

## 6. Measured physical performance

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The key points in this chapter include:

- Performance measures offer an objective marker of functioning, free from differences in attitudes to reporting difficulties. ELSA wave 2 (2004–05) included tests of lower limb functioning plus grip strength.
- Overall tested performance declines with age, but some of the oldest people maintain high functioning. For example, the weakest 25% of women aged 52–59 have measured grip strengths of 24 kg or less, but the top 5% women aged 80 and over have grip strengths of 25 kg and above.
- Those living in the poorest households have significantly higher rates of impairment on all tests. For instance, compared with those in the wealthiest fifth of households, men and women in the poorest fifth of households are approximately two and a half times as likely to perform poorly on the Short Physical Performance Battery of tests.
- Incidence rates of poor function on the gait speed test are also associated with low wealth. Both men and women in the poorest group are significantly more likely to have developed gait speed limitations between the first and second ELSA waves than those in the wealthiest group.
- Performance test results are useful in detecting differences among high- as well as low-functioning individuals, and provide reliable measures for identifying factors that might delay the onset of functional limitations.

### 6.1 Introduction

In this chapter we explore the results of the tests of physical performance that were carried out in 2004–05. Performance tests aim to assess physical functioning in a standardised way. The degree of objectivity introduced by these tests can be used to compare groups that face different environmental challenges and have different attitudes to reporting difficulties with everyday activities.

#### **Performance tests and the assessment of functioning**

ELSA wave 2 included tests of lower limb mobility (walking/gait speed, time to complete five chair stands, and balance tests), supplemented by a measure

### *Measured physical performance*

of muscle strength. Restricted mobility is an early and relatively culture-free marker of the development of disabilities and because of this has been used in the ELSA study as a principal marker of functioning. Well over nine-in-ten older people with any disability report problems with walking (Lan et al., 2002).

Differences between self-reports and the results of performance tests have long been reported (Hoeymans et al., 1996; Sayers et al., 2004). Performance measures provide a method of accounting for different thresholds for self-reporting of disabilities between people and groups (Iburg et al., 2001; Melzer et al., 2004; Murray et al., 2001). Also, tested performance can be more sensitive than self-reports, particularly for people with some degree of cognitive impairment: Melzer and colleagues (Melzer et al., 2005) showed that performance measures are sensitive to the effects of the Alzheimer's related ApoE-e4 genetic variant, while self-reported functioning is not.

Impaired function on performance tests has been shown to be strongly predictive of future disability, nursing home entry and mortality (Guralnik et al., 1994; Guralnik et al., 1995) in the USA. Performance tests thus have utility in the clinical assessment of older people (Guralnik and Ferrucci, 2003; Studenski et al., 2003), including the identification of those with pre-clinical limitations who are at higher risk of developing disabilities over the following few years (Cavazzini et al., 2004).

Similarly, lower muscle strength has emerged as a long-term predictor of earlier onset of disability (Rantanen et al., 1999): those with greater strength appear to have more reserves to cope with the effects of ageing and tend to be able to function well for longer. Declining muscle strength with advancing age may reflect accumulated damage as well as the effects of disease.

Performance measures quantify physical function on a continuous scale from very poor to excellent. The results are also expected to be valuable in detecting change in function over time, when enough time has elapsed so that differences in function are large compared to the measurement errors at each wave. The gait speed results from the ELSA baseline have supported comparisons with a US national study, indicating that performance and reporting of medium-distance mobility difficulties (over a quarter of a mile) are broadly similar in England and the USA (Gardener and Melzer, 2005).

Since the functions measured in the ELSA tests are not comprehensive and people can perform better on tests than in everyday life – for example by ignoring pain in order to do well in the test situation – these tests cannot be regarded as the only benchmark. Self-reported difficulties remain important, and combining self-reports with performance test data can be useful (Reuben et al., 2004). In addition, it is only by considering self-reported difficulties that we can gain insight into how an individual is doing in his or her own environment, which is important for providing supportive services and accommodation.

An obvious question is why several measures of function are needed. In a comparison of reported and measured mobility (walking) ability, Lan and colleagues (Lan et al., 2002) showed that while gait speed measures identify a lot of impairment, adding, for example, the chair stand measure significantly

increases measurement precision. Identifying poor function is relatively easy, but accurately measuring grades of good or excellent function is much more difficult. Curb and colleagues (Curb et al., 2006) have shown that measures such as grip strength, single-leg balance and chair stands discriminate well at the top end of functioning, but gait speed does not. The ELSA data will allow exploration of these issues in depth and will contribute to identifying the most efficient subset of markers for predicting future disability in individuals and monitoring population health.

