>
</tr>
<tr>
<td>C. Specific Aims</td>
<td>9</td>
</tr>
<tr>
<td>D. Hypotheses</td>
<td>9</td>
</tr>
<tr>
<td>E. Institutional Review Board</td>
<td>10</td>
</tr>
<tr>
<td>II. LITERATURE REVIEW</td>
<td></td>
</tr>
<tr>
<td>A. Literature Search Procedure</td>
<td>11</td>
</tr>
<tr>
<td>B. National Institutes of Health Report</td>
<td>12</td>
</tr>
<tr>
<td>C. Physical Activity</td>
<td>13</td>
</tr>
<tr>
<td>D. Cognitive Engagement</td>
<td>18</td>
</tr>
<tr>
<td>F. Nutrition</td>
<td>24</td>
</tr>
<tr>
<td>1. Omega-3 fatty acids</td>
<td>27</td>
</tr>
<tr>
<td>2. Fruit and vegetable consumption</td>
<td>27</td>
</tr>
<tr>
<td>3. Mediterranean diet</td>
<td>29</td>
</tr>
<tr>
<td>G. Social Engagement</td>
<td>30</td>
</tr>
<tr>
<td>H. Mental Health</td>
<td>35</td>
</tr>
<tr>
<td>1. Depression</td>
<td>37</td>
</tr>
<tr>
<td>2. Stress</td>
<td>38</td>
</tr>
<tr>
<td>I. Summary and Limitations of the Literature</td>
<td>38</td>
</tr>
<tr>
<td>J. Theoretical Foundation</td>
<td>39</td>
</tr>
<tr>
<td>K. Conceptual Models</td>
<td>40</td>
</tr>
<tr>
<td>III. METHODS</td>
<td></td>
</tr>
<tr>
<td>A. Study Design</td>
<td>44</td>
</tr>
<tr>
<td>B. Study Population</td>
<td>44</td>
</tr>
<tr>
<td>C. Setting</td>
<td>45</td>
</tr>
<tr>
<td>D. Procedures</td>
<td>46</td>
</tr>
<tr>
<td>E. Control Condition</td>
<td>47</td>
</tr>
<tr>
<td>F. Intervention Condition</td>
<td>48</td>
</tr>
<tr>
<td>1. Education on lifestyle behaviors related to cognitive health</td>
<td>49</td>
</tr>
<tr>
<td>2. Memory training</td>
<td>50</td>
</tr>
<tr>
<td>3. Cognitive training (Dakim Brain Fitness System)</td>
<td>50</td>
</tr>
<tr>
<td>G. Measures</td>
<td>51</td>
</tr>
<tr>
<td>1. Eligibility screener</td>
<td>51</td>
</tr>
<tr>
<td>2. Outcome measures</td>
<td>52</td>
</tr>
<tr>
<td>a. Physical, social, and intellectual activity participation</td>
<td>52</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS (continued)

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Nutrition</td>
<td>52</td>
</tr>
<tr>
<td>c. Mindfulness</td>
<td>53</td>
</tr>
<tr>
<td>d. Delayed memory</td>
<td>53</td>
</tr>
<tr>
<td>e. Verbal fluency</td>
<td>54</td>
</tr>
<tr>
<td>f. Category fluency</td>
<td>54</td>
</tr>
<tr>
<td>g. Applied cognition (subjective memory)</td>
<td>55</td>
</tr>
<tr>
<td>h. Processing speed and executive function</td>
<td>55</td>
</tr>
<tr>
<td>i. Course satisfaction and quality</td>
<td>55</td>
</tr>
<tr>
<td>3. Covariates</td>
<td>56</td>
</tr>
<tr>
<td>H. Sample Size and Power</td>
<td>56</td>
</tr>
<tr>
<td>I. Analytic Plan</td>
<td>57</td>
</tr>
<tr>
<td>IV. RESULTS</td>
<td>59</td>
</tr>
<tr>
<td>A. Sample Description</td>
<td>59</td>
</tr>
<tr>
<td>B. Enrollment and Attrition</td>
<td>61</td>
</tr>
<tr>
<td>C. Change in Frequency of Lifestyle Behaviors</td>
<td>66</td>
</tr>
<tr>
<td>D. Course Evaluation</td>
<td>69</td>
</tr>
<tr>
<td>V. CONCLUSIONS</td>
<td>73</td>
</tr>
<tr>
<td>A. Discussion</td>
<td>73</td>
</tr>
<tr>
<td>1. Behavior change outcomes</td>
<td>73</td>
</tr>
<tr>
<td>2. Cognitive change outcomes</td>
<td>76</td>
</tr>
<tr>
<td>3. Program feasibility</td>
<td>77</td>
</tr>
<tr>
<td>B. Additional Study Limitations</td>
<td>79</td>
</tr>
<tr>
<td>C. Summary</td>
<td>80</td>
</tr>
<tr>
<td>D. Follow-up Studies</td>
<td>80</td>
</tr>
<tr>
<td>E. Lessons for the Field</td>
<td>81</td>
</tr>
<tr>
<td>APPENDIX</td>
<td>83</td>
</tr>
<tr>
<td>CITED LITERATURE</td>
<td>85</td>
</tr>
<tr>
<td>VITA</td>
<td>95</td>
</tr>
</tbody>
</table>
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. REVIEW OF PHYSICAL ACTIVITY</td>
<td>15</td>
</tr>
<tr>
<td>II. REVIEW OF COGNITIVE ENGAGEMENT</td>
<td>20</td>
</tr>
<tr>
<td>III. REVIEW OF NUTRITION</td>
<td>25</td>
</tr>
<tr>
<td>IV. REVIEW OF SOCIAL ENGAGEMENT</td>
<td>32</td>
</tr>
<tr>
<td>V. REVIEW OF MENTAL HEALTH</td>
<td>36</td>
</tr>
<tr>
<td>VI. PARTICIPANT CHARACTERISTICS AT BASELINE</td>
<td>59</td>
</tr>
<tr>
<td>VII. ENROLLMENT AND ATTRITION BY SITE</td>
<td>63</td>
</tr>
<tr>
<td>VIII. STUDY COMPLETERS VS. NONCOMPLETERS</td>
<td>64</td>
</tr>
<tr>
<td>IX. ASSOCIATION BETWEEN ATTRITION AND BASELINE VALUE OF COGNITIVE MEASURES</td>
<td>65</td>
</tr>
<tr>
<td>X. ASSOCIATION BETWEEN ATTRITION AND BASELINE VALUE OF BEHAVIORAL MEASURES AND AGE</td>
<td>66</td>
</tr>
<tr>
<td>XI. ASSOCIATION BETWEEN BEHAVIORAL OUTCOMES AND TREATMENT ARM</td>
<td>67</td>
</tr>
<tr>
<td>XII. ASSOCIATION BETWEEN COGNITIVE OUTCOMES AND TREATMENT ARM</td>
<td>68</td>
</tr>
<tr>
<td>XIII. COURSE QUALITY</td>
<td>70</td>
</tr>
<tr>
<td>XIV. EXTENT TO WHICH COURSE OBJECTIVES WERE MET</td>
<td>70</td>
</tr>
<tr>
<td>XV. SATISFACTION WITH DAKIM BRAINFITNESS SOFTWARE</td>
<td>71</td>
</tr>
<tr>
<td>XVI. SATISFACTION WITH INDIVIDUAL PROGRAM MODULES</td>
<td>72</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Effect of lifestyle behaviors on cognition</td>
<td>41</td>
</tr>
<tr>
<td>2. Effect of intervention on targeted outcomes</td>
<td>43</td>
</tr>
<tr>
<td>3. Selecting the sample</td>
<td>61</td>
</tr>
</tbody>
</table>
### LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>Alzheimer’s Disease</td>
</tr>
<tr>
<td>AHRQ</td>
<td>Agency for Healthcare and Research and Quality</td>
</tr>
<tr>
<td>APOE</td>
<td>Apolipoprotein</td>
</tr>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>COWAT</td>
<td>Controlled Oral Word Association Test</td>
</tr>
<tr>
<td>[(^{11})C PiB</td>
<td>Carbon 11–labeled Pittsburgh Compound B</td>
</tr>
<tr>
<td>CR</td>
<td>Cognitive Reserve</td>
</tr>
<tr>
<td>CVD</td>
<td>Cardiovascular Disease</td>
</tr>
<tr>
<td>MCI</td>
<td>Mild Cognitive Impairment</td>
</tr>
<tr>
<td>MeDi</td>
<td>Mediterranean Diet</td>
</tr>
<tr>
<td>MMSE</td>
<td>Mini-Mental Status Exam</td>
</tr>
<tr>
<td>NIH</td>
<td>National Institute of Health</td>
</tr>
<tr>
<td>PROMIS</td>
<td>Patient-Reported Outcomes Measurement Information System</td>
</tr>
<tr>
<td>RBANS</td>
<td>Repeatable Battery for the Assessment of Neuropsychological Status</td>
</tr>
<tr>
<td>SCT</td>
<td>Social Cognitive Theory</td>
</tr>
<tr>
<td>WACS</td>
<td>Women’s Antioxidant Cardiovascular Study</td>
</tr>
</tbody>
</table>
SUMMARY

This study uses an existing dataset to examine data for potential associations between program participation and increases in “brain-healthy” behaviors and improvements in cognitive outcomes among older adults. Program participation entailed eight one-hour educational sessions and use of the Dakim BrainFitness System for online cognitive training. The education component provided information on the relationship between the following lifestyle behaviors and cognitive health: physical activity, healthy eating, social engagement, cognitive engagement, and maintenance of mental health through stress reduction. It also included instruction on memory strategies.

The study sample consisted of 118 adults, age 55 and older, from the Chicagoland area. Levels of baseline knowledge and behaviors related to cognitive health were compared to knowledge and behaviors immediately following program participation. After controlling for baseline level of each dependent variable assessed, analyses showed that program participation was associated with increases in four of the five lifestyle behaviors examined, the exception being stress reduction. In addition, program participation was associated with increases in category fluency and letter fluency; however, none of these associations were statistically significant.
I. INTRODUCTION

A. Background and Significance

Although estimates vary depending on how the condition is defined (Hebert et al., 2003), the Alzheimer’s Association (2012) currently states that approximately 5.4 million Americans, or one in eight individuals over age 65, have Alzheimer’s disease (AD) or other dementias. Alzheimer’s Disease is the sixth-leading cause of death in the United States and the fifth-leading cause of death in Americans age 65 years and older. It should not be confused as synonymous with the term “dementia,” for it is one of several types. As the baby boom generation ages, the number of older adults with AD and other dementias is expected to increase substantially. This increase in persons with AD is further exacerbated by simultaneous increases in life expectancy in the United States. Medical advances and improved social and environmental conditions have resulted in an increasing number of Americans living into their 80s and 90s (US Census Bureau, 2005). With the number of people with Alzheimer’s doubling for every five-year interval after age 65, greater longevity is likely to result in significant increases in the number of individuals with AD (Corrada, Brookmeyer, Paganini-Hill, Berlau, & Kawas, 2010; NIA, 2012).

Dementias, including AD, have numerous adverse consequences for individuals suffering from the disease and for their caregivers. Sousa and colleagues (2009) found that for older adults in several different countries, dementia contributed to disability even more than blindness. Moreover, dementia added 10.2% of years of disability in individuals 65 years or older. This was more than musculoskeletal disease, stroke, and cancer each contributed to disability. Alzheimer’s Disease and other dementias also increase the likelihood of nursing home placement. (Yaffe et al., 2002). Up to nine out of ten individuals with dementia are admitted
to a nursing home at some point in their lives. At even greater risk are the estimated 800,000 individuals with AD who live alone, many without any caregiver to help them. These individuals are more likely than those who live with others to experience many of the adverse effects associated with dementia, such as inadequate self-care, increased falls, insufficient medical attention, wandering, and accidental deaths (Alzheimer’s Association, 2012).

Extensive literature indicates that caring for a person with AD or other dementias is also associated with poor health outcomes for the caregiver. These adverse outcomes include emotional stress and depression (Schulz & Beach, 1999; Williamson & Schulz, 1993). Caregivers also have increased utilization of health services (Kiecolt-Glaser, Dura, Speicher, Trask, & Glaser, 1991) and more frequent use of psychotropic medications (Baumgarten et al., 1992; Grafstrom, Fratiglioni, Sandman, & Winblad, 1992).

The financial burden of AD, now estimated at $200 billion per year, is expected to grow with increased prevalence of the disease (Alzheimer’s Association, 2012). Medicare and Medicaid payments for services used by older adults with AD are disproportionately higher than for older adults without AD and other dementias. Specifically, Medicare costs are three times higher and Medicaid costs 19 times higher for older adults with AD than for those without. Added to these costs is the contribution of unpaid caregivers of persons with dementia. The Alzheimer’s Association (2012) estimates that more than 15 million unpaid individuals, often family members, provide care for a person with AD or other dementias. Although initially unpaid, informal caregiving is thought to result in greater costs to the healthcare system in the long run due to increased healthcare utilization by the caregivers. Part of the cost is also born by
the workplace, where caregivers of individuals with AD experience reduced productivity and increased absenteeism (Koppel, 2002).

The magnitude and increased recognition of AD as a major public health problem has spurred a wealth of clinical research aimed at developing effective treatments. Pharmacological trials have resulted in FDA approval of five medications designed to treat the symptoms of AD. Three of these are approved only for early-to-moderate stages of the disease, one for moderate-to-severe dementia, and one for all stages. However, these drugs treat only the symptoms of AD and cannot halt or reverse its progression (Alzheimer’s Association, 2012; Herrmann, Chau, Kircanski, & Lanctôt, 2011). Their effect is modest, achieving a delay in the worsening of symptoms for an average of six to 12 months in approximately half of individuals using them (Farlow & Cummings, 2007). In addition, effectiveness of these medications varies across individuals, and benefits may not be substantial enough to be noticed by the individual with AD or the caregiver (Alzheimer’s Association, 2012). Non-pharmacological care includes counseling, compensatory strategies such as memory aids, behavioral strategies, education for patients and caregivers, and additional support and resources meant to reduce the impact on caregivers. While such strategies can be valuable in managing AD symptoms or caring for someone with AD, they similarly do nothing to alter disease progression.

The looming consequences for the public health system and lack of effective treatments to prevent the onset of AD have prompted greater attention to prevention and delayed onset of disease as a strategy to address the crisis. In 2007, the Centers for Disease Control and Prevention embarked on a new initiative: The Road Map (2007), guided by a steering committee of representatives from federal agencies, universities, nonprofit organizations, and state health
departments. The overarching goal of the CDC Road Map was to set forth a vision for maintaining or improving the cognitive performance of all adults. As part of the CDC initiative, the committee developed ten priority actions for improving cognitive health. Two of the priority areas reflected increasing attention to lifestyle changes to reduce the risk of cognitive decline. Specifically, the priority items included “help[ing] people understand the connection between risk and protective factors and cognitive health,” and “conduct[ing] controlled clinical trials to determine the effect of reducing risk factors or lowering the risk of cognitive decline and improving cognitive factors” (CDC, 2007, p. 7).

The CDC priorities reflect a growing literature focused on modifiable lifestyle and behavioral factors potentially associated with cognitive decline. A key concept underlying these efforts is the idea of neuroplasticity. Neuroplasticity refers to the capacity of the brain to reorganize, change its neural structure, and form new neural connections throughout life (Roberston & Murre, 1999). The concept of neuroplasticity represents a departure from previous understanding of the brain as fully formed early in life. Researchers now believe that the brain changes throughout life, growing new brain cells and altering neural structures in response to certain environmental input. Brain injury is one such catalyst for new cell growth and restructuring. Several studies have explicated the brain’s ability to change to compensate for injury (Albensi & Janigro, 2003; Bach-y-Rita, 2003).

Other environmental factors such as exercise can also stimulate changes in the brain. For example, studies have demonstrated that exercise can increase the level of Brain-derived neurotrophic factor (BDNF), a hormone that promotes growth of new brain cells. The levels of this hormone have also been associated with larger volumes in the hippocampus, an area of the
this hormone have also been associated with larger volumes in the hippocampus, an area of the
brain associated with memory, and better cognitive function in older age (Middleton, Barnes,
Lui, & Yaffe, 2010).

The concept of cognitive reserve (CR) is also useful in understanding potential
relationships between lifestyle factors and onset of AD symptomology. The theory of cognitive
reserve seeks to explain differences in individuals’ abilities to cope with AD pathology (Stern,
2002). In an oft-cited study, Katzman et al. (1989) found that among patients whose brains
showed advanced AD pathology when autopsied, a subset had not demonstrated any symptoms
of AD while alive. In contrast, other patients in this group who had similar AD pathology in their
brains demonstrated symptoms of the disease before death, as would be expected. In other
words, two groups of individuals with similar levels of AD pathology had very different
cognitive abilities during their lives. Researchers speculated that innate intelligence or lifestyle
factors such as a high level of education may provide skills that enable some individuals to
compensate for AD pathology and delay the experience of AD symptoms.

