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Physical Status as a Moderator of Depressive Symptoms

Among Older Adults with Dual Sensory Loss

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Abstract

Objective: This study evaluated the ability of three measures of physical status (physical activity, physical condition, and body mass index [BMI]) to moderate the relationship between dual sensory loss (DSL) and depressive symptoms in older adults.

Method: Nationally representative longitudinal data were used to develop multilevel models predicting depressive symptoms among two groups of older adults, 1380 who developed DSL during the study and 1308 without sensory loss.

Results: All three measures were associated with depressive symptoms for persons who had or would develop a DSL: participation in physical activity and being in better physical condition were associated with lower levels of depressive symptoms, while lower BMI levels were associated with higher levels of depressive symptoms. All moderator variables had a larger effect for persons with DSL as compared to persons without sensory loss.

Implications: The implication of these findings is that participation in a regular program of physical activity may provide multiple benefits to older persons with DSL. Families and health care providers can offer support for being physically active by ensuring the person has the best possible correction for the sensory losses, providing encouragement, and/or providing physical assistance with exercise.

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Among Older Adults with Dual Sensory Loss

A simultaneous deficit in vision and hearing, referred to as dual sensory loss (DSL), is a common occurrence in older age. Population estimates of the percentage of older persons who experience DSL have varied widely (from a low of 7.3% to a high of 21%), based on method used to define hearing and vision loss and the age of the population studied (Brennan, Horowitz, & Su, 2005; Caban, Lee, Gomez-Marin, Zhen, & Lam, 2005; Campbell, Crews, Moriarty, Zack & Blackman, 1999; Crews & Campbell, 2004). Regardless of the current prevalence, DSL is expected to increase in future years as the population ages and the lifespan increases.

The occurrence of DSL in older adults is a concern because it is associated with several negative outcomes, including depression and functional disability (e.g., McDonnall, 2009a; Brennan, Horowitz, & Su, 2005; Capella-McDonnall, 2005; Crews & Campbell, 2004; Horowitz & Reinhardt, 1993; Keller, Morton, Thomas, & Potter, 1999; Lupsakko, Mantyjarvi, Kautiainen, & Sulkava, 2002). It has even been suggested that a primary pathway between sensory loss and depression is through functional disability (Horowitz, Reinhardt, Boerner, & Travis, 2003; Horowitz, 2006). Although the association between DSL and depression in older adults has been well documented, ways to moderate that relationship have not been investigated. Many variables could potentially moderate the relationship between depression and DSL, but only some of these variables are capable of being modified by the individual. Focusing on adaptable variables is important because they offer individuals a chance to reduce their experience of depressive symptoms and have the potential to be included in interventions with this population. The purpose of the present study was to evaluate three physical status variables (physical activity, physical condition, and body mass index) as potential moderators of the relationship between

DSL and depressive symptoms. In addition to being adaptable, physical status was selected for investigation because of the proposed relationship between functional disability and depression for persons with sensory loss, as decline in physical status has been shown to commonly precede functional disability in the general older population (Fonda & Herzog, 2004; Sarkisian et al., 2000).

The many health benefits of regular physical activity are well-known, and persons of all ages, including older adults, are encouraged to participate (U.S. Department of Health and Human Services, 1999). In fact, older adults may have more to gain by being physically active than younger persons, as a physically active lifestyle is considered one of the most important factors contributing to successful aging (Agency for Healthcare Research and Quality [AHRQ], 2002). Physical activity has been shown to enhance strength, aerobic capacity, and physical functioning in older adults, and there is even some evidence to suggest that physical activity slows the development or progression of functional limitations (Keysor, 2003). Despite all this, older adults are less likely to engage in regular physical activity than younger people and very few older adults achieve the minimum recommended amount of activity (AHRQ, 2002).

Physical activity is also known to have a positive effect on depression: Persons who participate in a regular program of exercise or physical activity have been shown to experience less depression than those who do not. A significant amount of research has supported this relationship for the general population (e.g., Farmer et al., 1988; De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006; see Mead et al., 2008 for a systematic review of randomized controlled trials in this area) as well as for the population of older adults (e.g., Barbour & Blumenthal, 2005; Blake, 2009; Taylor et al., 2004). With a few exceptions, the experimental research in this area has included only persons with major or minor depression or depressive

symptoms, but cross-sectional research has involved all persons regardless of their initial levels of depression.

Overweight and obesity are usually associated with a low level of physical activity, and they have increased at an alarming rate in recent years. The current estimate of adults age 60 and older who are overweight or obese is 68.6%, or more than two-thirds of the population (Flegal, Carroll, Ogden, & Curtin, 2010). Overweight and obesity are considered two of the most important public health problems of our time (Simmons-Morton, Obarzanek, & Cutler, 2006) because they are associated with a multitude of medical conditions and negative psychosocial outcomes (CDC, 2009; Ball, Crawford, & Kenardy, 2004; Simon et al., 2006). Obesity (as measured with body mass index [BMI]) has been associated with higher levels of depression (e.g., Bertakis & Azari, 2005; Johnston, Johnson, McLeod, & Johnston, 2004) and has been shown to predict future depression among older adults (Sachs-Ericsson et al., 2007; Strawbridge, Deleger, Roberts & Kaplan, 2002). In addition, fewer symptoms of depression was one of the benefits associated with decreasing BMI (Dixon, Anderson, Cameron-Smith, & O'Brien, 2004).

