5. Measures of physical health

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The focus of this chapter is on distribution of a number of biological measurements by age and sex, and age-specific wealth. Among other things, the cross-sectional analyses presented in this chapter show:

- The age patterns differ for Body Mass Index (BMI) and Waist-Hip Ratio (WHR). In men, BMI peaks earlier than in women (55–59 years compared with 60–64 years), while WHR peaks at 70–74 in men, but continues to increase with age in women.
- There is clear pattern of differences in anthropometric measures with wealth. BMI in women and WHR in both men and women, show linear negative trends across the quintiles of wealth. This pattern is not seen in BMI in men.
- Among ELSA participants, systolic and diastolic blood pressure show different patterns with age. Systolic blood pressure does not rise inexorably with age but peaks in people in groups in their 70s and thereafter falls. Diastolic pressure falls with age in all women and in men older than 60 years.
- Different cardiovascular risk factors pattern differently by age. The percentage of people with hypertension (except for the very oldest group), diagnosed diabetes and mean levels of C-reactive protein (CRP) increases with age. By contrast, the percentage of people with high total and LDL cholesterol decreases with age after 60 years.
- Different cardiovascular risk factors also show different patterns with wealth. As wealth increases, there is a decrease in mean systolic blood pressure, the percentage of people with hypertension, high risk levels of HDL cholesterol and triglycerides, diagnosed and undiagnosed diabetes and mean CRP levels. By contrast, there is no association with diastolic blood pressure and the prevalence of high total and LDL cholesterol increases with increasing wealth.
- Different lipids measures show different patterns by sex. The overall prevalence of high total and LDL cholesterol is very high and higher for women than for men. Detrimental levels of triglycerides are more prevalent in men than women.
- All measures of lung function deteriorate with advancing age and there is a shallow gradient with wealth, richer people being somewhat advantaged.
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There is a clear effect of smoking; lung function is always better in those who have never smoked than in those who currently smoke.

- Mean haemoglobin decreases with age in both men and women. The prevalence of anaemia is greatest in the oldest groups.
- Ferritin levels show an inverted U shape with age in both sexes. Low ferritin levels in women show the same pattern with age, but no age related pattern is seen in men. Mean haemoglobin is not associated with wealth and ferritin only shows some signs of an advantest grup.

5.1 Introduction

This chapter focuses on distribution of a number of biological measurements by age and sex, and age-specific wealth. These factors were chosen because they are associated with mortality or morbidity either directly or indirectly because they are cardiovascular risk factors.

Many of the biological measurements reported here have been found to be distributed by socio-economic position. One aspect of this is financial status and this has often been investigated using measures of income. However, the ELSA population is a combination of working and retired people, so we have developed and used a novel measure of total wealth (age-specific wealth) to represent the participants’ financial status more accurately.

The chapter includes separate sections on:
- Anthropometry – Body Mass Index, Waist-Hip Ratio
- Blood pressure
- Lipids and inflammatory markers
- Glycaemic control
- Lung function
- Haemoglobin and ferritin

The data for this chapter comes from the nurse visit to the core sample members living in private homes. Eighty-eight per cent of those who had a wave 2 interview had a nurse visit (n=7648). Important features of the methodology are highlighted in this chapter but the precise details of what was done are given in the technical report and the detailed response rates appear in the chapter on methodology.

Blood samples were taken from willing ELSA core members, except people who had ever had a fit/convulsion, clotting/bleeding disorders, or were on anticoagulants. Fasting blood samples were taken whenever possible, but subjects over 80 years, known to be diabetic and on treatment, and those who seemed frail or whose health the nurse was concerned about, were n ot asked to fast. Subjects were considered to have fasted if they had not had food or drink except water for a minimum of 5 hours prior to the blood test. Valid blood samples were taken from 5,884 people of which 4,432 (75% were fasting).
If participants gave permission, then the results of their BP and blood analytes were sent to their GPs.

5.2 Anthropometry

Body mass index and waist-hip ratio

Both obesity and underweight are important problems in the elderly. The prevalence of obesity is increasing in all age groups, including the elderly (Kopelman, 2000). Obese people have increased mortality compared with those who are overweight or desirable weight, but the relative risk of death associated with increasing BMI decreases with age (Calle et al., 1999).

Obesity is associated with a number of conditions that interfere with health and well-being. These include the metabolic syndrome (obesity, insulin resistance, hypertension, gout, dislipidemia), frank diabetes, arthritis, pulmonary abnormalities (obesity hypoventilation syndrome and obstructive sleep apnoea), urinary incontinence, cataracts and cancers (of breast, colon, gall-bladder, pancreas, kidney, bladder, uterus, cervix and prostate). Obesity exacerbates the age-related decline in physical function and impairs the quality of life of older people (Kopelman, 2000; Villareal et al., 2005).

Cross-sectional data from large population studies suggest that mean body weight and BMI gradually increase during adult life, reaching a peak at about 50–59 years and tending to decline thereafter. However, these observations could be affected by survival bias as obese people have higher mortality at younger ages, and data from cohort studies suggest that BMI does not change or decreases only slightly in older adults. Moreover, as people age, their body composition changes. After 30 years of age, free fat mass decreases and fat mass increases, and after 70 years both decline. The distribution of body fat also changes with age, with a relative increase in abdominal fat compared with skeletal or total body fat (Villareal et al., 2005).