### **The sample and response rates**

Some of the tests described in this chapter were performed as part of the nurse interview, but the gait speed test was performed during the main ELSA interview. The measures taken during the nurse interview included grip strength, balance measures, leg raises and chair rises.

All core sample members were eligible for a nurse visit, except those who required a proxy interview. Towards the end of the main interview, the respondent was asked if they were willing to be visited by a qualified nurse who would collect more medical information and carry out some measurements. If they refused to have a nurse visit then their reasons for refusal were recorded; if they agreed then the interviewer either arranged an appointment for the nurse to visit a few days later, or told the respondent that the nurse would telephone them to arrange the visit. The nurse asked separately for permission to do each test, so the respondent could decide at the time whether or not they wanted to participate in a particular test. The nurse demonstrated each test before the respondent was asked to do it.

Overall, 12% of core study members who had undertaken an interview did not receive a nurse visit. Chapter 12 of this report contains details of response rates for the second wave of ELSA interviews and for the nurse visit, by age group and wealth quintile. Within the group that took part in the nurse visit, refusal to participate in performance tests was rare: for example, although doing five chair stands can be demanding, particularly for older people, there were only six refusals to attempt this test. However, inability to complete a test is itself informative and so the proportions of respondents who were unable to do tests or who physically failed to complete the tests is provided in the tables.

### **The test procedures and results**

The first part of the results section below provides data on performance on each of the tests individually. Following this, the balance, gait speed and chair stand test results are combined into the Short Physical Performance Battery (Guralnik et al., 2000). This provides a highly validated summary marker of lower limb functioning in older people.

## **6.2 Grip strength**

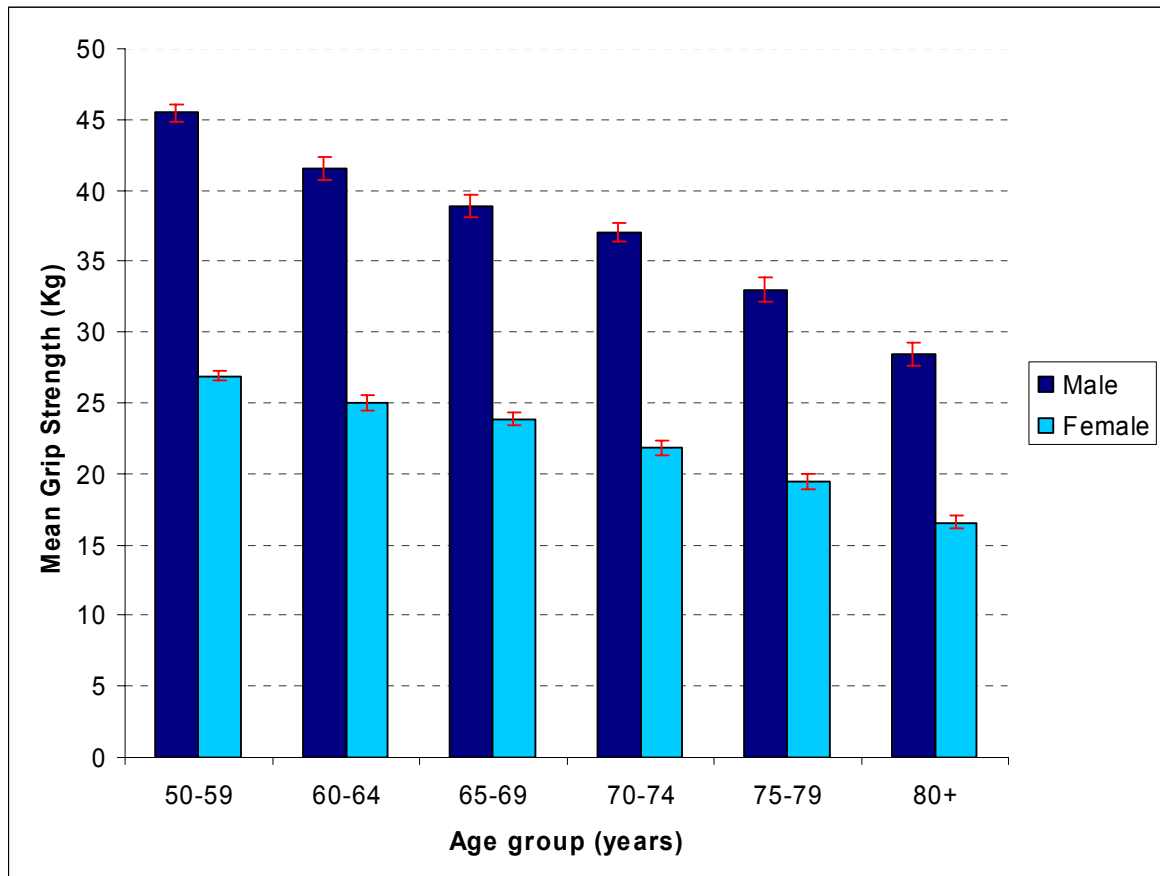
The grip strength test is a test for upper body strength. It was given to all respondents who were willing to take it, with no upper or lower age limits, but with certain exclusions on safety grounds (respondents were excluded if they had swelling or inflammation, severe pain, a recent injury, or if they had had