Depression is a significant problem for older persons who experience a DSL. This relationship is well-documented, but research on the ability of adaptable factors to moderate the relationship is lacking. Research involving the general population of older adults has documented an association between physical activity and lower levels of depression and between obesity and higher levels of depression. The purpose of the present study was to evaluate the ability of physical status, measured by physical activity, physical condition, and BMI, to moderate the relationship between DSL and depressive symptoms. It is possible that these variables have a greater association with depressive symptoms for persons with DSL than for persons without sensory loss. One of the common effects of developing a vision loss or DSL in

older age is a reduction in activities (McDonnall, 2009a; Rovner & Casten, 2002). This includes physical activity, because barriers such as lack of transportation, lack of accessible exercise equipment or facilities, and reduced opportunities for safe physical activities are commonly associated with the loss of vision and DSL. Therefore, it was hypothesized that these three measures of physical status would moderate the relationship between DSL and depressive symptoms, and provide a benefit larger than that exhibited for persons without sensory loss.

Method

The present study is part of a larger research project, funded by the National Institute on Aging (grant #1R03AG029355-01A1), whose purpose was to first determine the effect of developing a DSL on depression over time and to further evaluate the ability of adaptable variables to moderate this relationship. Results from the initial study, which documented the longitudinal relationship between DSL and depression, have been published elsewhere (McDonnall, 2009b) but are described briefly in the Results section (under *Base Models*). The descriptions of the data, sample, some of the variables (i.e., time, DSL, depressive symptoms) and the data analyses in this section are similar to those presented in the initial study (McDonnall, 2009b).

Data Source

Data were obtained from the Health and Retirement Study (HRS) and the Aging and Health Dynamics study (AHEAD). These nationally representative panel studies were initially conducted separately, but data collection was combined in 1998 and has since been referred to as HRS. HRS is an ongoing study conducted by the Institute for Social Research at the University of Michigan. Its focus is economic resources and retirement, but the data collected cover a wide range of topics, including physical and functional health, disability, employment, cognitive

status, and activity participation. Data are collected approximately every two years via in-person or telephone interview. Participants with hearing loss have several options for completing interviews, including in-person, by telephone with a TTY, with assistance from a family member or friend, or by proxy. Excellent follow-up of participants is provided, and reasons for missing data are available in the majority of cases. Data collection for HRS began in 1992 and for AHEAD in 1993, was repeated in 1995, and then was combined with HRS in 1998. HRS includes 22,000 participants who were born between the years of 1931-1941 or before 1923 and their spouses. Data from the years 1993, 1994, 1995, 1996, 1998, 2000, 2002, 2004, and 2006 were used for this research.

Sample

The population of primary interest was older persons who experienced a dual sensory loss (DSL) during the course of the study. Persons with a DSL at their first time point in the study were excluded from the sample. The sample consisted of two groups: (a) persons who developed DSL during the study and did not report improved hearing or vision at a later time (the DSL group) and (b) an approximately equal number of persons who did not report sensory loss during the study, matched to the DSL group based on age and gender (the comparison group). The purpose of the comparison group was to determine whether differences in the effect of the adaptable variables on depressive symptoms existed between the groups. Stratified random sampling (with gender and age at the first observation point for the DSL group serving as the strata) was used to select the comparison group. A total of 1380 people who developed persistent DSL during the course of the study and who had depression data available were identified for the DSL group. Because sensory loss is common in old age, there were not enough people without sensory loss to match to the DSL group in the oldest age groups. All available sample members

without sensory loss over the age of 75 were included in the comparison sample; this resulted in 1308 people for the comparison group. Rather than including additional younger people in the comparison group, unequal group sizes were used. Approximately 12% of persons eligible for the DSL sample and 15% of persons eligible for the comparison sample were excluded due to missing depression data. The sample size and number of observations differed slightly for each moderator variable analysis due to missing data. The available sample was 2,688 (11,997 observations) for the physical activity analyses, 2,688 (12,922 observations) for the physical condition analyses, and 2,677 (13,170 observations) for the BMI analyses. Number of observations per person ranged from 1 to 7, and a large majority had 3 or more observations.

A variety of intermittent missing data patterns were present in the data for a small percentage of participants; however, the most commonly occurring missing data pattern was dropout from the study. When a participant did not have data for a given year, HRS included information about why the data was missing. It was therefore possible to obtain reasons for missing data in the majority of cases. The most common reason for missing data for both groups was death, followed by use of a proxy to complete the interview for persons in the DSL group. In cases of a proxy interview, items measuring depressive symptoms were not asked, but other information was obtained. Therefore, persons who developed DSL were more likely to have missing depression data after the DSL was reported, due to proxy interviews. Inspection of the patterns of missingness based on depression score was conducted and no differences were found. The data are assumed to be missing at random, based on these analyses and on the knowledge that depression scores are highly correlated over time (Singer & Willett, 2003).