The theory of CR may also help to explain why engagement in social and intellectual
activities during leisure time is associated with reduced rate of cognitive decline in cognitively
normal older adults and possibly with reduced risk of incident dementia. Functional imaging
studies suggest that individuals participating in more leisure activities are not as susceptible to
the onset of symptoms that typically occur along with AD pathology (Scarmeas & Stern, 2003).
Researchers have speculated that engagement in leisure activities may result in cognitive
networks that are more highly functioning, providing a CR that translates into a delay in the
appearance of symptoms.
To better understand the potential impact of modifiable behaviors on cognitive decline and AD, the National Institutes of Health (NIH) brought together a 15-member panel of experts representing medicine, public health, neurology, health services research, and related fields (Daviglus et al., 2010). The committee relied in part on a systematic review of potential risk factors for cognitive decline and AD prepared by the Duke University Evidence-based Practice Center for the Agency for Healthcare Research and Quality (AHRQ) (Williams, Plassman, Burke, Holsinger, & Benjamin, 2010). The review examined evidence for associations between cognitive outcomes and a wide range of modifiable behaviors including exercise, cognitive engagement, nutritional/dietary intake, social engagement, and others. They concluded that current evidence was insufficient to support associations between any modifiable lifestyle factor and AD or cognitive decline. While some of the studies reviewed supported associations between lifestyle factors and AD or cognitive decline, others found no relationship. However, the committee encouraged additional higher quality research to examine potential risk and protective factors for cognitive effects.

The aforementioned review also pointed toward the kind of studies needed to advance our understanding of risk and protective factors. It, and other reviews, demonstrated that much of the evidence supporting a relationship between modifiable behavior and cognitive outcomes is observational. For example, there is substantial observational evidence supporting a positive relationship between physical activity and cognitive outcomes (Hamer & Chida, 2009; Weuve et al., 2004). However, in a recent review of physical activity interventions, Snowden et al. (2011) found insufficient evidence to demonstrate a cognitive benefit from physical activity. The authors concluded that larger and longer clinical trials using appropriate measures are needed in
authors concluded that larger and longer clinical trials using appropriate measures are needed in order to draw conclusions regarding the impact of exercise on cognitive outcomes. They also drew attention to the need for interventions that incorporate elements needed to sustain long-term behavior change.

To date, behavioral interventions have tended to focus on a single factor, such as exercise or cognitive engagement (e.g., Cassilhas et al., 2007; Hassmen, Ceci, & Backman, 1992; Rikli & Edwards, 1991, and many others). Few target multiple lifestyle factors with the potential to influence cognitive health. One notable exception is a study conducted by Miller et al. (2011) which found that a six-week program including memory training and promotion of lifestyle factors improved encoding and recalling of new verbal information and self-perception of memory ability in older adults. Should suspected associations between targeted behaviors and cognitive health be confirmed, interventions promoting multiple healthy behaviors may be more likely to demonstrate an effect than those which focus on a single factor.

Although better medications may be on the horizon, the magnitude of the problem and absence of effective treatment options suggests use of a multipronged approach including both pharmacological research and behavioral strategies that can promote cognitive reserve and delay onset of AD symptomology. At the 2012 Alzheimer’s Disease Summit, one of the key recommendations called for the combining of behavioral, lifestyle, and environmental interventions with pharmacological treatments to maximize the potential for benefit (NIA, 2012). Even a modest reduction in disease progression would have a significant societal impact. Helping older adults to maintain cognitive health could reduce the rate of nursing home admission as well as the physical and emotional burden felt by those caring for someone with
AD. Each of these outcomes would contribute to mitigating the financial impact of the disease on the healthcare system and the workplace. Although evidence supporting behavioral interventions is preliminary, the behaviors promoted—increasing physical activity, eating healthy foods, maintaining a high level of social and cognitive engagement, and stress reduction—are recommended health behaviors with numerous benefits far exceeding the risk of participation. Identifying behavioral interventions that delay the onset of AD symptoms would make a significant contribution toward addressing the problem.

B. **Study Purpose**

The purpose of this study is to evaluate additional variables from a multimodal intervention designed to promote activities thought to be associated with cognitive health. The intervention was developed by Mather LifeWays Institute on Aging in spring, 2012 and approved by the Mather LifeWays Institute on Aging Institutional Review Board. It consists of an eight-week course designed to promote “brain healthy” behaviors, teach memory strategies, and provide for individual use of the Dakim BrainFitness System. The program was piloted among older adults at six Mather LifeWays facilities and centers.

The pilot program was intended to provide data and feedback that can inform a larger future study. Pre- and post-surveys were used to collect information regarding activity participation, self-reported cognitive and emotional variables, and demographics. Subjects also completed objective cognitive assessments pre- and post-intervention. A wait-listed control group completed the survey and assessment at the same time points as the intervention group. In addition to examining the data for improvement in activity participation and cognitive outcomes, course evaluations will be used to identify needed program modifications relating to
appropriateness of content level, teaching methods, train-the-trainer procedures, integration of the Dakim BrainFitness System, and other program elements.

C. **Specific Aims**

The aim of this study is to examine data from a small, randomized trial of an eight-week educational initiative to promote cognitive health through multiple behavior changes; including physical activity, healthy eating, social engagement, cognitive engagement, and stress reduction, Specifically this study will:

1. Examine data for potential associations between knowledge gained through program participation and an increase in “brain-healthy” behaviors,
2. Examine data for potential associations between increases in behavioral factors and improved cognitive outcomes among older adults,
3. Assess the feasibility of implementing a new brain fitness program with older adults of differing socioeconomic backgrounds and living environments.

D. **Hypotheses**

The following questions were considered:

1. Does program participation result in greater adoption of behaviors related to cognitive health?
   - H1: Subjects in the intervention group will increase the frequency of healthy eating behaviors more than subjects in the control group.
   - H2: Subjects in the intervention group will increase time engaging in physical, social, and intellectual activities more than subjects in the control group.
2. Does program participation result in significant cognitive benefits?
- H3: Subjects in the intervention group will experience improvements in delayed memory more than subjects in the control group.

- H4: Subjects in the intervention group will experience increased verbal fluency more than subjects in the control group.

- H5: Subjects in the intervention group will increase in mindfulness more than subjects in the control group.

- H6: Subjects in the intervention group will improve in applied cognition more than subjects in the control group.

E. **Institutional Review Board**

The proposal for this study was submitted to the Institutional Review Board (IRB) of the University of Illinois at Chicago (protocol number # 2013-0218). The IRB determined that the study does not meet the definition of human subjects research because the information being used was obtained from an earlier study and had been de-identified.
II. LITERATURE REVIEW

A. Literature Search Procedure

A systematic literature search was conducted to identify studies examining potential associations between health behaviors and risk for cognitive decline or dementia. Search terms were used to find studies examining associations between one or more of five behavioral factors (physical activity, cognitive engagement, social engagement, nutrition, and mental health) and dementia (including AD) or cognitive decline.

1. Databases

An electronic search was conducted using the following databases: Medline, CINAHL including Digital Dissertations, and the Cochrane Library.

2. Search terms

Databases were searched for the occurrence of the following keyword pairings relating to cognition (“Alzheimer’s Disease,” OR “dementia,” OR “cognitive decline”) and lifestyle factors (e.g., “nutrition,” “physical activity,” “exercise,” “stress,” “depression,” “cognitive engagement,” “social engagement”)

The reference sections of all retrieved studies and theoretical publications that met the inclusion criteria were inspected.

The Social Science Citation Index (SSCI) was searched for additional relevant publications linked to seminal articles. The search resulted in 27 articles identified as relevant to the review. Meta-analyses and systematic reviews were counted as single articles.

This literature review examines studies including and published consequent to a systematic and comprehensive review on potential risk factors for cognitive decline and AD
commissioned by the NIH through AHRQ (Williams et al., 2010). The following inclusion criteria were used to select additional studies: (1) Materials were published between October 28, 2009 and September 15, 2012 or in press; (2) Publications that appeared in peer-reviewed journals were included; (3) Publications included, at minimum, an abstract in English language; and (4) Studies included variables relating to one or more of the five targeted lifestyle factors and dependent variables related to AD, dementia, or cognitive decline. Animal studies were excluded.

B. National Institutes of Health Report

This literature review uses as a starting point a comprehensive examination of potential risk factors for cognitive decline and AD commissioned by the NIH through AHRQ (Williams et al., 2010). The goal of the NIH report was to evaluate existing research on potential risk and protective factors for developing AD and cognitive decline and to determine whether interventions targeting these factors could be appropriately recommended based on existing evidence. Of the nearly 7,000 studies identified, 165 studies meeting the review criteria were included. These studies included observational, intervention, and systematic review studies published between 1984 and October, 28, 2009. The study examined a variety of purported risk and protective factors including medical conditions, medications, genetics, environmental factors (e.g., toxins) and behavioral factors. However, for the purposes of this review, only findings pertaining to the five areas of interest will be considered. Findings specific to each of these areas will be discussed in each respective section in addition to more recent literature identified for review. In several instances, studies examined by Williams et al. (2010) in their systematic review but that were published prior to the earlier date specified for inclusion, are included in the
discussion to better explicate Williams’s conclusions regarding the level of evidence for an association. Where these articles are particularly noteworthy, they are included in the respective table.

C. Physical Activity

Of the lifestyle factors discussed in this chapter, physical activity is one of the most heavily researched relative to cognitive decline and dementias and has some of the strongest evidence for an association. One suggested mechanism by which exercise confers a protective effect on cognition relates to brain plasticity. Brain plasticity refers to the ability of the brain to change in response to damage or other stimuli from the environment. Specifically, this refers to the brain’s ability to grow new neurons and for neurons to change their synaptic connections (Foster, Rosenblatt, & Kuljiš, 2011). For example, research has demonstrated that aerobic exercise can increase gray matter volume in areas of the brain involved in attention and performance on a given task (Foster et al., 2011). Because brain volume is inversely associated with cognitive decline and AD, increasing gray matter may be a way to delay the onset of major symptoms of cognitive decline and AD (Wolf, Julin, Gertz, Winblad, & Wahlund, 2004).

Research has also supported the theory that exercise increases the ability of the brain to manage the effects of oxidative stress, thought to be a factor in the pathology of mild cognitive impairment (MCI) and AD. Finally, exercise reduces vascular inflammation, helps to manage blood pressure, and positively affects the ratio of good to bad cholesterol levels, all potentially affecting one’s risk of cognitive decline (Davenport, Hogan, Longman, Poulin, & Eskes, 2012).

A search of recent articles using the procedures identified above yielded seven peer-reviewed publications included in this review. Table I contains annotated data of each of the
studies reviewed including (1) sample, (2) type of study, (3) definition of exposure, (4) cognitive outcome examined, and (5) main findings. Various types of studies were identified, including two systematic reviews, two randomized controlled trials, one meta-analysis, one prospective cohort, and one quasi-experimental study where intervention and control groups were not randomized. There is some diversity in type of physical activity and cognitive outcome examined as well as identification of potential confounders, such as age, gender, Apolipoprotein-E (APOE), and others.
<table>
<thead>
<tr>
<th>First author, year</th>
<th>Sample (n)</th>
<th>Study type/follow-up</th>
<th>Physical activity defined as:</th>
<th>Cognitive outcomes</th>
<th>Covariates</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson-Hanley (2010)</td>
<td>32 adults age 55–85 years</td>
<td>Quasi-experimental intervention, no follow-up.</td>
<td>4 weeks of 1-hour strengthening exercise classes, two to three times per week min.</td>
<td>Executive function, processing speed</td>
<td>None, no significant differences between intervention and control groups</td>
<td>Improved executive function compared with wait-listed controls</td>
</tr>
<tr>
<td>Baker (2010)</td>
<td>28 adults age 57–83 years</td>
<td>RCT, no follow-up.</td>
<td>4 days/wk. for 45–60 min/session for 6 months on treadmill, stationary bicycle, or elliptical trainer.</td>
<td>Executive function and short-term memory</td>
<td>Age and gender</td>
<td>Improved executive function compared to controls</td>
</tr>
<tr>
<td>Buchman (2012)</td>
<td>716 older adults (mean age: 81.6 years)</td>
<td>Prospective cohort, 5 years</td>
<td>Exercise and non-exercise physical activity measured with actigraphy for 10 days each year.</td>
<td>Cognitive function, AD</td>
<td>Self-reported physical, social and cognitive activities, motor function, depressive symptoms, chronic conditions, APOE allele status</td>
<td>A higher level of physical activity reduces risk of AD development.</td>
</tr>
<tr>
<td>Muscari (2010)</td>
<td>120 older adults, 65-74 years</td>
<td>RCT, no follow-up.</td>
<td>12 months of supervised endurance exercise training</td>
<td>Cognitive function</td>
<td>Age, gender, educational level and several other possible confounders</td>
<td>Significant decrease in cognitive function in control group as compared to intervention group</td>
</tr>
<tr>
<td>Snowden (2011)</td>
<td>30 studies, ranged from 42 to 916 adults</td>
<td>Systematic review, follow-up varied</td>
<td>Cardiorespiratory, strength, and multicomponent exercises</td>
<td>General cognition, executive function, memory, reaction time, attention, cognitive processing, visuospatial, and language</td>
<td>Varied</td>
<td>Evidence insufficient to conclude that physical activity or exercise improved cognition in older adults</td>
</tr>
<tr>
<td>Sofi (2011)</td>
<td>15 studies, 33,819 adults</td>
<td>Meta-analysis of prospective studies, 1–12 years</td>
<td>Self-reported physical activity.</td>
<td>Cognitive decline or cognitive impairment, defined as decline in cognitive functioning tests at follow-up examination</td>
<td>Varied</td>
<td>Significant and consistent protection for all levels of physical activity against the occurrence of cognitive decline</td>
</tr>
<tr>
<td>Williams (2010)</td>
<td>12 studies</td>
<td>Systematic review, 3.9 to 31 years</td>
<td>Self-reported physical activity</td>
<td>Cognitive decline and AD</td>
<td>Varied</td>
<td>Concluded “fairly consistent” association with AD and cognitive decline</td>
</tr>
</tbody>
</table>
Observational studies have found fairly consistent associations between physical activity, particularly at high levels, and reduced risk of AD and cognitive decline (Sofi et al., 2011; Williams et al., 2010;). In their systematic review of mainly prospective cohort studies, Williams et al. (2010) found that several studies demonstrated a dose-response relationship between physical activity and reduced risk of developing AD and cognitive decline. A recent meta-analysis by Sofi et al. (2011) demonstrated similar findings. In their analysis of 15 prospective studies, high levels of physical activity offered the greatest reduction in risk of cognitive decline (HR=.62, 95% CI: .54–.70; p<.001), although low and moderate levels of exercise were also protective (HR=.65, 95% CI: .57–.75; p<.001).

However, nearly all of the observational studies included in these analyses rely on self-reported measures of physical activity, which have the potential to introduce recall bias and may fail to capture the full scope of non-exercise physical activity someone is engaged in. A more recent study (Buchman, 2012) addresses this issue by assessing activity with an objective measure, namely, actigraphy. Actigraphy is a device worn like a bracelet that records all physical movement over a given time period. Participants in Buchman’s study wore the device for 24 hours a day for 10 days and completed annual cognitive assessments. The average follow-up time was four years. After adjusting for potential confounding lifestyle behaviors, physical and mental health variables, and APOE allele status, he found that an individual’s total daily physical activity was associated with the risk of developing AD (HR=.477; 95% CI: .273–.832).

While observational studies have been relatively consistent in suggesting the protective effect of physical activity on cognitive status, evidence from intervention studies is still lacking.
In a recent systematic review, Snowden et al. (2011) examined 30 intervention studies of physical activity and exercise on cognitive performance among older adults. Type of intervention was categorized as cardiorespiratory, strength, and multicomponent exercises. The researchers examined various measures of cognitive performance including general cognition, executive function, memory, reaction time, attention, cognitive processing, visuospatial function, and language. Although some of the studies had positive findings, the researchers concluded that evidence for a causal relationship between physical activity and cognition was insufficient.

Three additional studies conducted following the Snowden et al. (2011) article offer additional limited evidence for physical activity interventions (Anderson-Haley, Nimon, & Weston, 2010; Baker et al., 2010; Muscari et al., 2010); however, each of these studies has significant limitations. Baker et al. (2010) included only older adults with poor glucose regulation, a population with greater risk of cognitive decline and dementia. The six-month aerobic exercise intervention improved cognition for this higher-risk population, however, the sample size was small and results may not be generalizable to a normal population. The second study (Muscari et al., 2010) examined a 12-month endurance exercise program on cognitive decline. The study had a strong design; however, it relied on the Mini-Mental State Examination (MMSE), a tool that is not likely to be sensitive enough or appropriate for reliably detecting small changes in cognitive status among healthy older adults. Finally, a small, quasi-experimental study (Anderson-Haley et al., 2010) examined the relationship between cognitive performance and non-aerobic exercise using a four-week program that consisted of stretching and strengthening routines. The intervention group showed significantly improved scores on
several cognitive tests when compared to a wait-listed control group. However, lack of randomization and small sample size represent major limitations to their findings.