## Measured physical performance

surgery to the hand in the preceding six months). If there was a problem with only one hand, measurements were taken using the other hand.

After adjusting the gripometer<sup>1</sup> (grip gauge) to suit the respondent's hand and positioning the respondent correctly, the respondent was asked to squeeze the gripometer as hard as they could for a couple of seconds. Three values were recorded for each hand, starting with the non-dominant hand and alternating between hands. Any measurements carried out incorrectly were not included.

**Figure 6.1. Mean grip strength by age group and gender**



## Grip strength results

Mean strength declines with age, from 46 kg among men aged 52–59, to 28 kg in those aged 80 years and over. Strength in women is lower – 27 kg in 52–59-year-olds and 17 kg in those 80 and above – but shows a similar age-related decline (Figure 6.1 and Tables 6A.1 and 6A.2). There is an increase with age in the percentage of respondents who are unable to do the test. An additional factor apparent from Figure 6.1 is that the male-female ratio of mean grip strength remains approximately constant (at around 1.68) as each group ages.

In spite of the decline in average (mean) function, there are large differences in strength within each age group and some of the oldest respondents are stronger than some of the youngest (Table 6A.1). For example, the weakest

<sup>1</sup>The gripometer used was the 'Smedley's for Hand' Dynamo Meter, scale 0–100kg.

25% of the women aged 52–59 had measured grip strengths up to 24 kg, but the top 5% of the women 80+ had grip strengths of 25kg or more.

Many measures linked to health status at all ages show more limitation in less privileged groups. Grip strength in ELSA is no exception, rising from 37 kg in the poorest quintile of older men to 41 kg in the wealthiest; in women, the corresponding figures are 21 kg in the poorest quintile and 25 kg in the wealthiest (Table 6A.3).

### **6.3 Static balance tests**

Static balance was evaluated in three separate, progressively more difficult, tests. Respondents in the following circumstances were ineligible for the balance tests: if they were chair-bound or wheelchair-based; if it became clear after discussion that they were too unsteady on their feet; if they found it painful to stand; or if either the nurse or the respondent considered it unsafe to conduct the measurement. If the respondent was not willing to take part in the tests (for example, saying that they were too busy) they were coded as ‘refused’ and the reason for refusal was noted.

The tests were demonstrated once and walking aids such as canes, walkers or crutches could not be used (this applied to all balance, leg raise and chair stand tests). Respondents were asked to wear appropriate (flat) shoes and the nurse was able to help them get into position and to stand by in case they began to fall or lose their balance.

The balance measure evaluated the respondent’s ability to balance using five components, described in detail below: side-by-side, semi-tandem and full tandem, and for those aged 69 years and under, leg raise with eyes open and leg raise with eyes closed. All ages started with the side-by-side for 10 seconds; if they passed that, they then did the semi-tandem for 10 seconds; those who passed the semi-tandem then attempted the full tandem – for 10 seconds if aged 70 years or over, and for 30 seconds if aged 69 years or under. Those aged 69 years and under who successfully passed the full tandem stand then attempted the one-leg stand with eyes open for 30 seconds, and if they were successful in that, they then attempted it again with their eyes closed for 30 seconds. They were not allowed to practise for the side-by-side, semi-tandem or full-tandem stands, but they were allowed one practice for the one-leg stand.

If the respondent or the nurse felt any particular test was unsafe then it was not attempted.