Variables and Measures

Time. Time was measured in months since baseline, and then converted to years for these

analyses. The time variable associated with the first available data for each person (regardless of which wave it is from) was assigned a value of zero. The next time point was assigned an exact value based on the number of years and months since the previous data was collected. The second time point was approximately “2” for most participants; the third was approximately “4”, etc., as the waves are spaced approximately two years apart. A second time-related variable associated with the development of DSL was included in the models. This time-varying predictor, labeled “Time post-DSL,” documents the passage of time *after* the development of DSL. This variable provides the difference in slope of depressive symptoms after a person experiences DSL.

Dual Sensory Loss. The question used to measure vision loss was: “(With your glasses), Is your eyesight excellent, very good, good, fair, or poor?” Legally blind was a sixth category available for this question, if the person volunteered that information. Vision loss was identified by a report of fair eyesight, poor eyesight, or legal blindness. The question used to measure hearing loss was: “(With your hearing aid) Is your hearing excellent, very good, good, fair, or poor?” A report of fair or poor hearing was identified as a hearing loss. Persons were identified with DSL when they reported both vision loss and hearing loss at the same time point. This time-variant dichotomous variable had a value of 0 prior to the person reporting both hearing and vision loss and a value of 1 at and after this initial report. It represents the average increase in depression scores at the first time people report DSL. Another variable, Group, was included in the models to differentiate between the DSL group and the comparison group initially, as none of the participants had DSL at the first time point in the study and they developed DSL at different time points. This Group variable indicated whether there were pre-existing differences in depressive symptoms between participants who later developed DSL and those who did not. Pre-

existing vision loss and hearing loss were also included in the models as time-invariant variables to identify those persons who developed one sensory loss before developing the other. The majority of the sample experienced one sensory loss prior to developing DSL: 32% had a preexisting vision loss and 33% had a preexisting hearing loss.

Depressive Symptoms. Depressive symptoms were measured with the shortened Center for Epidemiologic Studies Depression scale (CES-D). Only respondents who answered items for themselves (rather than by proxy) were asked these questions. The original CES-D, one of the most widely-used measures of depression, contains 20 items that are rated on a four-level frequency scale (Radloff, 1977). The shortened version of the instrument used in HRS consists of 8 of these 20 items, rated with a yes-no response. Rather than asking how often the person experiences the feelings (i.e., symptoms of depression), the respondent is asked whether the statements are true for him or her *much of the time* during the past week. Responses to these eight items were summed, with responses indicative of depression given a score of 1. Therefore, scores ranged from 0 to 8 with higher scores associated with more depressive symptoms. The HRS Health Working Group (Steffick, 2000) evaluated the psychometric properties of this abbreviated CES-D scale. They determined that the scale shows good internal consistency, with Cronbach's alphas ranging from .77 to .83. Evidence for construct validity was provided by the scale's association with multiple variables known to be related to depression (e.g., gender, race, marital status, physical health, life satisfaction, economic situation). Analyses conducted by the group documented that non-response was not a large problem with the CES-D items. However, to maximize the sample size, responses for respondents who missed only one item were imputed with individual mean substitution for the missing item.

Covariates. Several variables that were not of focal interest to this study but are known to

be related to depression and/or the adaptable variables in older adults were included as covariates in the models. They included four time-invariant (minority status, gender, age [at first time point], education level) and two time-variant (net worth and health) variables. Minority status and gender were both dichotomous variables, with White persons and males coded as 0 and persons of any other race or Hispanic origin and females coded as 1. Education level was measured by the highest degree received on a 7-point scale, from no degree to a professional degree (Ph.D., J.D., M.D.). Net worth was a continuous variable that represented the dollar value of all assets the person held, minus liabilities. This variable was selected as a measure of socioeconomic status instead of income, as the majority of participants were not working. It was rescaled by dividing its value by 100,000 to make its scale more closely match the outcome variable. Health was measured by number of half days the respondent reported spending in bed due to illness or injury during the past month.