Underweight in the elderly is associated with increased mortality. This is partially but not completely explained by smoking and overt or covert disease (Calle et al., 1999; Seidell and Visscher, 2000).

Anthropometric measurements are distributed by socio-economic status. BMI has been shown to be negatively associated with income (Choiniere, Lafontaine and Edwards, 2000) and education (Yarnell et al., 2005; Silventoinen et al., 2005; Davey Smith et al., 1998). Overweight and obesity are negatively associated with education (Choiniere, Lafontaine and Edwards, 2000; Hoeymans et al., 1996). However, no association has been found between occupation and BMI (Davey Smith et al., 1998; Rosengren, Orth-Gomer and Wilhelmsen, 1998).

Height was measured using a portable stadiometer with a sliding headplate, a base plate and three connecting rods marked with a metric scale. Informants were asked to remove their shoes. One measurement was taken with the informant stretching to the maximum height and the head in the Frankfort plane. The reading was recorded to the nearest millimetre.
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Weight was measured using Tanita THD-305 portable electronic scales. Informants were asked to remove their shoes and any bulky clothing. A single measurement was recorded to the nearest 0.1 kg.

We report only the measurements of height and weight taken. People who stated that they were greater than 130 kg were not weighed and are therefore excluded.

The BMI associated with the lowest mortality is slightly higher in older than younger adults, so there is a debate about what desirable weight might be in an older population. In this chapter, the WHO classification is used, i.e. less than 18.5 kg/m² is called underweight, 18.5 kg/m² but less than 25 kg/m² is desirable, 25 kg/m² but less than 30 kg/m² is overweight; and 30 kg/m² or more is obese (James et al., 2001).

Waist-hip ratio (WHR) was also collected as it has been shown to be better than BMI as a predictor of total mortality, mortality from coronary heart disease, other cardiovascular diseases and cancer. Like BMI, WHR is associated with incidence of diabetes and hypertension (Folsom et al., 2000). WHR has been shown to be negatively associated with education (Silventoinen et al., 2005).

Waist was defined as the midpoint between the lower rib and the upper margin of the iliac crest. It was measured using a tape with an insertion buckle at one end. Hip was defined as the widest circumference around the buttocks below the iliac crest. Both measurements were taken twice using the same tape and were recorded to the nearest even millimetre. Those whose waist or hip measurements differed by more than 3 cms had a third measurement taken.

Unlike BMI, there is no consensus about appropriate WHR criterion levels (Molarius and Seidell, 1998), but for consistency we used the same cut-offs as the Health Survey for England 1994, 1998 and 2003, and a raised WHR for women was taken as 0.85 or more and for men 0.95 or more.

Results

BMI and WHR measurements by age and sex

The overall mean BMI is similar for men (27.8 kg/m²) and women (28 kg/m²). Among men, mean BMI starts decreasing after 55–59 years from 28.3 kg/m² to 26.6 kg/m² for those aged 80 years or over. In women, Mean BMI starts decreasing after 74 years from 28.3 kg/m² to 26.5 kg/m² for those aged 80 years or over (Table 5A.1).

Less than 1% of men and slightly more than 1% of women are underweight. Only 23% of men and 30% of women have their BMI in the desirable category. More men (49%) than women (39%) are overweight and this applies to all age groups, but more women (31%) than men (27%) are obese, particularly among people in their 70s (Table 5A.2). The very oldest are the least likely to be obese.

The mean WHR in men is 0.956 and in women it is 0.846. In men, WHR increases with age up to 74 years, thereafter it decreases. In women, a clear upward linear trend with age is found in WHR (Table 5A.3). Raised WHR was defined in men as 0.95 or greater and 0.85 or greater in women. Overall,
53% of men had raised WHR compared with 46% of women. The percentage of women with raised WHR increases with age, but for men the highest percentage is in the 70–74 year age group.

**BMI and WHR measurements by wealth and sex**

A decreasing trend in the BMI means by age-specific wealth quintiles is found in women (Table 5A.4). In men, respondents in the poorest wealth quintile have slightly higher mean BMIs than respondents in the richest wealth quintile.

Table 5A.5 shows the percentage of people in each WHO category of BMI by age-specific wealth quintiles and sex. At all levels of wealth, around three quarters of men are overweight or obese. The proportion of overweight men increases with wealth while the proportion of obese men decreases. In women, the percentages with desirable weight and overweight increase with wealth, while the percentages of underweight and obese decrease with wealth.

For both men and women, with increasing wealth the means of waist-hip ratio are lower. Thus, people in the poorest wealth quintile tend to have higher WHR than those in the richest wealth quintile (Table 5A.6). The percentage of both men and women with raised WHR decreases as wealth increases. For example, there are 44% of men with raised WHR in the richest wealth quintile compared with 63% of men in the poorest.

**Summary**

The age patterns differ for BMI and WHR. In men, BMI peaks earlier than in women (55–59 years compared with 60–64 years) (Table 5A.2), while WHR peaks at 70–74 years in men but continues to increase with age in women (Table 5A.4).

