# Chronic Stress and HPA Axis Dysregulation in Older Adulthood: Protective Effects of Self-Compassion

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## ABSTRACT

**Chronic Stress and HPA Axis Dysregulation in Older Adulthood: Protective Effects of Self-Compassion**

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The aging population is the fastest growing segment of the population. With aging, there is an increase in the number of uncontrollable stressors that arise. Stress is known to have an impact on biological processes (e.g., HPA axis function) and downstream physical health outcomes (e.g., chronic illness). However, the exact pathophysiological patterns of HPA axis dysfunction that arise from chronic stress experiences is vastly understudied. In addition, little is known about psychological factors that promote adaption to stress and reduce the negative consequences of stress on health in old age. This dissertation sought to investigate the impact of stress experiences on older adult's physical health and the benefits of the psychological trait self-compassion. Study 1 examined how chronic stress levels and changes predicted trajectories of diurnal cortisol (AUC and slope) over 12 years. Results indicated that older adults with high levels of chronic stress were likely to have significantly steeper declines in cortisol levels over the study. In addition, older adults with high and increasing stress levels displayed increasingly flatter cortisol slopes. Study 2 investigated cross-sectional associations between age-related stressors and diurnal cortisol, and whether self-compassion could buffer the impact of stress on cortisol patterns. The results found no association between age-related stress and diurnal cortisol. However, self-compassion moderated the association between age-related stress and cortisol. Specifically, older adults with higher levels of age-related stressors who were more self-compassionate were protected from higher levels of stress-related diurnal cortisol. Study 3 sought to explore the longitudinal health benefits of self-compassion across four years, and

whether they vary for older adults in early vs. advanced old age. The results revealed that self-compassion predicted lower levels of daily physical symptoms on average for those in advanced old age (but not early old age). Self-compassion also predicted fewer increases in chronic illness over four years among those in advanced, but not early old age. Overall, this dissertation provides significant contributions to theory and research on stress, aging and health.

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## CONTRIBUTION OF AUTHORS

This dissertation is comprised of three separate published research papers. All research utilized study data from the Montreal Aging and Health Study. Funding for this study was from CIHR research grants awards to Dr. Carsten Wrosch. I conducted all statistical analyses and prepared all manuscripts for submission. In study 1 Dr. Carsten Wrosch, Dr. Jeremy Hamm, Dr. Jens Pruessner collaborated with me on the manuscript which is published in *Psychoneuroendocrinology* (https://doi.org/10.1016/j.psyneuen.2020.104826). For study 2, Dr. Carsten Wrosch, and Dr. Jean-Phillipe Gouin and I collaborated on the manuscript which is published in *Journal of Behavioral Medicine* (https://doi.org/10.1007/s10865-018-9943-6). For study 3, I collaborated with Dr. Carsten Wrosch and published this manuscript in *Journal of Health Psychology* (https://doi.org/10.1177/13591053211002326). During the completion of my dissertation, I was supported by a SSHRC Joseph-Armand Bombardier Doctoral Scholarship, FRQS Bourses de doctorat en recherche and a Concordia University Special Entrance Award. I declare that I am the sole author of the entire dissertation document.

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# CHAPTER 1:

# GENERAL INTRODUCTION

The aging population is the fastest growing segment of the Canadian population. In 2014, adults 65 or older represented 15.6 percent of the population, however by 2030 older adults will make up over 23 percent (Statistics Canada – Action for Seniors Report, 2014). Further, the advances in medicine and technology have allowed humans to live longer lives than ever. As a result, more individuals are living well into advanced old age. By 2036, the average life expectancy in Canada is expected to increase from 84.2 and 80 to 86.2 and 82.9, for women and men respectively (Statistics Canada – Action for Seniors Report, 2014). While there are advantages of living longer, a host of new issues and problems can arise that have been vastly understudied among this growing population (Baltes & Smith, 2003). Notably, as individuals age there is an increase in the number of uncontrollable stressors (Heckhausen, Wrosch, & Schulz, 2019). One prevalent example would be chronic illness, over 80% of older adults in Canada report at least one chronic illness and the majority reports upwards of two or more chronic illnesses (Statistics Canada, 2009). Chronic illness can reduce quality of life by requiring extensive time and effort to manage their illness, increases in pain, reducing psychological well-being, and a reduction in functional abilities (Freund & Baltes, 2000; Williamson, & Schulz, 1995; Wrosch & Schulz, 2008). Other common age-related stressors can include loss of social networks, loneliness, life regrets, lack of daily structure related to retirement, caregiving, and bereavement (Moss, Moss, & Hansson, 2001; Kim & Moen, 2001; Van Tilburg, 1998).

## Stress, Cortisol, and Health

Stress is a multifaceted construct that can involve an objectively distressing event and/or the subjective perception that an event is taxing to the individual's own capabilities. The former

can be defined by quantifying certain events which are known to be stressful as an indicator of stress (e.g., early life adversity, divorce, bereavement, or chronic illness; Lantz, House, Mero, & Williams, 2005). The transactional model of stress and coping denotes the latter, by quantifying how stressful an event is based on the individuals' own appraisal of that experience (Lazarus & Folkman, 1984). Facets of the stress experience can also determine the extent to which a stressful experience is more likely to impact an individuals' mental and physical well-being. For example, controllability of the stressor has been shown to exacerbate the negative consequences of stressors on physiological dysregulation (e.g., cortisol output, Miller, Chen, & Zhou, 2007). Further, it is important to note the distinction between acute and chronic stress experiences (Hammen, Kim, Eberhart, & Brennan, 2009). Acute stress experiences are temporary experiences that have clearer length of duration, for example, being yelled at by your boss the day before an important deadline. Whereas chronic stress experiences involve longer term events which persist for extended periods of time, or have an unknown end, for example, if your boss yells at you consistently at work, this would fall under a chronic stressful experience (Gouin, 2011).

In addition, stress can also be defined by the biological reaction that stressful situations induce (Epel et al., 2018). When responding to threat, the human body is adept at maintaining homeostasis by triggering a cascade of biological systems. This response promotes adaption by assisting the individual in overcoming an imminent threat. Specifically, there are two systems activated when people experience stress: the sympathetic–adrenal–medullary (SAM) system and the hypothalamic– pituitary–adrenal (HPA) axis (Russell & Lightman, 2019). When a threat is perceived the amygdala and hypothalamus are activated, which leads to the release of corticotropin-releasing factor (CRF). The pituitary gland then releases adrenocorticotropic

hormone (ACTH), which travels in the bloodstream to the adrenal glands resulting in the secretion of glucocorticoids. Cortisol is one the main glucocorticoids (GCs) released in response to stress (Russell & Lightman, 2019). Cortisol is an evolutionary adaptive response to the perception of stress because it provides mobilizing energy to help the individual cope with the stressor. GCs, such as cortisol, inhibit further release by supressing CRF and ACTH production in a negative feedback loop fashion. The effectiveness of the negative feedback loop regulation can be influenced by an individual's sensitivity to GCs, which is dependent on number and accessibility of GC receptors (Gaffey et al., 2016).

Independent of stress-related cortisol production, cortisol is released throughout each day in a distinct circadian rhythm. Cortisol peaks appropriately 30 minutes upon awakening, displays a gradual decline over the course of the day and reaches a nadir during the night. This diurnal rhythm has several important homeostatic functions, such as mobilizing and providing energy to the organism and regulating various bodily systems (e.g., immune, metabolic, cardiovascular). Further, the daily cortisol pattern can be influenced by factors that affect circadian function such as an individual's sleep-wake patterns and exposure to light and dark (Van Cauter, 1990). In summary, cortisol displays distinct diurnal rhythms which are endogenously regulated but can also be influenced by stress and other environmental factors.

To measure cortisol there are a variety of methodologies based on the indicator that is of interest. Collecting salvia samples are considered the gold-standard method given their simple, non-invasive, and pain-free sampling protocol (Kalman, & Grahn, 2004). Using salvia samples researchers can determine the relative activity of the HPA axis at a given time during the day. This is particularly useful for measuring short-term HPA axis responsivity, such as how cortisol changes every 15-20 minutes during a stressful experience (e.g., Trier Social Stress Test;

Kirschbaum, Pirke, & Hellhammer, 1993). During this type of measurement, we expect a sharp increase in cortisol following a stressor and return to baseline afterwards. On the other hand, researchers can also determine an individual's diurnal cortisol patterns by measuring cortisol at a handful of specific times across the day. For example, taking measurements upon awakening, in the afternoon (approx. 2 and 4pm), and just before bed allows researchers to calculate indicators of an overall cortisol level (i.e., how much cortisol was released throughout the day; area under the curve [AUC]), and the rate at which cortisol declines over the course of the day (cortisol slope). Both cortisol levels and slopes are considered relevant measures to assess with regards to the health and functioning of the HPA axis (e.g., Heim et al., 2000; Kumari et al., 2011).

It is well-established that stress can predict a host of poor health outcomes, such as cardiovascular, cognitive, metabolic, and psychiatric problems (Cohen, Janicki-Deverts, & Miller, 2007; Lupien, McEwen, Gunnar, & Heim, 2009; Murri et al., 2014). The pathway in which stress can lead to poor health is believed to be through dysregulation of the HPA axis and GCs it releases such as cortisol. The theory of allostatic load posits that chronic activation of the HPA axis related to stress can lead to wear and tear on the biological systems that cortisol influences (e.g., cardiac, hormonal, immune, neural, cellular; McEwen, 1998). Notably, dysregulated cortisol patterns can predict health outcomes particularly relevant to those in old age, such as inflammation, frailty, poor balance, poor handgrip strength, less independence in carrying out daily tasks, and early mortality in cancer populations (Heaney et al., 2012; Johar et al., 2014; Kumari et al., 2011; Piazza et al., 2018; Sephton et al., 2013, 2000). In this way, cortisol may not have direct effects on health outcomes, instead it is more likely to influence regulation of a host of other bodily systems that contribute to health outcomes.

