CHAPTER 7. AGE DIFFERENCES IN ALLOSTATIC LOAD: AN INDEX OF FRAILTY*

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1. Introduction

Frailty is an emerging concept in the study of health outcomes at older ages (Cohen 2000; Fried et al. 2001; Morley, Perry, and Miller 2002). It is recognized as a downward trajectory in health and ability to perform daily tasks. This downward spiral results from the accumulation of acute and chronic diseases as well as the physiological decline and dysregulation that accompany the onset of diseases and advanced age (Cohen 2000).

This chapter investigates population differences in physiological frailty as evidenced by levels of allostatic load to determine how physiological deterioration occurs in a population as it passes through old age. We are interested in examining age differences in this summary indicator of biological risk—allostatic load—to see how physiological dysregulation in the population differs by age. We examine the age pattern of population increase in physiological frailty across the adult years, as represented by allostatic load. Of particular interest is whether there is any leveling off of average physiological risk as the oldest ages are approached. In addition, we are interested in the population variability in allostatic load as age increases. Our analysis does not provide insight into how frailty changes within an individual lifespan but clarifies how physiological challenge varies in the population at different ages. Because our analysis is cross-sectional we are examining frailty in a population that is comprised of a set of different cohorts, which have experienced differential selectivity because of death and which may have differed in many characteristics in their lifetime.

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2. Background

Measures of allostatic load have been both developed theoretically and related to a variety of health outcomes in a number of recent studies (McEwen 1998; McEwen and Stellar 1993; Seeman et al. 1997, 2001, 2004; Sterling and Eyer 1988). Allostatic load is an indicator of physiological dysregulation in a variety of bodily systems. In the course of normal life experiences, challenge to various physiological systems is met with physiological responses appropriate to eliminating the threat posed by the challenge. Such bodily responses should occur within an optimal range. When the body has received significant challenge over many years, physiological systems may begin to operate less efficiently essentially showing wear and tear. A central feature is that they begin to operate increasingly outside their optimal range or may have difficulty returning to optimal ranges after challenge. The concept of allostatic load takes a multisystems view of these dysregulations, postulating that it is the cumulative burden of dysregulation across multiple systems that predicts subsequent health and longevity (Karlamangla et al. 2002; Seeman et al. 2001). Allostatic load has been linked to mortality as well as other adverse health outcomes such as cardiovascular disease, loss of physical functioning, and cognitive failure (Seeman et al. 2001). Allostatic load can be regarded as a direct indicator of population frailty as it is indicative of the extent to which the body is at risk of adverse health outcomes because of physiologic dysregulation across multiple regulatory systems (Seeman et al. 2001).

A number of studies have examined both age differences and age changes in a variety of indicators of physiological capacity or of physiological reserve (Lipsitz and Goldberger 1992; Manton, Woodbury, and Stallard 1995; Shock et al. 1984). These studies make clear that in many indicators of physiological state there is decline with age in the population average although there is great variability across different biomarkers in the average rate of change and its relationship to age. On an individual level there is also great variability in the rate of decline resulting in increased population variability in physiological state with age.

Frailty is assumed to vary across population members because of both innate characteristics and environmental exposures. While persons are born with different susceptibility to frailty, individual frailty is assumed to increase with physiological changes related to aging, and also as a result of increasing exposure to challenging environmental conditions. As a population ages one assumes that innate characteristics and external circumstances join to operate so that those with greater frailty are more susceptible to the risks of mortality and morbidity (Vaupel, Manton, and Stallard 1979). If mortality continuously selects the most frail from the population, those who survive to the oldest ages may be those who began life with the highest innate resources and/or faced the least challenge (Vaupel et al. 1998). This would lead one to expect an age pattern of frailty that does not increase exponentially with age but slows in its increase with age at the oldest ages.

The demographic approach to frailty emphasizes the role of innate characteristics and genetic influences on frailty (Yashin et al. 1999), while the bio-geriatric approach to frailty