A Life Course Approach to Healthy Ageing

1

Diana Kuh

Key Messages

- A life course epidemiological approach to ageing studies how different capacities change across life for different populations, and whether there are periods of rapid change or transitions where exposures may have particularly long-term consequences for later life health.
- Those who experience socioeconomic disadvantage, or have poorer childhood growth or cognitive development, are less likely to survive to old age, have lower intrinsic capacity and a greater risk of decline.
- A lower level or an accelerated decline in physical and mental capacities by midlife is also associated with lower survival chances and a greater risk of disability and chronic disease.
- Promotion of healthy ageing needs to start early and continue across life.
- Those who take exercise, eat a healthy diet, maintain a normal weight, and do not smoke have a higher level of capacity and a slower rate of decline as they grow older.
- Health professionals need to consider intervening when there is accelerated decline and not necessarily wait until clinical thresholds are reached.

1.1 Introduction

The WHO is promoting a life course approach to healthy ageing [1]. This approach alerts us to: (1) the idea that ageing, the gradual accumulation of molecular and cellular damage, occurs throughout life; (2) the importance of monitoring, investigating,

D. Kuh
MRC National Survey of Health and Development, MRC Unit for Lifelong Health and Ageing at University College London, London, UK
e-mail: d.kuh@ucl.ac.uk

J.-P. Michel (ed.), *Prevention of Chronic Diseases and Age-Related Disability*, Practical Issues in Geriatrics, https://doi.org/10.1007/978-3-319-96529-1_1

and explaining how health is maintained at each life stage, not just in old age; and (3) the opportunities for promoting healthy ageing across life.

The contribution of this opening chapter is to demonstrate the value of the life course epidemiological approach to healthy ageing. Life course epidemiology [2, 3] is part of an interdisciplinary life course perspective on health, development, and ageing that has grown strongly in recent years [4]. Such an approach extends the WHO healthy ageing initiative by developing an understanding of the natural history of the growth, maintenance, and decline in physical and mental (cognitive and emotional) capacities across life, and how social and biological factors in childhood, early and middle adult life act independently or interactively to impair capacity leading to disability and chronic disease in later life. In this chapter, the focus is on the factors affecting physical capacity in early and middle adulthood, and the consequences of midlife capacity for later disability and disease.

From a policy perspective, the life course approach highlights when preventive strategies may be most effective. Early life prevention includes strategies for enhancing physical and mental capacities during growth and development; midlife prevention includes strategies for maintaining capacity for as long as possible after maturity by delaying the onset of decline.

Integral to a life course approach is the investigation of the impact of birth cohort, and lifetime social stratification (including the social relations governing the economic structure, gender, and ethnicity), on healthy ageing and the drivers and consequences of these group differences.

1.2 A Life Course Approach: Conceptual Framework

Life course epidemiology studies lifetime functional trajectories at three different levels: (1) at the individual or multi-system level where the terms physical and cognitive capability are often used to highlight their key roles as hallmarks of ageing and to distinguish them from (2) the functions of underlying body systems on which capability depends [5]. Using WHO terminology, both these levels of function would come under intrinsic capacity, and this chapter will therefore use this term. A life course approach is also being increasingly applied to study (3) changes in function at the molecular and cellular levels, and how these relate to change in intrinsic capacity at the body system or individual levels, a key area of research.

Whether our focus is on the age-related disability and chronic diseases, intrinsic capacity, or the cellular and molecular mechanisms of biological ageing, we need to understand better how they change across life (the life course trajectory) and are affected by the timing and duration of exposure to social and physical environmental factors acting right across life, as well as across generations. Health at any stage of life depends on the ability to respond—to resist, compensate, adapt to, and recover from environmental challenges. These responses may take place over different time scales: homeostasis acting over a short time scale, developmental plasticity across life, and natural selection over generations [6]. Big data—data intensive biology—is providing a better understanding of the mechanisms underlying

homeostasis and developmental plasticity; evolutionary theories offer a broad interpretative framework. Life course epidemiology studies how different capacities change across life, whether there are periods of rapid change or transitions where physical and social exposures may have more long-term consequences than at other times, and whether there are differences by birth cohorts, socioeconomic position, gender, or ethnicity. It investigates how childhood factors may affect the development of peak capacity and how child and adult factors maintain this peak, delay the onset, or modify the rate of decline. It recognises that while environmental stimuli are required to develop and maintain capacity, other environmental exposures, often highly socially patterned, have long-term damaging consequences. It seeks to understand how those most resilient to adversities draw on intrinsic or extrinsic characteristics in resisting, recovering, compensating, or adapting to these challenges.