Physical Status Variables

Physical Activity/Exercise. This time-variant variable was measured using several items from the HRS study. All but one wave of HRS (i.e., AHEAD 1993) included a question related to physical activity. Unfortunately, the exact wording of the question has differed. In 1994, an open-ended question related to frequency of both vigorous and light physical activity and exercise was included. The question used most consistently (in 1995, 1996, 1998, 2000, and 2002) is “On average over the last 12 months have you participated in vigorous physical activity or exercise three times a week or more?” The response option for this item was yes-no. Examples of vigorous physical activity followed the item. In 2004 and 2006, more detailed information about physical activity was collected again, with fixed response options for frequencies of vigorous, moderate, and mild activity. Because the most frequently available data

is in a yes-no response format, the data available from 1994, 2004, and 2006 were converted to a dichotomous format. The corresponding item from 2004 and 2006 was “How often do you take part in sports or activities that are vigorous?” This item was followed by examples, and response options were more than once a week, once a week, one to three times a month, and hardly ever or never. If the response “every day” was volunteered, this was documented. Persons who responded “more than once a week” or “every day” were assigned a value of 1 for this item in years 2004 and 2006. Therefore the exercise variable used in this study measures whether a person participated in vigorous physical activity several times a week. Because the items associated with vigorous exercise differed in 1994, 2004, and 2006, analyses were also run with the data from these years excluded. These results were compared to results with all years of data included, and because the results were essentially the same, the larger sample was used (observations = 11,997).

Physical Condition. Because the measure of physical activity available was a dichotomous variable associated with vigorous activity only, a related variable was identified for inclusion in the study. This time-variant variable measures physical condition in the areas of mobility, strength, and gross motor skills; these areas are known to be related to physical activity levels (Keysor, 2003). An individual’s physical condition is expected to be reciprocally related to the amount of physical activity he or she engages in. Being in poor physical condition limits the amount and intensity of physical activity, and reduced physical activity contributes to poor physical condition.

HRS contains many items related to physical functioning, including nine items that assess mobility, strength, and gross motor skills. These items were included in HRS with the intention that they could be used as a summed scale, and evidence for their internal consistency reliability

and construct validity has been documented (Fonda & Herzog, 2004). Cronbach alpha coefficients ranged from .85 to .87 (depending on year) and exploratory factor analyses indicated that the nine items used in this study generally loaded together on one factor (when all physical functioning items available in HRS were included in the analyses). Several studies have provided support for the construct validity of the physical condition items, and these studies are presented in Fonda and Herzog (2004). The items included in this scale relate to whether the person had difficulty with the following activities: running or jogging about a mile; walking several blocks; walking one block; getting up from a chair; climbing several flights of stairs; climbing one flight of stairs; lifting or carrying over 10 pounds; stooping, kneeling, or crouching; and pulling or pushing large objects. The items were worded in this format “Because of a health problem do you have any difficulty with _____?” Respondents were told to exclude difficulties that were expected to last less than three months. The response choices were yes, no, can’t do, and don’t do.

Weights were assigned to these items: the rationale for incorporating a weighting scheme was that three of the available items (physical tasks) represent a substantially greater degree of physical difficulty and the ability to perform them is considered indicative of better physical condition. Ability to carry out these tasks was therefore assigned a higher value in order to assess a person’s overall physical condition accurately. The items considered to be of sufficient difficulty to warrant additional weight were running or jogging about a mile (assigned a score of 4 if no difficulty reported), walking several blocks, and climbing several flights of stairs (each assigned a score of 2 if no difficulty was reported). No difficulty with the remaining items received a score of 1. Under this weighting scheme scores ranged from 0 to 14. This variable was centered on a score of 8, which represents a person in good physical condition with minimal

limitations. The only year of data collection that does not include all nine of these items was 1993. Only four of the nine items were included that year; scores for the remaining five items were taken from 1995 data when available (Engels & Diehr, 2003). A total of 12,922 observations were available for analyses with this variable.

Body Mass Index (BMI). The final measure of physical status used in this study was BMI, which is a measure of adult body fat based on height and weight. This time-variant measure was calculated from the height and weight information that is included in HRS. The following standard formula was used: $BMI = 703 \times (\text{weight} / \text{height in inches}^2)$, creating a continuous variable. This variable was centered on a score of 25 (i.e., 25 was subtracted from each BMI score prior to entry into the models), which is the cut-off for being classified as overweight. A total of 13,170 observations from 2,677 people were available for these analyses.

Data Analyses

The statistical technique used to analyze the data was multilevel modeling, also known as individual growth curve modeling. This method offers several advantages over more traditional techniques for studying change, such as multivariate repeated-measures. For example, the modeling of individual change with this technique allows for an estimation of individual change trajectories as a function of person-specific parameters and random error, and it allows for the number and timing of observations to vary randomly across participants (Raudenbush & Byrk, 2002). In other words, with multilevel modeling the researcher can determine the average rate of change and individual variability in change over time, and can utilize all observations in the estimation of parameters, even if they only include one time-point. Multilevel modeling is essentially a regression technique, and regression coefficients are estimated for each variable in the model. Fixed effects in multilevel models can be interpreted in essentially the same way

regression coefficients are interpreted in multiple regression models (i.e., each one unit increase in X results in an estimated increase equal to its coefficient value in the outcome variable), and standard errors can be used to evaluate precision of the estimates.