HPA dysregulation may be indicated by over or under- responding to stress, inefficiency of the negative feedback loop, or impaired (inefficient, or excess) GC sensitivity in bodily tissues which may change responsiveness to acute stress (Kiecolt-Glaser, Renna, Shrout, & Madison, 2020; Turner et al., 2020; Gaffey, Bergeman, Clark, & Wirth, 2016; McEwen, 1998; Rohleder, Wolf, & Wolf, 2010). While the exact pathophysiological effects of stress related HPA dysregulation are not fully elucidated, they seem to relate to the way HPA axis functioning is impaired. For example, enhanced cortisol may play a greater role in cardiovascular risk factors (e.g., hypertension), whereas lower or blunted cortisol has predicted more depression, anxiety, PTSD, obesity, generally poorer objective and self-rated health, musoskeletal pain and lower bone mass (Turner et al., 2020). Further, an individual's sensitivity to GC may also predict pathology, for example, greater GC sensitivity has been shown to relate to PTSD, whereas lower GC sensitivity may relate to depression (Rohleder, Wolf, & Wolf, 2010). Overall, these studies suggest that intermediate stress responses are likely most adaptive for health (Turner et al., 2020).

Currently, many theories exist which attempt to explain how chronic stress may lead to changing in the HPA axis over time. For example, theories have put forth the possibility that chronic stress experiences may influence an individual's responsiveness to GCs released during acute stress, or that stress may impair the functioning of the HPA itself, such that negative feedback loop is degraded (Kiecolt-Glaser, Renna, Shrout, & Madison, 2020; Turner et al., 2020; Gaffey et al., 2016). Given that chronic stress has predicted flatter slopes, it is also possible that damage to circadian function may also relate to cortisol dysregulation (Dumbell, Matveeva, & Oster, 2016). Regardless of the mechanism in which stress leads to dysregulated cortisol patterns, it is still not entirely understood what patterns of cortisol are indicative of chronic stress

experiences. For example, is a chronically stress individual more likely to have higher or lower than normal levels across the day, and/or is the diurnal rhythm itself more likely to be flatter? Such research is of great importance given the association that stress-related cortisol disruption can have on morbidity and mortality (for a review see O'Connor, Thayer, & Vedhara, 2021).

The previous discussion highlights that cortisol dysregulation can have negative downstream consequences on the physiological processes it influences (O'Connor, Thayer, & Vedhara, 2021). Less is known, however, which patterns of diurnal cortisol (e.g., high/low levels, flatter slope) represent those which are dysregulated by chronic stress experiences. As previously described, stress can be categorized into acute and chronic. The acute effects that stress has on temporarily enhancing cortisol section are well-known (e.g., Kudielka, Hellhammer, & Wüst, 2009). Based on these findings' researchers expected that prolonged exposure to high levels of GCs may be indicative of chronic stress and cause damage to the HPA axis over time (McEwen, 1998; Sapolsky et al., 1986). However, the literature on the effects of chronic stress on diurnal cortisol have been less clear. Greater chronic stress experiences have been linked to both higher and lower than normal levels of diurnal cortisol (for a review see, Miller et al., 2007). A metanalysis which utilized largely cross-sectional and short-term studies suggested that cortisol levels may be elevated initially due to chronic stress, and over time may rebound to be lower than normal over longer periods of stress (Miller et al., 2007). These findings suggest that the chronicity of stress experiences matter and may help explain some of the mixed findings. However, the extant literature has not studied this possibility using longitudinal methodology.

**Stress in Older Adulthood**

Older adults (those 65 and older) are particularly vulnerable to the effects of stress related HPA axis dysregulation. In support of this, there appears to be a stronger association between negative affect-related diurnal cortisol dysregulation in older (compared to younger) adults (Piazza et al., 2013). Vulnerability may also increase as individuals shift from early (65+) to advanced old age (e.g., 80+) age, this may be due to the frequency of which uncontrollable stressful experiences occur (Heckhausen et al., 2019). Stress which is uncontrollable is also most likely to trigger the HPA axis (Miller et al., 2007). Older adults may find it more difficult to overcome stressors due to the reduction in the number of opportunities and resources available (Heckhausen et al., 2019). In addition, older adults may be more vulnerable to stress related HPA axis disruptions because of the cumulative effects of stress over time (i.e., allostatic load; McEwen, 1998), or age-related declines in physiological functioning (Sapolsky et al., 1986). Either of which could lead to impairments in HPA function (e.g., GC sensitivity, amount of GC receptors, or impaired negative feedback loop; Ferrari et al., 1995; Sapolsky et al., 1986; Gaffey et al., 2016). While it seems clear that older adults are at greater risk for stress-related cortisol dysregulation, the literature on whether aging itself is associated with changes in diurnal cortisol is inconsistent. Aging has been associated with both higher and lower diurnal cortisol, flatter slopes, or no differences (for a review see Gaffey et al., 2016). The limitation of this research is that it is primarily composed of cross-sectional studies which inhibit the ability to distinguish between true age effects and possible cohort effects.

Given that aging is associated with greater vulnerability in HPA axis dysfunction it is critical that researchers examine how stress changes diurnal cortisol over time. It is not known whether the effects of chronic stress on cortisol are stronger, the same, or different as individuals

age. Interestingly, a metanalysis has found that older adults tend to display an exaggerated cortisol response to challenge (Otte, Hart, Neylan, Marmar, Yaffe, Mohr, 2005). This preliminary research points towards a more vulnerable model of stress-HPA axis influence in older adulthood. In the previous paragraph it was discussed that aging in general may change diurnal cortisol patterns. It's also known from literature on adult populations that the chronicity of stress experience matter (Miller et al., 2007). More recent/short-term stress experiences may be linked to elevated cortisol secretion, which can rebound to be below normal levels as stress experiences become more chronic. In addition, blunted cortisol slopes also seem to be indicative of chronic stress-related dysregulation. However, research has yet to disentangle the effects of aging versus stress on changes in diurnal cortisol patterns over time. Such work is important as it could contribute to identifying at-risk adults and implementing interventions to improve HPA axis function as a way to protect older adults from the negative consequences that stress-related cortisol dysregulation can have.

**Self-compassion as a Protective Factor**

Given the adverse effects that stress can exert in old age and that it is important to study modifiable psychological factors that could help older adults adjust to stress experiences (Gaffey et al., 2016). When attempting to understand which psychological factors may be most beneficial to those in older adulthood, we must consider the context of the challenges they are likely to face. Motivational life-span theories of development provide a theoretical basis to help identify which strategies would be beneficial (Brandtstädter & Renner, 1990; Freund, & Baltes, 2000; Heckhausen et al., 2019). During early and middle adulthood addressing many of the challenges and stressors requires strategies which utilize an individual's own energy, opportunities and resources to overcome (e.g., persistence). As individual's age, however, there is a decline in

energy, opportunities and resources available to cope with stressors. Consequently, older adults need to shift towards relying on strategies which involve self-protection that can facilitate regulation of negative emotions and enable individuals to deal with the occurrence of unattainable goals or intractable stressors (e.g., positive reappraisals or goal disengagement; Heckhausen et al., 2019; Jobin, & Wrosch, 2016; Wrosch et al., 2006).

This dissertation will focus on the psychological factor of self-compassion as a psychological resilience factor which is assumed to protect older adults from the negative consequences of stress on health. Self-compassion is a dispositional construct (that can also be increased via clinical intervention; Neff & Germer, 2013). Self-compassion involves treating yourself in the same kind and caring manner that a person would treat a close friend or loved one (Neff, 2003b). The three main components of self-compassion are self-kindness, mindfulness, and common humanity (Neff, 2003b). The component of self-kindness involved treating oneself in a gentle, caring, and understanding manner when experiencing pain, suffering or failure. Instead of being self-critical or angry at oneself for their imperfections or flaws. The component of mindfulness involves taking a non-judgemental and balanced perception during times of stress. It includes being able to observe and recognize one's thoughts without over-identifying with them and ruminating excessively on negative thoughts. Finally, self-compassion involves being able to recognize the common humanity in suffering. Humans are not alone in their imperfections and the experience of suffering and stress, therefore being able to recognize the shared human experience promotes more balanced responses to stress (Neff, Rude, & Kirkpatrick, 2007).

Indeed, research has demonstrated that self-compassionate individuals are more likely to engage in effective coping strategies such as positive reframing (Allen & Leary, 2010). Self-

compassion has been shown to facilitate more adaptive stress activity indicated via higher heart-rate variability, less inflammation, and lower negative affect (Breines et al., 2014; Luo, Qiao, & Che, 2018; Krieger et al., 2015; Neff et al., 2007). It is likely that these adaptive coping strategies and reduced stress reactivity help promote the robust association between self-compassion and enhanced psychological well-being (for a meta-analysis see Brown, Huffman, & Bryant, 2019).

There is also ample evidence that the benefits of self-compassion extend to physical health (e.g., global health, inflammation, sleep; Phillips & Hine, 2019). Such associations may be related to the findings that self-compassion seems to generally promote a wide variety of positive health behaviors (e.g., eating behavior, good sleep habits, physical activity, and medication adherence (Terry & Leary, 2011). However, research suggests that self-compassion shows weaker associations with health promoting behaviours in old age (Phillips & Hine, 2019). Indeed, the majority of the research on self-compassion and health has been conducted among younger-middle aged adults. Therefore, self-compassion is more likely to exert positive health benefits due to its reduction in stress reactivity among older adults, than by enhancing health behaviours (Breines et al., 2014, Luo, Qiao, & Che, 2018; Krieger et al., 2015; Neff et al., 2007). While the associations between self-compassion and psychological stress have been studied, little research has explored associations between self-compassion and biomarkers related to stress, such as cortisol. Given that cortisol is considered an important biological intermediary factor linking stress to health, it is important to address whether self-compassion can influence stress related HPA axis dysregulation. We would expect such associations based on the theoretical model which posits that psychological factors, such as self-compassion, promote strategies which become increasingly adaptive in old age. As a consequence, it’s plausible to

assume that the benefits of self-compassion will extend to the biomarkers related to stress (e.g., dysregulated cortisol patterns) and downstream physical health outcomes over time (Heckhausen et al., 2019; Wrosch, Schulz, & Heckhausen, 2004).