1.3 Assessing Trajectories of Intrinsic Capacity

A life course approach ideally requires cohort studies with long term, preferably lifelong follow-up. The UK is particularly fortunate in having a wealth of such studies; this chapter draws on examples from the MRC National Survey of Health and Development (NSHD) which has followed a nationally representative sample of British men and women since their birth in a week in March 1946, and on whom there is a wealth of data from 0 to 70 years [7]. Empirical evidence linking exposures earlier in life to later capacity and other health outcomes initially came from single cohort studies like NSHD, but where sufficient studies are available, systematic reviews, and meta-analyses have been conducted; these provide stronger evidence on which to base changes in policy and practice. Increasingly, the statistical power of cross cohort studies and large cohort studies is being utilised to provide reliable estimates of the associations between risk and protective factors acting at different ages and these later outcomes.

Physical capacity can be assessed by tests of muscle strength (e.g., grip strength), locomotor function (e.g., walking speed, timed get up and go, chair rising), balance (e.g., one legged stands) and dexterity (e.g., pegboard test) [8, 9]. These tests are commonly used in population studies, can be easily applied to a range of settings, and identify meaningful variation between and within individuals from at least as early as midlife; modification and/or substitution of these tests may be required at earlier ages. Similarly, tools that test the domains of cognitive function (e.g., verbal memory, processing speed, executive function) and those that test cardiovascular, lung, and immune function and other body systems relevant to ageing are readily available [9]. Self-reports of intrinsic capacity and functional ability are also important to capture the lived experience and to design intervention strategies.

Evidence to date shows that lifetime trajectories of physical and cognitive capacity generally show an increase in capacity during growth and development, peaking or plateauing at maturity, with an initial slow rate of decline across adulthood that accelerates later in life [10–13].

1.4 Lifetime Influences on Survival to Old Age

Survival to old age can be seen as a necessary but not sufficient condition for healthy ageing, but still needs to be considered given that even some high-income countries are experiencing worrying trends in mortality and life expectancy [14, 15].

A range of social, psychological, and biomedical factors from early life onwards have been shown to affect the risk of premature adult mortality. For example, in NSHD those who grew up in manual households or had lower childhood cognitive ability had a higher risk of dying prematurely than their peers from non-manual households [16]; similar findings have been replicated in many cohort studies [17, 18]. Of relevance to the focus of this book, lower midlife physical capacity was related to a higher mortality rate in NSHD [19], extending previous studies at older ages [20]. Lower cognitive capacity in early adulthood, also related to higher mortality rates, mediated the associations between early life factors (family background, cognitive ability, and education) and adult mortality [21]. These findings suggest that building capacity in childhood and early adult life will improve later life health and survival chances.

1.5 Early and Midlife Influences on Trajectories of Intrinsic Capacity

In NSHD, aspects of poor physical growth, neurodevelopment (delayed motor development, lower childhood cognitive ability, and poorer adolescent motor co-ordination), and early socioeconomic disadvantage have been related to midlife physical capacity in a series of publications (summarised in [8]). Systematic reviews and meta-analyses have strengthened the evidence [22, 23].

Furthermore, there is growing evidence that these early life factors are associated not just with the level but also the rate of decline in adult physical capacity. In NSHD, higher childhood cognitive ability was associated with a lower chance of being in a group who experienced significant decline in grip strength and chair rise performance in the sixth decade of life [24]. In contrast, early socioeconomic disadvantage was associated with a greater chance of being in this group. Additional assessments of grip strength at age 69 have confirmed that the association between lower childhood cognitive ability and lower grip strength has strengthened with age, whereas the pattern of associations of physical growth and motor development with adult grip strength have remained constant.

In addition, adult socioeconomic disadvantage and poorer cognitive function continue to be associated with a lower level of physical capacity and increased risk of decline. However, a healthy adult lifestyle—taking exercise, eating a healthy diet, maintaining a normal weight and not smoking—was associated with a higher level of capacity and a lower chance of decline in the sixth decade [25]. Maintaining physical activity is particularly important for physical capability when taking all the evidence together [26, 27].

The lifetime determinants of mental (cognitive and emotional) capacity are beyond the scope of this chapter. Many factors across life affect the level of adult cognitive capacity (including several associated with physical capacity), and there have been reports of a decline in age-specific dementia incidence or prevalence in several countries; however, identifying factors where there is strong evidence for preventing individual cognitive decline has been more challenging [28, 29]. This again highlights the importance of enhancing and maintaining mental capacity from early life onwards.