There is a clear pattern in anthropometric measures with wealth: BMI in women, and WHR in both men and women, show linear trends right across the quintiles of wealth. This pattern is not seen in BMI in men, where the poorest have slightly worse BMIs than the richest, but there is no clear pattern for the intermediate groups. These findings complement those of Choiniere et al., relating BMI inversely to income (Choiniere, Lafontaine and Edwards, 2000) and Silventoinen relating WHR inversely to education (Silventoinen et al., 2005).

### 5.3 Blood pressure

Elevated systolic and diastolic blood pressures are important risk factors for cardiovascular disease (CVD). A recent meta-analysis of 61 observational studies of people without pre-existing CVD has re-confirmed systolic and diastolic hypertension as being pre-eminent risk factors for CVD deaths (James et al., 2001; Lewington et al., 2002).

Based on clinical trial data, hypertension is defined as ‘the level of BP [blood pressure] at which there is evidence that blood pressure reduction does more good (in terms of CVD risk) than harm’. In ELSA we have used systolic equal to or greater than 140mmHg or diastolic equal to or greater 90 mmHg to
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define hypertension, as recommended by the IV British Hypertension Society Guidelines 2004 (Williams et al., 2004). Isolated systolic hypertension is defined as systolic equal to or greater 140 mmHg with diastolic less than 90mmHg. This classification is in keeping with the European society for Hypertension (2003), the WHO/ISH (1999) and the Joint British Societies Guidelines (2006).

Ageing in Western societies is associated with a rise in SBP across the whole age range, whereas DBP rises to the age of 60 years, plateaus and then falls, resulting in an age-related increase in pulse pressure and prevalence of isolated systolic hypertension (ISH) (Franklin et al., 1997). Trial evidence supports treatment in the elderly up to the age of 80 years, in that they have as good or better results from treatment. Until the HYVET study reports, there is no available guidance for those over 80 years at diagnosis (Bulpitt et al., 2003).

Many studies have shown that blood pressure varies with socio-economic status. Systolic, diastolic blood pressures (BP) and hypertension are negatively associated with education (Davey Smith et al., 1998; Hoeymans et al., 1996; Yarnell et al., 2005); systolic and diastolic BP negatively associated with occupational social class (Davey Smith et al., 1998) and hypertension negatively associated with income (Choiniere, Lafontaine and Edwards, 2000). However, there are some studies that have failed to show these associations, e.g. between systolic BP and occupational social class (Rosengren, Orth-Gomer and Wilhelmsen, 1998) and diastolic BP and education (Silventoinen et al., 2005).

High blood pressure may be asymptomatic and remain undetected until many years after onset. As ELSA has both self-reports of doctor diagnosed hypertension and actual measurements of blood pressure, this provided the opportunity to assess the extent to which this condition exists but is undiagnosed in the older population.

Blood pressure measurements were taken using the Omron HEM 907. Three measurements were taken, in the right arm, at one-minute intervals, with the subjects seated.

Results

Means of systolic and diastolic blood pressure (BP) by age and sex

The means of systolic and diastolic blood pressure are higher among men (135.9 mmHg and 75.8 mmHg respectively) than women (135.1 mmHg and 74.1 mmHg respectively). In men, systolic BP increases up to 70–74 years then it decreases slightly. In women, systolic blood pressure increases up to age 75–79 years. Diastolic blood pressure in men and in women is generally lower the older the age group, although the highest mean diastolic BP is seen in men aged 55–59 years (Table 5A.7). Figure 5.1 shows the widening of pulse pressure with age apparent in both sexes.

Table 5A.7 also lists the prevalence of hypertension in men and women. The overall prevalence of hypertension is similar in both sexes (56% in men and 55% in women) There is an increasing trend in the prevalence of hypertension with age in both sexes. In men 37% had hypertension in the age group 52–54
years compared with 64% in the age group 80 years and over; the corresponding percentages in women were 34% and 74%.

**Figure 5.1. The differences in mean systolic blood pressure (SBP) and diastolic (DBP) in mmHg with age and sex**

![Figure 5.1](image)

**Means of systolic and diastolic BP, by age-specific wealth quintiles and sex**

There is a decreasing trend in the means of systolic blood pressure by age-specific wealth quintiles in both men and women. Diastolic BP decreases with wealth in men, but no trend of diastolic BP with wealth was found in women. The prevalence of people with hypertension decreases with increase in wealth. For example, 63% of women in the poorest age-specific wealth quintile have hypertension, compared with 45% of women in the richest quintile (Table 5A.8).

**Undiagnosed high blood pressure, by age and sex**

Sixteen per cent of women and 18% of men had systolic BP equal to or greater than 140 mmHg or diastolic BP equal to or greater than 90 mmHg, but had not reported a diagnosis of hypertension or high blood pressure when asked in 2002–03 (wave 1) or 2004–05 (wave 2). There is a clear trend of increasing undiagnosed high blood pressure with increasing age, from 11% of women and 15% of men aged 52–59 years, up to 21% of women and 23% of men aged over 80 years (Table 5A.9).

**Undiagnosed high blood pressure, by age-specific wealth quintiles and sex**

No clear trend of increasing undiagnosed high blood pressure with wealth was apparent for men. For women, undiagnosed hypertension was more common in the poorest quintile (18%) than the richest (14%). There was a highly significant trend for women aged 52–54 years, but this was not significant in any other subgroup (Table 5A.10).
Summary

Differences by age and sex

In our population, systolic and diastolic BP show different patterns with age. Systolic BP does not rise inexorably with age but peaks in people in groups in their 70s and thereafter falls. Diastolic blood pressure in men and in women is generally lower the older the group, although the youngest men do not have the highest mean. The patterns observed are not exactly the same as the physiological pattern of change in BP with age, but this is probably because these analyses are cross-sectional and so the mean for the older groups is affected by the selective survival in the community of those whose systolic blood pressure was not at the higher end of the range.

