The impact of multiple impairments on disability in community-dwelling older people

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Abstract

Introduction: we have tested the hypothesis that the co-occurrence of common impairments (motor and cognitive impairments, vision and hearing loss, depressive symptoms) of later life have exacerbating effects on disability [activities and instrumental activities of daily living, social and role function, (in)activity].

Method: data were drawn from a community-based sample of 624 people aged 57 and older.

Results: motor impairments and depressive symptoms were associated with all disability measures, even when the effects of other impairments, age and gender were controlled. This indicates independent, predominant effects of motor impairments and depressive symptoms. Although several significant first-order interaction effects (indicating exacerbation) of impairments on disability were found, they were not very strong, but vision and hearing losses exacerbate the impact of the other impairments on disability.

Conclusions: impairments, particularly motor impairments and depressive symptoms, largely act 'solo', by main effects on disability. Only a few combinations including vision or hearing loss further exacerbate the effects of other impairments on disability.

Keywords: depression, disability, hearing impairment, vision

Introduction

Mental and physical impairments are the major immediate factors that cause dysfunction [1]. Older people often have more than one chronic condition or impairment [2]. Does the co-occurrence of impairments (as a result of multiple conditions) have disproportionate effects on disability?

Most studies have evaluated associations between one or two impairments and several domains of disability. There is little work on the effects of either individual or multiple impairments on disability.

We have studied the associations between selected impairments and their consequences for disability in community-dwelling elderly people. We hypothesized that these impairments have independent effects on different aspects of disability and that multiple impairments exacerbate these effects.

Methods

Research participants

Data come from a random subsample (\(n = 624\)) of the baseline sample (\(n = 5279\)) of the Groningen Longitudinal Aging Study (GLAS), a population-based prospective study of the determinants of health-related quality of life of older people, that focuses particularly on physical and social disability and general well-being [3-5]. The GLAS population is aged 57 years and older living independently or in a home for older people in the northeastern Netherlands in 1993. Those with severe cognitive problems at baseline [Mini-Mental State Examination (MMSE) score <17] were excluded (\(n = 78\), 1.5%).

One month after entry, additional data on performance-based motor and cognitive impairments and
vision and hearing loss were collected from a random subsample of participants (n = 624; 11.8%) in four gymnasias in participants’ neighbourhoods. The first 624 baseline participants were included in the subsample for reasons of feasibility. The subsample consists of 350 women (56.1%; mean age 69.0 years; standard deviation 7.7; range 57–90) and 274 men (43.9%; mean age 68.8 years; standard deviation 7.6; range 57–92). Only small age and gender differences were found between this subsample and the baseline population.

Disability measures

Five disability outcome measures were analysed: activities and instrumental activities of daily living (ADL/IADLs), role function, social function, amount of time spent on physical activities and amount of inactive time.

ADL/IADLs were assessed with the Groningen Activity Restriction Scale (GARS) [6, 7]. Developed to assess disability in personal care and domestic activities, the GARS comprises 18 items, with four response options for each. The score can range from 18 (no limitations) to 72 (maximum limitation). Role function and social function were measured with subscales from the SF-20 [8]. Role function measures the extent to which health interferes with usual daily activities such as work and housework. Social function measures how health interferes with normal social activities, such as visiting friends. Both measures were transformed to range from 0 to 100. The psychometric properties of the Dutch version of the SF-20 have been tested previously [9].

Two indicators were developed to assess amount of time spent in physical activities and inactivity. The first estimates number of hours per month regularly spent in nine physical activities: swimming, playing tennis, gardening, bowling, dancing, shopping, walking outside, cycling and gymnastics. We asked how much time was spent in each activity (for example: “During the past 4 weeks have you cycled either with a purpose or for pleasure?”). Answers are given in hours per day, week or month and transformed to range from 0 to 100. A composite score was computed by adding the amounts of time across all items. The mean physical activity score in the sample is 2.8 h per day. The psychometric properties of the questionnaire on time spent doing activities were tested in a pilot study [10].

