Depressive symptoms in addition to visual impairment, reduced strength and poor balance predict falls in older Taiwanese people

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Abstract

Objective: to determine whether depression is an important and independent predictor of falls in community-dwelling older people living in Taiwan.

Design: longitudinal study.

Setting: five randomly selected villages from Tainan city, Taiwan.

Participants and methods: in total, 280 community-dwelling people not taking anti-depressant medication aged 65–91 years (mean age 74.9). Participants completed the Geriatric Depression Scale and underwent a range of sensorimotor, balance and mobility tasks and were then followed up for 2 years with monthly telephone calls to determine falls incidence.

Results: of the 260 participants with complete follow-up data, 174 (66.9%) experienced no falls, 51 (19.6%) fell once and 35 (13.5%) fell two or more times. Depressive symptoms were significantly more prevalent in recurrent fallers (40.0%) and once-only fallers (27.5%) compared with non-fallers (16.1%). Negative binomial regression analysis identified depression, poor depth perception, reduced lower limb strength and increased sway as independent and significant predictors of falls.
**Depression and falls in older Taiwanese people**

**Conclusion:** depressive symptoms were found to be common in older Taiwanese people and associated with an increased fall risk. These findings suggest that in addition to implementing approaches to maximise vision, strength and balance, fall prevention strategies should also include interventions to assess and treat depression.

**Keywords:** accidental falls, aged, vision, muscle strength, postural sway, depression, older people

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**Introduction**

Falls in older people are a major public health issue, causing physical disability and reduced independence for the older person as well as considerable financial costs to health systems. In Taiwan, falls are the second highest cause of accidental death in older people [1] and with over 10% of the population now aged 65 years and above, preventive action is crucial.

Depression is common in older people with approximately 15% of older community-living people reporting significant depressive symptomatology [2, 3]. Depression has been shown to be a risk factor for falls, but the underlying mechanisms for this are not yet fully understood [4, 5]. Moreover, most fall risk factor studies have been undertaken in primarily Caucasian populations and it is possible that different health, behavioural and lifestyle factors may influence fall risk profiles in other cultures.

In a recent systematic review of 21 studies, Kwan et al. [6] reported an average falls rate of 18% per annum in community-dwelling Chinese older people living in China, Hong Kong, Macao, Singapore and Taiwan. This figure is considerably below the rate of 30–35% commonly reported in Caucasian populations. In total, 132 variables were identified as fall risk factors in the systematic review, but no consistent pattern emerged to help define key explanatory variables for falls in these populations. Only two studies identified depression as a risk factor for falls [7, 8], and these studies were retrospective in design and included a mix of marker variables such as ‘a history of falls’ and ‘use of a walking aid’ along with a restricted range of psychological and physical functioning measures.

A more comprehensive examination of fall risk factors is necessary to determine the fall risk profile in Chinese older people, and to establish if depression is a significant predictor of falls in the population. We conducted a prospective study to determine the incidence of falls in community-dwelling older people in Taiwan, and examine the extent to which a broad range of psychological, physiological and functional factors influence fall risk in this group.

**Methods**

**Participants**

The sample comprised residents from five randomly selected ‘villages’ identified by the Taiwanese Bureau of Health in the Northern district of Tainan City. This method facilitated recruitment of a random sample as all Taiwanese citizens are registered with the Bureau of Health. Participants were initially contacted at home and asked to participate in the study. Participants who were not available at the first visit were visited on up to two further occasions. Inclusion criteria were being 65 years of age or older, and living in one of the five selected village sites. Exclusion criteria were taking anti-depressant medication, blindness, in a wheelchair or bed-bound or a Mini-Mental Status Examination (MMSE) score less than 19—a criterion suggested for excluding participants with cognitive impairment in population groups with a low level of education [9]. The Human Studies Ethics Committee at the Cheng Kung University, Tainan gave approval for this study, and informed consent was obtained from all participants before entry to the study. A structured questionnaire was administered to gather information on medical conditions, medications, functional capacity and falls history. The Falls Efficacy Scale-International (FES-I) [10] was used to evaluate fear of falling and the Incidental and Planned Exercise Questionnaire (IPEQ) [11] to quantify planned and incidental activity levels. Items from SF12 [12] were used to evaluate the participants’ subjective health, ability to climb stairs and pain.