Not only is self-compassion understudied in older adulthood, but the extant literature has also yet to study how the benefits of self-compassion may change as individuals progress from early old age to advanced old age. In particular we expect that self-compassion is sensitive to an individual's developmental context and the beneficial effects would increase towards end of life. Such differences are expected based off of motivation life-span theories which posit that individual difference factors that support self-protection and facilitate disengagement from unattainable goals are sensitive to a person's age-related context (Heckhausen et al., 2019). In early age many older adults have sufficient resources and opportunities to overcome stress experiences. Whereas those in advanced old age may suffer from reduced capacities that impair the effectiveness of certain strategies that foster persistence or optimism as a means of goal attainment (Wrosch, Jobin, & Scheier, 2017; Wrosch, Heckhausen, &Lachman, 2000). In line with this, research has found that individual difference factors that promote self-protection show enhanced benefits for reducing depressive symptoms and physical disease in advanced compared to early old age (e.g., Jobin & Wrosch, 2016). As such, the adaptive function of self-compassion likely increases with age and could therefore represent an importance resource for protecting stress-related health declines in advanced old age.

**Limitations of Previous Research**

In summary, stress experiences can have negative consequences on health and such associations are particularly important to study among the rapidly growing aging population. Cortisol is a hormone which is theorized to link stress and health. However, the extant literature

is unclear how chronic stress experiences can change diurnal cortisol function over longer periods of time. Further, research has yet to study long-term trajectories of diurnal cortisol patterns as a function of age or stress. To buffer the negative effects of stress on health, psychological resilience factors, such as self-compassion are hypothesized to be beneficial in coping with stress. However, the majority of the research on self-compassion and health is among younger and middle-aged adults. There is paucity of research exploring the benefits of self-compassion for biomarkers such as cortisol, and longer-term health outcomes among older adults. Based on motivational life span theories it is believed that self-compassion will be exceptionally beneficial for these psychobiological process in old age and could have clinical implications for promoting successful aging, particularly among those in advanced old age.

## The Present Research

This dissertation consists of three empirical research studies which aim to explore the impact of stress on health in older adulthood, and the protective roles of self-compassion. The first study was published in *Psychoneuroendocrinology* (Herriot, Wrosch, Hamm, & Pruessner, 2020) and explores the longitudinal associations between chronic stress experiences and diurnal cortisol over 12 years. The second study was published in *Journal of Behavioral Medicine* (Herriot, Wrosch, & Gouin, 2018) and explores cross-sectional associations between age-related stress experiences and diurnal cortisol, and the stress-buffering effects of self-compassion. The final study, published in *Journal of Health Psychology* (Herriot & Wrosch, 2021), examines self-compassion as predictor of acute and chronic illness trajectories over 4 years among those in early versus advanced old age. This research aims to add to the broader literature on stress on health by clarifying some of the mixed literature on stress and cortisol. In addition, this

dissertation aims to add to the literature on successful and healthy aging by demonstrating the stress-protective benefits of self-compassion for older adult's physical health.

***Objective 1****: To investigate how stress experiences influence diurnal cortisol patterns.*

***Objective 2****: To examine the longitudinal trajectories of diurnal cortisol in older adulthood*

***Objective 3****: To explore the health benefits of self-compassion among older adults, and whether the benefits of self-compassion increase from early to advanced old age.*

Study 1 (Chapter 2) sought to examine how chronic stress experiences predict longitudinal levels and changes in diurnal cortisol (e.g., cortisol AUC and slope). This research utilized longitudinal data involving 190 community-dwelling older adults who provided three days of cortisol and stress perceptions at each wave for up to seven waves over 12 years. Chronic stress levels were defined by having high stress levels generally over 12 years and/or whether those stress experiences increased over 12 years.

***Hypothesis 1****: High and/or increasing levels of stress experiences over 12 years will predict declines in cortisol AUC over 12 years.*

***Hypothesis 2****: High and/or increasing levels of stress experiences will predict flatter cortisol slopes over 12 years.*

Study 2 (Chapter 3) aimed to determine whether self-compassion would buffer the effects of uncontrollable age-related stressors on diurnal cortisol section. This analysis used cross-sectional data from 233 community-dwelling older adults who provided measures of self-compassion, age-related stress (physical health problems, functional limitations, and life regrets), and diurnal cortisol (AUC and slope). However, given the cross-sectional nature of this study,

we could not explore the chronicity of such stress experiences, this led us to expect that higher stress experiences would be associated with concurrently high levels of cortisol.

***Hypothesis 1****: Higher age-related stress will predict higher daily cortisol levels, and flatter cortisol slopes.*

***Hypothesis 2****: The association between age-related stress and diurnal cortisol will be moderated by self-compassion. Specifically, among individuals will low self-compassion, higher age-related stress will predict higher daily cortisol levels, and flatter cortisol slopes.*

Study 3 (Chapter 4) investigated whether self-compassion could predict levels and trajectories of acute and chronic health problems over four years in a community dwelling sample of 264 older adults. This study also explored whether the benefits of self-compassion are particularly enhanced in advanced versus early old age.

***Hypothesis 1****: Self-compassion will predict lower levels or less increases in acute and chronic health problems.*

***Hypothesis 2****: The association between self-compassion and health will be moderated by age, such that the associations between self-compassion and health will be higher among those in advanced, as compared to early, old age.*

# CHAPTER 2:

# STUDY 1

# STRESS-RELATED TRAJECTORIES OF DIURNAL CORTISOL IN OLDER ADULTHOOD OVER 12 YEARS

Note: Copy edited version of this study was published in Psychoneuroendocrinology, Nov. 2020

## Abstract

**Objective:** Although evidence shows that stress experiences can predict both hyper- and hypo-cortisol regulation, there is a lack of research examining these associations longitudinally. Our study assessed whether levels and increases in psychological stress experiences predicted 12-year changes in circadian cortisol levels (area under the curve; AUC) and cortisol slopes in a sample of community-dwelling older adults. **Methods:** In 2004, 190 community dwelling older adults (57 to 94 years) started providing three days of diurnal cortisol and stress experience data every two years for a total of seven waves of data. All analyses controlled for relevant covariates including: SES, BMI, age, sex, cortisol-related medication, chronic illness, and smoking status. **Results:** Growth-curve modeling documented that compared to participants who reported generally lower stress experiences (*T-ratio* = -5.57, $p < .01$), their counterparts with higher stress experiences showed significantly steeper declines in cortisol AUC over time (*T-ratio* = -9.23, $p < .01$). Higher stress experience was associated with generally flatter cortisol slopes. In addition, among participants with high and increasing stress experience over 12 years, cortisol slopes became increasingly flatter over time (*T-ratio* = 2.78, $p < .01$). **Conclusions:** Among individuals with high, as compared to low, levels of chronic stress experience, cortisol levels displayed steeper declines across the study period. Moreover, cortisol slopes became increasingly flatter as a function of high and increasing stress experience. Implications for theory and research on the associations between stress experience and cortisol in the context of longitudinal observations are discussed.



Key words: cortisol; stress; longitudinal; aging

# INTRODUCTION

Stress involves both objective stressful events and their subjective experience (Lazarus & Folkman, 1984). Chronic stress experiences can trigger cortisol dysregulation of the circadian rhythm, the awakening response, or acute reactivity to a stressor (Russell & Lightman, 2019; Strueber, Strueber & Roth, 2014). Such processes of cortisol dysregulation are believed to increase vulnerability towards poor health outcomes (Cohen, Janicki-Deverts, & Miller, 2007). Cortisol dysregulation is theorized to accelerate the wear and tear of specific homeostatic systems of the body (e.g., metabolism or immunity), a concept referred to as allostatic load (McEwen, 1998). As such, cortisol is considered an important biological intermediary in the link between stress experiences and the development of disease (Miller, Chen, & Zhou, 2007). These processes may be particularly important in old age, a life phase when people frequently experience an increase of age-related stressors and physical health declines (Heckhausen et al., 2019). Related to this possibility, aging has been associated with disturbances in cortisol regulation (Gaffey et al., 2016; Otte et al., 2005; Nater et al., 2013; Piazza et al., 2010) that can predict inflammation, functional limitations, frailty, and mortality (Johar et al., 2014; Kumari et al., 2011; Piazza et al., 2018).

When experiencing a threat, the human organism mobilizes energy by activating the autonomous nervous system, and the hypothalamic-pituitary adrenal (HPA) axis with its final product cortisol. Cortisol has a myriad of anabolic effects, allowing the organism to appropriately deal with an increase in demand (for a review, see, for example, Ulrich-Lai and Herman, 2009). Cortisol follows a distinct circadian rhythm and is involved in regulating alertness, metabolism, and immune function (Dallman et al., 1994).

Both acute and chronic or cumulative stress experiences can influence the HPA axis. The former has been shown to result in temporary increases in cortisol at any time of day, and therefore have been studied over time periods of 1-2 hours as a measure of acute biological stress reactivity (Kudielka, Hellhammer, & Wüst, 2009). By contrast, to examine how chronic stress experiences influence diurnal cortisol secretion, metrics such as area under the curve (AUC; total daily secretion levels) and slope (the rate at which cortisol declines over the course of the day) are frequently employed.