The second indicator estimates how much of each 24-h period is spent being inactive: sitting down without doing anything, resting (including naps) and sleeping. Participants were asked the number of hours per day spent in each of these. The mean composite inactivity score for the sample is 9.0 h per day. The two indicators reflect function in a novel way for disability research.

Higher scores on the SF-20 for role and social function and physical activity indicate better function. Higher scores on the GARS and inactivity reflect poorer function. All disability outcome measures were assessed at baseline.

Impairments

The following impairments were assessed at the follow-up evaluation except for the MMSE and depressive symptoms, which were assessed at baseline. (Although we labelled them as impairments, several tests are more accurately tests of functional limitations as defined in the disablement process [1]. These include cognitive status, depressive symptoms, walking endurance, text reading.)

Motor impairments

For motor impairments, five tests were taken from the Groningen Fitness Test for the Elderly which measures different domains of motor impairments [11, 12].

Walking endurance was assessed with the ‘shuttle walk’ test. Subjects walked on a rectangular course where walking speed was increased by 1 km/h every 3 min from 4 to 7 km/h. Walking speed was increased by light signals on every corner of the course. Participants had to adjust their walking speed according to the signals and had to keep up the effort as long as possible. The score reflects the total distance walked.

Flexibility of the hip joint and the spine were assessed with a sit-and-reach test. Research participants sat on the floor, legs out-stretched, in front of a box and bent forward to push a slide as far as possible with their fingertips. The shift length of the slide was recorded. The best of three trials was taken as the final score.

Mobility (flexibility) of the shoulder joint was tested using a cord with a fixed handle on one end and a sliding handle on the other. Subjects had to hold both handles and pass the cord from the front of the body, over the head and behind the body, keeping arms straight and as close together as possible. The distance that the sliding handle moved during the process was recorded. The distance, combined with the person’s arm length, was used to determine the score. The final score was the best of three.

For manual dexterity, subjects moved 40 blocks from a full board to an empty board in a prescribed way, as quickly as possible using the preferred hand. The final score was the time to complete the task.

Grip strength (maximum isometric strength of the hand and arm muscles) was measured by a handgrip dynamometer. Participants held the meter in their preferred hand with the arm at their side and squeezed using maximum force. Final score was the best of three.

The summary measure for motor impairments is the factor score of the first factor obtained after conducting
principal component analysis with the five tests. Higher scores indicate better function.

**Cognitive impairments**

Two tests for cognitive impairment were administered.

One test for short-term memory is derived from the verbal learning test [13, 14], assessed at the follow-up evaluation. Fifteen words are presented visually, one after another, separated by 2-s intervals. Subjects are then asked to recall as many words as possible in free order. This procedure is repeated three times. After 20 min, during which no other cognitive testing takes place, delayed recall (recall of the 15 words) and recognition (recall of the 15 words from a visual list of 30 words) are tested. In its present form, the test allows for the separate probing of learning capacity, memory storage and memory retrieval of newly-learned material. One final summary score (memory) is calculated from the correctly recalled words of the initial three trials, the score of the delayed recall and the recognition score.

The second cognitive test is the MMSE [15], assessed at baseline. This measures cognitive dysfunctioning more generally (e.g. orientation to time and place, attention and calculation, language and visual construction). For both cognitive measures, higher scores indicate better function.

**Depressive symptoms**

Depressive symptoms were assessed with the subscale from the Hospital Anxiety and Depression Scale (HADS) [16, 17]. The range of this scale is 0 to 21. Scores are reversed for the present paper, so that higher scores indicate fewer symptoms.

**Visual and hearing loss**

For visual loss, four tests were used: visual acuity was assessed with the Early Treatment Diabetic Retinopathy Study chart, edge contrast sensitivity with the Groningen Edge Contrast chart and foveal light sensitivity with the Friedman Visual Field Analyzer [11, 12]. The final test was of ability to read text. Tests were performed on the better eye according to the research participant and with the usual spectacle correction. The vision tests produce results in different units. Visual acuity is measured in 1/min of arc, contrast sensitivity in 1/contrast, foveal light sensitivity in dB attenuation and reading in 1/points print. These results are converted to standardized units with a score range from 0 to 115.