The percentage of people with high blood pressure is high overall and rises with advancing age. The problem of undiagnosed hypertension is also an increasing problem as people get older. The non-detection and hence non-treatment of hypertension in the older population cannot be justified on clinical grounds as there is strong evidence of the benefit of treatment up to the age of 80 years (Williams et al., 2004).

Differences by wealth

Hypertension and systolic BP in both men and women, and diastolic BP in men, decrease with wealth, but there is no evidence of such an effect in women. These findings reinforce and extend the literature on the relationship between socio-economic status and BP and in particular support and extend the findings of Choiniere that income is inversely related to hypertension (Choiniere, Lafontaine and Edwards, 2000).

The problem of undiagnosed high blood pressure is only slightly more likely to occur in the poorest women than the wealthiest women and is not at all related to wealth in men. If detecting important asymptomatic conditions is taken as an indicator of quality of care, this indicates that in the UK the wealthier do not seem to be getting better care.

5.4 Lipids and inflammatory markers

Lipids

Cholesterol, HDL cholesterol and LDL cholesterol

Cholesterol levels in the blood are influenced by diet and the rate of manufacture in the liver. High levels of cholesterol are associated with the development of atheroma and there is a continuous positive relationship between total serum cholesterol level and CHD risk (Stamler et al., 1993).

Total cholesterol includes two fractions – LDL and HDL cholesterol. LDL cholesterol comprises 60–70% of total cholesterol. It is a risk factor for cardiovascular disease and intervention studies have shown that a reduction of LDL cholesterol with statins leads to a reduction in the incidence of coronary heart disease and other major vascular events (Baigent et al., 2005). HDL cholesterol is a smaller fraction of the total cholesterol, but it is
cardioprotective as it is involved in carrying cholesterol away from the arteries to the liver where it is metabolised (Assmann et al., 1996; Turner et al., 1998).

In ELSA we measured total cholesterol, HDL cholesterol on non-fasting samples and LDL cholesterol on fasting samples. We did not record whether participants had been given a diagnosis of hypercholesterolaemia or were taking lipid-lowering agents.

The NSF 2000 guidelines for the UK (Department of Health, 2000) suggest using lipid-lowering drugs and dietary advice to reduce raised total cholesterol to no more than 5 mmol/l (LDL cholesterol to below 3 mmol/l) or by 30% (whichever is the higher) in people at high risk of CVD. We have therefore taken 5 mmol/l as the cut-off for high total cholesterol and 3 mmol/l for a high LDL. We have taken the cut-off for a high-risk level of HDL cholesterol (less than 1 mmol/l) from the Expert Panel on HDL Cholesterol recommendations for primary and secondary prevention of CVD (Sacks, 2002).

In men, in the Health Survey for England (HSE) 2003, after an initial rise with age, mean total cholesterol flattened out after age 45 (at 5.9 mmol/l) and then fell from age 65–74 years to 5.3 mmol/l in those aged 75 years and over. In women, it fell slightly with age from 55–64 years. Neither LDL nor HDL fluctuated much between age groups for either gender, but as LDL cholesterol was measured in few people (it was done only on the fasting sample) the point estimates should be interpreted with caution. Mean HDL cholesterol was a little higher in women than in men.

**Triglycerides**

Triglycerides levels are an independent risk factor for CVD and based on the findings of a prospective study of people with familial hypertriglyceridemia, we have used ≥1.6 mmol/l as the cut-off for high triglyceride levels(Austin, 1998; Austin et al., 2000). As triglycerides are assayed on a fasting sample, the HSE 2003 results are to be interpreted with caution, but the mean triglyceride levels in women rose from 1.3 mmol/l in those 45–54 years to 1.6 mmol/l in those 65–74 years, and the corresponding percentages with high triglycerides from 25% to 43%. In men in the same age groups the mean went from 1.8 mmol/l to 1.7 mmol/l and the percentages with high triglycerides from 43% to 48%.

**Lipids and socio-economic status**

The literature relating cholesterol and socio-economic status is unclear, showing no association (Yarnell et al., 2005) or a negative association (Hoeymans et al., 1996) with education; no association (Rosengren, Orth-Gomer and Wilhelmsen, 1998) or a positive association with social class (Davey Smith et al., 1998); and a positive association with income (Choiniere, Lafontaine and Edwards, 2000).

Low HDL cholesterol is more common in lower educational groups (Hoeymans et al., 1996) and mean HDL is positively associated with education in women but not in men (Silventoinen et al., 2005). Triglycerides are negatively associated with education (Silventoinen et al., 2005).
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Results

Lipids by age and sex

Associations of four lipids namely, total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides with age and sex are presented in Table 5A.11. The table shows that men have lower levels of total cholesterol than women: 5.6 mmol/l compared with 6.1 mmol/l. In men, mean total cholesterol levels are flat from age 52–64 years and then fall from 5.8 mmol/l in those aged 60–64 to 4.9 mmol/l in those aged 80 years and more. In women, there is a little decrease in the mean cholesterol levels with age from the age of 70 years. These age-related findings are similar to those of HSE 2003.