Much theoretical work has explored how the build-up of stress experiences can lead to persistent alterations in the diurnal cortisol rhythm (Adam, 2012; McEwen, 1998; Del Giudice, Shirtcliff, & Ellis, 2013; Strüber, Strüber & Roth, 2014). The exact nature of how chronic stress influences the diurnal cortisol rhythm over time, however, is less established. With regards to the rate of decline in cortisol across the day (i.e., cortisol slope), studies frequently observe that chronic stress is linked with flatter daily cortisol slopes in cross-sectional research or over short time periods (e.g., DeSantis, Adam, Hawkley, Kudielka, & Cacioppo, 2015; Ice et al., 2005; Sephton et al., 2000), which may confer a risk for poor health outcomes (Adam et al., 2017; Heim et al., 2000).

The associations between chronic stress and total daily cortisol output (AUC), however, have been less clear. Early conceptual frameworks hypothesized that such stress experiences can lead to elevated cortisol secretion, which in turn confers an increased risk for disease (McEwen, 1998). These theories were informed by findings from experimental (e.g., acute stress reactivity) and correlational studies, suggesting that stress experiences can increase HPA axis activity or prevent the normative down-regulation of cortisol secretion across the day (hyper-cortisolism; Heim et al., 2000). Other evidence, however, has pointed to an inverse association, whereby

chronic stress is related to lower cortisol levels (hypo-cortisolism; Carroll, Ginty, Whittaker, Lovallo, & de Rooij, 2017; Heim et al., 2000; Vedhara et al., 2002). Hypo-cortisolism may thus also reflect long-term stress-related dysregulation of the HPA axis, and could play a role in the development of disease (Heim et al., 2000; Voellmin et al., 2015).

The extant literature is thus not clear on the diurnal cortisol pattern that is indicative of stress-related disruptions in the HPA axis regulation, which is also reflected in the theoretical contributions on that topic (Adam, 2012; Del Giudice, Shirtcliff, & Ellis, 2013 Strüber, Strüber, & Roth, 2014). One explanation for these inconsistent findings could be that differences in the chronicity or timing of a stressor could explain varying types of cortisol dysregulation. In this regard, a meta-analysis suggested that cortisol levels are elevated in samples that confronted more recent stressors, but levels are comparatively lower in samples that experienced a longer and chronic period of stress (Miller et al., 2007). It is difficult, however, to arrive at firm conclusions about links between recent and long-term stress and cortisol because much of the existing research is based on cross-sectional or short-term experimental studies. As such, there is a need for studies that follow stress-exposed populations over longer periods of time and examine the effects of both levels and changes in chronic stress on their long-term trajectories of cortisol secretion.

The present study sought to address this issue by examining the associations between chronic stress experiences and 12-year trajectories of cortisol functioning (i.e., cortisol AUC and slope) in a community-dwelling sample of older adults. Because stressful experiences may increase over time, particularly in older populations (Heckhausen et al., 2019), we chose to include both average long-term levels and long-term longitudinal changes in stress experiences as predictors of diurnal cortisol and tested their main effects and interaction for significance.

Given that chronic stress experiences may result in reduced cortisol levels (Miller et al., 2007), we hypothesized that high and/or increasing levels of stress experiences over 12 years would predict a relative decline of levels of older adults' cortisol secretion (AUC). Further considering the previously discussed link between stress experiences and a person's inability to downregulate the slope of the diurnal cortisol rhythm, we hypothesized that high and/or increasing levels of stress experiences would predict progressively flatter cortisol slopes over time.

## Methods

### Participants

A total of 215 older adults were assessed at baseline as part of the Montreal Aging and Health Study (MAHS). This sample included older adults (age range = 57 to 94 years) from an age-normative sample of community-dwelling individuals living in Montreal, QC, Canada. Participants were initially recruited via newspaper advertisements in the Montreal area in 2004. To be eligible for inclusion into the study, participants had to be older than 60 years of age (we note that one included participant misreported his age during recruitment and was only 57 years old) and living the in the Montreal area. Since our interest was to examine changes in cortisol, we included only those participants into this study who provided cortisol data in at least two waves (25 participants of the original sample were excluded). The analytic sample therefore included 190 older adults. Following the first wave, participants were assessed every two years for a total of 7 waves (12 years; T2: N = 182; T3: N = 164; T4: N = 136, T5: N = 125; T6: N = 96; T7: N = 87). Study attrition was due to death (N = 49), lost contact (N = 20), refusing to participate (N= 26), sickness (N = 4), unable to follow directions (N = 3), or personal reasons (N = 1). Written informed consent was obtained from all participants prior to participation in the study, and the institutional review board of Concordia University approved the study. At

baseline, the distribution of sociodemographic variables was within the normative range of older Canadians residing at home (National Advisory Council on Aging, 2006).

## Materials

**Diurnal Cortisol.** At each wave diurnal cortisol was assessed on three non-consecutive days over the course of one week. Five saliva samples were collected each day using salivettes at awakening, 30 min after awakening, 2 PM, 4 PM, and at bedtime. The first sample was collected by the participants when they woke up, after which they set a timer to collect the 30-min sample. Research assistants contacted the participants at 2 PM and 4 PM to facilitate the afternoon sample collection. The final sample was collected by participants just before they went to bed. Collection times for each sample were recorded by the participants. Participants were instructed to not eat or brush their teeth prior to saliva collection to prevent contamination with food or blood. Salivettes were stored in refrigerators until returned to the lab where they were frozen at -20 degrees Celsius until analysis. University of Trier completed all cortisol analyses using a time-resolved fluorescence immunoassay with cortisol-biotin conjugate as a tracer. The inter-assay variability from these cortisol analyses was on average 4.88%, and the intra-assay variability in this laboratory is routinely below 10%.

Cortisol scores that deviated more than three standard deviations from the mean cortisol level for that time of day were excluded. Cortisol values were skewed and log-transformed to stabilize variance. Daily cortisol levels were calculated using the area under the curve with respect to ground (AUC) across each day separately, based on hours after awakening (Pruessner et al., 2003). AUC was only calculated if participants provided four useable cortisol scores on each day. The 30-min measure was excluded from AUC calculation because the awakening response has been shown to be independent from circadian regulation (Chida & Steptoe, 2009).

Using these criteria, we were able to calculate cortisol scores for 95.70% to 98.44% of days on which participants collected saliva. Cortisol slope was calculated by regressing cortisol values on hours after awakening for each collection day (excluding the 30-min sample). At each wave, the three cortisol AUC and slope scores were averaged to obtain reliable indicators of average AUC and average slope. The three AUC ($\alpha$ = .75 - .91; *r*s = .42 - .83, *p*s < .01) and slope ($\alpha$ = .54 - .70; *r*s = .22 - .54, *p*s < .01) scores were positively correlated at each wave. The ICC for AUC was 0.24 (76% of the variance was located within-person), and the ICC for slope was 0.41 (59% of the variance was located within-person).

**Chronic stress experiences.** Daily stress levels were assessed at each wave on three non-consecutive days during one week. Towards the end of each day, participants were asked to report the extent to which they felt "stressed" during that day on a Likert scale ranging from *very slightly/not at all* (0) to *extremely* (4). Daily stress levels were comparable with other research on daily stress in older adulthood (e.g., Scott, Sliwinski, & Blanchard-Fields, 2013, see also Table 1). The three daily stress assessments were positively correlated at each wave ($\alpha$s = .74 - .85; *r*s = .38 -.85, *p*s < .01). To obtain an indicator of chronic stress levels, the three daily stress values were averaged at each wave, and then averaged across all waves. Daily stress levels were significantly correlated across waves (*r*s > .30, *p*s < .01). To assess long-term changes in stress experiences, we conducted a hierarchical linear model, predicting variability in stress experiences across the study period by time in study (and a residual term), and saved the obtained individual slope coefficients for further analysis. Stress experiences significantly increased over the course of the study (*coefficient* = .016, *T-ratio* = 3.32, *p* < .01). The ICC for stress experiences was 0.41 (therefore 59% of the variance was located within-person).

Table 1

*Means, Standard Deviations, Frequencies and Zero-Order Correlations of Main Study Variables (N = 190).*[a]

| Construct | *Mean (SD) or %* | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Average AUC | 11.85 (1.95) | | | | | | | | | | | | | |
| 2. Average Slope | -0.03 (0.01) | .17* | | | | | | | | | | | | |
| 3. Stress Levels | 0.55 (0.53) | -.05 | .12 | | | | | | | | | | | |
| 4. Stress Change | 0.03 (0.12) | -.03 | .06 | .15* | | | | | | | | | | |
| 5. SES | 0.00 (0.88) | .16* | .04 | .02 | .02 | | | | | | | | | |
| 6. BMI | 25.55 (3.72) | .03 | .12 | .05 | .03 | -.09 | | | | | | | | |
| 7. Female | 51.1 % | -.25** | -.06 | .13 | -.02 | -.15* | -.10 | | | | | | | |
| 8. Age | 72.33(5.91) | .27** | .22* | -.16* | -.02 | -.10 | -.15* | -.01 | | | | | | |
| 9. Smoking | 8.9% | .09 | -.05 | -.01 | -.01 | -.01 | .00 | -.10 | -.17* | | | | | |
| 10. Chronic Illness | 2.52 (1.67) | .05 | .01 | .05 | -.10 | -.10 | .21** | -.10 | .06 | .12 | | | | |
| 11. Thyroid Med | 16.3% | .15* | -.04 | -.07 | -.10 | .02 | .05 | .23** | .01 | .01 | .13 | | | |
| 12. Estrogen Med | 8.4% | -.11 | .06 | -.08 | -.12 | .05 | -.03 | .30** | -.04 | -.03 | .05 | .07 | | |
| 13. Cortico. Med | 5.3% | -.14* | .11 | .10 | -.06 | -.09 | .10 | -.01 | -.05 | .01 | .14* | -.04 | .01 | |
| 14. Other Heart Med | 7.9% | .11 | -.13 | -.12 | .04 | .03 | .09 | -.14* | .08 | .11 | .32** | .14 | -.09 | -.07 |

*$p \leq .05$; **$p \leq .01$.

[a]Data in this table are based on variables prior to mean-substitution and as such, some *N*s are slightly reduced for some variables.