The summary measure for vision loss is the factor score of the first factor obtained after conducting principal component analysis with the four tests. Higher scores indicate better function.

Hearing loss was assessed with pure-tone air-conduction audiometry in a relatively quiet room by assistants experienced in audiometry. For each ear, hearing thresholds without using hearing aid were determined for tones of 0.5, 1, 2 and 4 kHz. The mean loss in decibels over the four frequencies was computed. The score of best ear is used. Higher scores indicate better function [11, 12].

**Analytic strategy**

Bivariate associations were analysed by means of cross-tabulation, correlation coefficients and partial correlation coefficients controlling for age and gender. Before computing (partial) correlation coefficients, rank variables were created for all impairment and disability measures. For cross-tabulation of impairments—indicating descriptive associations between the impairments—three levels of each of the impairments were used based on the assignment of research participants to three groups with approximately equal numbers of people (e.g. tertiles). For all other analyses, the original continuous scores were used. Multivariate associations (e.g. independent effects) and interaction effects were studied by multiple regression analyses. Impairments were modelled as independent variables and disability as the outcome. Age and gender were included in all regression equations. First-order interaction effects among impairments are estimated. The distributions of the standardized residuals obtained with the regression analyses were checked for skewness in all regression models.

Distributions of outcome variables with a skewness coefficient greater than 1.50 (in SPSS/PC) were transformed logarithmically; this was done for ADL/IADLs, physical activity and inactivity. Data were analysed using SPSS/PC software version 5.0.2.

**Results**

First, we analysed the differences between the subsample in the present study and the GLAS baseline sample. We found only marginal age and gender differences between the two groups. Analyses of variance (controlling for age and gender, $P < 0.001$) showed no significant differences between participants in this study and other GLAS baseline participants in MMSE scores, HADS depressive symptoms, (self-reported) vision and hearing loss as assessed with the OECD-indicator [18], social and role function as assessed with the SF-20 subscales and inactivity. However, the participants reported lower levels of disability on the GARS and higher levels of physical activity. This latter result may have affected our outcomes. However, our results partly support findings from previous studies.

Table 1 shows the percentages of subjects for various combinations of three levels of impairments. Level of impairment is based on assignment to three groups of similar size (e.g. tertiles, only applicable for Table 1).
Table 1. Percentages and numbers of research participants with various levels of impairments

<table>
<thead>
<tr>
<th></th>
<th>Memory</th>
<th>MMSE</th>
<th>Depressive symptoms</th>
<th>Vision loss</th>
<th>Hearing loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Med</td>
<td>High</td>
<td>n</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>35</td>
<td>36</td>
<td>29</td>
<td>181</td>
<td>40</td>
</tr>
<tr>
<td>Med</td>
<td>28</td>
<td>32</td>
<td>40</td>
<td>182</td>
<td>14</td>
</tr>
<tr>
<td>High</td>
<td>33</td>
<td>35</td>
<td>32</td>
<td>184</td>
<td>19</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>36</td>
<td>40</td>
<td>24</td>
<td>193</td>
<td>38</td>
</tr>
<tr>
<td>Med</td>
<td>19</td>
<td>39</td>
<td>42</td>
<td>208</td>
<td>36</td>
</tr>
<tr>
<td>High</td>
<td>11</td>
<td>30</td>
<td>59</td>
<td>203</td>
<td>34</td>
</tr>
<tr>
<td><strong>MMSE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>43</td>
<td>30</td>
<td>27</td>
<td>132</td>
<td>32</td>
</tr>
<tr>
<td>Med</td>
<td>37</td>
<td>39</td>
<td>24</td>
<td>221</td>
<td>31</td>
</tr>
<tr>
<td>High</td>
<td>30</td>
<td>33</td>
<td>37</td>
<td>252</td>
<td>24</td>
</tr>
<tr>
<td><strong>Depressive symptoms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>40</td>
<td>37</td>
<td>23</td>
<td>222</td>
<td>35</td>
</tr>
<tr>
<td>Med</td>
<td>32</td>
<td>32</td>
<td>36</td>
<td>208</td>
<td>34</td>
</tr>
<tr>
<td>High</td>
<td>25</td>
<td>32</td>
<td>43</td>
<td>188</td>
<td>42</td>
</tr>
<tr>
<td><strong>Vision loss</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>47</td>
<td>38</td>
<td>15</td>
<td>202</td>
<td></td>
</tr>
<tr>
<td>Med</td>
<td>31</td>
<td>36</td>
<td>33</td>
<td>209</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>19</td>
<td>34</td>
<td>46</td>
<td>207</td>
<td></td>
</tr>
</tbody>
</table>