Overall, 70% of men and 84% of women have high total cholesterol levels (at least 5 mmol/l). At every age, the percentage of women with high cholesterol is greater than that of men. This is most extreme in the oldest group because the percentage with higher cholesterol declines sharply with age for men but more gradually for women. Four out of five women aged 75 years or above have raised cholesterol levels compared with 57% of men aged 75–79 years and 44% of men aged 80 years and over. In both sexes, the prevalence of high cholesterol decreases with age, but this is more marked in men than in women.

The mean LDL cholesterol levels are slightly lower in men (3.5 mmol/l) than in women (3.8 mmol/l). In men, LDL concentrations decrease with age, e.g., the LDL concentration for those aged 52–54 years is 3.7 mmol/l compared with 3.3 mmol/l at age 75–79. In women, there is little variation with age.

In total, 72% of men and 81% of women have high levels of LDL cholesterol (at least 3.0 mmol/l). The prevalence of high LDL levels in men decreases with age e.g. 81% of men aged 52–54 years compared to 60% aged 75–79 years. In women, the prevalence of high LDL decreases from age 55–59 years.

Mean HDL cholesterol was marginally higher in women (1.6 mmol/l) than in the men (1.4 mmol/l). Overall, mean HDL levels do not show any pattern with age in either sex. Seven per cent of men and 2% of women have high-risk levels of HDL (less than 1.0 mmol/l) and no consistent pattern of difference with age is seen in either sex.

Triglycerides concentrations are similar for the sexes (1.5 mmol/l in women and 1.6 mmol/l in the men) and there is little variation in mean level by age. Fifty one per cent of men and 43% of women have high levels of triglycerides (at least 1.6 mmol/l). The prevalence of high levels of triglyceride decreases with increasing age in men. In women, although the youngest groups had a higher prevalence of high triglycerides than the oldest, the pattern in the intervening age groups was inconsistent.

Lipids by age-specific wealth and sex

Table 5.A.12 shows the associations of four lipids namely, total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides with age-specific wealth quintiles for men and women. Total cholesterol levels in men do not show any trend with the age-specific wealth quintiles. In women, the mean cholesterol levels are slightly higher among those in the richest quintiles than those in the poorest quintiles. In men and women, there is a positive trend of increasing prevalence of high cholesterol (at least 5 mmol/l) with wealth.
Mean LDL cholesterol levels in men and women increase with age-specific wealth quintiles, as does the prevalence of men and women with high LDL levels. Mean HDL cholesterol concentrations show small increases with wealth in both sexes. The prevalence of low levels of HDL decreases with increasing age-specific wealth quintile, albeit the percentages are small at all levels of wealth for women.

The triglycerides concentrations show a slight decrease with wealth. For example, the mean triglycerides concentration among men in the poorest quintile is 1.8 mmol/l compared with 1.4 mmol/l for those in the richest quintile. The prevalence of high triglycerides decreases with wealth.

**Inflammatory markers**

Fibrinogen is a soluble protein essential to the blood clotting mechanism. Studies have shown that high fibrinogen is related to increased risk of cardiovascular disease in middle aged and older populations (Danesh et al., 2005; Smith et al., 2005).

C-reactive protein (CRP) is an inflammatory marker that is shown to be associated with atherosclerosis and is predictive of myocardial infarction in older men and women (Cushman et al., 2005; Strandberg and Tilvis, 2000).

Both fibrinogen (Myllykangas et al., 1995) and CRP (Lubbocket al., 2005) have been shown to be associated with low socio-economic status.

**Results**

**Inflammatory markers by age and sex**

Table 5A.13 reports the means of fibrinogen (g/l) and C-reactive protein (CRP) concentrations (mg/l) by age for men and women. The mean levels are similar for the two sexes. The mean levels of fibrinogen increase with age in both men and women, but the differences are small, the gradient is shallow and the means are not consistently higher in successively older groups. CRP levels increase with age, plateauing from 70–74 years.

**Inflammatory markers by age-specific wealth and sex**

With increasing wealth, CRP levels decrease. The gradient of fibrinogen with wealth is very slight; for example, in the poorest quintile the mean levels of fibrinogen in men is 3.3 g/l compared to 3.1 g/l in the richest quintile (Table 5A.14). These findings accord with those of Lubbock, relating CRP inversely to socio-economic status (Lubbock et al., 2005).

**Summary**

**Differences by age and sex**

The different lipids measured show quite different patterns with age and sex, and are similar to the findings of HSE 2003. Although generally differences in mean values by age or wealth were small, the percentages in high-risk groups showed more variation. The overall prevalence of detrimental (high) lipid levels is very high and is higher for women than for men for both total and LDL cholesterol. In both men and women we find an age-related fall in the
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percentages with high values from the age of 60 years. In women, the age-related fall in the prevalence of high values is shallower. High levels of triglycerides decrease with increasing age from the youngest group in men.

The means for inflammatory markers (CRP and fibrinogen) and differences with age are similar to those found in HSE 2003. CRP levels increase with age and there is a similar but slight trend for fibrinogen.