#### *Side-by-side stand*

The respondent was asked to stand with feet together, side-by-side, for at least 10 seconds, using their arms, bending their knees or moving their body to maintain balance, but not moving their feet. If the respondent was unable to hold the position for 10 seconds, then the time held in seconds (to 2 decimal places) was recorded. If the respondent was able to hold the position for 10 seconds, then they moved on to the semi-tandem stand.

## *Measured physical performance*

### *Semi-tandem stand*

Here, respondents had to stand with the side of the heel of one foot touching the big toe of the other foot for at least 10 seconds. If they were able to hold the position for 10 seconds then they moved on to the full tandem stand.

### *Full tandem stand*

For this test respondents had to stand with the heel of one foot in front of and touching the toes of the other foot, for at least 30 seconds (if aged 69 years or under), or for about 10 seconds (if aged 70 years or over).

### *Leg raise with eyes open*

This test was carried out for those aged 69 years or under who had held the full tandem stand for 10 seconds. They were asked to try to stand on one leg, raise the other leg off the ground a few inches, and stand for as long as they could, but stopping at 30 seconds. (One-leg balance is an important predictor of injurious falls in older persons (Vellas et al., 1997).) Timing began as soon as the foot was raised and stopped either when either (1) the raised leg touched the floor as the respondent lost balance, or (2) 30 seconds had elapsed, whichever happened first. If respondents were able to hold the position for 30 seconds then they moved on to do the leg raise with eyes shut.

### *Leg raise with eyes shut*

This test was the same as the leg raise with eyes open, except respondents were asked to close their eyes as they stood on one leg. The test was stopped if (1) the raised leg touched the floor as the respondent lost his or her balance, or (2) the respondent opened his or her eyes, or (3) 30 seconds had elapsed, whichever happened first.

## **Balance test results**

The balance tests were designed to pose increasing difficulty and a general fall-off in performance is evident across the range of tests. While 99% of men can complete the side-by-side test, only 87% can maintain the full-tandem stand for 10 seconds (Table 6A.4). For the leg-raise tests, designed to challenge younger people, only a small minority of both men (3%) and women (2%) are able to maintain their position, standing on one leg with their eyes closed, for 30 seconds.

As expected, performance declines with age: for example, for men the percentage holding the full tandem position for 10 seconds declines from 96% at age 52–59 years, to 56% at age 80 years and over.

The percentage of women successfully performing these tests is only marginally lower than of men at ages under 70 years. Again, performance declines markedly with age. For example, for the full tandem stand, 94% of women can maintain their position for 10 seconds in the youngest group, while only one-third of those aged 80 years and over can do this. Reflecting a greater difference between the sexes, the same figures in men show a marked, but smaller, drop: 96% of men in the youngest group and 56% in the oldest group can complete this test.

## **6.4 Chair rise measures**

The chair stand is a simple test with complex requirements: it depends on several body systems working together, including muscular strength, balance, coordination, lower limb joint range of motion and exercise tolerance. Respondents were asked to stand up from a firm chair without using their arms. If they succeeded in doing a single rise, they were asked to stand up and sit down as quickly as they could for five rises if they were aged 70 years or over, or up to ten rises if aged 69 years or under, and the time taken was noted. While doing the test, respondents had to keep arms folded across the chest and feet on the floor. The nurse counted the rises out loud as they did them and each rise was counted as complete when the respondent was fully standing with his or her back straight. (For younger people, the time taken was measured at the end of both 5 and 10 rises.)

No-one attempted this test who could not stand up without assistance; the use of walking aids, such as a walker or cane, was not permitted. The test was stopped if the respondent became too tired or short of breath; if the participant used their hands; if after one minute, the participant had not completed all the rises; or if the nurse felt concerned for the respondent's safety.

### **Chair stand results**

Performance on the initial single chair stand was good, with relatively small proportions of the oldest respondents unable to do this screening test (Table 6A.5).

On the more demanding 5 or 10 chair stand tests (Table 6A.6), with advancing age there is a marked increase in the proportions unable to complete the test, and there are sharp declines in ability to complete the test evident in men aged 80 years and over and in women aged 75 years and over. The mean time taken to complete the stands increases with age, but while most tests show significantly poorer performance for women, an interesting aspect of the chair stand results is that, among those able to complete the test, performance in women is similar to that in men. In women, the mean times taken to complete five stands are 10.3 seconds at age 52–59 years and 15.7 seconds at age 80 and over; in men, the corresponding times are 9.9 seconds and 15.3 seconds. These results should be treated with caution, though, because a greater proportion of older women than older men were unable to complete this test.