**Covariates.** Demographic and health-relevant covariates were incorporated into the analyses. The covariates included SES, BMI, age, sex, cortisol-related medication usage, chronic illness, and smoking status. Socioeconomic status was indexed via two variables: income and education. These two variables were standardized and averaged to obtain a reliable indicator of SES ($r$ =.47, $p < .001$). Our sample represented a diverse socioeconomic status, 28.9% completed high school, 29.5% completed college or a trade, 22.6% completed a bachelor's degree, and 10% completed a postgraduate education (approximately 5.8% did not provide education information, and 3.2% did not complete any schooling). 19.5% had an income less than $17,000, 35.3% of the sample had an income between $17,001 and $34,000, 30% had an income between $34,001 and 68,000, and 7.4% had an income greater than $68,000 ($CAD; 7.9% of the sample did not provide income information). Participants height and weight were self-reported and BMI was then calculated ($M$ = 25.55, $SD$ = 3.72). Sex was coded as 1 = *male*, 2 = *female* (51.1% female). Smoking status was coded as 0 = *No*, 1 = *Yes* (8.9% were smokers). Chronic illness was assessed at baseline using a 17-item checklist of different chronic illnesses used in previous research (e.g., cardiovascular problems, arthritis, cancer, diabetes, high blood pressure, Wrosch et al., 2007). The number of chronic illnesses reported was counted to represent a total score of chronic illness ($M$ = 2.52, $SD$ = 1.67).

To control for the possibility that certain medications may influence cortisol trajectories, we coded baseline data of medication usage into major categories of medication that could influence the HPA axis. Participants were coded as 0 (*taking zero medications*) or 1 (*taking one or more medications*) in a respective category. Medications were coded into the following categories: blood pressure-related medication (e.g., beta blockers, calcium-channel blockers, ACE inhibitors; 48.4%), non-narcotic pain medication (e.g., Acetaminophen, Ibuprofen,

Naproxen; 46.3%), cholesterol-related medication (e.g., Statins; 36.8%), psychiatric medication (e.g., SSRIs, Benzodiazepines; 20.5%), thyroid-related medication (e.g., Synthroid; 16.3%), diuretic medication (e.g., Hydrochlorothiazide, Indapamide, 15.3%), diabetes medication (e.g., Metformin; 12.6%), estrogen and progesterone-related medication (e.g., Premarin; 8.4%), other heart-related medication (e.g., Lanoxin, Imdur, Nitroglycerin; 7.9%), Corticosteroid medication (e.g., Symbicort, Flonase; 5.3%), narcotic pain medication (e.g., Valium; 1.6%), and other medication that may influence HPA axis but not fit these major categories (11.6%).

**Data analyses**

Preliminary analyses were conducted by computing descriptive statistics of the main study variables and zero-order correlations among the main study variables (Table 1). The descriptive statistics of cortisol and stress variables across all waves are reported in Supplemental Table 1. The hypotheses were tested in two separate growth-curve models, predicting trajectories of AUC and slope over 12 years (using HLM 6.0, Raudenbush, 2004). The reported effects are based on models using restricted maximum likelihood estimation and robust standard errors. At Level 1, we estimated variance in participants' AUC and cortisol slope from T1-T7 as a function of an intercept, person-centered scores of time in the study and a residual term. The intercept represented participants' average levels of AUC and averaged cortisol slope across T1-T7, while the time slope coefficient represents the yearly changes in AUC and cortisol slope from T1 to T7.

At Level 2, we predicted the intercept and slope of cortisol AUC and cortisol slope as a function of average stress levels (T1-T7), changes in stress levels (T1-T7) and the covariates (SES, BMI, sex, age, medication, smoking). To reduce the number of medication-related covariates in our models, we conducted preliminary analyses in HLM predicting cortisol AUC

and slope separately from each medication category. Based on these analyses, we included only those medication categories into the Level-2 models for predicting cortisol AUC (or cortisol slope) that were significantly associated with levels or changes in cortisol AUC (or cortisol slope). The preliminary analyses showed that taking thyroid and other heart-related medication was associated with higher cortisol AUC levels on average, while taking corticosteroid or estrogen and progesterone-related medication were associated with lower cortisol AUC (intercept effects; *T-ratios* >|1.94|, $p < .05$). Thyroid and corticosteroid medication significantly predicted increasingly flatter cortisol slopes over time (slope effects; *T–ratios* > 2.21, $p < .03$). In addition, other heart-related medication significantly predicted flatter average levels of cortisol slopes (intercept effect; *T-ratio* = -2.32, $p < .03$). None of the other medication categories were associated with either cortisol AUC or cortisol slope and thus not included in the respective models.

In subsequent models, we tested the interactions between levels and changes of stress experiences for significance. Level 2 main effect predictors were standardized prior to conducting the analyses. Significant interaction effects were followed up by calculating simple slopes of the effects of stress experiences on changes in AUC and cortisol slope over time at high (+1 SD) and low (-1 SD) stress levels and changes. Since HLM is capable of handling missing data at Level 1 (i.e., cortisol AUC and slope), missing data in the outcome variables were not replaced. There was a small amount of missing data of between-person predictors variables (SES: N = 1, changes in stress experiences = 4, BMI: $N = 2$, Smoking: $N = 2$), which were replaced with the sample mean (Tabachnik, Fidell, & Osterlind, 2013).

Given that any findings related to predicting a flatter cortisol slope across day could occur as a result of either decreasing morning levels and/or increasing evening levels, we also

conducted a set of supplemental analyses. These analyses explored which aspect of the daily cortisol rhythm was associated with longitudinal changes in cortisol slopes. Morning cortisol levels reflected the first cortisol sample of the day, and evening cortisol levels represented the last cortisol sample of the day. To explore how changes in diurnal cortisol slope predicted changes in these specific cortisol measures, we saved the HLM time slope coefficients of the diurnal cortisol slope as an indicator of change in cortisol slope for each individual, and used this measure to predict levels and longitudinal changes in morning and evening cortisol levels at Level 1, controlling for the included covariates at Level 2.

## Results

### Predicting Cortisol Level (AUC)

The Level 1 intercept of cortisol AUC was significant, indicating that participants' average cortisol levels across waves were significantly different from zero (see Table 2). In addition, the time slope of AUC was significantly different from zero, indicating that cortisol levels significantly decreased over 12 years. Finally, results from the Level 1 model for AUC displayed significant variance around participants' average intercept, $\chi^2 = 616.47$, $df = 189$, $p < .001$, and time slope, $\chi^2 = 241.23$, $df = 189$, $p < .01$.

The Level 2 model predicted the observed variance in participants' intercepts and time slopes of AUC scores as a function of levels and changes in chronic stress experiences and the covariates. As documented in Table 2, higher SES, being male, and older age significantly predicted higher average AUC scores. Of the medication variables, thyroid medication was associated with higher average cortisol AUC scores, and taking corticosteroid medication was associated with lower cortisol AUC scores on average. None of the covariates were significantly

Table 2

*Results of Growth-Curve Analysis Predicting Cortisol AUC Trajectories by Stress, and Covariates (N =190).*

| | Cortisol AUC | | | |
|---|---|---|---|---|
| | Intercept (Average levels) | | Slope (Time) | |
| Effects | Coefficient (SE) | T-ratio | Coefficient (SE) | T-ratio |
| Level 1 ($\beta_0$; $\beta_1$)[a] | 11.7512 (0.1341)** | 87.629 | -0.2678 (0.0233)** | -11.486 |
| Level 2: | | | | |
| Stress level | 0.1252 (0.1195) | 1.047 | -0.0673 (0.0236)** | -2.848 |
| Change in stress | -0.0431 (0.1535) | -0.281 | 0.0516 (0.0410) | 1.258 |
| SES | 0.2490 (0.1268)* | 1.964 | 0.0033 (0.0261) | 0.126 |
| BMI | 0.1431 (0.1071) | 1.336 | -0.0219 (0.0239) | -0.918 |
| Sex | -0.5208 (0.1337)** | -3.896 | 0.0318 (0.0263) | 1.205 |
| Age | 0.5845 (0.1335)** | 4.379 | 0.0343 (0.0263) | 1.304 |
| Smoke | 0.2466 (0.1517) | 1.625 | -0.0354 (0.0300) | -1.182 |
| Chronic Illness | -0.1077 (0.1454) | -0.741 | 0.0364 (0.0252) | 1.445 |
| Thyroid Med | 0.3659 (0.1105)** | 3.311 | 0.0026 (0.0247) | 0.106 |
| Estrogen Med | 0.0617 (0.1047) | -0.589 | -0.0106 (0.0227) | 0.464 |
| Corticosteroid Med | -0.2354 (0.1059)* | -2.223 | 0.0015 (0.0260) | 0.057 |
| Other Heart Med | 0.0242 (0.1084) | 0.223 | 0.0059 (0.0211) | 0.281 |
| Interaction: Stress | | | | |
| Level X change | -0.0857 (0.1362) | -0.629 | 0.0484 (0.0417) | 1.162 |

*$p \leq .05$; **$p \leq .01$. SE = standard error

[a] The first parameter (e.g., $\beta_0$) estimated the intercept, which represents participants' average levels of cortisol AUC across T1 – T7, and the second parameter (e.g., $\beta_1$) estimated the slope, which represents the within-person associations between years in study from T1-T7 and participants' cortisol AUC. The Level 1 model had 189 *df*s, the Level 2 models had 177 *df*s, and the model including the stress level X change interaction term had 176 *df*s.

associated with the time slope of AUC scores. Of importance, however, chronic stress levels significantly predicted the time slope of AUC scores. In contrast, chronic stress level changes did not predict the intercept of AUC scores (see Table 2). No significant interaction emerged between stress levels and changes in predicting the AUC intercept or time slope.