Differences by wealth

Different lipid show quite different patterns by wealth. Surprisingly, the prevalence of high cholesterol and high LDL cholesterol increases with wealth, with wealthier people being high risk, although the absolute differences are not large. These findings support the findings of a positive association with socio-economic status reported by Davey Smith (Davey Smith et al., 1998) and Choiniere (Choiniere, Lafontaine and Edwards, 2000).

High-risk levels of HDL cholesterol and triglycerides are less common among the wealthier than the poor. These findings are in keeping with those of Hoeymans et al. (1996) and Silventoinen et al. (2005), who report a negative association with socio-economic status. The means for CRP levels decrease with wealth. The pattern for fibrinogen is similar but the gradient is shallow.

5.5 Glycaemic control

Diabetes is associated with profound medical complications particularly affecting the eyes, kidneys, peripheral nerves and the cardiovascular system. People with diabetes have more than double the risk of cardiovascular disease (Kannel and McGee, 1979; Huxley, Barzi and Woodward, 2006) than people without diabetes. Even among non-diabetics, higher glucose levels are associated with increased risk of death from coronary heart disease (Fuller et al., 1983)

Increasing age is one of the most important risk factors for diabetes. The relationship between diabetes and occupational social class (NS-SEC) is complex, but a clear gradient by equivalised household income has been found, with diabetes more prevalent among people from households with the lowest income than those with the highest (HSE 2003).

As the onset of type 2 diabetes is insidious, people may have diabetes for many years without knowing it. The ELSA protocol allowed us a unique opportunity to examine the issue of undiagnosed diabetes. In the interviews at waves 1 and 2, participants were asked if a doctor had ever told them that they had diabetes and whether they were taking medication for diabetes or insulin. We calculated the percentage of people without diabetes who had fasting blood glucose of 7 mmol/l or more and examined this by age/sex and wealth.

A definitive diagnosis of diabetes in clinical practice requires single fasting blood glucose of equal to or greater than 7 mmol/l in the presence of symptoms, or in the absence of symptoms, two such fasting blood glucose measurements on different days (Report of the Expert Committee 1997). In ELSA we had only one fasting blood glucose measurement and so we may be overestimating the percentage of people with undiagnosed diabetes.
Results

**Fasting blood glucose, by age and sex, and by wealth**

Table 5A.15 shows the mean fasting glucose levels by age and sex in participants without known diabetes. Mean fasting glucose is slightly higher at all ages in men than in women. There is a small increase with age in both sexes; the mean rises from 4.9 mmol/l in the youngest men to 5.1 mmol/l in the oldest and from 4.8 mmol/l to 4.9 mmol/l in same age groups among the women. There was no clear pattern by wealth in either sex (data not shown).

**Diagnosed and undiagnosed diabetes by age and sex**

Table 5A.16 shows the proportion of the ELSA population under 80 years of age who reported a doctor diagnosis of diabetes at either wave 1 or wave 2 interviews, by age and sex. There was an increase in the prevalence of doctor-diagnosed diabetes with age in both sexes, from one-in-twenty of the youngest men to one-in-seven of the oldest, and from one-in-thirty of the youngest women to one-in-ten of the oldest.

Table 5A.17 shows the prevalence of fasting blood glucose of 7 mmol/l or more (which is suggestive of undiagnosed diabetes) in those people who did not have a doctor diagnosis of diabetes. The overall proportion of people with fasting blood glucose suggestive of undiagnosed diabetes (7 mmol/l or more) was low (less than 2% for men and women combined) compared with other studies (Thomas et al., 2005; Williams et al., 1995) and was more than twice as high for men than for women. This sex difference was apparent in all but one age group. The oldest (75–79 years) have a higher prevalence of undiagnosed diabetes than the youngest (52–52 years) in both sexes, but the pattern in the intervening age groups is not consistent. There is no clear trend of increasing undiagnosed diabetes with increasing age.

**Diagnosed and undiagnosed diabetes by wealth**

Table 5A.18 shows the proportion of the ELSA population under 80 years of age who reported a doctor diagnosis of diabetes at either wave 1 or wave 2 interviews, by age-specific wealth quintile. The percentage of men and women with undiagnosed diabetes was higher in the poorest quintile of age-specific wealth than the richest quintile. In men 5.6% of those in the poorest quintile and 1.4% in the richest quintile had undiagnosed diabetes. In women less than 2% of the poorest and none of the richest had undiagnosed diabetes. (Table 5A.19) In every wealth group, a higher proportion of men than women had fasting blood glucose levels suggestive of diabetes. Figure 5.2 shows clearly that the combined prevalence of diagnosed and undiagnosed diabetes decreases as wealth increases. A similar pattern is seen for women but with smaller percentages.
Summary

Both the prevalence of diagnosed diabetes and the mean fasting blood glucose in people without diabetes are higher in men than women, and rise with age. The percentage of people with undiagnosed diabetes is higher in the oldest than the youngest group. The prevalence of undiagnosed diabetes is higher in the poorest than the richest groups, in accordance with the findings of HSE 2003. If detecting important asymptomatic conditions is taken as an indicator of quality of care, then this indicates that in the UK, the wealthiest do seem to be getting better care with respect to the detection of diabetes than the poorest, in contrast with the situation with respect to hypertension. This illustrates how quality of care may be condition-specific and underlines the difficulty of generalising about it.