It is notable, however, that within each age group, there is a wide range of performance such that, for example, the slowest 25% of 52–59-year-old women takes more than 11.9 seconds, while the quickest 25% of 80+ year-old women take less than 12.0 seconds to complete the five stands. The same thing is evident among men: the slowest quarter of 52–59-year-olds takes 11.4 seconds or more for the five stands and the fastest quarter of men aged 80 or over completes the same test in 11.2 seconds or less (Table 6A.6).

## **6.5 Gait speed measurement**

All respondents aged 60 years and over completing the interviews on their own behalf were eligible for the walking speed test, which was performed as part of the main ELSA interview. The test involved timing how long it took to walk a distance of eight feet.

Respondents began with both feet together at the beginning of the course. The interviewer started timing as soon as the respondent placed either foot down on the floor across the start line. They were asked to walk (not race) to the other end of the course at their usual speed, just as if they were walking down the street to the shops, and to walk all the way past the other end of the tape before stopping. Timing was stopped when either foot was placed on the floor across the finish line. Respondents were then asked to repeat the test by lining up their feet and walking back along the course, all the way past the other end.

The gait speed test was also carried out at baseline (ELSA wave 1), making measures of change in performance possible. There is evidence that gait speed and other Short Physical Performance Battery (SPPB) components are responsive to change (Ostir et al., 2002), especially with the onset of major episodes of disease like heart attacks, strokes or hip fractures. In patients who recover from these major events, scores tend to improve and reflect recovery.

### **Gait speed results**

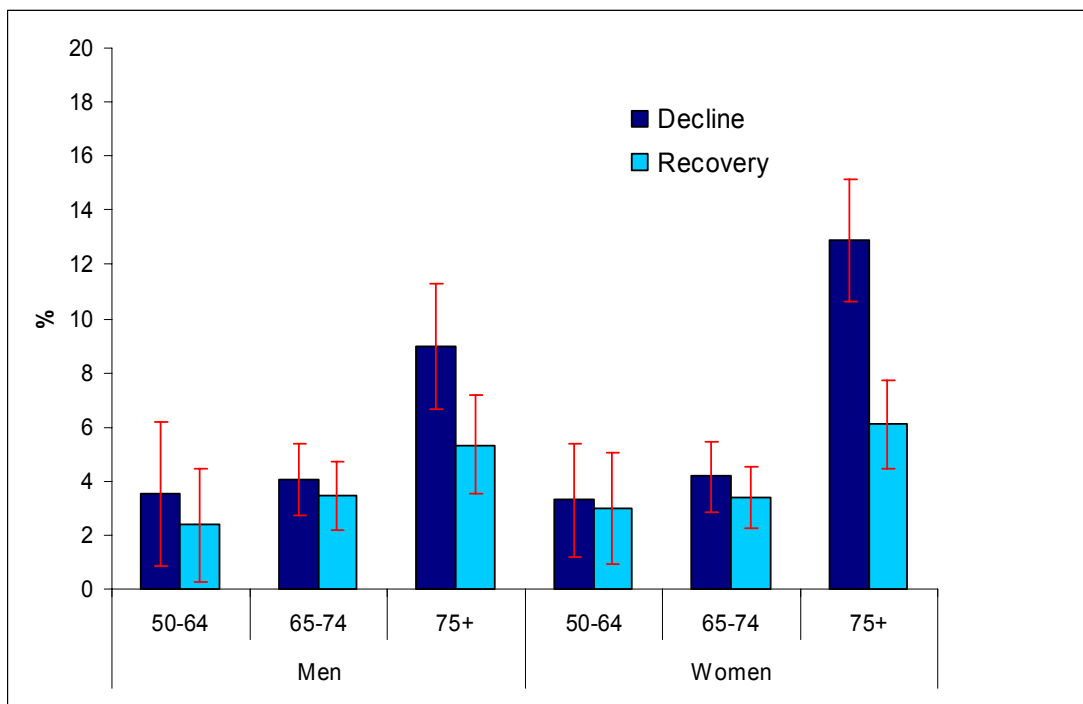
As with the other tests, the percentage of respondents unable to complete the gait speed test increases with age. Mean speeds (in metres per second) also decrease with age, and speeds are slightly lower in women than men (Table 6A.7).