**Measurement of depression**

The 15-item Geriatric Depression Score (GDS-15) via interview was used to assess for the symptoms of depression with a score of 6 or more suggestive of depression [13]. This cut-off score has a sensitivity of 81.5% and a specificity of 75.4% with a structured clinical interview for depression [14].

**Physical assessment**

Visual acuity and visual contrast sensitivity were assessed using a logMAR chart and the Melbourne Edge Test, respectively [15]. Depth perception was evaluated using a Howard-Dohlman depth perception apparatus [15]. Proprioception was measured using a composite lower limb task, involving primarily the knee and ankle joints [15]. Tactile sensitivity was measured at the lateral malleolus using a Semmes-Weinstein aesthesiometer [15]. Knee extension and flexion strength was measured using a simple strain gauge in the dominant leg with participants seated [15]. Simple reaction time was measured using a light as the stimulus and a finger-press as the response [15]. Postural sway was measured using a swaymeter.
that measured displacements of the body at the level of the waist [15]. Testing was performed with participants standing on the floor and a foam rubber mat (65 cm × 65 cm × 15 cm thick) with eyes open. Leaning balance was measured using the \textit{coordinate stability} test [16] using the swaymeter extended in the anterior plane [16]. Standing balance was also assessed with the single leg stance [17] and near tandem stand [18] tests.

Functional mobility was assessed with the Timed Up and Go [19], six-metre walking speed [20], alternate step [18], sit-to-stand [18] and minimal chair height standing [21] tests. Participants were not provided with specific information about their test performances, and so test administration should not have affected their behaviour during the follow-up period. Full descriptions of the sensorimotor performance, balance and functional mobility tests are included as Supplementary data available in \textit{Age and Ageing} online, Appendix 1, and test–retest reliability data are published elsewhere [16–21].

Falls follow-up procedure and analysis
Participants were followed up with monthly telephone contact for a 2-year period. The participant and their family members or carers were asked about the occurrence of any falls. A telephone, rather than fall diary, follow-up was used as many participants were illiterate (15.8% of participants had no formal education). A fall was defined as ‘inadvertently coming to rest on the ground or other lower level with or without loss of consciousness, and other than as a consequence of sudden onset of paralysis, epileptic seizure, excess alcohol intake or overwhelming external force’ [22].

Statistical analysis
The presence of depressive symptoms and other health and lifestyle measures were dichotomously scaled. For four participants (1.5%) who completed 10–14 GDS items, we used the proration method [23] with the available GDS items to impute complete GDS scores. The physical measures (i.e. the sensorimotor, neuromuscular, anthropometric, functional, static and dynamic balance measures) were coded as continuous variables. Initially, univariate negative binomial regression analyses were used to calculate incident rate ratios (IRR) for fall risk factors. In these analyses, physical measures were entered in standardised (\(z\)-score) form. A multivariate negative binomial regression model was then used to identify the best set of significant and independent risk factors for falls. To minimise the problem of co-linearity, only the variable most strongly associated with falls from each of the following domains was included in the models: psychological functioning, sensorimotor function, strength and balance. Age was included as a possible predictor variable but no adjustments for medical conditions were made as our underlying premise is a functional/physiological one. As such, we maintain that the effects of any medical conditions (diagnosed or not) would manifest in one or more of the physiological and neuropsychological measures assessed [24] and that the inclusion of medical conditions in the multivariate models may result in ‘over-adjusting’ and dilution of important explanatory findings [25]. Data were analysed using SPSS (SPSS, Inc., Chicago, IL, USA) and Stata (StataCorp LP, College Station, TX, USA).

Results

Demographic characteristics of the sample
Of the 394 participants initially contacted, 280 participants (160 men, 120 women) aged 65–91 years (mean 74.9, SD = 6.4) met the inclusion criteria and agreed to participate in the study. Reasons for refusal were: poor health, still working, too busy and living in institutions. Those who refused participation were of similar age to those who did not (\(t = 0.40, df = 391, P = 0.69\)). One participant was excluded due to the use of anti-depressant medication. Information with respect to falls for the complete 2-year follow-up period was obtained from 260 participants (93.2%). The 19 participants (6.8%) who were lost to follow-up were significantly older (mean age 77.7 years \((t_{1,277} = -1.99, P = 0.047)\), but did not differ from those with complete falls follow-up in terms of gender distribution \((\chi^2 = 0.19, df = 1, P = 0.68)\), number of co-morbidities \((t_{1,275} = -1.35, P = 0.18)\), cognitive function as measured by MMSE \((t_{1,276} = -0.17, P = 0.86)\), falls in the previous year \((\chi^2 = 1.80, df = 1, P = 0.18)\) or depressive symptoms \((\chi^2 = 0.24, df = 1, P = 0.63)\).