1.5.1 Cardio-Metabolic and Respiratory Function

Optimal functioning of cardio-metabolic and respiratory systems are important aspects of intrinsic capacity, underlying many other aspects of functional change. Here, there is a growing wealth of evidence, sometimes obtained by piecing together multiple longitudinal studies with repeated measures covering different periods of the life course, on the changes (including greater heterogeneity) that occur with age [30], their lifetime determinants, and functional and disease consequences [31, 32].

For example, understanding the natural history of lung function and the development of COPD requires a life course perspective. About 50% of COPD cases are due to accelerated decline of FEV1 in adult life but the other 50% already have low FEV1 in early adulthood [33]. Over 40 years ago, the NSHD was one of the first to show that infant lower respiratory tract illness, overcrowding, air pollution and manual paternal occupation were associated with symptoms of chronic bronchitis in young adulthood [34]. Most recently, this study has shown how those who experience this early disadvantage had particularly low levels of midlife lung function if they took up smoking [35]. It is possible that adolescent smoking when the lungs are still developing prevents their recovery from earlier deficits. Those who smoke also have a faster decline in lung function, as do those who experience more episodes of mucus hypersecretion in early and mid-adulthood [36]. Young adulthood is a sensitive period for lung capacity and is an important time for tailored interventions.

There is a wealth of evidence that poor early growth (e.g., lower birthweight or ponderal index) and socioeconomic disadvantage are early determinants of reduced adult cardiovascular and metabolic function [37, 38]. Early disadvantage is related to adverse changes in adult blood pressure, partly due to the earlier and greater increase in adiposity among those from poorer backgrounds [39]. NSHD and other studies have shown that those who have an accelerated rise in blood pressure during early and mid-adulthood are more likely to have adverse indicators of cardiac structure and function and atherosclerosis subsequently [40–42]. Importantly, these associations apply to rises within the normal range of blood pressure raising the question of whether intervention be based on the change in blood pressure, rather than a clinical threshold.

1.5.2 Common Mechanisms Underlying Intrinsic Capacity

There is a growing interest in understanding and potentially modifying the lifetime trajectories and determinants of common ageing phenotypes that underlie many aspects of intrinsic capacity, decline, and variation between social groups; these include changes in body composition, homeostatic dysregulation, and age-related declines in energy efficiency and in central and peripheral nervous system processes [13]. Similarly, a life course perspective would help further understanding of the molecular and cellular mechanisms that may link the epigenome, metabolome, and microbiome (and other -omics data) to healthy ageing.

It is equally important to maintain research and policy interest in the lifetime socioeconomic pathways that influence intrinsic capacity and functional ability. The role of lifetime body composition, particularly adiposity, on intrinsic capacity can hardly be underestimated, and is a good example of the need to integrate both social and biological approaches, supported by a wealth of evidence (e.g., [43, 44]). Here again, factors from early life affect the chance of maintaining a healthy weight [13, 45]. In NSHD, there are striking differences in fat mass in the seventh decade of life, especially for women, by socioeconomic indicators right across life [46]. Cross cohort studies show how childhood and adult social inequalities in lifetime BMI trajectories have been maintained and the overall upward shift in these trajectories [47–49]. These are important trends to tackle, if we are to ensure an equal chance of healthy ageing for all socioeconomic groups.

1.6 Implications for Policy and Practice of a Life Course Approach to Healthy Ageing

Promotion of healthy ageing needs to start early and continue across life. Enhancing the development of intrinsic capacity during growth and development is essential, supported by strong evidence of critical and sensitive periods in early life, and by moral, ethical, and economic arguments to improve child health and reduce social inequalities. In adult life, there needs to be a greater focus on strategies that maintain capacity, and delay the onset and modify the rate of decline. Evidence is growing that early and mid-adulthood is a time of significant functional change when it may be easier to modify the trajectory than at later ages. Health professionals need to consider intervening when there is accelerated decline, and not necessarily wait until clinical thresholds are reached. We also need to identify ways to promote physiological, psychological, and social resilience to maintain intrinsic capacity and functional ability well into old age and improve the well-being of older people.

Acknowledgements Thanks to Dr. Rachel Cooper, Professor Rebecca Hardy, Professor Marcus Richards, and Professor Yoav Ben-Shlomo for their helpful comments on an earlier draft of this chapter.