Although physical activity has the strongest evidence suggesting an association with cognitive decline and AD, a number of research issues remain. In both observational and intervention studies, there is substantial heterogeneity of findings. Reviews of observational studies reveal that risk estimates from individual studies were not all statistically significant, and in some studies the risk estimate was in the direction of increased risk of AD. In both observational and intervention studies, there are considerable differences in the study sample, methodologies used, and measures of exposure. Intervention studies with more attention to program adherence, a longer follow-up time, and consistency in the measures used to assess level of exercise and cognition are needed to confirm existing findings.

D. **Cognitive Engagement**

Five recent studies examine the association between cognitive engagement and cognitive decline or Alzheimer’s risk. Table II provides annotated information on each of the studies included, including the measures used. The theory of CR has been suggested to explain a possible association between cognitive engagement and a lower risk of cognitive decline or AD (Scarmeas & Stern, 2002; Stern, 2002), although specific biological mechanisms have not been identified. The effect of education has been frequently studied because of its suspected potential to compensate for AD pathology, and numerous of studies have demonstrated its association with reduced AD (Caamano-Isorna, Corral, Montes-Martinez, & Takkouche, 2006). Controlling for this effect is important when attempting to assess the potential association of AD development with other cognitively engaging behaviors. One recent study (Sattler, Toro, Schonknecht, & Schroder, 2012) tested the related hypothesis that cognitive activity in leisure
time, education, and socioeconomic status would independently reduce the risk of MCI and AD by adding to CR. The researchers found that subjects who had a high level of participation activities such as reading the newspaper, doing crossword puzzles, or playing an instrument at baseline were significantly less likely (OR=.38, 95% CI: 0.15–0.99, p<.05) to develop MCI or AD 12 years later, after adjusting for several potential confounding variables. While high education level and high socioeconomic status also demonstrated a reduced risk (OR=.15, 95% CI: 0.06–0.38, p<.001) and (OR=.31, 95% CI: 0.14–0.73 p<.01), respectively, Sattler’s finding that these kinds of cognitive activities acted independently of socioeconomic status and education adds to existing evidence for the protective effect of long-term cognitive engagement.
<table>
<thead>
<tr>
<th>First author, year</th>
<th>Sample (n)</th>
<th>Study type/follow-up</th>
<th>Cognitive engagement defined as:</th>
<th>Cognitive outcomes</th>
<th>Covariates</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross (2012)</td>
<td>35 studies (mean sample age, 72.4 years)</td>
<td>Meta-analysis</td>
<td>Memory training</td>
<td>Average of multiple measures of memory ability</td>
<td>Varied</td>
<td>Interventions demonstrated a significant increase in memory</td>
</tr>
<tr>
<td>Landau (2010)</td>
<td>65 healthy adults (mean age, 76.1 years), 10 adults with AD (mean age, 74.8 years), and 11 young adults (mean age, 24.5 years)</td>
<td>Cross-sectional; N/A</td>
<td>Participation in activities such as reading books or newspapers, writing letters or e-mails, and playing games, at 6, 12, 18, and 40 years and the current age</td>
<td>β-amyloid deposition, measured by ($^{11}$C)PiB uptake</td>
<td>age, sex, years of education, and episodic memory, past cognitive activity, physical activity</td>
<td>Individuals with greater early- and middle-life cognitive activity had less deposition of β-amyloid and may have slowed AD pathology</td>
</tr>
<tr>
<td>Miller, et al. (in press)</td>
<td>41 non-demented older adults (mean age, 82 years)</td>
<td>Quasi-experimental</td>
<td>Online cognitive training</td>
<td>Attention/working memory, language, executive function, memory, and mood</td>
<td>Not reported.</td>
<td>Improvements in two measures of auditory memory</td>
</tr>
<tr>
<td>Sattler (2012)</td>
<td>321 older adults</td>
<td>Prospective cohort</td>
<td>Participation in activities such as reading books, reading newspapers/magazines, solving crossword puzzles, and taking classes</td>
<td>AD and MCI</td>
<td>Education, SES, depressive symptoms</td>
<td>Cognitive engagement was protective against MCI and AD development even after controlling for education and other potential confounders</td>
</tr>
<tr>
<td>Williams (2010)</td>
<td>4 prospective cohort studies</td>
<td>Systematic review. Follow-up ranged from 3 to 5 years.</td>
<td>Participation in activities such as reading books, reading newspapers, solving crossword puzzles, playing cards, playing an instrument and other</td>
<td>AD diagnosis</td>
<td>Varied</td>
<td>Higher levels of cognitive engagement showed an association with a moderately decreased risk of AD and cognitive decline</td>
</tr>
<tr>
<td>Willis (2006)</td>
<td>2,802 older adults (mean age, 73.6)</td>
<td>RCT; 5 year</td>
<td>Memory training</td>
<td>Self-reported and performance-based measures of daily function and cognitive abilities</td>
<td>Baseline age and MMSE score</td>
<td>The cognitive training group showed improved cognitive abilities on tasks trained at 5 years post-intervention</td>
</tr>
</tbody>
</table>
In contrast to the CR theory, Landau et al. (2012) sought to demonstrate a direct relationship between cognitive engagement and amyloid (βA) deposition, a marker of AD pathology. Recent medical advances have led to the ability to image βA in living individuals. Amyloid-beta is a major component of the amyloid plaque found in the brains of individuals with AD. Presence of amyloid plaque in the brain is indicated by carbon 11–labeled Pittsburgh Compound B ([11C]PiB) accumulation. In individuals with AD, ([11C]PiB) accumulation is typically found throughout the cerebral cortex. In the Landau et al. study, researchers demonstrated that subjects who had a higher level of cognitive engagement across the lifespan, but particularly in early and middle life, had lower [11C]PiB uptake, indicating that they also had less βA deposition. They additionally concluded that these individuals experienced delayed onset of the disease because of this effect.

While the two studies above support an association between cognitive engagement and reduced risk of cognitive decline or AD, four additional high-quality studies examined in the Williams et al. review (2010) provide further evidence for this relationship (Akbaraly et al., 2009; Verghese et al., 2003; Wilson, Scherr, Schneider, Tang, & Bennett, 2007; Wilson, Bienias, Berry-Kravis, Evans, & Bennett, 2002). The four cohort studies used similar definitions of exposure, considering cognitive engagement as self-reported frequency of behaviors such as doing crossword puzzles, reading the paper, visiting a library or attending a play, and doing board games. Length of follow-up time across the studies ranged from three to five years. One study examined the potential influence of APOE e4 status and determined that it did not affect the risk estimate (Wilson et al., 2002). Another of the four studies (Akbaraly et al., 2009) conducted a sensitivity analysis to try to rule out a possible effect of early onset AD, and found that prodromal AD was not likely to be involved. All of the studies showed a decreased risk of
AD and cognitive decline to be associated with more frequent involvement in activities considered to be cognitively engaging.

In addition to participation in common daily activities such as those described above, cognitive engagement may take the form of specialized cognitive training. Evidence from several recent cognitive training interventions and meta-analyses suggests that such training may improve or help maintain memory performance among cognitively normal adults (Gross et al., 2012; Gross & Rebok, 2011). Typically, studies of cognitive training have focused on specific short-term outcomes related to cognitive performance and memory. A recent meta-analysis (Gross et al., 2012) examines evidence for the effect of memory strategies on memory performance among community-dwelling older adults without dementia. The review, including 35 studies, confirms the general conclusion of previous research that memory training is effective in enhancing cognitive performance on specific memory tasks. The effect of training for interventions designed for the purpose of memory training was 0.43 SD (95% CI: .29, .57) using an average of scores across multiple tests of memory. The analysis also revealed that a combination of strategies may be more efficacious than training on a single one, showing a trend toward greater improvement with training on multiple strategies.

The Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study is the first to examine long-term effects of cognitive training on older adults without dementia (Willis et al., 2006). The study design is a multisite, randomized controlled trial in which 2,802 community-dwelling older adults were randomly assigned to receive one of three types of cognitive training interventions: reasoning, speed of information processing, or memory training. A fourth group served as a control. A subsample of participants received booster training at 11 months and 35 months following the initial intervention. All three intervention groups
demonstrated improvement in the targeted cognitive ability compared with baseline, with the effect persisting at two years after the intervention. For memory, the effect size was 0.17 (p<.001). For reasoning, it was 0.26 (p<.001), and for speed of processing it was 0.87 (p<.001). At five years post-intervention the memory effect size was 0.23 (99% CI: .11 to .35). For reasoning, it was 0.26 (99% CI: .17 to .35). Finally, for speed of processing the effect size was 0.76 (99% CI: .62 to .90). In addition, booster training improved gains in speed and reasoning at one- and two-year follow-ups.

A smaller clinical trial conducted by Miller et al. (in press) reports that training on the Dakim BrainFitness System led to significant improvement compared to controls on memory. As part of the six-month study, a convenience sample of 41 older adults were recruited from independent living facilities. A total of 40 sessions, each 30-minutes long, was completed by the intervention group over the course of two months. Both intervention and control groups were then allowed to use the program for the next four months. During the study, the intervention group completed an average of 93 sessions, while the control group completed an average of 45 sessions. Cognitive assessments measuring attention (working memory), executive function, auditory memory, and language were conducted with both groups at baseline, at two months, and at six months. Compared to the control group, the intervention group showed significant improvements in delayed recall and verbal learning (p<.001). It should be noted that the study was funded by Dakim and that one of the co-authors, Dr. Small, is their Chief Scientific Advisor.

In conclusion, there is limited but relatively consistent evidence suggesting that increased involvement in unstructured cognitive activities and in cognitive training in later life is associated with various short- and long-term benefits. Participation in common, intellectually stimulating activities may lead to reduced risk of AD and incident MCI, while informal
activities, such as reading or playing an instrument, as well as structured cognitive training may reduce an individual’s risk of cognitive decline. Specialized cognitive training may also lead to specific short-term memory gains. Limitations of the studies described include, in some cases, relatively small effect sizes and effects that were limited to selective measures of exposure. As with studies of physical activity and cognitive status, there is inconsistency in measures of exposure and use of measures that have not been validated. Finally, reverse causality remains an issue in interpreting findings from the majority of studies in this area. Alzheimer’s Disease has a long sub-clinical prodromal period, which means that undetected AD may be causing reduced cognitive engagement many years before a diagnosis is made. Additional longitudinal studies are needed to further clarify the causal direction.

E. Nutrition

Both dietary patterns and isolated dietary components have been studied for their potential association with cognitive outcomes. Of the nine studies identified for inclusion, two review evidence for omega-3 supplementation, two investigate fruit and vegetable consumption, and five examine adherence to the Mediterranean diet (MeDi) or a similar dietary pattern. The studies take into account numerous covariates, such as systolic blood pressure (SBP) and body mass index (BMI). Table III provides annotated information for each of the studies pertaining to nutrition.
<table>
<thead>
<tr>
<th>First author, year</th>
<th>Sample (n)</th>
<th>Study type/follow-up</th>
<th>Nutrition variable</th>
<th>Cognitive outcomes</th>
<th>Covariates</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eskalin (2011)</td>
<td>525 older adults, age 65–79 years</td>
<td>Prospective cohort, 14 years</td>
<td>Healthy diet (healthy-diet index &gt; 8 points)</td>
<td>AD</td>
<td>Age, sex, education, follow-up time, community of residence, and APOE e-4 carrier status, midlife SBP, serum total cholesterol, BMI, presence of late-life myocardial infarction/stroke/diabetes mellitus, midlife leisure-time physical activity, and smoking.</td>
<td>Persons with a healthy diet had a decreased risk of dementia compared with persons with an unhealthy diet.</td>
</tr>
<tr>
<td>Gardener (2012)</td>
<td>723 healthy controls, 98 MCI and 149 AD participants</td>
<td>Cross-sectional study, N/A</td>
<td>Adherence to MeDi</td>
<td>AD and MCI status</td>
<td>age, sex, country of birth, education, APOE genotype, total caloric intake, current smoking, BMI, history of diabetes, hypertension, angina, heart attack, and stroke</td>
<td>Compared with healthy controls, each additional unit in the MeDi score was associated with 13%–19% lower odds of being in the MCI category, and 19%–26% lower odds of being in the AD category.</td>
</tr>
<tr>
<td>Hughes (2010)</td>
<td>3,779 members of the Swedish Twin Registry</td>
<td>Prospective cohort, 30 years</td>
<td>Fruit and vegetable consumption (assessed by a single item on a 4-point scale)</td>
<td>Dementia diagnosis</td>
<td>Age, gender, education, smoking status, BMI, exercise level, alcohol consumption, angina pectoris, total food intake, marital status</td>
<td>Higher fruit and vegetable intake may reduce risk of dementia, especially among women and those with angina pectoris in midlife.</td>
</tr>
<tr>
<td>Nooyens (2011)</td>
<td>2,613 adults, age 43–70 years</td>
<td>10 years</td>
<td>Consumption of fruits, vegetables, legumes and juices</td>
<td>Change in cognitive function</td>
<td>Age, sex, education, total energy intake, smoking, baseline level of cognitive function, blood pressure, depression</td>
<td>Total intakes of fruits, legumes, and juices were not associated with baseline or change in cognitive function. Some subgroups of fruits and vegetables demonstrated protective effects.</td>
</tr>
<tr>
<td>First author, year</td>
<td>Sample (n)</td>
<td>Study type/follow-up</td>
<td>Nutrition variable</td>
<td>Cognitive outcomes</td>
<td>Covariates</td>
<td>Results</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------</td>
<td>----------------------</td>
<td>--------------------</td>
<td>-------------------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>Sydenham (2012)</td>
<td>Cochrane database review (4,080 subjects)</td>
<td>3 RCTs; 6–40 months in duration</td>
<td>Omega-3 supplementation</td>
<td>Cognitive function as measured by MMSE scores, word learning, digit span, and verbal fluency</td>
<td>None</td>
<td>None of the studies demonstrated a benefit of omega-3 supplementation on cognitive function.</td>
</tr>
<tr>
<td>Tangney (2011)</td>
<td>3,790 older adults</td>
<td>Prospective cohort, 7.6 mean time to follow-up</td>
<td>Adherence to a MeDi or to the Healthy Eating Index–2005</td>
<td>Cognitive decline</td>
<td>Age, gender, education, depressive symptoms, participation in cognitive activities, hypertension, smoking, stroke history</td>
<td>Adherence to the MeDi but not Health Eating score was associated with a reduced rate of cognitive decline.</td>
</tr>
<tr>
<td>Vercambre (2012)</td>
<td>2,504 women with CVD or at least three CVD risk factors.</td>
<td>Ranged from 4.1 to 6.1 years.</td>
<td>Adherence to the MeDi</td>
<td>Rate of change in a global composite score, the mean of tests on global cognition, verbal memory, category fluency</td>
<td>Age, education, and energy from diet, study randomization assignments, and numerous lifestyle and health variables, incident vascular events during follow-up.</td>
<td>Adherence to a MeDi was not associated with subsequent 5-year cognitive change.</td>
</tr>
<tr>
<td>Williams (2010)</td>
<td>4 studies</td>
<td>Systematic review, studies had follow-up of 4 to 7 years</td>
<td>Adherence to a MeDi</td>
<td>Cognitive decline and AD</td>
<td>Varied.</td>
<td>MeDi was associated with a small to moderate decrease in risk of AD and cognitive decline.</td>
</tr>
<tr>
<td>Williams (2010)</td>
<td>7 studies</td>
<td>Systematic review, studies had follow-up of 2.1 to 9.1 years;</td>
<td>Omega 3 supplementation</td>
<td>Cognitive decline and AD</td>
<td>Varied.</td>
<td>Omega 3’s were associated with a small-to-moderate decrease in risk of cognitive decline but not AD.</td>
</tr>
</tbody>
</table>
1. **Omega-3 fatty acids**

Existing literature does not support an association between omega-3 fatty acids and cognitive decline or AD. This conclusion is based upon two comprehensive reviews analyzing the available literature. In the first, (Williams et al., 2010) assessment of the association between omega-3 fatty acids and incident AD is largely derived from a reexamination of a high-quality systematic review conducted by Fotuhi, Mohassel, & Yaffe, (2009) of seven prospective cohort studies. In these studies, exposure included any form of omega-3 fatty acids, including fish or other omega-3 rich foods. Consistent with Fotuhi et al., Williams et al. (2010) found no consistent association between omega-3 fatty acid intake and risk for dementia, and limited evidence for an association with cognitive decline. Two additional prospective cohort studies examined by Williams et al. (2010) also failed to demonstrate an association. These results were confirmed by a recent review of intervention studies in which Sydenham, Dangour, & Lim (2012) found no beneficial effect of omega-3 supplementation on the cognitive status in older adults. None of the four randomized controlled trials demonstrated any differences in cognitive performance between intervention and placebo control groups in up to four years of follow-up.

2. **Fruit and vegetable consumption**

Many of the existing studies on nutrition and cognitive status have focused on a single dietary component or supplement, such as the omega-3 research described above. However, trying to assess the effect of a single nutrient is challenging since the nutrient in focus is consumed within a larger diet that can enhance or diminish the effect of a smaller component. In addition, certain foods may be synergistic, thus making it difficult to assess which of the foods consumed may be responsible for any identified effect. Because of the research challenges of
examining a single nutrient, a number of researchers have begun to look at larger dietary patterns and their association with cognitive status.