5.6 Lung function

Lung function tests are commonly used in clinical practice to assess impairment due to chronic lung disease and asthma. Lung function is known to decline with age and with smoking. Lung function test results are predictive of mortality from respiratory and cardiovascular diseases, and all cause mortality (Bang et al., 1993; Ebi-Kryston, 1988; Sorlie, Kannel and O’Connor, 1989; Wannamethee, Shaper and Ebrahim, 1995). Lung function is also associated with socio-economic position (Herrick, 2005; Prescott, Lange and Vestbo, 1999).
The measures of lung function obtained during the nurse visit were:

1. Forced Expiratory Volume (FEV1) – the volume in litres that can be expelled in the first second of a forced expiration, starting from a maximal inspiration.

2. Forced Vital Capacity (FVC) – the full volume in litres that can be expelled following a maximal inspiration.

3. Peak Expiratory Flow rate (PEF) – the fastest rate of exhalation (in litres per minute) recorded during the measurement.

These tests were not done if the ambient temperature was less than 15 degrees centigrade or more than 35 degrees, as this affects the accuracy of the readings. People were also excluded if they had had eye or chest surgery during the three weeks prior to the visit, or if they had been hospitalised for heart disease or a stroke in the previous six weeks. The protocol requires three measurements and the highest satisfactory score is taken as the valid one.

Lung function depends on lung size. Sex and height correlate strongly with lung volume; the results are presented separately for two different height categories in each sex, as was done in the Scottish Health Survey 2003 (Herrick, 2005). Results are presented only for participants for whom reliable height measurements were obtained.

Results

Lung function, age, sex and height

Owing to a training error, some nurses reported FEV1/FVC ratio instead of FEV1. Since it was not possible to detect where this error had occurred, any FEV1 that was less than 1.00 was disregarded. Nevertheless, the remaining FEV1 results were approximately normally distributed. Table 5.A.20 shows that mean FEV1, FVC and PEF are all greater in men than in women and greater in taller people of either sex. Within each gender-specific height band, the FEV1, FVC and PEF decrease with advancing age.

Lung function and age-specific wealth quintile

Tables 5A.21–23 show FEV1, FVC and PEF by age-adjusted wealth quintile. For each of the measurements, a similar pattern is observed: generally, as wealth quintile increases, so does the lung function, but the gradient is shallow.

Lung function and smoking

There is a clear difference in FEV1, FVC and PEF with smoking status, the means being higher in those who have never smoked compared with current smokers. The pattern of measurements in ex-smokers is variable. Generally, but not always, the measurements in the ex-smokers are worse than for those who have never smoked (Table 5A.24–26). This may be related to the level of exposure to tobacco and to the length of time since they gave up smoking.
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Summary

All measures of lung function deteriorate with advancing age. There is a shallow gradient of lung function with wealth, the richer people being somewhat advantaged. This confirms and extends the finding of the Scottish Health Survey (Herrick, 2005), where both socio-economic classification (NS-SEC) and income were found to be related to FEV1 but not to PEF or FVC, and those of Prescott who found that both FEV1 and FVC are positively associated with income (Prescott, Lange and Vestbo, 1999). There is a clear effect of smoking; lung function is always better in those who had never smoked than in the current smokers.

5.7 Haemoglobin and ferritin

Haemoglobin is the oxygen-carrying, iron-containing molecule in red blood cells. The level of haemoglobin is partially determined by the iron status in the body. Low haemoglobin or anaemia may be caused by iron deficiency, which arises when iron requirements exceed supply, either through excessive blood loss or inadequate dietary supply. Anaemia is common in older adults and is an independent predictor for increased morbidity and mortality in several disease states. It is associated with a very wide range of complications, including increased risk of mortality, cardiovascular disease, cognitive dysfunction, longer hospitalisation for elective procedures and comorbid conditions, reduced bone density, and falls and fractures (Eisenstaedt, Penninx and Woodman, 2006). Anaemia is also prognostic for diminished physical performance and loss of mobility in people 65 years and older. This report uses the World Health Organization definition of anaemia, which is a haemoglobin concentration of less than 13 g/dl in men and less than 12 g/dl in women (World Health Organisation, 1972).

In HSE 2000, the prevalence of anaemia in people aged 65 years and above in private residences was greater in men (16%) than in women (11%) and increased with age (Bajekal, 2000). In the third National Health and Nutrition Examination Survey (NHANES) 1988–1994, anaemia was present in 11% of men and 10% of women aged 65 years and older, with the prevalence rising to over one-in-five among people 85 years and more. One third of the cases were due to nutritional deficiencies and another third due to chronic illness, including, but not only, chronic kidney disease. The final third of the cases of anaemia remained unexplained (Woodman, Ferrucci and Guralnik, 2005).

Ferritin is a circulating protein that indicates the amount of iron stored in the body. It provides a more definite indicator of low iron status than haemoglobin, as ferritin is often depleted before the haemoglobin concentration. Moreover, low haemoglobin can be due to conditions other than iron deficiency. On the other hand, infection and several chronic diseases can raise the levels of ferritin.

Ferritin was measured by immunoassay, a method that shows a wide variability between laboratories. There is, therefore, no universally accepted level of ferritin to indicate low iron status. For the purposes of this report, sex specific quintiles were used to categorise ferritin levels. Those in the lowest
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quintile (less than 62 µg/l for men and less than 39 µg/l for women) were classified as having low ferritin. As ferritin is not normally distributed, the geometric mean is used in describing ferritin levels.