The model-fitting method recommended by Singer and Willett (2003) was followed. The statistical models have two levels: (a) the level-1 model, referred to as the individual growth model, which represents the change in the outcome measure experienced by each respondent over time and (b) the level-2 model which represents differences in changes in the outcome measure across respondents. Preliminary model fitting to determine the trajectory of depressive symptoms for persons who experience DSL was undertaken initially and is described in detail elsewhere (McDonnall, 2009b). The physical status variables, interaction terms associated with these variables, and additional covariates potentially related to the physical status variables were added to the final model from the previous analyses. Interaction terms (DSL x physical status variable and Time-post DSL x physical status variable) were included in the models to determine whether physical status moderates the relationship between DSL and depressive symptoms. If the interaction with DSL was not significant, the interaction between Group x physical status variable was tested, as persons in the DSL group had been found to differ from the comparison group in level of depressive symptoms at the outset of the study (McDonnall, 2009b). The covariates were added first, then each of the physical status variables and their interaction terms were added to the models individually. Variables that were not significant at $p < .05$ were dropped from the final models. SAS version 9.2 (SAS Institute, Inc., Cary, NC), specifically the PROC MIXED procedure with full maximum likelihood estimation, was used for the analyses.

Results

Descriptive Information

Descriptive information about the samples is provided in Table 1. The groups were very similar in terms of gender and age as they were matched on these variables, but due to the inclusion of all available comparison group members in the oldest age groups, they do not match exactly. Differences were noted between the groups in terms of race/ethnicity, education level, net worth, and health (the DSL group had more minority group members, lower levels of education, lower average net worth, and had a higher average number of bed days per month). There were also differences in terms of participation in vigorous physical activity and physical condition levels, with the DSL group reporting lower levels of both. Percentages who reported participation in vigorous physical activity were slightly lower for persons in the DSL group, but were significantly lower when comparing persons before and after they developed the DSL (33.4% participation prior to the DSL and 15.5% participation after the DSL). A substantial difference was also present in terms of physical condition levels: average physical condition score was 6.49 (3.86) prior to the DSL but was 4.33 (3.63) after the DSL. Average BMI levels were similar, and a similar percentage in each group was overweight or obese.

Base Model

All fixed and random effects retained in the final models (presented in Table 2) were statistically significant predictors of depressive symptoms. Depressive symptoms changed over time in a curvilinear fashion, although this effect was small. Following a DSL, change over time in depressive symptoms was also curvilinear, but it increased at a faster rate. Five covariates were significant: gender, minority status, education level, net worth, and health. Women and minorities experienced a higher level of depressive symptoms and those with higher levels of education and net worth experienced a slightly lower level of depressive symptoms. Poorer health, as measured by a greater number of bed days, was associated with a higher level of

depressive symptoms. The effect of DSL did not differ based on any of these variables. Change over time in depressive symptoms was significantly different for minorities also. Significant random effects included initial status, Time, DSL, and Time post-DSL.

Physical Activity

Physical Activity (fixed and random effects), Time x Physical Activity, DSL x Physical Activity, and Time post-DSL x Physical Activity were entered into the base model to determine their effects on depressive symptoms. The only variable that was significant was the interaction between Time and Physical Activity, indicating that the depressive symptoms trajectory was different for people who participate in physical activity. Essentially, the positive effects of physical activity on depressive symptoms increased over time, as the participants aged. Because DSL x Physical Activity was not significant, Group x Physical Activity was tested. This variable was significant, although its positive effect on depressive symptoms was small (see Table 2).

Physical Condition

Physical Condition (fixed and random effects), Time x Physical Condition, DSL x Physical Condition, and Time post-DSL x Physical Condition were entered into the base model. Both Physical Condition effects (i.e., fixed and random) and Physical Condition's interaction with Time were significant predictors of depressive symptoms. Group x Physical Condition was tested next, and this interaction was also significant. For all fixed effects, higher levels of physical condition were associated with lower levels of depressive symptoms. It is relevant to note that the inclusion of the Physical Condition variables in the model resulted in a significant reduction of the effect of DSL on depressive symptoms, which is indicative of a mediation effect.

BMI

BMI (fixed and random effects), Time x BMI, DSL x BMI, and Time post-DSL x BMI were entered into the base model. When both BMI and DSL x BMI were included in the model, each one approached but did not reach statistical significance at $p < .05$ ($p = .05$ and $.06$ respectively). The random effect of BMI was significant, but the other variables were not significant. BMI and DSL x BMI were significant predictors of depressive symptoms if entered into the model separately; because the primary purpose of the study was to determine the effect of the moderator variables on persons with DSL, the DSL x BMI model was retained. The effect of BMI for persons with DSL was larger than the size of the effect for persons without sensory loss, although its effect was relatively small. It is important to note that the direction of the effect was the opposite of what was expected: as BMI increased above 25, depressive symptoms decreased.

Due to the unexpected findings, post-hoc analyses were conducted in which weight categories associated with BMI (i.e., underweight, overweight, and obese) were introduced as dichotomous variables into the base models (instead of the continuous BMI variable). The interaction between these variables and DSL, as DSL x BMI was the variable retained in the original analyses, were used. Only DSL x underweight was a significant predictor of depressive symptoms ($\gamma = 0.48$, $SE = 0.21$, $p = .02$).