For example, several studies have investigated the effect of fruit and vegetable consumption on cognitive decline and AD (Hughes et al., 2010; Nooyens et al., 2011; Williams et al., 2010) and have offered largely inconsistent findings. Two recent studies examined fruit and vegetable consumption in midlife and its association with later cognitive status. In one of these, Hughes et al. (2010) analyzed data from a longitudinal study of dementia among Swedish twins. Dietary information was collected from 3,779 members of the Swedish Twin Registry 30 years prior to data on cognitive status including a dementia screening. They found that, after controlling for standard demographic differences, subjects who reported consuming proportionally more fruits and vegetables had a decreased risk of dementia as compared to those with a small proportion of fruits and vegetables in their diet. However, this effect was observed only among women and subjects with angina pectoris in midlife. Researchers speculated that the first finding may be due to more severe oxidative stress known to occur in women, from which fruit and vegetable intake may offer protection. The greater effect among those with angina may be explained by the vascular benefit of a healthier diet, which in turn affects AD risk.

A second study examining fruit and vegetable intake provided somewhat contradictory findings. Nooyens et al. (2011) found that greater consumption of fruits, legumes, and fruit juice was not associated with baseline value of cognitive function or with later changes in function. When looking at high intakes of some subgroups of fruits, and particularly leafy green vegetables, researchers found an association with better cognitive function at baseline and/or in some cases, lesser cognitive decline; however, there was no apparent explanation for the differences in effect between fruits, vegetables, and juices as a whole and findings for the
subgroups. Two studies reviewed by Williams et al. (2010) also failed to find a significant association between total intake of fruit and cognitive decline; however, they did find a protective association between vegetable intake and AD risk, and between vegetable intake and cognitive decline. Based on these findings, it seems there may be a small reduction in risk related to leafy green vegetable intake; however, the effect may not be clinically significant.

3. **Mediterranean diet**

The MeDi has been the subject of a number of studies examining diet and cognitive health. It includes a high intake of fruits, vegetables, legumes, grains, and fish, and is low in meat and dairy products. Previous studies have suggested pathways by which the MeDi may provide a protective effect for dementia. The diet encourages moderate alcohol consumption, which has been shown to be protective in a number of epidemiological studies (Anstey, Mack, & Cherbuin, 2009). Wine in particular has been shown to reduce dementia risk (Mehlig et al., 2008; Truelsen, Thudium, & Grønbæk, 2002). In addition, the MeDi may improve cardiovascular health, which in turn is thought to be protective against dementia and cognitive decline (Newman et al., 2005).

Recent studies are relatively consistent in suggesting a protective effect of the MeDi (Gardener et al., 2012; Tangney et al., 2011, Williams et al., 2010), although in some cases, effect sizes were small (Williams et al., 2010). In one study, Tangney et al. (2011) examined adherence to a MeDi or to the Healthy Eating Index–2005 (HEI-2005) in relation to cognitive change in older adults. Participants in the ongoing Chicago Health and Aging project, a longitudinal study of adults aged 65 and over, completed two cognitive assessments and questionnaires evaluating adherence to the two dietary patterns. Mean time to follow up was 7.6 years. Greater adherence to a MeDi was associated with slower rates of cognitive decline after
adjusting for potential confounders. No association was found between HEI Scores and rate of cognitive decline, suggesting an effect specific to the MeDi pattern. However, using a modified version of the MeDi scale, another study (Eskelinen, Ngandu, Tuomilehto, Soininen, & Kivipelto, 2011) demonstrated that subjects who had the highest score on the healthy eating scale had an 86%–90% decreased risk of dementia and a 90%–92% decreased risk of AD compared to subjects with the lowest healthy diet score.

The association between MeDi and cognition was not upheld in a study of individuals with or at high risk for cardiovascular disease (CVD). Vercambre, Grodstein, Berr, & Kang (2012) investigated adherence to the MeDi and cognitive change among this special population with an elevated risk for cognitive decline. Subjects were drawn from the Women’s Antioxidant Cardiovascular Study (WACS) and had been diagnosed with vascular disease or reported at least three coronary risk factors. No association was detected between MeDi adherence and cognitive change; however, this study was limited in that it relied on a single baseline assessment of dietary behavior that may have been inconsistent with later diet habits, particularly in women who may have changed their eating habits due to CVD. The authors suggested that differences in absolute intakes of Mediterranean-style eating or measurement of diet adherence may be responsible for inconsistency between their findings and those of recent studies. Another plausible explanation is that the effect of vascular disease or risk factors on cognitive health is too strong to counteract with dietary changes.

F. **Social Engagement**

Five recent articles examining the potential association of social engagement to cognitive status were identified for inclusion here. Four of these were longitudinal studies and one a systematic review. The studies each examined slightly different variables related to social
engagement, making comparison difficult. Definitions of exposure are included, along with other annotated data from these studies, in Table IV.
**TABLE IV**
REVIEW OF SOCIAL ENGAGEMENT

<table>
<thead>
<tr>
<th>First author, year</th>
<th>Sample (n)</th>
<th>Study type/follow-up</th>
<th>Social engagement defined as:</th>
<th>Cognitive outcomes</th>
<th>Covariates</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amieva (2011)</td>
<td>2,089 French adults (mean age, 73.7)</td>
<td>Retrospective cohort, N/A</td>
<td>Marital status, size, and nature of social network, satisfaction, perception of being understood, and reciprocity in social exchanges</td>
<td>Dementia and AD diagnosis</td>
<td>Sex, education, MMSE score, positive affect subscore of the Center for Epidemiological Studies Depression Scale, Instrumental Activities of Daily Living, and presence of chronic diseases</td>
<td>Two of six social network variables were associated with reduced dementia risk: satisfaction with network interactions and perception of reciprocity in relationships (also associated with reduced AD risk).</td>
</tr>
<tr>
<td>Dickenson (2011)</td>
<td>112 depressed and 101 non-depressed adults (mean age 68.9 years)</td>
<td>Prospective cohort, 2 years</td>
<td>Subjective social support, instrumental social support, social network size, and social interaction assessed with items from the Duke Social Support Index</td>
<td>Cognitive decline</td>
<td>Depression status, age, education, and sex</td>
<td>Decrease in social interaction, and instrumental social support predicted significant decline in cognitive performance.</td>
</tr>
<tr>
<td>James (2011)</td>
<td>1,138 adults (mean age 79.6 years)</td>
<td>Retrospective cohort, N/A</td>
<td>Social activity</td>
<td>Cognitive decline</td>
<td>Age, sex, education, race, social network size, depression, chronic conditions, disability, neuroticism, extraversion, cognitive activity, and physical activity</td>
<td>More social activity was associated with less cognitive decline.</td>
</tr>
<tr>
<td>Stoykova (2011)</td>
<td>2,055 older adults</td>
<td>Prospective cohort 20 years</td>
<td>Size of social network, satisfaction with relationships, perception of being understood, and participation in social activities</td>
<td>Cognitive decline</td>
<td>Age, sex, education, race, depression, chronic conditions</td>
<td>A statistically significant association was found between social network and cognitive decline only at baseline.</td>
</tr>
<tr>
<td>Williams (2010)</td>
<td>18 prospective cohort studies</td>
<td>Systematic review, follow-up ranged 2–21 years</td>
<td>Varied by study, including marital status, living situation, number of people in social network, feelings of loneliness, and perceptions of social support</td>
<td>AD and cognitive decline</td>
<td>Varied</td>
<td>Varied. Evidence was found for some association between objective and subjective factors and risk of AD or cognitive decline.</td>
</tr>
</tbody>
</table>
As has been suggested for cognitive engagement, any potential cognitive benefits derived from social engagement may be due to increases in CR, which results in the delay of expression of AD symptoms. Social engagement typically entails comprehension, memory, and problem solving required to manage and sustain social relationships. Consequently, it produces additional cognitive stimulation that may promote neurogenesis. However it may also be that more social individuals are healthier than less social individuals, or that social engagement and cognitive health are caused by a third factor not yet identified. Finally, individuals with stronger social networks may have greater access to instrumental resources (e.g., healthy diet, exercise partner) as they age that in turn are protective for cognitive health. The studies described below attempt to control for some of these factors.

There is some suggestion that loss is a key factor in determining the association between aspects of social support and cognitive status. Among the social engagement variables, the strongest evidence is seen for the association between loss of a spouse and cognitive decline (Williams et al., 2010). Similarly, a more recent study (Dickinson, Potter, Hybels, McQuoid, & Steffens, 2011) found that decreased social interaction and decreased instrumental social support predicted decline in cognitive performance. More specifically, loss of social support in a given year predicted an increase in cognitive decline over the next year even after controlling for depression and other potential confounders. There is also preliminary evidence that a decrease in social network size may be a risk factor for AD (Williams et al., 2010). While consistently low or high levels of social engagement are not associated with AD risk, a change from high to low social engagement from mid-to-late life was associated with a higher risk of AD. However, decrease in social engagement may also be due to prodromal AD.
Findings in relation to social network size and social support are inconsistent across multiple studies (Amieva et al., 2010; Williams et al., 2010; Stoykova, Matharan, Dartigues, & Amieva et al., 2011) and seem to disappear when reverse causality is controlled for. In an examination of multiple aspects of social engagement, Amieva et al. (2010) found no relationship between social network or social support and subsequent dementia. The only variables associated with subsequent dementia or AD were those reflecting the quality of relationships. Follow-up time from social network assessment to dementia diagnosis ranged from 5 to 15 years, thus minimizing the problem of reverse causality. In another study of social network size and cognitive decline, Stoykova et al. (2011) controlled for reverse causality by excluding participants who developed dementia prior to a 20-year follow-up. Before controlling for this bias, they found a significant association between social network size and cognitive decline; however, the association did not persist when individuals with dementia were excluded from the analysis.

It may be that social activity, rather than social network size or perceived social support, has a protective effect on cognitive decline among older adults (James, Wilson, Barnes, & Bennett, 2011). A recent retrospective study by James et al. (2011) assessed the relationship between social activity and cognitive decline 12 years later. After adjusting demographic variables, personality traits, and several lifestyle behaviors, they concluded that “a one point increase in social activity score (range = 1–4.2; mean = 2.6; SD = 0.6) was associated with a 47% decrease in the rate of decline in global cognitive function (p < .001)” (p. 998). Subjects who were the most socially active (90th percentile) had a 70% reduction in rate of cognitive decline as compared to those who were least socially active (10th percentile). The association held across five domains of cognitive function. Researchers conducted sensitivity analysis to test for
reverse causality bias, but found that subjects with the lowest levels of cognition at baseline were not driving the relationship, making it unlikely that the effect was a reflection of early AD pathology.

Additional findings in this area include an association between being single and living without a partner with increased AD risk, but only for those who were never married or who were widowed in mid- or later life (OR=7.67; 95% CI: 1.67–40.0) (Williams et al., 2010). The association did not remain for those who were divorced. As previously discussed, heterogeneity of exposure definition makes assessing the strength of evidence for social engagement more challenging. The area of social engagement is also difficult to disentangle from cognitive engagement and mental health. Because of many different sources of exposure, identifying potential confounders can be difficult as well. In conclusion, there is limited preliminary evidence for an association between social engagement and cognitive status, however, strength of evidence varies greatly depending how exposure is defined.

G. **Mental Health**

Table V contains annotated data of each of the five studies relating to mental health and cognition that have been included in this review. The identified studies examine associations between depression or stress and cognitive decline, AD, or other dementias. Research investigating an association with anxiety was also sought but sufficient high-quality studies were lacking.
<table>
<thead>
<tr>
<th>First author, year</th>
<th>Sample (n)</th>
<th>Study type/ follow-up</th>
<th>Mental health variable</th>
<th>Cognitive outcomes</th>
<th>Covariates</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byers (2011)</td>
<td>16 studies</td>
<td>Systematic review, follow-up time was 0–17 years</td>
<td>Absence of early-life and late-life depression</td>
<td>AD and vascular dementia</td>
<td>Varied</td>
<td>Earlier-life depression has consistently been found to be a risk factor for dementia, late-life depression may be prodrome of dementia.</td>
</tr>
<tr>
<td>Comijs (2011)</td>
<td>1,356 adults, 55-85 years</td>
<td>Retrospective cohort, N/A</td>
<td>Stressful life events from previous 3 years, including “widowhood, divorce, severe illness of partner, death of a relative, death of a child, relocation, severe conflicts, or being a victim of a crime” (Comijs, 2011, p. i113)</td>
<td>Cognitive decline</td>
<td>Age, gender, and level of education cardiac disease, peripheral atherosclerosis, stroke, diabetes mellitus, COPD, arthritis, cancer, Benzodiazepine use</td>
<td>Death of a (grand) child was associated with a higher rate of cognitive decline. Illness of a partner or relative, or serious conflicts, were associated with better cognitive function.</td>
</tr>
<tr>
<td>Gao (2012)</td>
<td>12 studies</td>
<td>Meta-analysis, follow-up time was 3 months–27 years</td>
<td>Depression</td>
<td>All types of dementia and MCI</td>
<td>Varied</td>
<td>Depression is a major risk factor for any type of dementia and MCI.</td>
</tr>
<tr>
<td>Tschanz (2012)</td>
<td>2,665 adults, 76.6 years</td>
<td>Prospective cohort, 3 and 7 years</td>
<td>Stressful life events</td>
<td>Cognitive decline</td>
<td>Age, gender, education, occupation, and APOE genotype</td>
<td>Effect of stressful life events vary by age and level of education.</td>
</tr>
<tr>
<td>Williams (2010)</td>
<td>6 studies</td>
<td>Systematic review</td>
<td>Depression</td>
<td>AD and cognitive decline</td>
<td>Varied</td>
<td>Fairly consistent associations were associated with a small increased risk of cognitive decline.</td>
</tr>
</tbody>
</table>
Byers and Yaffe (2011) propose the following ways in which depression may cause or be physiologically linked to dementia: “vascular disease, alterations in glucocorticoid steroid levels and hippocampal atrophy, increased deposition of amyloid-β plaques, inflammatory changes, and deficits of nerve growth factors” (p. 323). Although stress is a contributor to incidence and severity of depression, stress can also cause a physiological response that affects cognitive function independent of depression. In this response, stressful events cause elevated levels of the stress hormone cortisol. Cortisol may affect cognitive function by binding to receptors in the brain, where it can also weaken synaptic connections and prevent formation of new connections in various regions of the brain involved in learning and memory. In this way stress may impair the ability to make new memories and lead to a decline in cognitive function (Lupien, Maheu, Tu, Fiocco, & Schramek, 2007; McEwen, 2007).

1. Depression

Numerous observational studies have demonstrated that depression increases the risk of developing AD or cognitive decline (Williams et al., 2010). A recent meta-analysis (Gao et al., 2012) of 12 longitudinal studies added to existing evidence for the association between depression and any dementia. The quantitative analysis calculated pooled relative risk, finding that subjects with depression had a higher incidence of AD (RR=1.66, 95% CI: 1.29–2.14), any dementia (RR=1.55, 95% CI: 1.31–2.83), and MCI (RR=1.97, 95% CI: 1.53–2.54) than subjects without depression. Although the analysis was based on observational studies, length of follow-up and plausible mechanisms by which depression may affect cognition support the conclusion that it is a risk factor and not merely a consequence of dementia pathology. One additional study found an association between late-life depression and dementia risk (Byers & Yaffe, 2011), however, reverse causality bias could not be ruled out.
2. **Stress**

Comijs, Kommer, Minnaar, Penninx, & Deeg (2011) hypothesized that accumulation of stressful life events or various kinds of life events may be associated with decline in general cognitive performance, speed of information processing, learning, or retention. They found no evidence of an association between cumulative stress events and cognitive decline, but did find certain events to be associated with a higher rate of cognitive decline, even after controlling for depression. They theorized that chronic stressors such as illness of a partner or chronic conflict stimulated rather than impaired cognitive performance. A second longitudinal study (Tschanz et al., 2012) of older adults yielded inconsistent results, finding that education affected the impact of stressful life events on cognitive decline, with those having fewer years of education experiencing faster decline. They concluded that the effects of stressful life events may differ according to age and education.

H. **Summary and Limitations of the Literature**

Strength of evidence for an association between the five lifestyle behaviors examined and cognition varies by behavior. Observational studies provide relatively consistent evidence for an association between physical activity and cognitive decline and AD; however, additional high-quality intervention studies are needed to further confirm this relationship. There is also a relatively high degree of consistency in observational studies of cognitive engagement. Within the category of nutrition, the majority of recent studies have demonstrated a protective effect of the Mediterranean dietary pattern. Conversely, high-quality randomized controlled trials have demonstrated the absence of an association between omega-3 fatty acid supplements and cognitive decline or AD. Evidence for the effect of social support is growing but remains
preliminary. Depression is a known risk factor for AD and cognitive decline, however, the effect of stressful life events is unclear and may vary depending on other individual factors.