Depression and its correlates
Fifty six of the 260 participants (21.5%) reported depressive symptoms (GDS-15 score \(\geq 6\)). GDS scores were significantly correlated with MMSE scores \((r = -0.18, P = 0.003)\), poor subjective health \((r = 0.14, P = 0.023)\), stair-climbing limitations \((r = 0.25, P < 0.001)\) and pain \((r = 0.27, P < 0.001)\). The presence of depressive symptoms was not associated with increased age, sex, living arrangements (living alone), functional capacity (instrumental activities of daily living) health status (number of co-morbidities) and the use of multiple \((\geq 4)\) medications.

Falls
Eighty-six people (33.1%) reported having one or more falls in the 2-year follow-up period, with a total of 145 falls, which is equivalent to an annual fall rate of 27.8%. For those who fell, 51 (59.3%) fell once only, 18 (20.9%) fell twice and 17 (19.7%) fell three or more times. Table 1 shows the demographic, health and lifestyle profiles of participants in each category (Table 1)
Table 2 shows the scores for each continuously scored test measure and prevalence of other potential fall risk factors. Univariate analyses revealed that recurrent fallers reported more depressive symptoms and performed worse in the tests of depth perception, balance, knee extension and flexion strength, tactile sensitivity, single leg stance (worse leg), minimal chair height standing, timed up and go and six-metre walk tests compared with non-recurrent fallers (those who suffered 0 or 1 falls). Significantly higher proportions of recurrent fallers also reported stair-climbing limitations and pain (Table 2). Independent and significant predictors of falls, using negative binomial regression analyses, were the presence of depressive symptoms IRR 1.91 (95% CI: 1.21–3.00), standard deviation increases in sway IRR 1.43 (95% CI: 1.18–1.73), standard deviations decreases in combined lower limb strength scores IRR 0.75 (95% CI: 0.60–0.95) and standard deviation reductions in depth perception IRR 1.22 (95% CI: 1.01–1.48). The model changed very little when adjusting for age, but depth perception became only borderline significant—IRR 1.20 (95% CI: 0.99–1.45).

### Discussion

In this prospective study of falls in older community-dwelling Taiwanese people, the annual fall rate was 27.8%, a figure below that commonly reported in Caucasian populations but similar to that reported from previous prospective fall risk studies undertaken in Chinese populations [26]. In contrast, the prevalence of depressive symptoms was found to be high (21.5%), a figure consistent with other studies conducted in Taiwan [27–29].

Depression has been shown to be a risk factor for falls in previous Caucasian studies [30, 31], and this current study shows that depression is also an independent predictor of recurrent falls in older Chinese people. The underlying mechanisms for the association between depression and falls are not yet fully understood; however, some studies have shown these conditions share some common risk factors, such as poor health, impaired ADL and inactivity [32, 33]. Anti-depressant medication independently increases fall risk [34], but this factor can be ruled out from the present study findings as taking anti-depressant medication was an exclusion criterion. Participants with depressive symptoms in the current population were also found to be significantly more sedentary and have reduced lower limb strength than participants without depressive symptoms (data not shown). However, the fact that depressive symptoms were included in the final model suggests that this factor contributes to falls over and above muscle weakness and instability-related factors.