*For this table, level of impairment is based on the assignment of research participants to three groups of approximately equal size. High levels indicate better function (less impairment). The total number of research participants for each combination of impairments (n) varies due to missing values. Med, medium; MMSE, Mini-Mental State Examination.
The largest proportions of corresponding levels of impairments are found for vision loss and motor impairments \([51 + 33 + 31] / 3 = 45\%\) and for memory and the Mini-Mental State score (also 45\%), followed by vision and hearing loss (43\%). The lowest proportions of corresponding levels of impairments were in depressive symptoms and hearing loss and for motor impairments and memory (both 33\%). Co-occurrence of impairments (e.g. category 'low') is highest for motor impairments and vision loss: 51\% of the research participants with motor impairments show vision loss.

Table 2 shows the correlations for all impairments. The rank correlation coefficients indicate that motor impairments are slightly to moderately associated with depressive symptoms (0.256) and both vision (0.431) and hearing loss (0.215), but less with cognitive impairments (0.040 for memory and 0.206 for MMSE). Vision and hearing loss are moderately inter-related (0.346). However, the statistical significance of several correlation coefficients, especially for hearing loss, disappear when adjusted for gender and age. Motor impairments, vision loss and hearing loss are strongly associated with age.

Table 3 shows correlations between the impairments and disability. The rank correlation coefficients indicate that motor impairments, vision loss and depressive symptoms are significantly related to all disability measures, while hearing loss is related to all outcome measures except role function. Cognitive impairments are significantly associated with inactivity.

The partial correlation coefficients indicate the degree of association between impairments and disability after adjusting for age and gender. Depressive symptoms and motor impairments are still significantly associated with all disability measures. Cognitive impairments are still significantly related to inactivity. Vision loss is slightly associated with ADL/IADLs and role dysfunction and hearing loss is weakly associated with social function.

Tables 4 and 5 present the results of the multiple regressions. Motor impairments and depressive symptoms are significantly associated with all disability measures, even when effects of other impairments, age and gender are controlled. Vision loss is uniquely related to role function, while hearing loss is specifically related to social function.

A few first-order interaction effects are significant, although they are not very strong. Vision loss and to some extent hearing loss exacerbate the impact of the other impairments on disability. Co-occurrence of vision loss and motor impairments consistently exacerbates ADL/IADLs, role function, social function and physical activity.

The check of the distributions of the standardized residuals obtained for all regression models show that the highest skewness coefficient identified was 1.51 which we consider as acceptable.
Table 3. Correlations and partial correlations between impairments, age, gender and disability