Several issues in interpreting the findings are common across the five behaviors studied. These include inconsistency and lack of validated measurement tools, differences in the way in which behavioral variables are defined, and not enough time to follow-up. In addition, intervention studies sometimes lacked attention to program adherence and were inconsistent in reporting dose and duration, making them difficult to compare. The issue of reverse causality remains a challenge in studying any of the five behaviors, but particularly relative to social and cognitive engagement. Finally, in the meta-analyses, publication bias may have inflated the summary estimate of effect.

I. **Theoretical Foundation**

As discussed in earlier sections, numerous mechanisms may explain a protective effect of specific lifestyle behaviors on AD risk and cognitive decline. Of these, the theory of CR has the most applicability across behaviors. The CR hypothesis has been suggested to explain discrepancies in degree of AD pathology and symptoms of dementia (Fratiglioni & Wang, 2007). Lack of a strong correlation between the two suggests that the brain has the ability to compensate for cognitive deficits, thereby reducing expression of clinical symptoms. Numerous studies, including many of those discussed above, have sought to identify protective factors against AD, which work by contributing to CR.

Each of the five lifestyle factors discussed can be learned or incorporated into a healthy lifestyle. The intervention evaluated in this study was designed to promote behavioral factors that may enhance brain health through participation in a program based on social cognitive theory (SCT). The SCT explains behavior in terms of reciprocal interaction between cognitive,
behavioral, and environmental influences (Bandura, 1977; 1986). The theory recognizes the influences of environment on behavior, but focuses on the ability of the individual to utilize aspects of the environment for their own benefit as well as the capacity for collective action. The educational intervention incorporates key components suggested by SCT including: in-class modeling of targeted behaviors, promotion of participant goal-setting for increasing healthy behaviors; social support provided in the classroom environment, particularly through group discussion of barrier and obstacles; access to cognitive training resources; promotion of self-efficacy through realistic expectations; and a reward system of “badges” given for completing levels of the Dakim BrainFitness System.

J. **Conceptual Models**

As illustrated in Figure 1, the first proposed model suggests that the five lifestyle behaviors (physical activity, cognitive engagement, nutrition, social engagement, and mental health) have a protective effect on cognitive status. The influence of certain demographic factors and chronic conditions on frequency of lifestyle behaviors is represented in the model as is their independent association with cognitive outcomes. Demographic factors and chronic conditions can impact cognitive outcomes through reduced participation in any of the lifestyle behaviors, and in some cases, directly. For example, Type 2 diabetes is an independent risk factor for cognitive decline and AD.
Figure 1. Effect of lifestyle behaviors on cognition.

Figure 2 illustrates the how the intervention affects short- and long-term cognitive outcomes. The three components of the intervention are included as independent variables: (1) education and encouragement of lifestyle behaviors promoting cognitive health, (2) cognitive training using the Dakim BrainFitness System, and (3) in-class memory training techniques. Although participation in the educational program and in-class memory training techniques are both assessed through program attendance, the way in which they affect the dependent variables differs, and so they have been represented as two distinct influences. Activity participation denotes frequency of engagement in the five lifestyle behaviors, each assessed by a subscale of the Community Healthy Activities Model Program for Seniors (CHAMPS) measure. The
illustration depicts the long-term cognitive effects (distal outcomes) of sustained adoption of the five lifestyle behaviors. Measurement of those distal outcomes would require a longitudinal study that is beyond the scope of this project. It is hypothesized that cognitive training and memory training will primarily affect the short-term outcomes of subjective and objective memory, the latter being measured by the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), the Controlled Oral Word Association Test (COWAT), and Trails A and B. Mindfulness, assessed with the Mindful Attention Awareness Scale (MAAS), is encouraged as a stress reduction strategy, and is expected to increase. Although the intervention components may have the potential to affect the distal outcomes, it is not expected that the dosage and duration of the intervention involving these cognitive and memory training is sufficient to have a long-term impact. Similarly, increases in one or more of the lifestyle behaviors may affect subjective or objective memory over time, but it is not expected that any such effect would be measurable at post-intervention. However, participation in the educational intervention may instill confidence in participants, which could in turn affect their ratings of subjective memory, measured by the Patient-Reported Outcomes Measurement Information System (PROMIS). Since this study did not include an active control group, this may represent a practice effect not controlled for in this study.
Figure 2. Effect of intervention on targeted outcomes.
III. METHODS

A. **Study Design**

This study utilized data from a randomized controlled trial design to evaluate a multimodal intervention to promote cognitive health among older adults in the Chicago area. The intervention consisted of three components: (1) an eight-week educational initiative to promote cognitive health through adoption of behaviors thought to be associated with reduced cognitive decline, AD, or MCI; (2) practice of memory training techniques; and (3) use of the Dakim BrainFitness system, an online cognitive training program. The primary purpose of this study was to examine the feasibility of the program among the targeted population and to provide preliminary data on the efficacy of the intervention that could serve as the basis for a larger study. Analysis employed a combination of bivariate and general linear models while controlling for potential confounders. Additional information on the analysis is provided in the analytical plan.

B. **Study Population**

Older adults were recruited for participation from community-based organizations and independent living residences in the Chicagoland area. Subjects were randomly assigned to either the behavioral change intervention or a wait-list control group. Participants were male and female, 55 years of age or older. Inclusion criteria were: (1) English-speaking; (2) no diagnosis of dementia; (3) age 55 and older. Exclusion criteria were: not English speaking or had been diagnosed with any form of dementia by a medical professional. Trained research technicians screened the applicants during their scheduled “informational and consent meeting.”
screening process consisted of asking each applicant if he or she was comfortable taking the course in English, had no diagnosis of dementia, and was 55 or older.

C. **Setting**

Participants were recruited from six locations owned by Mather LifeWays, a not-for-profit organization based in Evanston, Illinois. The recruitment sites also served as locations for the intervention, with participants attending the program at the site at which they were recruited. Participating sites included three independent living residences for older adults: Mather Place at Wilmette in Wilmette, Illinois; The Mather in Evanston, Illinois; and Splendido near Tucson, Arizona. Participants were also recruited from three Mather’s More-than-a-Café locations in Chicago. Mather’s More-than-a-Café sites serve an older adult population and offer many of the same services as senior centers.

Although the convenience sample described above was likely to result in a significant sample bias, it was used to maximize the number of participants in the study with the given resources. Characteristics of the sample are described in the results; however, it was anticipated that the sample would not be representative of the entire population. Five of the six project sites have a resident or customer base that is predominantly white. Older adults recruited from the three senior living residences (from which half of the sample was drawn) also tend to have considerably higher incomes than the general population. Older adults recruited from the Cafés are mainly from lower-middle income groups, thus lower income groups are largely left out. One of the six sites has an almost exclusively African American population; however, other minority racial groups were not well represented at any of the sites. Because of the association between income and health, the sample is also likely to have better health than the general population of
older adults. The use of a convenience sample results in a “limitation in generalization … making about the entire population. Since the sample is not representative of the population, the results of the study cannot speak for the entire population. This results to a low external validity of the study” (“Convenience Sampling,” n.d., para. 10).

D. **Procedures**

Prospective participants were recruited through presentations given by project staff, study announcements sent via email to resident and customer lists, and brochures describing the study that were posted at each of the six locations and given out at the front desk of the senior living communities. Project staff also held “brain fairs” at each study location to advertise the project and recruit participants. At these events, “brain healthy” foods were made available and brochures were given out. Interested individuals registered for an “information and consent meeting” that was conducted by research technicians to assess eligibility and complete the consent process.

At the onset of the study, each participant met individually with a research technician for approximately one hour. At the beginning of this meeting, the participant completed the Informed Consent process. After obtaining consent, the research technician administered a cognitive assessment and provided the individual with a self-report pre-survey to complete.

Participants were randomized into the intervention arm or a control arm for the study. After enrolling all subjects into the study, names were drawn from a hat, with the first half being assigned to the intervention arm and the second to the control arm. Research technicians administering the cognitive assessments were blinded to the study arm condition. All study participants completed measures at baseline, defined as the time period within three weeks prior
and one week following the start of the course for the intervention group. Participants in control and intervention groups also completed measures within three weeks following the course attended by the intervention group (i.e., the wait-list control group completed the second set of measures before the beginning of the course they attended).

The intervention was delivered using a train-the-trainer model. Mather LifeWays staff from each of the six study sites served as trainers. It was expected, though not required, for trainers to have academic backgrounds in nursing, exercise physiology, and gerontology. These staff members attended one of three one-and-one-half-day train-the-trainer sessions to be conducted by project staff. During these training sessions, project staff delivered the content for the intervention, discussed teaching strategies, and explained procedural items such as taking attendance. In addition, trainers were given an orientation to the Dakim BrainFitness software.

Managers from each site were asked to identify three available trainers who could deliver the educational component of the intervention so as to reduce difficulties with scheduling.

In addition to the in-class educational component, the intervention included use of the Dakim Brain Fitness software. Means of accessing Dakim software use also varied by site. At two of the Independent Living Facilities (The Mather and Splendido), most of the participants installed the Dakim brain fitness system on their personal computers. Participants at these sites who did not have computers that met the technical requirements for installation were given access to the Dakim program on facility computers.

E. **Control Condition**

This study used a wait-list control group that had access to usually available programs in their community. Participants randomized to the control arm of the study were tested during the
same time periods as the intervention group. Those in the control group were told that they would have the opportunity to take the same course as that offered to the intervention group at a later date. The control group also had the opportunity to use the Dakim BrainFitness software during and after the course they attended.

F. **Intervention Condition**

As noted in the Introduction, few interventions targeting cognitive health have been multimodal in nature, however, positive findings from the Miller et al. study (2011) provided a partial basis for further exploration in this area. In addition, Karp et al. (2006) found that participation in a combination of lifestyle behaviors (mental, physical, and social) reduced the risk of dementia. More specifically, they found that high participation in at least two of the three domains caused the greatest decrease in risk of dementia six years later. Scarmeas et al. (2001) additionally found that as an individual increased the number of protective behaviors engaged in, their risk of dementia decreased. One other study (Lee et al., 2008) demonstrated similar findings. In this case the researchers looked at physical activity, smoking behavior, vegetable consumption, and social activity. At two years following the study, each of these lifestyle behaviors was found to be independently associated with cognitive performance. The researchers also found that there was an additive benefit obtained by participating in more than one lifestyle behavior.

In addition to support for memory training and lifestyle factors found in that study, there is reason to believe that adding online cognitive training may further enhance outcomes. A study of the Dakim brain fitness system, described in further detail in the literature review, found
significant improvements in delayed recall and verbal learning in an intervention group versus a control group (Miller et al., in press).

1. **Education on lifestyle behaviors related to cognitive health**

The educational intervention was delivered in eight one-hour sessions. This included one introductory session, six sessions focused on lifestyle factors, and one concluding session. The introductory session introduced foundational concepts (e.g., dementia, brain plasticity, CR) and provided an overview of the structure of the course and specific topics to be covered. With the exception of the introductory session, the instructor began each session by asking participants to report progress and engage in a brief discussion about overcoming any barriers or obstacles the participants may encounter in trying to increase their participation in a given area. Next, the instructor presented material covering literature related to one of six areas related to brain health. This material included discussion of current research linking a specific lifestyle behavior to cognitive health and mechanisms by which the behavior promoted brain health. Following the presentation, the instructor led participants in a brief activity related to the topic area. Participants were also asked to set short-term goals relating to increasing their activity in the area addressed.

Trainers utilized a training guidebook and Power Point slides prepared by the project staff. The presentations were scripted, providing for a high degree of fidelity in implementation and a minimum of preparation time. Participants were given a Participant Workbook that included key information presented in the Power Point slides, Log Sheets to record activity participation, and a list of common activities associated with each of the six areas covered (e.g., for physical activity, the list included running, walking). As part of a self-accounting system,
participants earned points for participation in various activities in each of the six areas discussed. Point values for common activities were included in participant workbooks. Participants were asked to use log sheets to record their activity in each of the six areas and the given point value of each. Trainers collected log sheets from participants at the end of the eight-week program as a secondary assessment of activity participation. Activity participation was assessed with a self-administered survey pre- and post-intervention.

2. **Memory training**

In addition to discussion of lifestyle behaviors, the instructor presented information on each of the following memory training techniques at the end of six of the eight sessions: (1) Improve Attention to Improve Memory, involves strengthening attention-related skills such as listening through training in divided attention tasks; (2) Link-it, entails creating imaginary links between items that are to be remembered, (e.g., using images, sentences, senses); (3) Get Organized, or categorization, uses grouping of similar items together so that the conceptual group serves as a cue; (4) Roman Room Method (aka Method of Loci) associates each item to be remembered with a known place so that seeing the place will prompt memory of the item; (5) Rehearsal, uses repetition of information to enhance encoding in memory; and (6) External Memory Aids, such as creation of lists, post-it notes, or emails to oneself. The instructor discussed each strategy with the participants and encouraged them to practice the strategy at home before the next class. Participants were also given a handout summarizing each strategy.

3. **Cognitive training (Dakim BrainFitness System)**

In addition to the two components described above, the intervention provided for use of the Dakim BrainFitness system. According to the Dakim website, the program
focuses on “six essential cognitive domains: Long-Term Memory, Short-Term Memory, Critical Thinking, Visuospatial Orientation, Computation, and Language” and includes games and exercises that target each of these domains (“Stimulation,” n.d., para. 5). The website also notes that exercises are based upon “those found in standardized neurological evaluations” (“Neurological Tests,” n.d., para. 4). The company uses components of those evaluations as the basis of exercises that include music, graphics, stories, video clips, and other elements. Dakim exercises include five levels of difficulty for each of the six cognitive domains. Level 1 is designed for individuals with no cognitive decline. Levels 2 and 3 are for those with some age-related cognitive decline, and levels 4 and 5 are for individuals with mild-to-moderate cognitive impairment or dementia. The program assesses the user level and the appropriate exercise for each cognitive domain based on performance on previous challenges. As a motivational strategy, Dakim provides participants with a daily “scorecard” of correctly completed challenges at the end of each session. Participants were given free access to the Dakim BrainFitness system and encouraged to use it three to five times per week. The dosage is derived from a study, further described in the literature review, of Dakim use among older adults (Miller et al., in press). The research team received information from Dakim on the frequency but not the duration of use by each participant.

G. Measures

1. Eligibility screener

Research staff screened participants during their scheduled “informational and consent meeting.” Each applicant was screened by asking him/her if he/she was comfortable taking the course in English-speaking, has had no diagnosis of dementia, and was 55 and older.
If the participant answered affirmatively to all three of these criteria, he/she was considered eligible for the study. Individuals who were not eligible for the study were told that they could still attend the course without participating in the study.