Group Effects versus Pre-existing Vision Loss Effects

Two of the three moderator variables exhibited an effect not just for persons who currently had a DSL, but also for this group prior to development of the DSL. A large percentage of persons who experienced a DSL had either a vision loss or hearing loss prior to developing the other sensory loss (i.e., DSL). Having a pre-existing vision loss was associated with a higher initial level of depressive symptoms, although having a pre-existing hearing loss was not (results

described in McDonnall, 2009b). Therefore, whether the group effect exhibited with Physical Activity and Physical Condition was primarily associated with a pre-existing vision loss was considered. This was tested by replacing the Group interaction with an interaction between each variable and the vision loss (VL) variable. VL x Physical Activity did significantly predict depressive symptoms, with an effect that was approximately the same size as the Group interaction. When both variables were entered into the model, only the Group interaction remained significant; therefore this variable was retained for the final model. VL x Physical Condition was also a significant predictor of depressive symptoms, but its effect was much smaller than the Group x Physical Condition variable; therefore the Group interaction was retained in the final model.

Discussion

All three measures of physical status acted as moderators of depressive symptoms: Physical activity and physical condition exhibited a moderating effect for persons in the DSL group throughout the study (before and after they developed DSL) and BMI exhibited a moderating effect only for persons after the development of DSL, although the effect of BMI was in the opposite direction of what was expected. Physical status had a larger effect on depressive symptoms for members of the DSL group than the comparison group. A discussion of the results for each physical status variable will be provided individually, followed by implications of the overall findings.

For the group of persons who would develop or currently had a DSL (referred to as “the DSL group” from this point forward), participation in regular vigorous physical activity was associated with a slight decrease in depressive symptoms. This relationship was not present for older adults without sensory loss. However, vigorous physical activity did have an effect over

time for all persons in the study, resulting in a different depression trajectory for those who continued to participate in vigorous activity. The interaction with time indicates that as the participants aged, participation in this type of activity had an increasingly positive effect on depressive symptoms. At the first time-point in the study, there was no effect (as all persons started the study at Time=0), but at the last time point in the study (approximately 12 to 13 years for persons with all 7 data points available), this effect was estimated to be between -0.28 and -0.30. When the effect of this interaction with time is added to the effect for the DSL group, vigorous physical activity for persons with DSL resulted in a moderate positive effect on depressive symptoms as they aged. The effect may have been small due to the nature of the available variable: a dichotomous variable that referred specifically to frequent vigorous physical activity. A variable that provided more information about the overall level of physical activity or exercise participated in may have provided different results.

Physical condition level predicted depressive symptoms for both the DSL group and the comparison group, but the effect was more than twice as large for the DSL group. The effect of physical condition on depressive symptoms also varied randomly across people, as documented by the significant random effect associated with the variable. The variable entered in the model was centered on 8, which represents a person in good physical condition with minimal limitations. For someone in the DSL group in excellent physical condition (a score of 14), depressive symptoms would be reduced by 0.69 on average. This compares to a reduction of 0.31 for a person without sensory loss. On the other hand, for someone in the DSL group in very poor physical condition (a score of 0), depressive symptoms would be increased on average by 0.92 (compared to 0.41 for a person without sensory loss). Physical condition also exhibited a significant effect over time for all participants, but the size of that effect was very small.

Physical condition level for persons in the DSL group had a strong relationship with their level of depressive symptoms. It functioned as a moderator of depressive symptoms for members of the DSL group (pre and post DSL). In addition to the direct effect of physical condition on depressive symptoms, it also had an indirect effect, exhibited by the reduced size of DSL's effect on depressive symptoms seen in that model, regardless of physical condition level. This indicates that some of the variance associated with DSL's effect is shared with physical condition; in other words physical condition also acted as a mediator between DSL and depressive symptoms. A proposed pathway connecting the relationship between vision loss and depression is functional disability (Horowitz et al., 2003; Horowitz, 2006). This research suggests that the broader measure of physical condition, or physical functioning, provides a pathway between DSL and depression: Not only does a reduced ability to perform ADLs and IADLs result in depression, but a reduced ability to perform physically (which is, conceptually, one step before functional disability) also affects the experience of depressive symptoms associated with sensory loss.

Being in above average physical condition provided persons with DSL a substantial benefit against depressive symptoms. Participation in vigorous physical activity also provided a benefit, but its effect was smaller. These results may have occurred because the development of sensory loss is often associated with other losses. This is true for single sensory losses, but even more so for DSL. Loss of valued activities as well as difficulties with communication often occur (McDonnall, 2009a). The ability to maintain physical functioning may prevent persons with DSL from experiencing as much loss, or it may just have more importance to them psychologically than it does for persons without sensory loss. Being strong physically and being able to continue participating in vigorous physical activity take on added importance when sensory losses occur.