<table>
<thead>
<tr>
<th>Impairment</th>
<th>Disability</th>
<th>Role function</th>
<th>Social function</th>
<th>Amount of time spent in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADL/IADLs</td>
<td></td>
<td></td>
<td>Physical activity</td>
</tr>
<tr>
<td>Motor</td>
<td>-0.395c (-0.316c)</td>
<td>0.272° (0.297°)</td>
<td>0.288° (0.205°)</td>
<td>0.447° (0.197°)</td>
</tr>
<tr>
<td>Memory</td>
<td>-0.057 (0.005)</td>
<td>-0.024 (-0.043)</td>
<td>0.047 (0.043)</td>
<td>0.036 (0.052)</td>
</tr>
<tr>
<td>MMSE</td>
<td>-0.107° (-0.057)</td>
<td>0.069 (0.051)</td>
<td>0.058 (0.030)</td>
<td>0.053 (-0.011)</td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>-0.333° (-0.314°)</td>
<td>0.293° (0.280°)</td>
<td>0.355° (0.335°)</td>
<td>0.265° (0.210°)</td>
</tr>
<tr>
<td>Vision loss</td>
<td>-0.283° (-0.137°)</td>
<td>0.180° (0.133°)</td>
<td>0.155° (0.069)</td>
<td>0.262° (0.085°)</td>
</tr>
<tr>
<td>Hearing loss</td>
<td>-0.177° (-0.025)</td>
<td>0.063 (0.012)</td>
<td>0.116° (0.054)</td>
<td>0.167° (0.047)</td>
</tr>
<tr>
<td>Age</td>
<td>0.321°</td>
<td>-0.118°</td>
<td>-0.173°</td>
<td>-0.345°</td>
</tr>
<tr>
<td>Genderb</td>
<td>0.091°</td>
<td>-0.058</td>
<td>-0.121°</td>
<td>-0.320°</td>
</tr>
</tbody>
</table>

*Higher scores for all impairments, role function, social function and physical activity indicate better function. Higher scores on ADL/IADLs and inactivity indicate poorer function. Partial correlation coefficients control for age and gender. Correlations are based on continuous scores and rank transformation of the variables.

b1 = male, 2 = female.

cP < 0.05.

ADL/IADL, activities and instrumental activities of daily living; MMSE, Mini-Mental State Examination
Table 4. Multiple regressions of disability on impairments, age and gender: main effects

<table>
<thead>
<tr>
<th>Impairment</th>
<th>Disability ADL/IADLs</th>
<th>Role function</th>
<th>Social function</th>
<th>Physical activity</th>
<th>Inactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β/P</td>
<td>SE β</td>
<td>β/P</td>
<td>SE β</td>
<td>β/P</td>
</tr>
<tr>
<td>Motor</td>
<td>-0.441/0.000 b</td>
<td>0.069</td>
<td>0.412/0.000 b</td>
<td>0.073</td>
<td>0.182/0.013 b</td>
</tr>
<tr>
<td>Memory</td>
<td>0.044/0.353</td>
<td>0.047</td>
<td>-0.075/0.137</td>
<td>0.050</td>
<td>0.003/0.945</td>
</tr>
<tr>
<td>MMSE</td>
<td>0.027/0.540</td>
<td>0.044</td>
<td>-0.008/0.858</td>
<td>0.046</td>
<td>-0.007/0.886</td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>-0.220/0.000 b</td>
<td>0.043</td>
<td>0.200/0.000 b</td>
<td>0.045</td>
<td>0.273/0.000 b</td>
</tr>
<tr>
<td>Vision loss</td>
<td>-0.083/0.090</td>
<td>0.049</td>
<td>0.107/0.039 b</td>
<td>0.052</td>
<td>0.067/0.196</td>
</tr>
<tr>
<td>Hearing loss</td>
<td>-0.017/0.727</td>
<td>0.047</td>
<td>-0.005/0.928</td>
<td>0.050</td>
<td>0.114/0.022 b</td>
</tr>
<tr>
<td>Age</td>
<td>0.004/0.941</td>
<td>0.059</td>
<td>0.154/0.014 b</td>
<td>0.062</td>
<td>0.044/0.478</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.256/0.000 b</td>
<td>0.060</td>
<td>0.246/0.000 b</td>
<td>0.063</td>
<td>-0.002/0.974</td>
</tr>
<tr>
<td>Overall R²</td>
<td>0.249</td>
<td>0.163</td>
<td>0.166</td>
<td>0.247</td>
<td>0.096</td>
</tr>
<tr>
<td>Overall F</td>
<td>18.809/0.000 b</td>
<td>11.026/0.000 b</td>
<td>11.299/0.000 b</td>
<td>18.567/0.000 b</td>
<td>6.001/0.000 b</td>
</tr>
</tbody>
</table>

*Higher scores for all impairments, role function, social function and physical activity indicate better function. Higher scores on ADL/IADLs and inactivity indicate poorer function. Results are based on continuous scores. β coefficients indicate unique contributions of impairments to disability.

bP < 0.05.