2. **Outcome measures**
   
a. **Physical, social, and intellectual activity participation**

   Subjects were encouraged to increase participation in four of the five targeted lifestyle behaviors: physical activity, cognitive engagement, social engagement, and mental health/stress reduction. Items from the CHAMPS self-administered questionnaire were included in the self-administered survey participants completed pre- and post-intervention. This measure was designed specifically for evaluating physical activity interventions among older adults. Although CHAMPS was intended to measure physical activity, it included items on social activity (e.g., attendance at church or social meetings) and cognitive engagement (e.g., playing an instrument, reading). Respondents were asked to report weekly frequency of participation and duration of activities. Studies of CHAMPS have reported good reliability for moderate-to-vigorous exercise with good sensitivity to changes (Hekler et al., 2012; Stewart et al., 2001).

b. **Nutrition**

   Dietary behavior was assessed by the modified Harvard Service Food Frequency Questionnaire (HSFFQ). The HSFFQ is a self-administered survey that asks about an individual’s food and supplement intake over the past month. One study (Morris, Tangney, Bienias, Evans, & Wilson, 2003) found that the measure is reliable and fairly valid for the assessment of overall diet among diverse community-dwelling older adults. The study also found
that correlations for comparative validity were similar across individuals with varying cognitive scores, including a subset with MMSE scores indicating cognitive impairment.

c. **Mindfulness**

Kabat-Zinn (1994) defines mindfulness as “paying attention in a particular way: on purpose, in present moment, and non-judgmentally” (p. 4). Numerous studies demonstrate the efficacy of mindfulness as a stress reduction strategy (Fjorback, Arendt, Ornbøl, Fink, & Walach, 2011). As part of the mental health module, mindfulness practice was introduced as a way to relieve stress and promote mental health. During that week of the course, the instructor led a mindfulness meditation session and encouraged participants to participate in activities that promoted mindfulness, such as meditation and yoga. Mindfulness was measured on pre- and post- self-administered surveys by the Mindful Attention Awareness Scale (MAAS), which is a 15-item scale that asked respondents to indicate on a 6-point Likert scale how frequently they had the experience described in each statement. The measure has been demonstrated as a valid and reliable tool among a general adult population (Brown & Ryan, 2003).

d. **Delayed memory**

The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) was used to measure delayed memory. The RBANS is a short assessment that is administered individually. It is intended to measure the neuropsychological status of adults up to age 89. The RBANS has two parallel forms, which makes it possible to measure change in an individual’s neuropsychological status over time. The subtests used to measure delayed memory are: List Learning Free Recall, List Learning Recognition, Story Memory Free Recall, and Figure Free Recall. Raw scores from these subtests are combined to create index scores, and then
toted, which results in a total scale score. Split-half reliability for the delayed memory index of the RBANS across the three oldest age groups examined is as follows: age 60–69 years (R=.85), age 70–79 years (R=.81) and age 80–89 years (R=.83) (Randolph, 1998).

e. **Verbal fluency**

The Controlled Oral Word Association Test (COWAT) is used to measure verbal fluency, which is considered to be an executive function. The COWAT assesses a person’s ability to spontaneously produce words that begin with certain letters within a given time limit. Specifically, the test uses the letters F, A, and S. The test taker is given a practice trial with a different letter prior to beginning the actual test. In this study, the COWAT was administered individually at pre- and post-time points by a trained research technician. Internal consistency of the COWAT was relatively high for such a short test (coefficient alpha of R=.83). It has also demonstrated good test-retest reliability (R=.74, p<.001) (Ruff, Light, Parker, & Levin, 1996).

f. **Category fluency**

Category fluency is generally thought to reflect retrieval from semantic memory and is measured by a subtest in the RBANS. Subjects are given one minute to provide as many examples as they can from a given semantic category such as fruits and vegetables. Split-half reliability for the RBANS language index, of which the category subtest is a part, has been shown to be good across older age groups: age 60–69 years (R=.85), age 70–79 years (R=.81) and age 80–89 years (R=.83) (Randolph, 1998). Reliability for the category fluency subtest has not been reported.
g. **Applied cognition (subjective memory)**

A measure of applied cognition was taken from the Patient-Reported Outcomes Measurement Information System (PROMIS), a set of instruments developed by NIH to provide reliable and valid measures of self-reported physical, mental, and social well-being. The PROMIS Applied Cognition instrument measures perception of cognitive ability with regard to concentration and memory within the past seven days (NIH, 2012). The psychometric properties of the Applied Cognition scale have not been examined.

h. **Processing speed and executive function**

These two cognitive functions were measured by a neuropsychological test called the Trail-making test (Trails A and B), which measures visual attention and task switching. Test takers have to connect a number of dots in sequence as quickly as possible. The test provides information about a variety of cognitive abilities, including: speed of processing, mental flexibility, visual search speed, and executive functioning. It is also sensitive to detecting several cognitive impairments such as AD and dementia (Tombaugh, 2004).

i. **Course satisfaction and quality**

Course satisfaction and quality were assessed through quantitative and qualitative methods. Participants completed a self-administered survey following the last session of the program that included items asking about satisfaction with course components and extent to which objectives were met. Trainers and study participants also participated in separate feedback sessions held following the study. Feedback sessions were held at a minimum of two of the study sites in order to best represent the study participants. Participants were asked about
their general satisfaction with different elements of the program, barriers to participation, suggestions for future iterations of the program. In addition feedback sessions were held with program trainers, at which they were asked to share difficulties and challenges in implementation of the study materials and in carrying out the study protocol.

3. **Covariates**

Demographic data included gender, age, income, race, self-reported health, and health conditions. Intervention and control groups were compared to identify whether the groups differed by demographic variables. If differences in specific variables were found, those variables were used as covariates in the analyses. In addition, baseline values of the outcome measures were used as covariates.

H. **Sample Size and Power**

Because of the unique multimodal nature of the intervention, previous literature does not provide a good estimate of the expected effect size. One purpose of this pilot study is to generate an effect size that may be used in the design of a larger study. In order to estimate sample size, Cohen’s Conventions for small, medium, and large effects were used to determine the sample needed to detect a significant difference between groups for a range of effect sizes (Cohen, 1988). At an alpha level of 0.05 with 80% power and an effect size of 0.80 SDs, a sample size of 26 participants per study condition (total N=52) is required to detect a statistically significant difference between groups. To identify a medium effect size of 0.50 SDs with an alpha level of 0.05 and 80% power, 63 participants are required in each of the two study arms to detect a statistically significant difference between groups (total N=126). In order to identify a statistically significant difference between groups with a small effect size of 0.20 SDs, an alpha
level of 0.05, and 80% power, 391 participants are required per condition (total N=782). A sample size of 140 older adults was targeted for recruitment. Allowing for 10% attrition, the resulting sample would have the power to detect a medium effect of the intervention.

I. Analytic Plan

First, t-tests and chi-square tests were used to identify significant differences between intervention and control groups. Specifically, demographic variables and baseline values of the outcome measures were compared to determine if any of these variables should be controlled for in the analysis. Analyses were conducted to check for differential attrition. Chi-square analysis was used to detect any effect of attrition by study group and by site on demographics and on baseline values of the outcome measures. Additionally, t-tests were used to identify potential associations between attrition and any of the following: baseline cognitive performance, activity participation, or age. If differential attrition had occurred, affected variables would have been used as covariates in the outcome analyses.

Summary scores were created for activity participation, diet, mindfulness, and applied cognition. The distribution of change scores was examined for normality by visually plotting them against a normal distribution. If assumptions regarding normality are upheld, general linear models were used with group (intervention or control) as the between-group factor and time (baseline, pre-intervention, and post-intervention) as the within-subject factor. If the change scores did not follow a normal distribution, ordinal logistic regression was to be used. Categorical variables were evaluated for logical distribution. Low frequency categories were pooled for the analyses.
First, the association between program participation (attendance) and behavioral outcomes of activity participation and diet was assessed. Next, associations between the intervention and objective memory were assessed. Since this is a pilot study with a relatively small sample size, it was not expected that the intervention would yield significant associations between intervention components and objective memory. Analyses examined whether the association between the intervention and measures of objective memory demonstrated a trend toward significance.

Additionally, data from course evaluations were assessed by examining mean responses to items measuring satisfaction with Dakim BrainFitness software, satisfaction with each of the program modules, and extent to which course objectives were met. Qualitative data collected through direct observation of training sessions by research staff were analyzed to identify issues with implementation. This included a review of observations taken by research staff during site visits designed to capture the extent to which trainers are able to deliver the course materials and their adherence to study protocol.
IV. RESULTS

A. Sample Description

The demographic characteristics of the study sample are presented in Table VI. The sample consists of 118 adults, with a mean age of 76.45 years (SD: 9.17) who range in age from 56 to 98 in the year 2012. Just over three-quarters of the sample is female (76.6%) and Caucasian (80.0%). Nearly half (44.5%) are married. The sample is highly educated, with more than a quarter (28.8%) having some college and just over half having a college degree or higher (51.3%). Only 14.0% of participants are in the lowest income category (less than $20,000/year) with the remaining participants divided nearly evenly across the three higher categories. Most participants (56.6%) reported their health as “good” and none reported it as “poor.” Participants reported a mean of nearly three (2.93) health conditions (SD: 1.87). Demographic characteristics were further analyzed for the intervention group and control group separately. There are no statistically significant differences on demographic characteristics between the two groups.

<table>
<thead>
<tr>
<th>TABLE VI</th>
<th>PARTICIPANT CHARACTERISTICS AT BASELINE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>N/Mean</td>
<td>Percent/SD</td>
</tr>
<tr>
<td>Recruited/randomized</td>
<td>118</td>
</tr>
<tr>
<td>Lost to follow-up</td>
<td>22</td>
</tr>
<tr>
<td>Completed study</td>
<td>96</td>
</tr>
<tr>
<td>Age (mean)</td>
<td>76.45</td>
</tr>
<tr>
<td>Gender (Female)</td>
<td>85</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>88</td>
</tr>
<tr>
<td>Black</td>
<td>20</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
</tbody>
</table>
## PARTICIPANT CHARACTERISTICS AT BASELINE

<table>
<thead>
<tr>
<th></th>
<th>Total N/Mean</th>
<th>Intervention N/Mean</th>
<th>Control N/Mean</th>
<th>Difference at Baseline</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ethnicity (Hispanic Origin)</strong></td>
<td>1 .9</td>
<td>1 1.8</td>
<td>0 0.0</td>
<td>0</td>
<td>0.328</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>49 44.5</td>
<td>28 50.0</td>
<td>21 38.9</td>
<td>—</td>
<td>0.263</td>
</tr>
<tr>
<td>Living with a partner</td>
<td>2 1.8</td>
<td>1 1.8</td>
<td>1 1.9</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Separated or divorced</td>
<td>23 20.9</td>
<td>8 14.3</td>
<td>15 27.8</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Widowed</td>
<td>29 26.4</td>
<td>17 30.4</td>
<td>12 22.2</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Never married</td>
<td>7 6.4</td>
<td>2 3.6</td>
<td>5 9.3</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.695</td>
</tr>
<tr>
<td>8th grade or less</td>
<td>2 1.8</td>
<td>1 1.8</td>
<td>1 1.8</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Some high school</td>
<td>2 1.8</td>
<td>0 0.0</td>
<td>2 3.6</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>High school graduate</td>
<td>18 16.2</td>
<td>10 17.9</td>
<td>8 14.5</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Some college</td>
<td>32 28.8</td>
<td>14 25.0</td>
<td>18 32.7</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>College graduate</td>
<td>28 25.2</td>
<td>16 28.6</td>
<td>12 21.8</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Master’s or professional degree</td>
<td>24 21.6</td>
<td>13 23.2</td>
<td>11 20.0</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Doctoral or Medical degree</td>
<td>5 4.5</td>
<td>2 3.6</td>
<td>3 5.5</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td><strong>Income (n=78)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.695</td>
</tr>
<tr>
<td>Less than $20,000/year</td>
<td>13 14.0</td>
<td>8.3 10.4</td>
<td>8 17.8</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>$20,000–$49,999/year</td>
<td>31 33.3</td>
<td>30.0 37.5</td>
<td>13 28.9</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>$50,000–$79,999/year</td>
<td>24 25.8</td>
<td>20.0 25.0</td>
<td>12 26.7</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>$80,000 or more/year</td>
<td>25 26.9</td>
<td>21.7 27.1</td>
<td>12 26.7</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td><strong>Self-reported (n=94)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>0 0.0</td>
<td>0 0.0</td>
<td>0 0.0</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>26 21.3</td>
<td>12 21.1</td>
<td>14 25.5</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>69 56.6</td>
<td>36 63.2</td>
<td>33 60.0</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>17 13.9</td>
<td>9 15.8</td>
<td>8 14.5</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td><strong>Number of health conditions</strong></td>
<td>2.93 1.87 SD</td>
<td>2.87 1.97 SD</td>
<td>3.00 1.77 SD</td>
<td>.391</td>
<td></td>
</tr>
</tbody>
</table>
B. **Enrollment and Attrition**

A minimum of twelve and a maximum of 24 individuals were recruited at each of the six study sites, providing for class sizes of 6 to 12 following randomization. Recruitment targets were chosen so that class size (6 to 12 participants) would allow for participation and interaction among all participants. Study sites also had limited room space, making larger class sizes impractical.

![Diagram](Image)

Figure 3. Selecting the sample.
The format and language used in Figure 3 is based on recommendations for presenting data offered by Moher, Schultz, & Altman (2001). As indicated, a total of 120 individuals were initially screened for the intervention. Two met the inclusion criteria but declined to participate following discussion with research staff due to individual characteristics that were identified during screening. One of these was perceived to have aphasia by the research technician. The other was accompanied by a spouse who reported a previous stroke, memory decline, and severe aphasia. Although not rejected from the study, discussions between the participant, spouse, and research technician about the level of difficulty of the course led both potential participants to decline to participate.

The remaining 118 individuals were randomly assigned to the treatment arm or intervention arm, with one exception. One of the site trainers allowed one individual to join the intervention group rather than the randomly selected control group because of a stated inability to take the course in the fall, thus making the two groups initially uneven, with 60 in the intervention group and 58 in the control group. Two individuals in the intervention group and one from the control group discontinued the study before beginning the course (see Figure 3 for specific reasons given). Among participants who attended at least one of the eight sessions, 19 did not complete the course. Of these, 13 provided reasons for their withdrawal as follows: having a health problem(s) (n=6), being too busy to attend remaining classes (n=5), being both too busy and having health problems (n=2), or moving during the course of the program (n=1). The remaining participants (n=5) could not be contacted to ascertain their reason(s) for discontinuing the program. Because of the short study timeline, the eight-week course was scheduled to begin in the summer, a time during which many residents and customers were
taking vacations. This may have resulted in a higher rate of attrition due to conflicts in scheduling than if the course was offered at another time of the year.

Table VII shows a breakdown of enrollment and attrition by site, excluding the two subjects that were screened but not enrolled in the study. As indicated in the table, recruitment targets were met at all of the study sites. Twenty-two individuals withdrew from the study before completing the post-assessment measures, for an attrition rate of 18.6%.

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Enrolled</th>
<th>Did not complete n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Living</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Mather</td>
<td>21</td>
<td>2(9.5%)</td>
</tr>
<tr>
<td>Mather Place at Wilmette</td>
<td>20</td>
<td>3(15.0%)</td>
</tr>
<tr>
<td>Splendido</td>
<td>18</td>
<td>2(11.1%)</td>
</tr>
<tr>
<td>More than a Café locations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norwood Park</td>
<td>17</td>
<td>5(29.4%)</td>
</tr>
<tr>
<td>Portage Park</td>
<td>22</td>
<td>6(27.3%)</td>
</tr>
<tr>
<td>Chatham</td>
<td>20</td>
<td>4(20.0%)</td>
</tr>
<tr>
<td>Total enrollment</td>
<td>118</td>
<td>22(18.6%)</td>
</tr>
</tbody>
</table>

Attrition was considerably higher among individuals participating in the program at the Cafés than it was among those participating at senior living residences. A comparison of the two types of study sites (Café versus senior living) demonstrates that study site significantly predicts attrition (p=.04).

Table VIII shows the demographic characteristics of those who failed to complete the study as compared to those who completed it. There were no significant differences in demographic characteristics between the two groups, except in number of health conditions...
Those who completed the study had more health conditions than those who did not complete it.

**TABLE VIII**
STUDY COMPLETERS VS. NONCOMPLETERS

<table>
<thead>
<tr>
<th></th>
<th>Completed study (n=96)</th>
<th>Lost to follow-up (n=22)</th>
<th>Difference at Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N/Mean</td>
<td>Percent/SD</td>
<td>N/Mean</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>76.3</td>
<td>9.4</td>
<td>76.91</td>
</tr>
<tr>
<td><strong>Gender (Female)</strong></td>
<td>73</td>
<td>75.3</td>
<td>15</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>74</td>
<td>80.4</td>
<td>14</td>
</tr>
<tr>
<td>Black</td>
<td>16</td>
<td>17.4</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>2.2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Ethnicity (Hispanic Origin)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>1</td>
<td>1.1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>42</td>
<td>45.7</td>
<td>7</td>
</tr>
<tr>
<td>Living with a partner</td>
<td>2</td>
<td>2.2</td>
<td>0</td>
</tr>
<tr>
<td>Separated or divorced</td>
<td>17</td>
<td>8.5</td>
<td>6</td>
</tr>
<tr>
<td>Widowed</td>
<td>24</td>
<td>26.1</td>
<td>5</td>
</tr>
<tr>
<td>Never married</td>
<td>7</td>
<td>7.6</td>
<td>0</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8th grade or less</td>
<td>1</td>
<td>1.1</td>
<td>1</td>
</tr>
<tr>
<td>Some high school</td>
<td>1</td>
<td>1.1</td>
<td>1</td>
</tr>
<tr>
<td>High school graduate</td>
<td>14</td>
<td>15.1</td>
<td>4</td>
</tr>
<tr>
<td>Some college</td>
<td>25</td>
<td>26.9</td>
<td>7</td>
</tr>
<tr>
<td>College graduate</td>
<td>25</td>
<td>26.9</td>
<td>3</td>
</tr>
<tr>
<td><strong>Master’s or professional degree</strong></td>
<td>23</td>
<td>24.7</td>
<td>1</td>
</tr>
<tr>
<td><strong>Doctoral or Medical degree</strong></td>
<td>4</td>
<td>4.3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $20,000/year</td>
<td>9</td>
<td>11.5</td>
<td>4</td>
</tr>
<tr>
<td>$20,000–$49,999/year</td>
<td>25</td>
<td>32.1</td>
<td>6</td>
</tr>
<tr>
<td>$50,000–$79,999/year</td>
<td>20</td>
<td>25.6</td>
<td>4</td>
</tr>
<tr>
<td>$80,000 or more/year</td>
<td>24</td>
<td>30.8</td>
<td>1</td>
</tr>
<tr>
<td><strong>Self-reported</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>Fair</td>
<td>20</td>
<td>21.3</td>
<td>6</td>
</tr>
<tr>
<td>Good</td>
<td>58</td>
<td>61.7</td>
<td>11</td>
</tr>
<tr>
<td>Excellent</td>
<td>16</td>
<td>17.0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Number of conditions</strong></td>
<td>3.10</td>
<td>1.90</td>
<td>2.14</td>
</tr>
</tbody>
</table>
In addition, t-tests were used to identify potential associations between attrition and baseline 1) cognitive performance, 2) activity participation, 3) and age. As indicated in Table IX, Trails B and Delayed Recall significantly predicted attrition.