References

1. World Health Organization (2015) World report on ageing and health
2. Ben-Shlomo Y, Kuh D (2002) A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives. Int J Epidemiol 31(2):285–293
3. Kuh D, Ben-Shlomo Y (2004) A life course approach to chronic disease epidemiology, 2nd edn. Oxford University Press, Oxford
4. Ben-Shlomo Y, Cooper R, Kuh D (2016) The last two decades of life course epidemiology, and its relevance for research on ageing. Int J Epidemiol 45(4):973–988
5. Cooper R, Hardy R, Sayers A, Kuh D (2014) A life course approach to physical capability. In: Kuh D, Cooper R, Hardy R, Richards M, Ben-Shlomo Y (eds) A life course approach to healthy ageing, 1st edn. Oxford University Press, Oxford, pp 16–31
6. Gluckman PD, Hanson MA, Bateson P et al (2009) Towards a new developmental synthesis: adaptive developmental plasticity and human disease. Lancet 373(9675):1654–1657
7. Kuh D, Wong A, Shah I et al (2016) The MRC National Survey of Health and Development reaches age 70: maintaining participation at older ages in a birth cohort study. Eur J Epidemiol 31(11):1135–1147
8. Kuh D, Karunananthan S, Bergman H, Cooper R (2014) A life-course approach to healthy ageing: maintaining physical capability. Proc Nutr Soc 73(2):237–248
9. Lara J, Cooper R, Nissan J et al (2015) A proposed panel of biomarkers of healthy ageing. BMC Med 13:222
10. Dodds RM, Syddall HE, Cooper R et al (2014) Grip strength across the life course: normative data from twelve British studies. PLoS One 9(12):e113637
11. Dodds RM, Syddall HE, Cooper R, Kuh D, Cooper C, Sayer AA (2016) Global variation in grip strength: a systematic review and meta-analysis of normative data. Age Ageing 45(2):209–216
12. Davis D, Bendayan R, Muniz G, Hardy R, Richards M, Kuh D (2017) Decline in search speed and verbal memory over 26 years of midlife in a British birth cohort. Neuroepidemiology 49:121–128
13. Ferrucci L, Cooper R, Shardell M, Simonsick EM, Schrack JA, Kuh D (2016) Age-related change in mobility: perspectives from life course epidemiology and geroscience. J Gerontol A Biol Sci Med Sci 71(9):1184–1194
14. Case A, Deaton A (2015) Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. Proc Natl Acad Sci U S A 112(49):15078–15083
15. Hiam L, Harrison D, McKee M, Dorling D (2018) Why is life expectancy in England and Wales 'stalling'? J Epidemiol Community Health 72:404–408
16. Kuh D, Shah I, Richards M, Mishra G, Wadsworth M, Hardy R (2009) Do childhood cognitive ability or smoking behaviour explain the influence of lifetime socio-economic conditions on premature adult mortality in a British post war birth cohort? Soc Sci Med 68(9):1565–1573
17. Galobardes B, Lynch JW, Smith GD (2008) Is the association between childhood socioeconomic circumstances and cause-specific mortality established? Update of a systematic review. J Epidemiol Community Health 62(5):387–390
18. Calvin CM, Deary IJ, Fenton C et al (2011) Intelligence in youth and all-cause-mortality: systematic review with meta-analysis. Int J Epidemiol 40(3):626–644
19. Cooper R, Strand BH, Hardy R, Patel KV, Kuh D (2014) Physical capability in mid-life and survival over 13 years of follow-up: British birth cohort study. Br Med J 348:g2219
20. Cooper R, Kuh D, Hardy R (2010) Objectively measured physical capability levels and mortality: systematic review and meta-analysis. Br Med J 341:c4467
21. Davis D, Cooper R, Terrera GM, Hardy R, Richards M, Kuh D (2016) Verbal memory and search speed in early midlife are associated with mortality over 25 years' follow-up, independently of health status and early life factors: a British birth cohort study. Int J Epidemiol 45(4):1216–1225