Three other measures were also identified as independent predictors of falls. Depth perception is crucial for judging spatial relationships and is important for negotiating and avoiding hazards in the environment. Poor depth perception has been shown to increase the risk of multiple falls [4, 35] and hip fractures [36, 37], and studies have shown that people who have good vision in one eye, but only moderate or poor vision in the other, have an elevated risk of falls and hip fracture [35, 38]. There is good evidence that impaired strength in the lower limb muscle groups and poor balance are important risk factors for falls [39]. Adequate lower limb muscle strength is necessary for everyday tasks such as rising from a chair and stepping and...
is a significant predictor of performance in the functional mobility measures included in this study that were also associated with an increased risk of multiple falls in univariate analyses (minimal chair height standing [21], timed up and go [40] and six-metre walk test performances [20]). The inclusion of postural sway in the final model indicates that reduced balance control is also a crucial factor in predisposing older people to fall.

This study has highlighted several fall risk factors that are easily identifiable and potentially amenable to intervention and therefore has implications for future prevention in this population. Firstly, fall risk assessment should include an objective measurement of mood in addition to assessments of vision, strength and balance [41]. Depression may be addressed directly through psychological intervention or careful medication use although it is acknowledged that anti-depressants also appear to increase the risk of falls. Exercise programmes have been shown to reduce the levels of the depression [42, 43] and improve cognitive abilities [43] and the sleep quality [42] in older people, and thus may reduce falls by these mechanisms in addition to improving strength and balance.

Secondly, older Taiwanese people should be encouraged to take part in physical activity programmes that focus on improving balance [44], muscle strength and cardiovascular fitness. Exercise has been shown to counteract the age-related cognitive decline [45], reduce the cognitive resources expended to control a locomotor task [46] and

Table 2. Psychological, physiological and functional characteristics of non-fallers, single fallers and recurrent fallers for participants with a full 2-year follow-up (n = 260)