#### *Incident gait speed performance*

By excluding people with poor performance at the ELSA baseline on the gait speed test, it is now possible to examine the percentages of respondents who have developed gait speed impairments since then. The gait speed test is really designed to identify impairment, as it asks people to walk at their normal pace and does not attempt to measure high performance. Table 6A.8 summarises the proportions of respondents who walk at or less than half a metre per second, or who cannot walk at all, by age-specific wealth quintile and sex. (For reference: a person walking at half a metre per second takes 15 seconds to cross a typical 7.5 metre single-carriageway road. Standard timings on pelican crossings in a 30 mph zone display a red light to traffic for between four and nine seconds, and a flashing amber for an additional six to eighteen seconds (Department for Transport, 1995).)

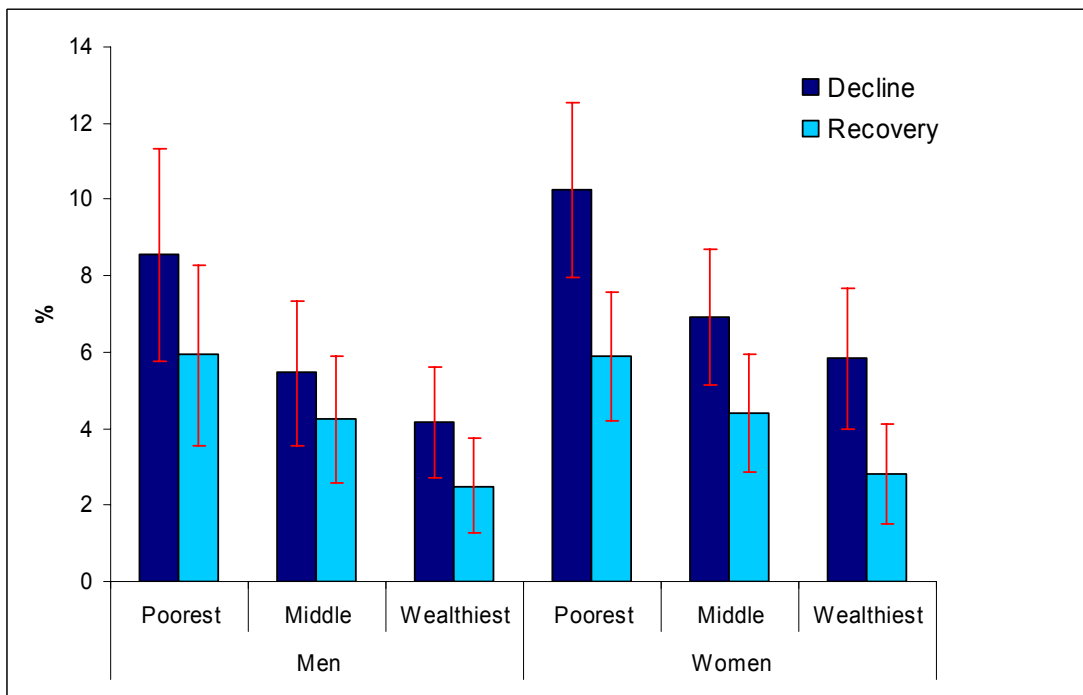
Figures 6.2 and 6.3 show change in gait speed limitations (gait speed  $\leq 0.5$  m/s) by age group and by age-specific wealth tertiles. In Figure 6.2, a trend indicating greater levels of decline associated with increasing age is evident. The oldest group shows a marked and statistically significant difference from the younger groups, with the greatest decline for older women. Figure 6.3 indicates that there are higher levels of decline in individuals living in poorer households. As with the age groups, the differences in recovery may relate to

**Figure 6.2. Change in gait speed limitations, by age group and sex, with 95% confidence intervals**



Note: Decline is defined as gait speed of >0.5m/s in 2002/03 and gait speed of ≤0.5m/s or being unable to complete the test in 2004/05; recovery is defined as gait speed of ≤0.5m/s or being unable to complete the test in 2002/03 and gait speed >0.5m/s in 2004/05

**Figure 6.3. Change in gait speed limitations, by age-specific wealth tertiles and sex, with 95% confidence intervals**



Note: Decline is defined as gait speed of >0.5m/s in 2002/03 and gait speed of ≤0.5m/s or being unable to complete the test in 2004/05; recovery is defined as gait speed of ≤0.5m/s or being unable to complete the test in 2002/03 and gait speed >0.5m/s in 2004/05

higher levels of baseline impairment. Overall levels of decline are fairly low and future waves of ELSA will provide a clearer picture of how incident decline in gait speed performance is related to socio-economic and other factors.