<table>
<thead>
<tr>
<th></th>
<th>Completed study</th>
<th>Lost to follow-up</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>List Recall</td>
<td>26.68</td>
<td>5.07</td>
<td>23.64</td>
<td>6.38</td>
</tr>
<tr>
<td>Delayed recall</td>
<td>5.18</td>
<td>2.48</td>
<td>4.05</td>
<td>3.11</td>
</tr>
<tr>
<td>Category fluency</td>
<td>18.27</td>
<td>5.03</td>
<td>18.5</td>
<td>4.51</td>
</tr>
<tr>
<td>Letter fluency</td>
<td>38.43</td>
<td>11.4</td>
<td>35.73</td>
<td>13.29</td>
</tr>
<tr>
<td>Trails A</td>
<td>46.02</td>
<td>18.74</td>
<td>47.91</td>
<td>24.26</td>
</tr>
<tr>
<td>Trails B</td>
<td>118.39</td>
<td>63.43</td>
<td>155.55</td>
<td>83.42</td>
</tr>
<tr>
<td>Applied cognitive ability</td>
<td>21.989</td>
<td>5.72</td>
<td>20.071</td>
<td>6.43</td>
</tr>
<tr>
<td>Depression</td>
<td>3.813</td>
<td>4.82</td>
<td>5.412</td>
<td>5.48</td>
</tr>
<tr>
<td>Anxiety</td>
<td>2.478</td>
<td>2.7</td>
<td>3.4</td>
<td>3.09</td>
</tr>
</tbody>
</table>

Analysis also examined potential associations between attrition and baseline values of participation in targeted behaviors and age. As indicated in Table X, the mean scores for physical activity, cognitive engagement, and diet were higher than among those who completed the study but were not significant predictors of attrition. The same was true for most objective measures of cognition, including list recall, delayed recall, and letter fluency, for all of which a higher score indicates better cognitive performance. Letter fluency was slightly lower among those who did not complete the study, but was not significantly different. The score for Trails A and B were
lower (which indicates better cognition), but again, were not significant predictors of attrition. Only social engagement was significantly associated with attrition (p=.05). Individuals with higher levels of social engagement were less likely to complete the study.

<table>
<thead>
<tr>
<th>Table X</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSOCIATION BETWEEN ATTRITION</td>
</tr>
<tr>
<td>AND BASELINE VALUE OF BEHAVIORAL</td>
</tr>
<tr>
<td>MEASURES AND AGE</td>
</tr>
<tr>
<td>Completed</td>
</tr>
<tr>
<td>study</td>
</tr>
<tr>
<td>phys</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>Physical activity</td>
</tr>
<tr>
<td>17.654</td>
</tr>
<tr>
<td>Cognitive engagement</td>
</tr>
<tr>
<td>13.133</td>
</tr>
<tr>
<td>Diet</td>
</tr>
<tr>
<td>33.888</td>
</tr>
<tr>
<td>Social engagement</td>
</tr>
<tr>
<td>11.815</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>76.34</td>
</tr>
</tbody>
</table>

1. **Change in frequency of lifestyle behaviors**

The distribution of change scores was examined for normality by visually plotting them against a normal distribution. Since assumptions regarding normality were upheld, linear models were used with group (intervention or control) as the between-subject factor and time (baseline and post-intervention) as the within-subject factor. The baseline value of the outcome measure for each participant was entered as a covariate. Although initially part of the research plan, attendance could not be used as a measure of participation in the analysis. Instructors were asked to take attendance; however, it was not recorded consistently across study sites, with less
than a third (n=37, 30.3%) doing so. For this reason, study condition was used as the primary independent variable in assessing the efficacy of the intervention.

After controlling for baseline level of each behavior and type of site (Senior Living versus Café), data showed that mean change scores were greater for the intervention group than for the control group in every area except social engagement; however, none of these differences reached the level of statistical significance. (See Table XI). Physical activity increased an average of 1.84 points (10.53%) relative to the baseline score in the intervention group and decreased 1.53 points (8.19%) in the control group. Cognitive engagement decreased in both groups, but the decrease was greater in the control group (-0.813) than in the intervention group (-0.177). Diet scores among both groups also decreased; however, change in this direction is desirable because a lower score indicates fewer poor eating behaviors. Although not statistically significant, the mean decrease for the intervention group (-4.340) in nutrition (poor eating behaviors) is lower than the mean decrease for the control group (-2.383). Social engagement worsened among the intervention group, with participants in that group decreasing their score by an average of -0.644 and control group participants increasing their mean score by 0.050.

### TABLE XI

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Intervention change score</th>
<th>Control change score</th>
<th>F value</th>
<th>P value</th>
<th>Partial eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical activity</td>
<td>96</td>
<td>1.843</td>
<td>11.9</td>
<td>9.42</td>
<td>2.097</td>
<td>0.151 .086</td>
</tr>
<tr>
<td>Cognitive engagement</td>
<td>96</td>
<td>-0.177</td>
<td>4</td>
<td>-0.813</td>
<td>4.27</td>
<td>0.55 0.460</td>
</tr>
<tr>
<td>Diet¹</td>
<td>96</td>
<td>-4.34</td>
<td>7.59</td>
<td>-2.383</td>
<td>7.51</td>
<td>0.253 0.616</td>
</tr>
<tr>
<td>Social engagement</td>
<td>96</td>
<td>-0.644</td>
<td>5.15</td>
<td>0.05</td>
<td>4.53</td>
<td>0.648 0.423</td>
</tr>
</tbody>
</table>

¹Baseline value of the outcome variable and type of site (Senior Living vs. Café) were included as covariates.
²The diet scale asks about poor eating behaviors, thus a lower score indicates better diet.
TABLE XII
ASSOCIATION BETWEEN COGNITIVE OUTCOMES AND TREATMENT ARMa

<table>
<thead>
<tr>
<th></th>
<th>Intervention change score</th>
<th>Control change score</th>
<th>F value</th>
<th>P value</th>
<th>Partial eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Delayed recall</td>
<td>1.21</td>
<td>4.98</td>
<td>2.56</td>
<td>4.83</td>
<td>2.055</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.155</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.081</td>
</tr>
<tr>
<td>Category fluency</td>
<td>0.92</td>
<td>6.15</td>
<td>-1.06</td>
<td>5.18</td>
<td>1.263</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.264</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.274</td>
</tr>
<tr>
<td>Letter fluency</td>
<td>3.08</td>
<td>8.77</td>
<td>-0.02</td>
<td>7.61</td>
<td>2.288</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.134</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.060</td>
</tr>
<tr>
<td>Trails A</td>
<td>6.25</td>
<td>12.81</td>
<td>2.67</td>
<td>14.48</td>
<td>1.178</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.281</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.286</td>
</tr>
<tr>
<td>Trails B</td>
<td>-11.17</td>
<td>36.73</td>
<td>-12.75</td>
<td>44.58</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.945</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.277</td>
</tr>
<tr>
<td>Applied cognitive ability</td>
<td>0.907</td>
<td>5.18</td>
<td>1.075</td>
<td>4.61</td>
<td>0.073</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.787</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.176</td>
</tr>
<tr>
<td>Mindfulness</td>
<td>1.08</td>
<td>12.33</td>
<td>-0.0991</td>
<td>6.93</td>
<td>0.179</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.674</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.213</td>
</tr>
</tbody>
</table>

a Baseline value of the outcome variable and type of site (Senior Living vs. Café) were included as covariates.

The same procedure was utilized to analyze differences between the control and intervention groups in cognitive performance measured through objective cognitive assessments and self-reported applied cognitive ability and mindfulness (See Table XII). Again, baseline value of the outcome variable and type of site (Senior Living versus Café) were entered as covariates. There were no significant differences between intervention and control groups in the measures of cognitive performance. Magnitude of change for both groups was small. Intervention group participants scored higher on category fluency, where the mean change of 0.92 represents a 5.24% change over the baseline score for this measure. The control group score of -1.06 is a decrease of 4.56% relative to baseline. Individuals in the intervention group also improved (3.08, 8.45%) on letter fluency, while those in the control group had nearly the same score (mean change=-.02, 0.00%) as they did at baseline. Intervention group participants also saw slight improvements in mindfulness (mean change=1.08, 3.5%) while control group
participants remained nearly the same (mean change=-.0991, 0.30%) in this area. With regard to the remaining measures, however, intervention group participants did not score as well as control group participants. The mean change score for delayed recall was 1.21 (5.30% higher than baseline) for the intervention group and 2.56 (11.00% higher than baseline) for the control group. The control group also saw greater improvements in Trails A and B, timed tests where a lower score indicates better cognitive performance. On Trails A, the intervention group increased an average of 6.25 points, and the control group increased only 2.67 points. Both groups improved on Trails B, but control group participants improved slightly more, with an average change of -12.75 versus -11.17 for the intervention group. Finally, on applied cognition, control group participants increased their score slightly more on average (1.075) than the intervention group (0.907).

C. Course Evaluation

Participants were asked to rate the course relative to a number of criteria listed in Table XIII. On a scale of 1–4 where 1=poor, 2=fair, 3=good and 4=excellent, mean ratings ranged from 2.82 for “usefulness of class activities” to 3.11 for “trainers’ training style.” In addition, the great majority (83%) of participants in the intervention (34 of 41) said they enjoyed the course. Another six (14.6%) said they were “indifferent,” and only one (2.4%) said s/he did not enjoy the course. The same response distribution (34, 6, and 1) was found in relation to the question of whether the course was useful. Half of participants (n=21, 50%) said that the course motivated them “a lot,” and slightly less (n=18, 42.5%) said it motivated them “a little” to live a healthy lifestyle. Participants generally felt they met the objectives of the class to a moderate or great
extent. (See Table XIV). Participants gave the lowest average rating (Mean: 2.73, SD: .788) in response to the question of whether they had made changes to their lifestyle. The higher rating (Mean: 3.2, SD: 1.025) on intention to change in coming months may be more indicative of future change. A large majority (85%) said they would recommend the course to a friend.

**TABLE XIII**

COURSE QUALITY (n=44)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization of class content</td>
<td>2.95</td>
<td>.61</td>
</tr>
<tr>
<td>Relevance of information presented</td>
<td>3.09</td>
<td>.56</td>
</tr>
<tr>
<td>Usefulness of class activities</td>
<td>2.75</td>
<td>.78</td>
</tr>
<tr>
<td>Usefulness of visual aids</td>
<td>2.82</td>
<td>.92</td>
</tr>
<tr>
<td>Trainers’ knowledge of material</td>
<td>3.05</td>
<td>.78</td>
</tr>
<tr>
<td>Trainers’ training style</td>
<td>3.11</td>
<td>.87</td>
</tr>
</tbody>
</table>

On a scale of 1–4 where 1=poor, 2=fair, 3=good and 4=excellent

**TABLE XIV**

EXTENT TO WHICH COURSE OBJECTIVES WERE MET (n=44)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I understand how lifestyle affects my risk for dementia.</td>
<td>44</td>
<td>3.39</td>
<td>.78</td>
</tr>
<tr>
<td>I understand more about how the adult brain changes.</td>
<td>42</td>
<td>3.26</td>
<td>.77</td>
</tr>
<tr>
<td>I understand why staying mentally active can lower my risk for dementia.</td>
<td>44</td>
<td>3.68</td>
<td>.64</td>
</tr>
<tr>
<td>I understand how what I eat affects how my brain ages.</td>
<td>44</td>
<td>3.48</td>
<td>.79</td>
</tr>
<tr>
<td>I understand how managing stress can lower my risk for dementia.</td>
<td>44</td>
<td>3.55</td>
<td>.76</td>
</tr>
<tr>
<td>I understand how being socially active lowers my risk for dementia.</td>
<td>44</td>
<td>3.66</td>
<td>.61</td>
</tr>
<tr>
<td>I understand how physical exercise can help lower my risk for dementia.</td>
<td>44</td>
<td>3.68</td>
<td>.67</td>
</tr>
<tr>
<td>I have made changes in my lifestyle based on what I learned in this course.</td>
<td>44</td>
<td>2.73</td>
<td>.79</td>
</tr>
<tr>
<td>I plan to continue the lifestyle changes I have made.</td>
<td>44</td>
<td>3.23</td>
<td>.94</td>
</tr>
<tr>
<td>I plan to make even more lifestyle changes in the coming months to lower my risk for dementia.</td>
<td>44</td>
<td>3.2</td>
<td>1.03</td>
</tr>
</tbody>
</table>

On a scale of 1–4 where 1=not at all, 2=to a slight extent, 3=to a moderate extent, and 4=to a great extent.
Participants using the Dakim program rated their experience with the program very positively. (See Table XV). Technical problems were an ongoing issue (addressed more fully in the Discussion section), but this did not appear to impact the overall rating of the program. Furthermore, participants indicated that they were only slightly to moderately impacted by technical issues. Participants also rated their overall experience using the Dakim program as 4.14 (SD: .887) on a scale of 1–5 with 5 being the highest (“very positive”).

**TABLE XV**
SATISFACTION WITH DAKIM BRAINFITNESS SOFTWARE

<table>
<thead>
<tr>
<th>Dakim Evaluation items</th>
<th>n</th>
<th>Mean rating</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoyed using the Dakim program</td>
<td>38</td>
<td>4.34</td>
<td>.91</td>
</tr>
<tr>
<td>The Dakim program was easy to use</td>
<td>37</td>
<td>4.26</td>
<td>1.17</td>
</tr>
<tr>
<td>I feel like the Dakim program challenged my brain</td>
<td>38</td>
<td>4.36</td>
<td>.80</td>
</tr>
<tr>
<td>I was frustrated by technical issues</td>
<td>38</td>
<td>2.75</td>
<td>1.55</td>
</tr>
<tr>
<td>I was frustrated by other aspects of the Dakim program</td>
<td>37</td>
<td>2.66</td>
<td>1.45</td>
</tr>
<tr>
<td>(nontechnical)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I will continue to use the Dakim program on my own</td>
<td>38</td>
<td>4.12</td>
<td>1.53</td>
</tr>
</tbody>
</table>

On a scale of 1–5 where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.

Participants were also asked questions about preference for individual program modules. As shown in Table XVI, the largest number (n=16, 39%) reported finding the module focusing on nutrition to be the most useful, while the module addressing spirituality was most frequently reported (n=10, 27.8%) as least useful. The greatest number of participants (n=10, 24.4%) said
they enjoyed the module on social engagement the most, and the closing module (n=9, 26.5%) the least.

**TABLE XVI**
SATISFACTION WITH INDIVIDUAL PROGRAM MODULES

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Introduction</th>
<th>Physical Activity</th>
<th>Emotional</th>
<th>Intellectual</th>
<th>Nutrition</th>
<th>Spiritual</th>
<th>Social</th>
<th>Closing</th>
</tr>
</thead>
<tbody>
<tr>
<td>The session I found most useful was:</td>
<td>41</td>
<td>0</td>
<td>2 (4.9)</td>
<td>3 (7.3)</td>
<td>9 (22.0)</td>
<td>16 (39.0)</td>
<td>3 (7.3)</td>
<td>3 (7.3)</td>
<td>5 (6.0)</td>
</tr>
<tr>
<td>The session I found least useful was:</td>
<td>36</td>
<td>6 (16.7)</td>
<td>2 (5.6)</td>
<td>6 (16.7)</td>
<td>3 (8.3)</td>
<td>1 (2.8)</td>
<td>10 (27.8)</td>
<td>3 (8.3)</td>
<td>5 (13.9)</td>
</tr>
<tr>
<td>The session I enjoyed most was:</td>
<td>41</td>
<td>0</td>
<td>9 (22.0)</td>
<td>3 (7.3)</td>
<td>5 (6.0)</td>
<td>6 (14.6)</td>
<td>2 (4.9)</td>
<td>10 (24.4)</td>
<td>6 (14.6)</td>
</tr>
<tr>
<td>The session I enjoyed least was:</td>
<td>34</td>
<td>4 (11.8)</td>
<td>2 (5.9)</td>
<td>4 (11.8)</td>
<td>4 (11.8)</td>
<td>3 (8.8)</td>
<td>7 (20.6)</td>
<td>1 (2.9)</td>
<td>9 (26.5)</td>
</tr>
</tbody>
</table>
CONCLUSIONS

A. Discussion

This study utilized data from a randomized controlled trial that was designed to promote cognitive health among older adults in the Chicagoland area. Specifically, this study examined the association between participation in the eight-week program and “brain-healthy” behaviors and cognitive performance. The targeted behaviors are: physical activity, healthy eating, social engagement, cognitive engagement, and stress reduction. The intervention also included classroom-based instruction in memory strategies and use of an online “brain training” software. With a sample of 118 older adults, this study did not demonstrate significant increases in targeted behaviors or in short-term cognitive performance that could be attributed to the intervention.