<table>
<thead>
<tr>
<th>Risk factor variable</th>
<th>Non-fallers (n = 174)</th>
<th>Single fallers (n = 51)</th>
<th>Recurrent fallers (n = 35)</th>
<th>IRR†</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDS score ≥6, n (%)</td>
<td>28 (16.1)</td>
<td>14 (27.5)</td>
<td>14 (40.0)</td>
<td>1.82 (1.12–2.94)</td>
</tr>
<tr>
<td>Sensory, mean (SD)</td>
<td></td>
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<tr>
<td>Visual acuity—high contrast (logMAR)†</td>
<td>2.23 ± 1.79</td>
<td>1.99 ± 1.10</td>
<td>2.26 ± 1.05</td>
<td>1.04 (0.81–1.34)</td>
</tr>
<tr>
<td>Edge contrast sensitivity (dB)‡</td>
<td>18.72 ± 2.94</td>
<td>18.57 ± 3.03</td>
<td>18.37 ± 2.46</td>
<td>0.96 (0.88–1.03)</td>
</tr>
<tr>
<td>Depth perception (cm)§</td>
<td>3.88 ± 3.94</td>
<td>3.22 ± 3.05</td>
<td>5.79 ± 4.94</td>
<td>1.25 (1.02–1.53)</td>
</tr>
<tr>
<td>Proprioception (degree)¶</td>
<td>2.07 ± 1.61</td>
<td>2.21 ± 1.63</td>
<td>2.11 ± 1.41</td>
<td>1.10 (0.88–1.38)</td>
</tr>
<tr>
<td>Tactile sensation (log10 mg pressure)</td>
<td>4.35 ± 0.53</td>
<td>4.38 ± 0.54</td>
<td>4.59 ± 0.59</td>
<td>1.33 (1.09–1.64)</td>
</tr>
<tr>
<td>Strength, mean (SD)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Knee extension strength (N)</td>
<td>241.1 ± 95.1</td>
<td>223.8 ± 108.0</td>
<td>184.2 ± 75.5</td>
<td>0.72 (0.57–0.91)</td>
</tr>
<tr>
<td>Knee flexion strength (N)</td>
<td>108.3 ± 40.1</td>
<td>104.8 ± 48.5</td>
<td>82.9 ± 29.6</td>
<td>0.74 (0.59–0.94)</td>
</tr>
<tr>
<td>Combined strength measure (N)</td>
<td>349.0 ± 127.8</td>
<td>328.6 ± 151.0</td>
<td>267.2 ± 98.7</td>
<td>0.72 (0.57–0.90)</td>
</tr>
<tr>
<td>Reaction time, mean (SD)</td>
<td></td>
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<tr>
<td>Hand reaction time (ms)</td>
<td>308.9 ± 90.8</td>
<td>309.4 ± 78.0</td>
<td>307.1 ± 72.8</td>
<td>0.99 (0.78–1.25)</td>
</tr>
<tr>
<td>Balance, mean (SD)</td>
<td></td>
<td></td>
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<tr>
<td>Sway—floor with eyes open (mm)†</td>
<td>80.4 ± 39.7</td>
<td>91.3 ± 57.4</td>
<td>106.3 ± 53.1</td>
<td>1.40 (1.14–1.71)</td>
</tr>
<tr>
<td>Sway—foam with eyes open (mm)‡</td>
<td>197.0 ± 107.7</td>
<td>227.1 ± 132.6</td>
<td>245.6 ± 124.5</td>
<td>1.29 (1.05–1.60)</td>
</tr>
<tr>
<td>Co-ordinated stability (errors)</td>
<td>15.26 ± 12.47</td>
<td>14.09 ± 11.35</td>
<td>19.40 ± 13.94</td>
<td>1.22 (0.98–1.51)</td>
</tr>
<tr>
<td>Near tandem stand (s)§</td>
<td>20.16 ± 10.73</td>
<td>18.55 ± 11.86</td>
<td>16.39 ± 12.06</td>
<td>0.80 (0.65–0.99)</td>
</tr>
<tr>
<td>Single leg stance—worse (s)¶</td>
<td>10.82 ± 10.15</td>
<td>9.98 ± 9.95</td>
<td>7.21 ± 7.81</td>
<td>0.78 (0.62–0.99)</td>
</tr>
<tr>
<td>Single leg stance—better (s)¶</td>
<td>15.23 ± 10.86</td>
<td>14.65 ± 11.69</td>
<td>11.87 ± 10.37</td>
<td>0.83 (0.66–1.03)</td>
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<tr>
<td>Functional tests, mean (SD)</td>
<td></td>
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<tr>
<td>Sit-to-stand (s)§</td>
<td>12.80 ± 4.59</td>
<td>14.35 ± 5.37</td>
<td>14.18 ± 5.82</td>
<td>1.22 (0.99–1.50)</td>
</tr>
<tr>
<td>Timed up and go (s)¶</td>
<td>10.52 ± 3.02</td>
<td>11.04 ± 3.44</td>
<td>12.18 ± 4.63</td>
<td>1.27 (1.04–1.56)</td>
</tr>
<tr>
<td>Alternate step test (s)¶</td>
<td>11.27 ± 3.56</td>
<td>13.90 ± 8.72</td>
<td>12.16 ± 4.45</td>
<td>1.24 (1.00–1.53)</td>
</tr>
<tr>
<td>Minimal chair height standing (cm)§</td>
<td>24.97 ± 9.09</td>
<td>27.94 ± 9.36</td>
<td>30.05 ± 9.16</td>
<td>1.44 (1.16–1.80)</td>
</tr>
<tr>
<td>Six-metre walk test (m/s)§</td>
<td>1.04 ± 0.25</td>
<td>1.02 ± 0.33</td>
<td>0.91 ± 0.21</td>
<td>0.95 (0.60–0.94)</td>
</tr>
<tr>
<td>Cognition, mean (SD)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>MMSE score</td>
<td>26.8 ± 2.9</td>
<td>26.6 ± 2.9</td>
<td>26.1 ± 2.7</td>
<td>0.94 (0.87–1.02)</td>
</tr>
<tr>
<td>Self-rated health</td>
<td></td>
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</tr>
<tr>
<td>Poor self-rated health, n (%)</td>
<td>125 (72.7)</td>
<td>40 (78.4)</td>
<td>29 (82.9)</td>
<td>1.55 (0.91–2.66)</td>
</tr>
<tr>
<td>Limit in stair climbing, n (%)</td>
<td>77 (44.3)</td>
<td>29 (56.9)</td>
<td>25 (71.4)</td>
<td>1.83 (1.18–2.84)</td>
</tr>
<tr>
<td>Moderate-extreme pain, n (%)</td>
<td>45 (25.9)</td>
<td>21 (41.2)</td>
<td>19 (54.3)</td>
<td>2.06 (1.33–3.17)</td>
</tr>
</tbody>
</table>

Note: Data on the visual acuity and the near tandem stand test were available for 258 participants; data on the knee extension and flexion strengths, single leg stance, six-metre walk test were available for 260 participants; data on the maximal balance range and poor self-rated health were available for 259 participants.