## 6.6 The Short Physical Performance Battery (SPPB) score

The SPPB combines the results of the gait speed, chair stand and balance tests (Guralnik et al., 2000). As described, this battery has been extensively validated, is predictive at the pre-clinical stage of later disability and has application in routine clinical settings in monitoring the functioning of older people. Figure 6.4 and 6.5 show the relationship between poor performance in the SPPB (defined as a score of 8 or lower) and wealth, at different ages (see also Tables 6A.9 and 6A.10). At the younger ages, we see very large relative differences in performance, with the poorest group showing markedly worse performance. Differences remain in the 75+ group, although these are relatively less marked.

**Figure 6.4. Impairment on SPPB, by age and age-specific wealth quintile, men, with 95% confidence intervals**

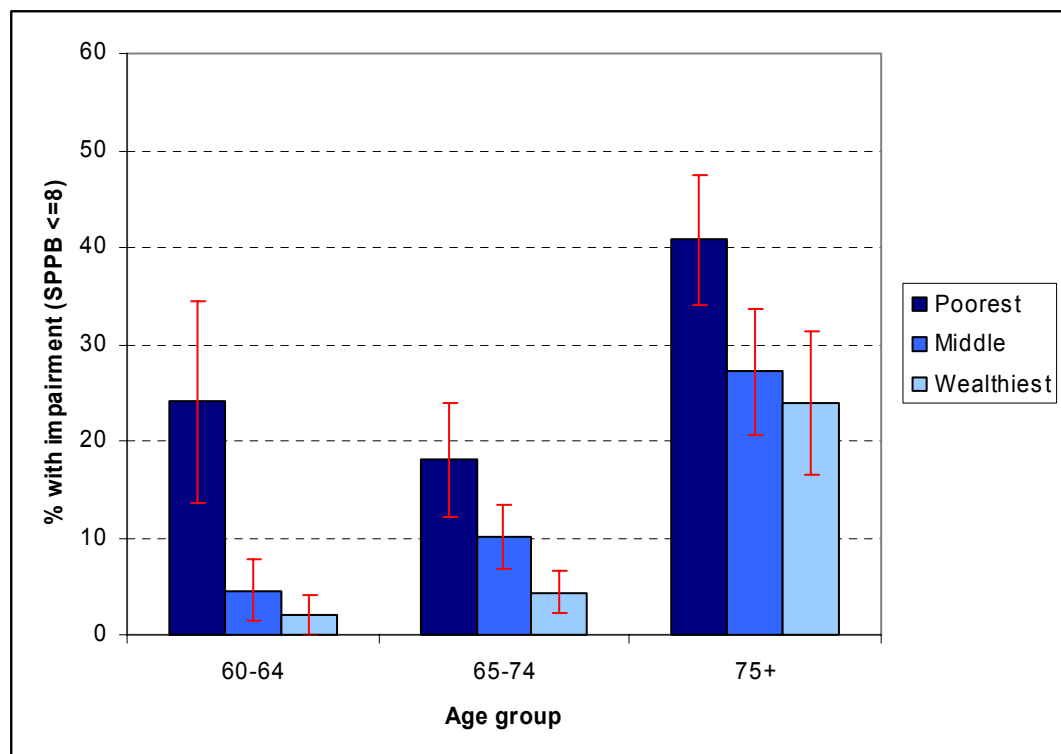
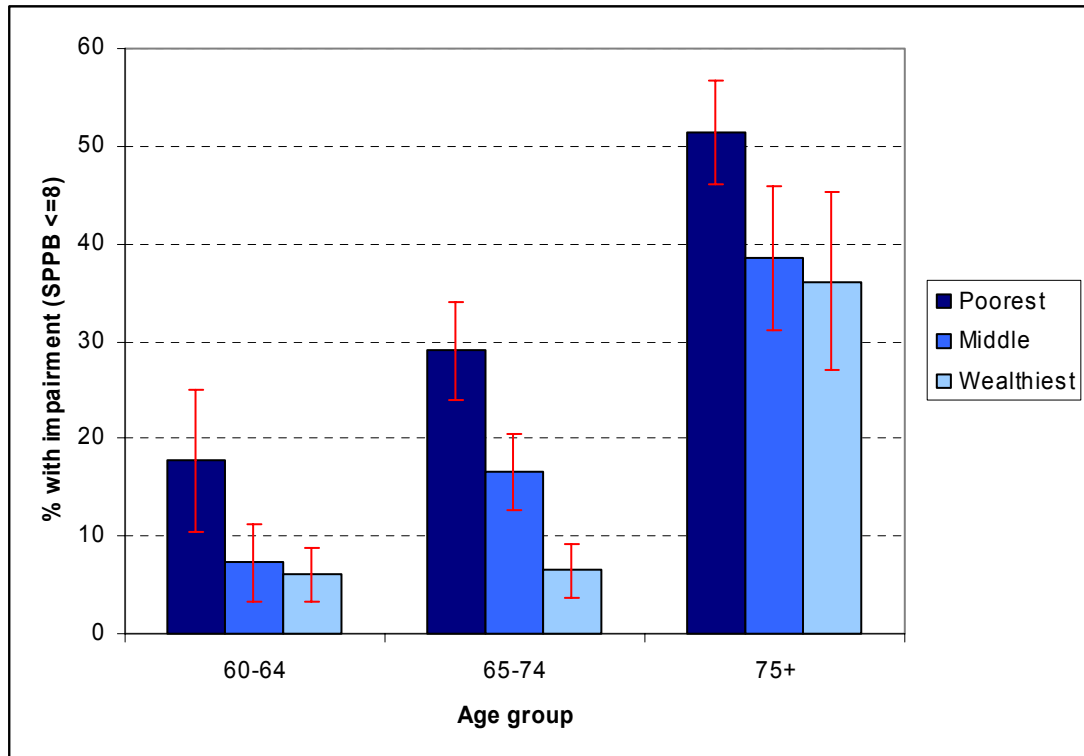