1. Behavior change outcomes

Participants in both intervention and control groups increased their activity in four of the five behavioral outcomes examined, with the exception of social engagement; however, these increases were not significantly greater than increases demonstrated in the control group. Lack of statistically significant changes in the targeted lifestyle behaviors may be due to several factors. First, participants already had high levels of physical, social, and intellectual activity at baseline. This was particularly true of those living at two of the three independent living residences included in the study. Specifically, The Mather and Splendido offer a wide variety of activities in each of the areas promoted in this program. At informal feedback sessions held after the eight-week program, many of the residents at these sites reported that they already had active schedules and were not able and/or motivated to incorporate more activity into their lives. Café
participants were also active, many of whom took part in the programs and activities offered at their location.

In contrast, age and related frailty may have affected ability of participants from the third independent living residence, Mather Place at Wilmette, to increase targeted behaviors. Participants from this study site had a mean age of 85 years (SD: 7.14) and limited physical function. Although technically an independent living residence, the majority of residents have some form of instrumental assistance from a home health care aide. Participants who already had some level of activity may not have had the ability to make significant increases or had the self-efficacy to do so. Although social and intellectual activities and those geared toward stress reduction do not require the same physical capability as increasing physical activity, many of the related activities offered by the residence are group activities and involve attending a session. According to staff, many residents spend the large majority of their time resting in their apartments and do not have the physical reserve to attend more than infrequent group activities. In addition, many of the residents at Mather Place at Wilmette reported an inability to make healthier food choices because they relied upon a limited set of options offered by dining services at the residence. This suggests that the program may be better for a slightly younger group of older adults with a higher level of physical function.

Participants were asked to attend one-hour long sessions once per week for eight weeks in which they learned about the potential benefits of each of the targeted behaviors in relation to cognitive health. Program instructors were asked to take attendance at each of the sessions in order to assess each individual’s degree of participation, but did not do so reliably. Where instructors did take attendance, the data show that participants attended between three and eight
of the eight sessions (Mean: 6.43, SD: 1.48). However, when participants reported their attendance in the post-program survey, they reported attending between five and eight of the sessions (Mean: 7.00, SD: .91). In addition to the potential issue of recall bias, participants did not report which of the sessions they attended. For this reason, overall program participation was used as the independent variable. This means that participants were included in the analysis of behavior change for a certain behavior (e.g., physical activity), when they may not have attended the session promoting change in that area.

An additional issue related to assessment is the timing of the social engagement module relative to the follow-up survey assessing change. This module was conducted second to last within the eight sessions of the program. Participants took the post-test assessing social engagement either immediately after or on a different date within two weeks of completing the final module. This meant that participants had only one to three weeks to increase their social engagement. Although an individual may choose to attend additional activities that are social in nature, availability of existing social contacts, level of social functioning, and willingness of social contacts to participate in interactions also heavily influence social engagement and may be difficult to change. Therefore, this study may not have provided sufficient time or resources to demonstrate increased activity in this area.

Finally, the absence of significant behavior change may be due to characteristics of the program, most notably, the limited nature of the intervention. For each of the targeted behavioral areas, the intervention consisted of only one hour of classroom-based instruction with limited follow-up in the next session and as a review in the closing session. Changing long-term habits and behaviors is challenging for older adults, and one hour of education may have been
insufficient to develop the necessary motivation and enable participants to overcome obstacles such as a perceived lack of time or resources. Although the intervention incorporated features of social learning theory, such as creating a supportive environment and goal-setting, observations conducted by research staff and informal feedback sessions suggested that there was poor fidelity to the research protocol.

2. **Cognitive change outcomes**

Lack of improvement in cognitive performance may be the result of an insufficient dose and duration of the online component of the intervention. Change in performance on cognitive tests was expected to result mainly from use of the Dakim BrainFitness software, however, technical difficulties prevented many participants from utilizing the system at the recommended frequency of three times per week for eight weeks. These problems were largely due to glitches in the software that had been recently adapted for installation on personal computers. Although software installation was planned for a month prior to the beginning of the study, technical problems were extensive and ongoing at each of the six sites. Resolving these issues required a large investment of time by IT personnel, who had to travel to each of the six sites repeatedly. This resulted in significant delays in accessing the software, which meant that some participants were not able to use it until more than halfway into the study. After being provided with access, participants largely enjoyed using Dakim and rated it highly, however, their limited exposure to the training may account for a lack of significant change in cognitive performance.

In addition to these obstacles to access, it was not possible to obtain a highly accurate measure of Dakim use among participants. Dakim provided data showing the frequency with
which users logged onto the system but not the length of time they spent on the system. This meant that there was no way to differentiate between an online session lasting five minutes and one lasting two hours. Because of the difficulties in providing participants with access to the system and with tracking the amount of their usage, data were insufficient to separate the effect of Dakim BrainFitness software from the educational instruction provided on lifestyle factors and memory strategies.

3. **Program feasibility**

In addition to examining the data for associations with the targeted outcomes, another purpose of the study was to assess the feasibility of implementing a new brain fitness program among older adults. Survey results and informal feedback sessions following the program provided information on participants’ response to the course content, format, and other elements. The response to the program was generally positive, as indicated by the survey results relating to course quality and extent to which objectives were met. Feedback sessions with participants and instructors provided a greater depth of understanding as to the perceived strengths and weakness of the course. Survey data and informal feedback sessions suggested the following strengths: perceived relevance, utility, and enthusiasm for the course among this population, the belief that course objectives were largely met by the program, and receptiveness to online brain training programs reflected by the high ratings of the Dakim BrainFitness program and their reported interest in continuing to use it.

The most common suggestions for revision given by participants were to: reduce the overall program length, omit some of the classroom activities that were simple in nature (e.g., in-class meditation, chair exercises), and increase the length of time the Dakim BrainFitness system
was available. Instructors expressed an enthusiasm and appreciation for the course material and a belief in its value and relevance. The most frequently reported challenge pertained to difficulty in covering the weekly material within the allotted hour of classroom time and a need to edit the content to better fit time constraints of the study.

Attrition can be considered another measure of program feasibility. Attrition for this study was 18.6 percent. This calculation considers dropouts to be any individuals who enrolled in the study and were randomized to the intervention group or control group but did not complete the post-test assessment even if they completed the course. Because a reliable record of attendance was not taken, there are not complete data on the number of sessions the dropouts attended. Incomplete records indicate that nearly all of the dropouts failed to attend multiple sessions, and most typically withdrew from the study in the first half of the program. There is no agreed-upon rate of attrition that is acceptable or for which related bias is known to be a problem. Schulz and Grimes (2002) argue that loss to follow-up of 20% or higher means that possibility of bias should be a concern, whereas losses between 5% and 20% percent are of lesser concern, though they may still be a source of bias. Attrition was significantly higher among participants from the Café sites as compared to those at the independent living residences. One reason for this may be the greater degree of convenience in attending classes experienced by those at the independent living residences as compared with those in the Cafés. Participants at the residences attended the classes in the same building in which they lived, while those at the Cafés needed to travel to the study site. In addition, participants at the residences most likely had greater interaction with the course trainers who worked in their building, as compared with participants at the Cafés. This interaction may have strengthened their commitment to continue the course, either through
reminders and encouragement given by trainers, or through a greater sense of accountability or obligation. Similarly, those at the independent living sites were attending the program with others they knew, making the social aspect of attendance a potential motivation.

Number of health conditions was also significantly, though inversely, associated with attrition. While this seems counterintuitive, it may be that those who were healthier were more likely to travel, thereby missing more classes. Missing classes was a common reason given for failing to complete the course. Finally, data were examined for potential associations between attrition and baseline values of participation in targeted behaviors and age. Of these, social engagement was the only measure significantly associated with attrition, with higher levels of social engagement predicting failure to complete the study. It may be that individuals with more social interaction had a higher frequency of social commitments that competed with program attendance.

B. Additional Study Limitations

An additional limitation of this study was a lack of representativeness of the study population. The study utilized a convenience sample rather than a representative, population-based sample, thereby introducing a threat to external validity. As described in the Results chapter, participants were more likely to be white, female, highly educated, and from a higher income group than the general population of older adults. In addition, approximately half of the study participants resided in independent living residences, which provided them with a wealth of options to participate in activities related to the targeted behaviors. The community-dwelling participants were also already connected with similar resources available through the Café sites where they attended the program. However, the analysis did demonstrate that demographic
factors including race/ethnicity, gender, education, and income, did not predict the efficacy of the intervention, nor did study site (independent living residence versus Café). Moreover, this study was meant as an initial pilot of the material and as a step toward future studies.

Lastly, the sample size, although large for a pilot study, was small for a randomized controlled trial. It was large enough to detect a moderate to large effect, but not a small effect that can be considered statistically significant.

C. **Summary**

Observational studies are relatively consistent in suggesting an association between certain lifestyle factors and cognitive decline and AD; however, few high-quality intervention studies have been conducted to test this relationship. This study was unique in that it used a randomized controlled trial to test variables including behavior change, training in memory strategies, and online memory training among older adults. The original intervention study was very ambitious in scope, which may have diluted the strength of any one component of the intervention. Challenges described above pertaining to measurement and data collection also precluded analyses of the separate effects of each component of the intervention. While this study failed to show significant associations between program participation and behavioral or cognitive change, it provided important information in the feasibility of this type of study with an older adult population.

D. **Follow-up Studies**

A second study testing a modified form of this intervention was begun in April, 2013. The program being delivered as part of this study was revised in content and format based on lessons learned from the initial implementation. First, the targeted behaviors were reduced from
five to three, with the revised program focusing on physical activity, cognitive engagement, and stress reduction. This allows for more attention to be paid to promoting these behaviors and to the behavior change process itself. The program was also shortened from eight weeks to six weeks based on feedback from instructors and participants. In addition, improved measures were included for recording program participation and participation in the promoted behaviors. Study staff are also dedicating greater time and attention to ensuring that site trainers track attendance at each session and encourage participants to complete logs of their activities each day. Activity logs provide a better measure of participation in the targeted behaviors than program participation alone. In addition to these changes, the post-program survey is being delivered at a third time point, six weeks following to the program, in order to assess whether any behavior change or cognitive benefit continues over time.

The revised program is being tested with older adults at 14 independent living residences throughout the United States. Although this does not increase the diversity of the sample, except geographically, it does match organizational plans to further disseminate this program following completion of the study.

E. Lessons for the Field

This study was intended to test the feasibility of a new brain fitness program among older adults, and to provide some indication as to the efficacy of the program. Findings from this study and the review of the relevant literature indicate that additional, larger, and more representative studies are needed which could better assess the efficacy of multimodal interventions to promote cognitive health. Several studies have suggested that increasing multiple behaviors may be more effective in reducing risk of AD and dementia than increasing a single behavior (Eisenstein,
Future studies of this kind should include protocols to ensure measurement of dosage and duration of targeted behaviors and other components is as accurately as possible. Measures of physical activity would be strengthened by use of a biometric data. In addition, lessons learned from this study suggest that program feasibility and fidelity of implementation would be strengthened by additional supports for staff disseminating the program, such as ongoing meetings or conference calls in which they could discuss challenges of program implementation. Although limited in its representativeness, this study also demonstrates the general receptiveness among older adults in this demographic segment to regularly engage with an online brain training program and to participate in and complete a behavior change program focused on preserving cognitive health.

In addition to advancing understanding of behavioral factors in cognitive health, future studies should address the limited but growing body of research on online memory training programs (Anguera et al., 2013). As evidence for the benefits of these types of online training games becomes stronger, researchers can better assess the value of combining programs such as Neuro Racer, Dakim BrainFitness, or Posit Science, with behavioral change programs, as well as the likelihood that older adults will be willing to adhere to a level of online training that will provide a sufficient dose for the training to be efficacious. In regard to both the study of behavioral factors and online training, there remains a need for longitudinal assessment that could better address the long-term impact of such programs.
March 12, 2013

Catherine O'Brien, MA
Public Health
1401 Madison Street
Evanston, IL 60202
Phone: (847) 492-6803 / Fax: (847) 492-6789

RE: Research Protocol # 2013-0218
“Testing a Conceptual Model of Variables Associated with Cognitive Health among Older Adults”

Sponsor: None

Dear Ms. O'Brien:

The above proposal was reviewed on March 10, 2013 by OPRS staff/members of IRB #2. From the information you have provided, the proposal does not appear to involve “human subjects" as defined in 45 CFR 46. 102(f).

The specific definition of human subject under 45 CFR 46.102(f) is:

*Human subject* means a living individual about whom an investigator (whether professional or student) conducting research obtains

1. data through intervention or interaction with the individual, or
2. identifiable private information.

*Intervention* includes both physical procedures by which data are gathered (for example, venipuncture) and manipulations of the subject or the subject’s environment that are performed for research purposes. *Interaction* includes communication or interpersonal contact between investigator and subject. *Private information* includes information about behavior that occurs in a context in which an individual can reasonably expect that no observation or recording is taking place, and information which has been provided for specific purposes by an individual and which the individual can reasonably expect will not be
made public (for example, a medical record). Private information must be individually identifiable (i.e., the identity of the subject is or may readily be ascertained by the investigator or associated with the information) in order for obtaining the information to constitute research involving human subjects. All the documents associated with this proposal will be kept on file in the OPRS and a copy of this letter is being provided to your Department Head for the department's research files.

If you have any questions or need further help, please contact the OPRS office at (312) 996-1711 or me at (312) 355-2908. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Charles W. Hoehne
Assistant Director
Office for the Protection of Research Subjects

cc: Paul Brandt-Rauf, Public Health, M/C 923
    Susan Hughes, Community Health Sciences, M/C 275
CITED LITERATURE


Amieva, H., Stoykova, R., Matharan, F., Helmer, C., Antonucci, T. C., & Dartigues, J. F. (2010). What aspects of social network are protective for dementia? Not the quantity but the quality of social interactions is protective up to 15 years later. *Psychosomatic Medicine, 72*(9), 905.


VITA

Catherine J. O’Brien, MPH, MA
Doctoral Candidate
1603 Orrington Avenue
Evanston, Illinois, 60201

EDUCATION

University of Illinois, Chicago  PhD candidate  Public Health  2008–2014
San Diego State University  MPH  Epidemiology  2003–2005
Univ. of California, San Diego  MA  Anthropology  1997–2000
Univ. of Wisconsin, Madison  BEd  English  1989–1993

PROFESSIONAL EXPERIENCE

Mather LifeWays Institute on Aging, Evanston, IL (9/05–present)
Director of Workforce Research, 3/06–present
Project Manager, 11/05–3/06
Senior Research Associate, 9/05–11/05

PUBLICATIONS

essentials program: Importance of trainers in achieving targeted outcomes. Gerontology &

preparedness: A study of organizational types and levels of preparedness for a disaster or

living: Perspectives of 23 pioneering communities. Seniors Housing & Care Journal,
18(1), 53–65.

Geriatric Nursing, 31(3), 228–230

disaster response and recovery. Journal of Public Health Management and Practice,
Supplement, 2, S20-4.


PROFESSIONAL PRESENTATIONS

O’Brien, C. (November 2013). Evaluation of a Multimodal Intervention to Promote Cognitive Health Among Older Adults. John & Gwen Smart Symposium, Chicago, IL.


GRANTS/FUNDING SUPPORT

2012 Spencer Powell Brain Fitness Program, $165,000, Spencer Powell Endowment, January 1, 2012–December 31, 2012 (PI)

2009 REALPREP: Real-Time Planning and Training System to Improve Long-Term Care Disaster Preparedness, $99,982, Small Business Innovative Research grant funded by CDC (COTPER program) December 1, 2009–June 1, 2010. (Co-Investigator)

2009 Best Care III: Developing Cultural Competency to Enhance Quality of Care, $158K, funded by Illinois Department of Public Health, Sept 1, 2009–December 31, 2010. (K. Messner, C. O’Brien, co-PIs/PDs)


2006 PREPARE: Bioterrorism and Emergency Preparedness Training for the Long-Term Care Workforce. Competitive award for supplemental funds $435K, funded by Department of Health and Human Services (DHHS) and transferred to the Assistant Secretary of Preparedness and Response (ASPR), September 1, 2006–August 31, 2007 (PI/PD)

2005 PREPARE: Bioterrorism and Emergency Preparedness Training for the Long-Term Care Workforce. $1.8m, funded by Department of Health and Human Services (DHHS) and transferred to the Assistant Secretary of Preparedness and Response (ASPR), September 1, 2005–August 31, 2008 (PI/PD).

MEMBERSHIPS

American Public Health Association
American Society on Aging
Gerontological Society of America
Association for Anthropology and Gerontology

PROFESSIONAL ACTIVITIES

2012–13 Editorial Board, Anthropology and Aging Quarterly (AAQ)
2011 Grant Proposal Review Panel, Chicago Department of Public Health
2011 Abstract Reviewer, 4th Annual UIC Minority Health in the Midwest Conference
2010–13 Abstract Reviewer, American Public Health Association (APHA)
2010–12 Reviewer, Disaster Medicine and Public Health Preparedness
2007–08 Advisory Group for disaster preparedness in long-term care, Chicago Department of Public Health
2006–07 ASPR National Education Strategy Team, a group of ASPR grantees tasked with identifying components of a national strategies to train healthcare providers in disaster preparedness, response and recovery