†Smallest logMAR (logarithm of the minimum angle of resolution) correctly reported at 3 m (min).
‡dB log contrast.
§Error in aligning two visual targets at a test distance of 3m (cm).
¶Error in degrees.
E Millimetres traversed by the pen on the swaymeter in 30 s.
Time taken to complete the test.
C Centimetres off the ground.
M Speed (m/s).
JIRR calculated based on all participants (n = 279), adjusting for the length of the follow-up.
have beneficial effects in relation to depression [47]. Finally, as over 70% of visual impairments in older people are remediable [48], regular eye health evaluation should be advocated for early identification and subsequent intervention of any visual impairment. Surgery for those with cataracts and the provision of single lens distance glasses to multifocal glasses wearers have been shown to reduce falls [49, 50], with cataract surgery also shown to improve anxiety, depression and confidence [50].

A major strength of this study was the selection of a cohort in which anti-depressant use was rare—only one participant was excluded on this basis. Thus, the study findings provide important information on the association between depression and falls in a representative community sample without the presence of anti-depressant use as a confounding factor. Some study limitations also deserve comment. Firstly, the measurement of depression was based on the GDS, which provides a measure of depressive symptoms, and is therefore suggestive rather than diagnostic of clinical depression. Secondly, it is acknowledged that as assessments were made only at baseline, the health status and related measures may have changed over the course of the 2-year follow-up. Such changes, however, would have only weakened the associations uncovered in the analyses. Finally, environmental risk factors were not addressed, and future studies are required to provide a better understanding of interactions between physical, psychological and environmental factors.

Conclusion
Depressive symptoms were found to be common in older Taiwanese people and associated with an increased risk of falls. These findings suggest that in addition to implementing approaches to maximise vision, strength and balance, fall prevention strategies should specifically assess and consider interventions to address depression in this population.

Key points
- Depressive symptoms were found to be common and independently associated with an increased risk of falls in a representative community sample of older people living in Taiwan. Poor depth perception, reduced lower limb strength and increased postural sway were also identified as key fall risk factors.
- The association between depression and falls was not due to the use of anti-depressant medications as no participants were taking these medications.
- The findings indicate multifactorial interventions are required to address fall risk in older Taiwanese people.
- These strategies should include interventions to address depression.

Depression and falls in older Taiwanese people

Funding
This research was supported by the National Science Council of Taiwan (NSC 96-2516-S-006-003 and NSC 96-2314-B-006-061) and National Cheng Kung University Project of promoting academic excellence and developing world class research (D96-1100). Additional support was provided by an NSW Health Capacity Building in Population Health (Injury, Trauma, Rehabilitation) Scholarship to M.M-S.K. and an Elizabeth Fyffe Postgraduate Research Scholarship for Falls Prevention to M.M-S.K. The funding bodies had no role in the study design, data collection and analysis, writing of the manuscript or in the decision to submit the paper for publication.

Supplementary data
Supplementary data mentioned in the text is available to subscribers in Age and Aging online.

References
The very long list of references supporting this paper has meant that only the most important are listed here and are represented by bold type throughout the text. The full list of references is available at Supplementary data in Age and Aging online, Appendix 2.


Received 10 August 2011; accepted in revised form 5 April 2012

Interpreting and evaluating the CASP-19 quality of life measure in older people

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Abstract

Objective: to investigate how to interpret changes on the CASP-19 quality of life scale for older people, and whether it discriminates between, and is responsive to, relevant differences or changes in participants’ circumstances.

Methods: analysis of data from the English Longitudinal Study of Ageing for those completing CASP-19 in both Wave 1 and Wave 2 (n = 6,482). Cross-sectional and longitudinal comparisons, using multiple linear regression, of CASP-19 scores with respect to eight anchor variables.

Results: cross-sectional comparisons found differences in mean CASP-19 scores at Wave 1 between categories of anchor variables varied from 1.9 for living alone to 8.0 for being able to walk ¼ mile with difficulty. Longitudinal comparisons of changes in CASP-19 found that subjects that had moved between categories of the anchor variables over 28 months, had