ADL/IADL, activities and instrumental activities of daily living; MMSE, Mini-Mental State Examination; SE, standard error.
Discussion

Several studies have examined the co-occurrence of impairments. Reuben and Siu [19] report only moderate associations between performance-based gait measures and cognitive dysfunctioning on MMSE [15]. Cress et al. found negative associations between gait speed and depressive symptoms in older people living at home and in nursing homes [20] but Rozzini et al. found no association between physical performance and depression scores in community-based older people [21]. Despite associations between self-reported vision loss and depressive symptoms [22], no associations were found between performance-based visual loss and depressive symptoms [23].

Several studies have focused on associations between both vision and hearing loss and functional outcomes. Vision loss was related to functional decline and disability [24-27]; however, hearing loss was either unrelated or related to a lesser extent [24, 26]. Weak associations were found between physical performance and six aspects of daily function in a small sample of older people [28]. The effect of cognitive impairments on daily function has been reported: there are moderate associations between cognitive performance and both active lifestyle and self-reported health in older people [29]. In their review, Tombaugh and McIntyre found strong associations between cognitive impairments and ADL and IADL dysfunction [30].

Three major conclusions can be drawn from the present study:

1. Impairments are not very strongly related to disability. This suggests that other factors (including adaptations such as proper footwear, modified stairs and surfaces, handrails and personal help) may moderate the associations between impairments and disability.

2. Motor impairments and depressive symptoms are associated with all disability measures, even when the effects of other impairments, age and gender are controlled. The close association between all domains of disability and depressive symptoms is of particular interest to those in primary care.

3. Our hypothesis that the co-occurrence of common impairments of later life exacerbate disability is weakly supported. Visual loss and, to a lesser extent, hearing loss particularly exacerbate the impact of the other impairments on different domains of disability. Co-occurrence of vision loss and motor impairments consistently exacerbates all disability domains except inactivity.

Our results are consistent with those of Ormel et al. [31] who reported a consistent relationship between psychological illness and disability across a wide range of countries and cultures. In our study we found that depressive symptoms maintain their broad effect on all
disability domains, even when the influences of the other impairments, age and gender are controlled. Kempen et al. [32] found that self-reported levels of ADLs are sensitive to levels of emotional function. Older people with higher levels of depressive symptoms tend to report lower levels of ADLs compared to their performance-based levels of ADLs. These results are supported by our results: people with more depressive symptoms report lower levels of function when other impairments are controlled. However, we found that depressive symptoms are also moderately associated with motor impairments, suggesting the co-occurrence of depressive symptoms and motor impairments.

Our study has several limitations. By using a cross-sectional design, it is not possible to study causal relationships. For example, one can hypothesize that the amount of time spent on physical activities or inactivity may affect subsequent levels of motor impairments; future longitudinal analyses are needed to evaluate this. In addition, we have performed many statistical tests which may have resulted in some spuriously significant results. Furthermore, we have used aggregated scores. Specific motor impairments or vision loss functions may affect specific ADL or IADL items. Such analyses require more detail and probably a larger sample. For answering our research questions on main and interaction effects of impairments on disability, aggregated scores are sufficient.

In conclusion, impairments largely act individually on disability. Although several first-order interaction effects do occur, their impact is not very strong.

Acknowledgements

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Key points

- Our study of the association between impairments and disability in a random community-based sample of older people shows that a combination of impairments do influence disability, but the effect is small.
- Even when older people have many impairments, further disability is not inevitable.
- Motor impairments and depressive symptoms are individually associated with all aspects of disability.

References


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