It is important to realize that the relationships between physical activity and physical

condition and depressive symptoms were also present prior to the development of the DSL. Some of this effect was associated with the pre-existing vision loss, but it is possible that other factors were also relevant. There were several differences noted between the groups prior to the development of DSL, including a higher level of depressive symptoms for the DSL group. The DSL group was more disadvantaged than the general population in major demographic areas (e.g., education level, net worth, health, minority status), and it is possible that persons disadvantaged in these ways – whether they develop a DSL or not – could receive more benefit from physical activity and being in better physical condition than those who are not. Additional research with other samples would be necessary to determine whether the effect seen here is related primarily to the sensory losses or to the disadvantages the DSL group faced.

BMI did not have the effect expected: Instead of higher BMI being associated with greater levels of depressive symptoms, it was associated with lower levels of depressive symptoms for persons with a DSL, although the effect size was small. The significant random coefficient associated with this variable indicates that the effect did vary randomly across people. For persons in the normal range of BMI or those who were overweight, the effect was minimal (an increase or decrease of less than .125). Observing an effect associated with being *underweight* may not be surprising, as this would likely to be associated with frailty and poor health in older adults. Older adults who are underweight may be less capable of vigorous physical activity and in poorer physical condition. It is also possible that depressed persons lose weight due to a loss of appetite, a common symptom of depression. It is less clear why obesity would be associated with a larger decrease in depressive symptoms. Results of the post-hoc analyses (utilizing weight categories rather than actual BMI score) support the idea that the association may have largely been due to the positive relationship between being underweight

and depressive symptoms.

Limitations

A limitation of this study is the use of self-report sensory data rather than clinically measured data. It is recognized that there may be some differences in the DSL population identified by self-report as opposed to measured acuities. The use of self-report sensory data in this study creates an evaluation of the relationship between *self-perceived functional dual sensory loss* and depressive symptoms rather than clinically measured dual sensory loss and depressive symptoms, and this distinction should be considered in the interpretation of results. Another limitation is that the wording of the items to measure physical activity differed during some years of the study. However, given the large number of observations available and the fact that analyses were run with and without the data that was different, this limitation is likely minor in terms of its effect on results. The fact that physical activity could only be measured as a dichotomous variable associated with frequent vigorous activity is also a limitation.

Implications

The purpose of this study was to evaluate the ability of physical status, as measured by physical activity, physical condition, and BMI, to moderate the effects of DSL on depressive symptoms among older adults. The results support the importance of being in good physical status for the psychological health of older persons who have or will develop a DSL. The implication of this finding is that persons with DSL, as well as persons with single sensory loss, should participate in a regular program of physical activity, which in itself has a positive influence on depressive symptoms, but which also can maintain or improve their physical condition.

Few older adults from the general population participate in the recommended levels of

physical activity, and the percentage who participate declines sharply from the age of 75 (Taylor et al., 2004). Results from this study indicate that persons with DSL are less likely to participate in vigorous physical activity and are in poorer physical condition than persons without sensory loss. This may be associated directly with the DSL (i.e., physical activities become more difficult due to sensory losses), or may be associated with other health problems that can occur co-morbidly with the DSL. It is also possible that physical inactivity and poor physical condition are associated with the severity of depressive symptoms, as documented in a study of older adults with vision loss (Jones, Rovner, Crews & Danielson, 2009). To maintain or improve physical activity and physical condition levels following a DSL will likely require support from others. Ideally, older persons who experience a significant DSL will receive rehabilitation services to help them adjust and adapt to the sensory losses. Such a rehabilitation program would be an ideal place to include a program of physical activities with the goal of improving physical condition level. This could involve a physical activity program during the period of rehabilitation and could also involve providing information about how to continue to exercise safely at home with the sensory losses.

Having the best possible correction for the sensory losses may also be an important factor influencing whether a person participates in physical activity. This is particularly important for persons who do not receive formal rehabilitation services for their sensory losses. Health care providers and families should ensure that persons with DSL have up-to-date hearing aids, assistive listening devices, and any low vision aids that may be beneficial to them. Beyond just possessing these devices, persons with DSL must know how to use them. For those with severe hearing loss, cochlear implants could be considered. Orientation and mobility training teaches persons with vision loss how to travel safely and independently; receipt of this service would

also be valuable for older persons with DSL to enable them to participate in physical activity. Physicians can make the appropriate referrals to specialists who can provide these devices (along with training in their use) or service to the individual with DSL. Families can request such referrals if they are not made, and can ensure that the person with DSL is actually using the devices.

Support could also come in the form of encouragement for physical activity by physicians and other health care providers. Less than half of older persons reported that their physicians encouraged them to exercise (CDC, 2002; Damush, Stewart, Mills, King & Ritter, 1999). It seems likely that physicians may be even less inclined to encourage persons with a DSL to exercise because of safety concerns, although no research has been conducted in this area. Older adults who were asked about physical activity by their physicians were more likely to engage in the recommended level of physical activity (CDC, 2002). Given the value of physical activity and being in good physical condition, particularly for persons who have a DSL or who will develop one, it is important for physicians and health care providers to encourage them to maintain or increase their physical activities, despite the sensory losses. Several promising physical activity interventions in primary care settings have been identified, including patient goal setting, written exercise prescriptions, individually tailored physical activity regimens, and follow-up (AHRQ, 2002).