To illustrate the significant cross-level interaction between levels of stress experiences and the time slope, we used recommended growth-curve techniques (Preacher et al., 2006), plotting the trajectories of AUC scores over 12 years separately for those with low (-1 SD) and high stress experiences (+1 SD). Figure 1 shows that AUC significantly declined across all participants over the 12 years. However, participants who reported higher chronic stress levels exhibited significantly steeper AUC declines over time (*T-ratio* = -9.24, $p < .001$), as compared to their counterparts who reported lower stress levels (*T-ratio* = -5.57, $p < .001$). Including levels of perceived stress in the model explained an additional 18.17% of variance in changes in AUC across waves, controlling for all covariates. In sum, these analyses indicate that higher levels of chronic stress over the 12-year observation period were associated with a stronger decline in AUC levels.

**Predicting Cortisol Slope**

The Level 1 intercept of cortisol slope was significant, indicating that the average cortisol slope across all participants was significantly different from zero (see Table 3). The time slope of cortisol slope was not significant, which suggests that, on average, daily cortisol slopes did not change over time among all participants. The Level 1 model for cortisol slope displayed significant variance around participants' average intercept, $\chi^2 = 869.51$, $df = 189$, $p < .001$, and time slope, $\chi^2 = 228.74$, $df = 189$, $p < .03$.

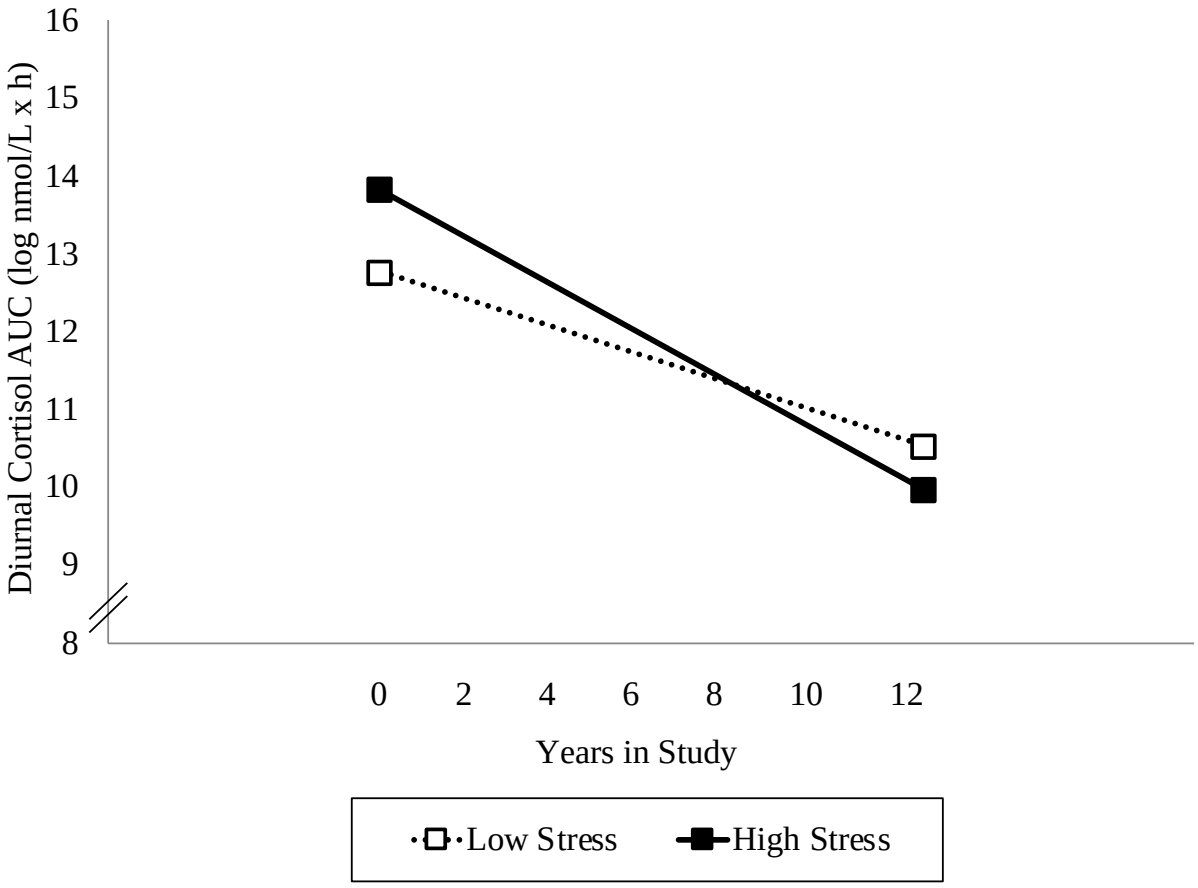


*Figure 1.* Trajectories of diurnal cortisol AUC plotted as a function of participants' levels of stress experiences. Trajectories were estimated one standard deviation above and below the mean of the moderator variable.

Table 3

*Results of Growth-Curve Analysis Predicting Cortisol Slope Trajectories by Stress, and Covariates (N =190).*

| | Cortisol Slope | | | |
|---|---|---|---|---|
| | Intercept (Average levels) | | Slope (Time) | |
| Effects | Coefficient (SE) | T-ratio | Coefficient (SE) | T-ratio |
| Level 1 ($\beta_0$; $\beta_1$)[a] | -0.0317 (0.0008)** | 37.385 | 0.0002 (0.0001) | 1.426 |
| Level 2: | | | | |
| Stress level | 0.0016 (0.0008)* | 1.973 | 0.0001 (0.0001) | 1.462 |
| Change in stress | 0.0007 (0.0009) | 0.849 | 0.0003 (0.0002) | 1.413 |
| SES | 0.0009 (0.0010) | 0.957 | 0.0000 (0.0001) | 0.276 |
| BMI | 0.0018 (0.0008)* | 2.254 | -0.0001 (0.0001) | -0.633 |
| Sex | -0.0008 (0.0008) | -0.952 | 0.0000 (0.0001) | 0.312 |
| Age | 0.0035 (0.0009)** | 4.013 | 0.0000 (0.0001) | 0.184 |
| Smoke | 0.0002 (0.0011) | 0.216 | 0.0001 (0.0001) | 0.922 |
| Chronic Illness | -0.0004 (0.0009) | -0.401 | 0.0000 (0.0001) | 0.304 |
| Thyroid Med | 0.0000 (0.0007) | 0.038 | 0.0002 (0.0001)* | 2.422 |
| Corticosteroid Med | 0.0011 (0.0008) | 1.324 | 0.0002 (0.0001)* | 2.365 |
| Other Heart Med | -0.0017 (0.0007)* | -2.295 | -0.0001 (0.0001) | -0.876 |
| Interaction: Stress | | | | |
| Level X change | 0.0004 (0.0009) | 0.458 | 0.0004 (0.0002)* | 2.092 |

*$p \leq .05$; **$p \leq .01$. SE = standard error

[a] The first parameter (e.g., $\beta_0$) estimated the intercept, which represents participants' average levels of slope across T1 – T7, and the second parameter (e.g., $\beta_1$) estimated the slope, which represents the within-person associations between years in study from T1-T7 and participants' slope. The Level 1 model had 190 *df*s, the Level 2 models had 178 *df*s, and the model including the stress level X change interaction term had 177 *df*s.

The Level 2 model predicted the variance in the intercepts and slopes of participants' daily cortisol slope scores as a function of levels and changes in chronic stress and covariates. Higher BMI and being older predicted significantly flatter average cortisol slopes across all waves, that is, lower morning and/or higher evening levels of cortisol. Of the medication variables, other heart-related medication predicted steeper cortisol slopes on average. In addition, thyroid and corticosteroid medication categories significantly predicted the time slope. Taking these medications were associated with increasingly flatter cortisol slopes over the course of the study. No other covariates significantly predicted the intercept or time slope. In addition, the main effects of changes in chronic stress did not significantly predict the intercept or time slope or daily cortisol slope values. Importantly, however, the analysis showed a significant Level-2 effect of stress levels in predicting the intercept (but not the slope) of cortisol slope scores (*T-ratio* = 1.97, $p \leq .05$). The stress level effect on the intercept indicated that higher stress experiences were associated with flatter average cortisol slopes. The addition of chronic stress levels to the model explained additional 1.47% of variance in the intercept of participants' cortisol slope scores, controlling for all covariates.

Finally, a significant interaction emerged between levels and changes of stress experiences in predicting changes over time in cortisol slope (*T-ratio* = 2.09, $p < .04$, see Table 3). To examine the cross-level, 3-way interaction of stress levels and stress changes on changes over time in cortisol slope, we plotted the trajectories of cortisol slope across waves for participants with high (+1 SD) and low stress levels (-1 SD) and increasing (+1 SD) and decreasing (-1 SD) stress (see Figure 2). The calculation of the simple time slopes showed that cortisol slopes remained stable over 12 years among participants who experienced relatively low levels of stress regardless of whether stress decreased (*T-ratio* = 0.73, $p > .05$) or increased over

time (*T-ratio* = -0.84, $p > .05$). Cortisol slopes also remained stable for those participants with high levels of stress experiences that decreased over time (*T-ratio* = -0.75, $p > .05$). By contrast, daily cortisol slopes became progressively flatter among participants with high stress levels that increased over time (*T-ratio* = 2.78, $p < .01$). The addition of the interaction between levels and changes in stress to the model explained additional 4.65% of variance in the time slope of participants' cortisol slope scores, controlling for all covariates.