22. Birnie K, Cooper R, Martin RM et al (2011) Childhood socioeconomic position and objectively measured physical capability levels in adulthood: a systematic review and meta-analysis. PLoS One 6(1):e15564
23. Dodds R, Denison HJ, Ntani G et al (2012) Birth weight and muscle strength: a systematic review and meta-analysis. J Nutr Health Ageing 16(7):609–615
24. Cooper R, Richards M, Kuh D (2017) Childhood cognitive ability and age-related changes in physical capability from midlife: findings from a British Birth Cohort Study. Psychosom Med 79(7):785–791
25. Cooper R, Muniz-Terrera G, Kuh D (2016) Associations of behavioural risk factors and health status with changes in physical capability over 10 years of follow-up: the MRC National Survey of Health and Development. BMJ Open 6(4):e009962
26. World Health Organization (2010) Global recommendations on physical activity for health. WHO, Geneva
27. Anton SD, Woods AJ, Ashizawa T et al (2015) Successful aging: advancing the science of physical independence in older adults. Ageing Res Rev 24(Pt B):304–327
28. Leshner AI, Landis S, Stroud C, Downey A, Committee on Preventing Dementia and Cognitive Impairment (2017) Preventing cognitive decline and dementia. The National Academies Press, Washington, DC
29. Livingston G, Sommerlad A, Orgeta V et al (2017) Dementia prevention, intervention, and care. Lancet 390:2673–2734
30. Wills AK, Lawlor DA, Matthews FE et al (2011) Life course trajectories of systolic blood pressure using longitudinal data from eight UK cohorts. PLoS Med 8(6):e1000440
31. Hardy R, Lawlor DA, Kuh D (2015) A life course approach to cardiovascular aging. Future Cardiol 11(1):101–113
32. Lawlor DA, Hardy R (2014) Vascular and metabolic function across the life course. In: Kuh D, Cooper R, Hardy R, Richards M, Ben-Shlomo Y (eds) A life course approach to healthy ageing, 1st edn. Oxford University Press, Oxford, pp 146–161
33. Lange P, Celli B, Agusti A et al (2015) Lung-function trajectories leading to chronic obstructive pulmonary disease. N Engl J Med 373(2):111–122
34. Colley JRT, Douglas JWB, Reid DD (1973) Respiratory disease in young adults; influence of early childhood lower respiratory tract illness, social class, air pollution, and smoking. Br Med J 3:195–198
35. Allinson JP, Hardy R, Donaldson GC, Shaheen SO, Kuh D, Wedzicha JA (2017) Combined impact of smoking and early life exposures on adult lung function trajectories. Am J Respir Crit Care Med 196:1021–1030
36. Allinson JP, Hardy R, Donaldson GC, Shaheen SO, Kuh D, Wedzicha JA (2016) The presence of chronic mucus hypersecretion across adult life in relation to chronic obstructive pulmonary disease development. Am J Respir Crit Care Med 193(6):662–672
37. Whincup PH, Kaye SJ, Owen CG et al (2008) Birth weight and risk of type 2 diabetes: a systematic review. JAMA 300(24):2886–2897
38. Galobardes B, Smith GD, Lynch JW (2006) Systematic review of the influence of childhood socioeconomic circumstances on risk for cardiovascular disease in adulthood. Ann Epidemiol 16(2):91–104
39. Hardy R, Kuh D, Langenberg C, Wadsworth M (2003) Birthweight, childhood social class, and change in adult blood pressure in the 1946 British birth cohort. Lancet 362:1178–1183
40. Ghosh AK, Hardy RJ, Francis DP et al (2014) Midlife blood pressure change and left ventricular mass and remodelling in older age in the 1946 British birth cohort studydagger. Eur Heart J 35:3287–3295
41. Allen NB, Siddique J, Wilkins JT et al (2014) Blood pressure trajectories in early adulthood and subclinical atherosclerosis in middle age. JAMA 311(5):490–497
42. Ghosh AK, Hughes AD, Francis D et al (2016) Midlife blood pressure predicts future diastolic dysfunction independently of blood pressure. Heart 102:1380–1387

43. Hardy R, Cooper R, Sayer AA et al (2013) Body mass index, muscle strength and physical performance in older adults from eight cohort studies: the HALCyon programme. PLoS One 8(2):e56483
44. Singh-Manoux A, Dugravot A, Shipley M et al (2017) Obesity trajectories and risk of dementia: 28 years of follow-up in the Whitehall II Study. Alzheimers Dement 14:178–186
45. Senese LC, Almeida ND, Fath AK, Smith BT, Loucks EB (2009) Associations between childhood socioeconomic position and adulthood obesity. Epidemiol Rev 31:21–51
46. Bann D, Cooper R, Wills AK, Adams J, Kuh D (2014) Socioeconomic position across life and body composition in early old age: findings from a British birth cohort study. J Epidemiol Community Health 68(6):516–523
47. Bann D, Johnson W, Li L, Kuh D, Hardy R (2017) Socioeconomic inequalities in body mass index across adulthood: coordinated analyses of individual participant data from three British birth cohort studies initiated in 1946, 1958 and 1970. PLoS Med 14(1):e1002214
48. Johnson W, Li L, Kuh D, Hardy R (2015) How has the age-related process of overweight or obesity development changed over time? Co-ordinated analyses in five United Kingdom birth cohorts. PLoS Med 12(5):e1001828
49. Bann D, Johnson W, Kuh D, Hardy R (2018) Socioeconomic inequalities in childhood and adolescent body-mass index, weight, and height from 1953 to 2015: an analysis of four longitudinal, observational, British birth cohort studies. Lancet Public Health 3(4):e194–e203