Table 6A.11 shows poor performance on the SPPB by number of mobility activities of daily living (ADLs), i.e., the number of problems reported with the following six activities: walking 100 yards; sitting for about two hours; getting up from a chair after sitting for long periods; climbing several flights of stairs without resting; climbing a single flight of stairs without resting; stooping, kneeling, or crouching. As we might expect, there is a strong

relationship between these two measures for both men and women. Among men reporting three or more mobility ADLs, nearly six-in-ten perform poorly in the SPPB; among women with three or more mobility ADLs, the equivalent figure is nearly nine-in-ten.

The unadjusted correlation between gait speed and grip strength is 0.37, suggesting that, for at least some older people, there is a general increase in frailty in upper and lower limbs.

**Figure 6.5. Impairment on SPPB, by age and age specific wealth quintile, women, with 95% confidence intervals**



## 6.7 Summary

The physical performance tests in ELSA were designed to provide an objective measure of lower limb function and (upper limb) muscle strength, using a well-validated battery of tests.

The results show that performance declines with age and that limitation is more common in women than men. The latter finding is commonly seen in self-reported responses to questions on disability, and it is sometimes suspected that this is due to differences between men and women in willingness to report difficulties. However, in these objective tests, the higher prevalence of limitations in women is confirmed, despite the fact that women have significantly longer life expectancies than men.

In spite of the overall pattern of decline with chronological age, the test results also show a great diversity of function, with some older people performing at higher levels than some of the middle-aged respondents. Similarly, some of

## Measured physical performance

the younger respondents have (prematurely) impaired functioning, showing the very different ages of onset of impairments: the link between chronological age and ‘age-related’ impairments is once again shown to be very loose.

As with other measures of health, physical limitations are more common in those with lower incomes. This effect is substantial; it is most marked in the younger age groups but still present in the older groups. These performance differences by wealth indicate that the self-reported differences in disability noted in the first ELSA report are not due to differences in attitude or environment only, but reflect real and large differences in the ages of onset of physical impairment across the income range. On average, ‘ageing’ clearly affects members of less privileged groups earlier in their lives.

For most tests, the 2004–05 examination provides a baseline for future monitoring, but for the gait speed test, the study now has two waves of measures. These show that new onsets of limitations in short distance walking follow the same age, sex and wealth patterns discussed above. Recovery from limitation was also present, but recovery rates rise less with age and do not show a simple trend across the wealth range.

As noted in the introduction, the performance test measurements will support a variety of detailed analyses in the future. The results identify both poor and high functioning and enable prediction of future disability onsets. As markers of the ageing process they can be used to explore the role of the many factors that might slow or accelerate decline. The early age at which some people develop ‘age-related’ limitations is clearly a concern, but the high functioning of some of the oldest people indicates that much could be achieved to prevent premature ageing and to postpone the onset of disability. Enabling us to identify the extent to which social and other inequalities are related to both the development and avoidance of disability in old age is among the key roles that ELSA will play in the coming months and years.

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