Results

Haemoglobin by age and sex

Mean haemoglobin is 15 g/dl in men and 14 g/dl in women. It decreases in concentration with increasing age. Overall, 5% of men and 6% of women have low haemoglobin (anaemia). In both men and women there is a clear upward flip in the prevalence of anaemia in the oldest groups. In men, the prevalence of anaemia increases from one-in-fifty among the youngest to one-in-five among the oldest, with substantial differences between those aged 75 years and over and those younger. In women, those in the oldest group have the highest prevalence of anaemia (17%) (Table 5A.27).

Ferritin by age and sex

Geometric mean ferritin is 110 µg/l in men and 70 µg/l in women. In men, mean ferritin concentrations present an inverted U shape, showing increases with age, up to the group 60–64 years. Thus, mean ferritin concentrations increase from 111 µg/l in those aged 52–54 years, to 122 µg/l in those aged 60–64 years. There is a decrease in mean ferritin with increasing age in those aged 65 and over, falling to 90 µg/l in those aged 80 years and more. In women, a similar pattern is observed as for men, with the highest mean ferritin concentration found in those aged 60–69 years (Table 5A.28).

The prevalence of low ferritin in men (as defined by the lowest quintile) remains constant in age groups younger than 75 years, but rises in older age groups: from 21% in the 70–74 year group to 32% in those aged 80 years or more. On the other hand, the prevalence of low ferritin in women shows a U-shaped curve, with the highest prevalence found among the oldest (26%) and the youngest (33%) age groups, and the lowest prevalence in the groups aged 60–64 years (15%) and 65–69 years (17%) (Table 5A.28).

Wealth, haemoglobin and ferritin

There is no clear pattern in the distribution of mean haemoglobin by wealth; mean haemoglobin does not vary by age-specific wealth quintile in either sex. (Table 5A.29) The same applies to the prevalence of anaemia (data not shown).

Ferritin levels do vary by wealth. Ferritin concentrations show a U-shaped pattern by age-specific wealth quintile in men. Thus, in men, ferritin concentrations were 103 µg/l in the third age-specific wealth quintile, rising to 124 µg/l in the highest age-specific wealth quintile. In women, ferritin levels were unrelated to age-specific wealth quintile, except in the richest group, which has significantly raised level of ferritin (Table 5A.29).

Summary

Mean haemoglobin decreases with age in both men and women. The prevalence of anaemia increases markedly at the upper end of the age range.
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for both men and women. The proportion of people (especially men) over 65 years with anaemia is lower than found in HSE 2000 and closer to that found in NHANES.

Ferritin levels show an inverted U-shaped curve with age in both sexes. Low ferritin levels in women show the same pattern with age. In men, low ferritin is most common among the oldest.

In terms of both haemoglobin and ferritin, the oldest people are at a disadvantage, even though this is a select group still living in the community, rather than in institutions.

Haemoglobin levels show no pattern of association with wealth, but the richest group appears to be at an advantage with respect to ferritin levels.

5.8 Conclusion

Differences by age

As expected, most of the biological features we examined deteriorate with age. This is clear for glycaemic control, lung function and haemoglobin levels. More of the elderly are anaemic and have low ferritin levels. BMI and WHR measures increase with age and then level off.

Differences in blood pressure with age are complex. Systolic blood pressure does not rise inexorably with age but peaks and thereafter falls. Diastolic pressure falls with age in all women and in men older than 60 years. These differences result in a widening of the pulse pressure with age.

Other cardiovascular risk factors pattern differently by age. The percentage of people with hypertension (except for the very oldest), mean levels of C-reactive protein (CRP) and mean levels of fasting blood glucose increase with age, whereas detrimental lipid levels do not.

It is important when interpreting these results to remember that these are cross-sectional analyses. The patterns observed may not be the same as the physiological pattern of change with age. The distributions of variables in the different age groups are affected by both cohort and survival effects. Taking the extremes, people born in the 1920s and the early 1950s are likely to have had quite different environmental exposures given the societal changes that occurred between these two periods. This could result in the two groups having different distributions of biological measures that are nothing to do with ageing per se. Furthermore, the least healthy people in each age group will die earlier or move to long-term care, so that the survivors in the community in the older age groups may have ‘healthier’ characteristics.

Differences by wealth

Some conditions appear to be differently distributed by wealth, whereas others do not. As for differences by age, the observed patterns by wealth may have been affected by differential survival in the different wealth groups.

Obesity in women and lung function in both sexes show linear trends, with richer groups being advantaged over the poorer. With respect to mean blood
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glucose, ferritin levels and obesity in men, the richest group is advantaged over the poorest, but no clear pattern is seen in the intermediate groups. There is no effect of wealth on haemoglobin levels.

The effect of wealth on cardiovascular risk factors is complex. Different cardiovascular risk factors show different patterns with wealth. As wealth increases, there is a decrease in mean systolic blood pressure, the percentage of people with hypertension, high-risk levels of HDL cholesterol and triglycerides, and mean CRP levels. By contrast, there is no association between wealth and diastolic blood pressure, and the prevalence of high total and LDL cholesterol increases with increasing wealth.

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