**Supplemental Analyses: Cortisol Slope and Morning and Evening Cortisol**

We conducted supplemental analyses to explore how longitudinal changes in cortisol slope were associated with changes in morning and evening cortisol levels. In two separate models, variance in the intercept and slope of morning and evening cortisol levels were estimated as a function of change in cortisol slope scores, controlling for covariates (SES, BMI, sex, age, cortisol medication [thyroid, corticosteroid, estrogen-progesterone, and other heart-related medication]) chronic illness and smoking status). Across all participants, morning (*T-ratio* = -8.28, $p < .001$) and evening (*T-ratio* = -6.52, $p < .001$) cortisol generally declined over the course of the study. Thyroid and corticosteroid medication significantly predicted the intercept of morning cortisol levels. Taking thyroid medication was associated with higher morning cortisol (*T-ratio* = 2.02, $p < .05$), while corticosteroids were associated with lower morning cortisol levels on average (*T-ratio* = -2.54, $p < .02$). No other covariates significantly predicted morning cortisol. For evening cortisol, only being older (T-ratio = 5.43, p <.01), and having a higher SES (*T-ratio* = 2.29, $p < .03$) were associated with higher evening cortisol levels on average (intercept effect). In addition, thyroid medication predicted higher evening cortisol levels on average (intercept effect; *T-ratio* = 2.01, $p < .05$).

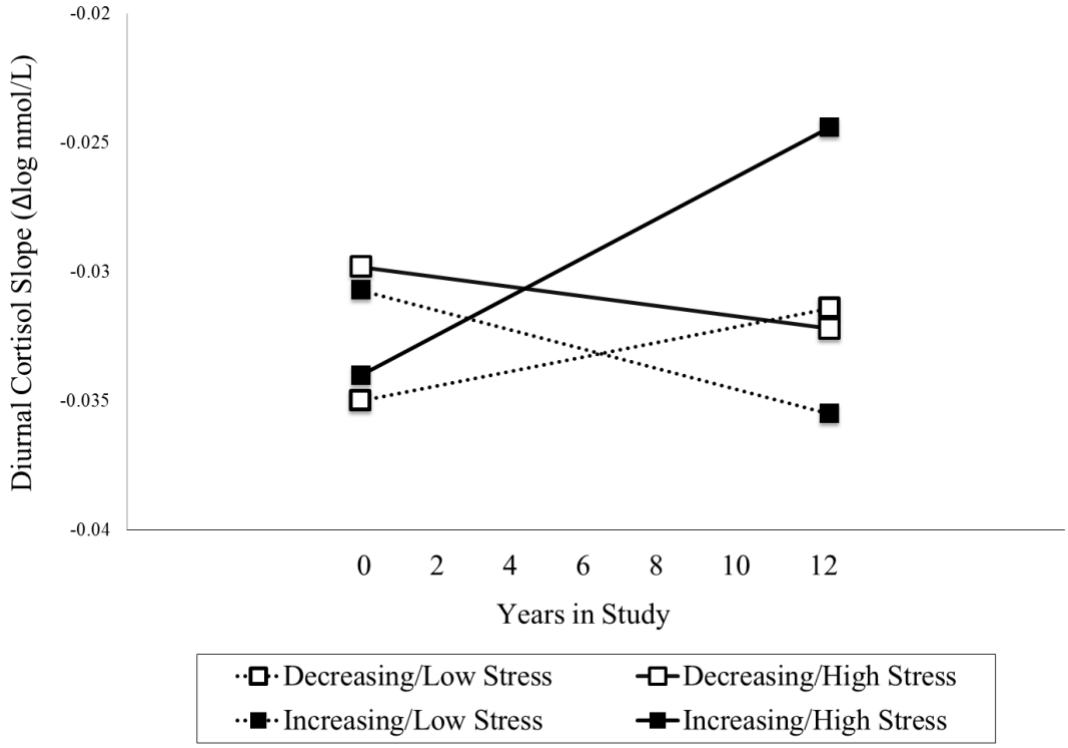


*Figure 2.* Trajectories of diurnal cortisol slope as a function of participants' levels and changes of stress experiences. Trajectories were estimated one standard deviation above and below the mean of the moderator variables. Only the slope for increasing and high stress experiences reached significance (*T-ratio* = 2.78, $p < .01$; all other *T-ratio*s < |0.84|, *p*s > .05).

Of importance, the analyses further showed that change in cortisol slope significantly predicted the time slope of morning cortisol (*T-ratio* = -8.74, $p < .001$) and evening cortisol levels (*T-ratio* = 6.24, $p < .001$), but not the intercept of morning or evening cortisol. The effects of cortisol slope on the time slope of morning (left panel) and evening (right panel) cortisol levels are illustrated in Figure 3. Simple slope analyses documented that changes in daily cortisol slope across the study period were associated with longitudinal changes in both morning and evening cortisol levels. Among participants whose daily slopes became progressively flatter (+1 SD) over time, morning cortisol levels significantly declined across the study period (*T-ratio* = -9.45, $p < .01$), while evening cortisol levels significantly increased (*T-ratio* = 3.32, $p < .01$). By contrast, among participants whose daily cortisol slopes became increasingly steeper across the study period (-1 SD), morning cortisol displayed significant increases over time (*T-ratio* = 5.65, $p < .01$), while evening cortisol levels became increasing reduced (*T-ratio* = -8.76, $p < .01$). Above and beyond the covariates, changes in cortisol slope across the study explained between 64.29% and 40.00% of variance in the time slope of participants' morning and evening cortisol scores, respectively.

## Discussion

The present study showed that average levels and changes in chronic stress experiences predict longitudinal trajectories of older adults' diurnal cortisol output (AUC and daily slope). Across all participants, AUC levels – and thus total cortisol output – declined over the course of the 12 years. In contrast, diurnal slope – the decrease from morning to evening of cortisol – did not change on average. These trajectories were moderated by average levels, and changes, in chronic stress. Among older adults who perceived high, as compared to low, levels of chronic stress, AUC levels were relatively enhanced at the beginning of the study. However, the AUC

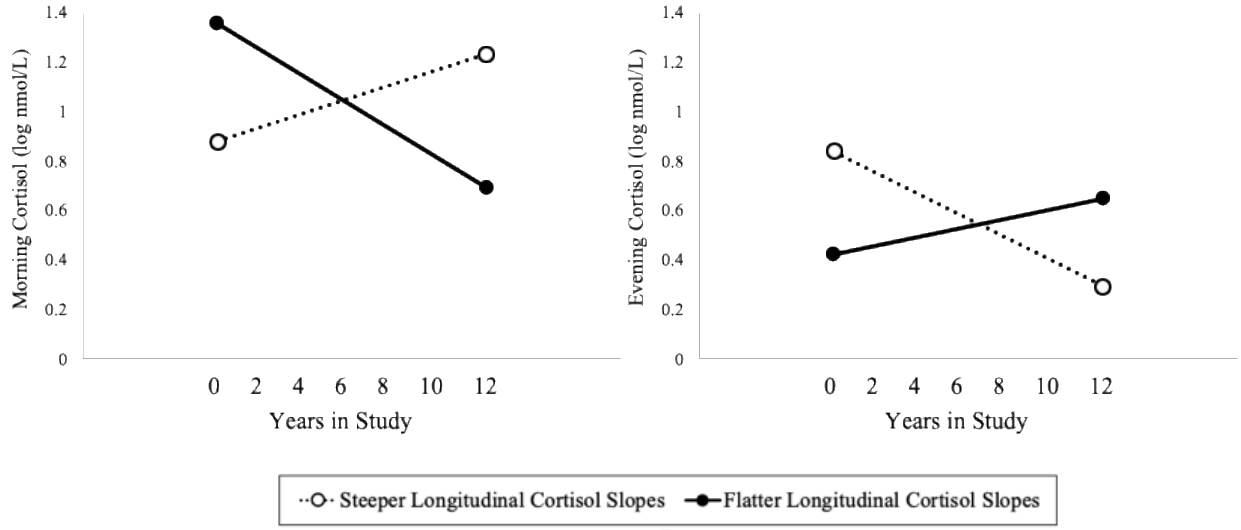


*Figure 3.* Trajectories of morning cortisol levels (left panel) and evening cortisol levels (right panel) as a function of participants' changes in cortisol slopes across the study period. Trajectories were estimated one standard deviation above and below the mean of the moderator variable.

levels of highly stressed participants exhibited significantly steeper linear declines over the subsequent 12 years, resulting in substantially reduced cortisol levels towards the end of the study period.

Levels of stress experienced also increased over time (see Methods) and higher stress levels predicted generally flatter daily cortisol slopes across the study period. The results further showed that participants who perceived high and increasing levels of chronic stress exhibited progressively flatter diurnal cortisol slopes over time. To this end, supplemental analyses revealed that progressively flatter cortisol slopes were associated with a reduction in morning cortisol levels and an increase in evening cortisol levels. Note that the observed effects of stress experiences were substantial, explaining between 4.65% and 18.17% of the variance in cortisol change, and the results were independent of covariates that have shown significant effects on cortisol in previous research (i.e., age, sex, BMI, smoking, chronic illness, and cortisol-related medication; Nater et al., 2013).

These findings document that the trajectories of older adults' diurnal cortisol levels (AUC) and daily cortisol slopes differed markedly as a function of chronic stress experiences. Higher chronic stress levels predicted an accelerated decline in cortisol levels over time. By contrast, cortisol slopes became progressively flatter over time as a function of both high and increasing levels of chronic stress. As such, cortisol AUC and slope displayed differential patterns, which points to the potential independence of different aspects of the diurnal cortisol rhythm (Ice, 2005; Vedhara et al., 2006). In support of this possibility, cortisol AUC and slope only exhibited a modest correlation in our study ($r$ = .17; see Table 1).

On the one hand, these results could be interpreted to mean that chronically high and increasing stress experiences could progressively degrade the ability of the body to regulate the

HPA axis, contributing to flatter cortisol slopes over time. Indeed, researchers have theorized that the negative feedback loop that governs the regulation of cortisol secretion may be impaired and underlie the emergence of flatter cortisol slopes (Kumari et al., 2010). On the other hand, chronic stress may have different effects on daily cortisol levels (AUC). Consistent with meta-analytic findings (Miller et al., 2007), our results suggest that during earlier exposure to chronic stress experiences, HPA activation is peaking. The continued exposure to prolonged stress however may then create a counter-regulatory response, downregulating the HPA axis and resulting in below normal levels of cortisol in the long-term.