Families are also an important source of support to help older persons with DSL remain physically active and maintain their physical condition. Support from families could come in the form of encouragement, assistance with transportation, and physical assistance with exercise (such as taking regular walks with the person). Walking independently around the neighborhood for persons with significant DSL may not be safe; having a family member (or friend) who is

willing to become an exercise partner may enable him/her to become or remain active, providing health as well as mental health benefits.

Beyond these individual-focused implications, changes to the environment and policies could have a positive impact on participation in physical activity by older persons with DSL. For example, providing well-lighted and maintained sidewalks or walking tracks in communities would allow people with sensory losses, as well as all people, to exercise more safely. Hearing aids, assistive listening devices, and low vision aids, all of which have the potential to improve quality of life as well as increase opportunities for physical activity, are not usually covered by insurance or Medicare. Many older adults with DSL, who we know to be more disadvantaged than persons without sensory loss, will not be able to afford these devices. Policy changes to allow coverage for these devices, as well as orientation and mobility services, for persons with DSL could increase participation in physical activity, promoting improved health outcomes.

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Table 1

Descriptive Statistics of DSL and Comparison Group Samples

Variable	DSL Group	Comparison Group
Gender – Male	45.9%	46.6%
Average age	69.15 (10.91)	67.86 (10.14)
Race/ethnicity		
White, Non-Hispanic	74.8%	84.1%
Black/African American	13.6%	10.5%
Hispanic	10.3%	3.4%
Other	1.3%	2.0%
Education level		
Less than high school	40.1%	20.6%
High school/GED	46.8%	53.3%
College degree (2 or 4 year)	9.3%	16.2%
Master’s or Professional degree	3.8%	9.9%
Average net worth	250,694 (681,075)	410,532 (1,005,610)
Average number of bed days	0.86 (3.71)	0.34 (2.08)
Regular vigorous physical activity	27.8%	38.1%
Average physical condition level	5.87 (3.92)	8.03 (3.48)
Average BMI	26.62 (5.37)	26.40 (4.61)
Overweight	37.0%	39.1%
Obese	21.9%	20.1%

Table 2

Results of Model Building: Estimates of Fixed and Random Effects

Parameter estimates (SE) for Depression			
	Physical Activity	Physical Condition	BMI
<i>Fixed effects</i>			
Intercept	0.52 (0.06)	0.66 (0.05)	0.52 (0.05)
Time	0.11 (0.01)	0.07 (0.01)	0.08 (0.01)
Time ²	-0.006 (0.001)	-0.004 (0.001)	-0.004 (0.001)
Group	0.77 (0.06)	0.57 (0.05)	0.75 (0.06)
DSL	0.34 (0.06)	0.18 (0.06)	0.38 (0.06)
Time post-DSL	0.18 (0.04)	0.16 (0.04)	0.17 (0.04)
Time post-DSL ²	-0.02 (0.006)	-0.02 (0.006)	-0.02 (0.006)
Gender	0.35 (0.05)	0.22 (0.05)	0.38 (0.05)
Minority	0.37 (0.08)	0.41 (0.07)	0.34 (0.07)
Minority*Time	-0.04 (0.01)	-0.04 (0.01)	-0.04 (0.01)
Education	-0.13 (0.02)	-0.10 (0.02)	-0.14 (0.02)
Net worth	-0.005 (0.002)	-0.004 (0.002)	-0.005 (0.002)
Health	0.06 (0.005)	0.05 (0.005)	0.06 (0.005)
Vision Loss	0.34 (0.08)	0.23 (0.07)	0.34 (0.08)
Phys. status variable	--	-0.05 (0.01)	--
Group*Phys. status	-0.14 (0.06)	-0.06 (0.01)	--
DSL*Phys. status	--	--	-0.02 (0.009)

Physical Status, Depressive Symptoms, & Dual Sensory Loss

Parameter estimates (SE) for Depression			
	Physical Activity	Physical Condition	BMI
Time*Phys. status	-0.02 (0.006)	-0.003 (0.001)	--
<i>Variance components</i>			
Within- Person	1.56 (0.03)	1.50 (0.03)	1.54 (0.03)
Intercept	1.44 (0.08)	1.01 (0.06)	1.30 (0.07)
Time	0.009 (0.002)	0.007 (0.001)	0.008 (0.001)
DSL	1.40 (0.18)	1.49 (0.18)	1.36 (0.17)
Time post-DSL	0.06 (0.02)	0.06 (0.02)	0.05 (0.02)
Phys. status variable	--	0.01 (0.002)	0.01 (0.002)

Note: All variables are significant at $p < .05$.