A corollary of the previous discussion is that research examining cortisol dysregulation may require more detailed assessment of the aspects associated with stress experiences. In our study, the obtained patterns related to both high levels and/or changes in stress experiences over a relatively long period of time, and as a consequence, point to the importance of examining chronicity and timing of stress experiences in relation to cortisol output (AUC). These findings suggest that it may be critical for researchers to consider the length and changes related to stress experiences to determine whether cortisol is dysregulated.

With respect to cortisol slope, our findings are consistent with previous research linking chronic stress to flatter cortisol slopes (Ice et al., 2005; Sephton et al., 2000). These results advance the literature by documenting that both levels and changes in stress experiences predicted cortisol slope trajectories, whereas cortisol levels were related only to levels of stress experiences. In addition, they could imply that cortisol slope may be more sensitive than cortisol levels to the cumulative effects of increasing stress levels. These findings further suggest that cortisol slope is a promising construct to consider in research on stress and health, given that there is less uncertainty about the relationship between stress experiences and cortisol slopes.

We also conducted supplemental analyses to explore whether flatter cortisol slopes were associated with changes in morning and/or evening cortisol. The results showed that participants who exhibited progressively flatter cortisol slopes over time secreted both reduced morning levels and increased evening levels of cortisol. These findings replicate earlier research, linking flatter cortisol slopes to lower morning levels, higher evening levels, or both (Bower et al., 2005; Pruessner, Hellhammer, & Kirschbaum, 1999; Sephton et al., 2000). In addition, they may imply that as daily cortisol slopes become flatter the entire diurnal rhythm is affected. While the underlying mechanisms of this process requires further study, it is for example possible that a stress-related disruption of the circadian rhythm, associated with sleeping problems or general HPA axis dysfunction, could explain the obtained pattern of findings (McEwen, 1998; Sephton et al., 2000). Regardless of the underlying mechanisms, the observation that a flatter diurnal slope is systematically associated with chronic stress is an important observation that is currently understudied.

Our study also sheds light on how cortisol may generally change in aging populations. Previous research has reported mixed associations between age and cortisol levels, with some studies finding positive associations (Adam et al., 2006; Dmitrieva et al., 2013; Evans et al., 2011; Gaffey et al., 2016; Nater et al., 2013), and others documenting negative associations (Brandtstädter et al., 1991; Evans et al., 2011; Heaney, Phillips, & Carroll, 2012). The cross-sectional findings from our study revealed that being older was associated with generally higher cortisol levels and flatter diurnal cortisol slopes (see Table 1). However, our longitudinal analyses showed that, on average, cortisol slope remained relatively stable and cortisol levels declined over time.

These patterns point to inconsistencies between cross-sectional and longitudinal data (for methodological considerations, see Sliwinski, & Buschke, 1999). Although more research is clearly needed to shed light on these inconsistencies, we suggest two preliminary explanations for the obtained pattern. First, it should be noted that longitudinal time range (12 years) was much narrower than the cross-sectional age range at study entry (more than 35 years, as described in the Methods). As such, it is possible that we could have observed progressively flatter cortisol slopes, matching the cross-sectional age effects, if our study had continued following participants past the 12-year period. Second, even though cortisol levels may have declined in the entire sample as a function of increasingly chronic stress experiences, such an effect may not rule out the possibility that cortisol levels could still be elevated in advanced, as compared to early, old age. Diurnal cortisol levels have been shown to be enhanced during the onset of new stressors and for uncontrollable stress experiences (Miller et al., 2007), and the prevalence and frequency of such experiences may increase particularly in advanced old age (Heckhausen et al., 2019). Cortisol levels could thus be relatively higher in advanced, as compared to early, old age, but still decline over time in both age segments as stress experiences become more chronic.

A final implication of the current research relates to the potential clinical consequences on the health of older adults. Aging populations are at risk of experiencing disturbances in HPA axis function (Gaffey et al., 2016; Nater et al., 2013; Nicolson et al., 1997; Otte et al., 2005). Research has also demonstrated that HPA axis disruption could play a role in cognitive decline or neurodegeneration (Conrad & Bimonte-Nelson, 2010), depression (Murri et al., 2013), morbidity, and mortality (Heim et al., 2000, Kumari et al., 2011). Since both enhanced and reduced of cortisol output is likely to increase vulnerability to physical disease (Björntorp &

Rosmond, 1999; Heim et al., 2000), future research should examine whether the documented effects of stress experiences on cortisol dysregulation forecast long-term health outcomes. We feel that research along these lines is warranted and has the potential to contribute to our understanding of how stress experiences can shape pattern of physiological and physical health outcomes across the human lifespan.

**Limitations and Future Directions**

Although this study has many strengths, including the analysis of 12-year longitudinal biomarkers in a normative sample of community dwelling older adults, it also has several limitations. First, our sample size was not as large as it could have been, and as a result, the reported findings may not be generalizable to all older adults. In addition, we observed significant attrition over the course of our study. However, we note that supplemental analyses, conducted using only the 85 participants that participated at T7 documented effects of stress experiences that were consistent with the reported findings. The sole exception was the interaction between stress levels and increases in predicting the longitudinal trajectory of the cortisol slope, which was of marginal significance in the supplemental analyses.

Second, our stress measurement was limited to daily stress experiences at each wave on three different days. As such, it will be important for future research to examine chronic stress experiences over longer periods of time and more thoroughly capture different features of the stress process. These aspects may include the onset and conclusion of stress experiences, the chronicity of different stress experiences, as well as the nature of the stressor itself (e.g., controllability; Miller et al., 2007). Note that although the original goal of our study was to test associations between stress and cortisol, it was not designed to examine the full complexity of stress experiences. As a result, a more comprehensive assessment of stress experiences could

help future research to address important remaining questions regarding cortisol dysregulation. For example, it will be important to examine how long stress-related cortisol levels tends to stay elevated, and at what point they shift from elevated to blunted cortisol dysregulation.

Third, while old age is an important life phase to study HPA axis functioning, we were unable to examine whether the documented effects of stress experiences on cortisol output extend across the entire lifespan. Future research should therefore attempt to replicate the reported findings among samples that cover the entire lifespan. Fourth, some research has shown that older adults may be more likely to display inconsistent cortisol patterns across days (e.g., Ice et al., 2004). While three days of cortisol assessment is considered sufficient to produce good reliability for cortisol AUC at each wave, research has suggested that more than three days can produce more reliable measures of cortisol slope (Segerstrom, Boggero, Smith, & Sephton, 2014). Future research should therefore measure cortisol over more days to ensure the assessment of reliable cortisol slopes.

Finally, we acknowledge that some psychiatric conditions have been known to be associated with dysregulation of the HPA axis (e.g., depression; Pariante & Lightman, 2008). While our study did not include any psychiatric diagnoses, it incorporated a baseline measure of depressive symptoms, which can function as a screening instrument for clinical depression (i.e., CESD-10; Andresen, Malmgren, Carter, & Patrick, 1994). In our original conceptualization, we did not consider this variable as a covariate, since the negative mood associated with depressive symptoms could represent an important pathway linking stress experiences and cortisol regulation (Cohen et al., 2007). As such, controlling effects of stress experiences for depressive symptoms could remove important variance from the stress-cortisol link. Nonetheless, we note here that both the interaction between average stress levels and the time slope in predicting

cortisol AUC, and the interaction between stress levels and increases in predicting change in cortisol slope over time, remained significant if baseline levels of depressive symptoms were added to the models. However, the main effect of average stress levels predicting the intercept of cortisol slope became marginally significant after controlling for depressive symptoms ($p < .08$).

**Conclusions**

The present study identified stress-related trajectories of diurnal cortisol secretion over 12 years among a community-dwelling sample of older adults. Among individuals with high, as compared to low, levels of chronic stress experiences, cortisol levels displayed steeper declines across the study period. Cortisol slopes across days, by contrast, became increasingly flatter over time as a function of high and increasing stress levels (which reflected both longitudinal declines in morning cortisol and increases in evening cortisol). These findings have important implications for theory and research on stress, cortisol, and health by shedding light on the stress-related conditions that predict patterns of hyper- and hypo-cortisolism.

Table 4

*Means and Standard Deviations, of Cortisol and Stress Variables at Each Wave (N = 190).*

| | | AUC | Slope | Morning Cortisol | 2PM Cortisol | 4PM Cortisol | Evening Cortisol | Stress |
|---|---|---|---|---|---|---|---|---|
| | | Mean (Standard Deviation) | | | | | | |
| T1 | (Cortisol: N = 186) (Stress: N = 187) | 12.324(2.586) | -0.031(0.015) | 1.067(0.210) | 0.771(0.173) | 0.725(0.182) | 0.579(0.190) | 0.439(0.623) |
| T2 | (Cortisol: N = 180) (Stress: N = 174) | 12.932(2.511) | -0.034(0.015) | 1.135(0.204) | 0.821(0.182) | 0.741(0.181) | 0.598(0.204) | 0.558(0.732) |
| T3 | (Cortisol: N = 161) (Stress: N = 161) | 12.952(2.593) | -0.032(0.015) | 1.097(0.210) | 0.842(0.183) | 0.757(0.185) | 0.607(0.194) | 0.601(0.720) |
| T4 | (Cortisol: N = 132) (Stress: N = 127) | 10.088(2.614) | -0.031(0.019) | 0.926(0.249) | 0.636(0.179) | 0.573(0.213) | 0.448(0.217) | 0.556(0.677) |
| T5 | (Cortisol: N = 118) (Stress: N = 124) | 10.762(2.567) | -0.030(0.016) | 0.960(0.241) | 0.680(0.169) | 0.611(0.190) | 0.503(0.217) | 0.671(0.887) |
| T6 | (Cortisol: N = 92) (Stress: N = 96) | 10.472(2.659) | -0.034(0.016) | 0.970(0.226) | 0.671(0.177) | 0.605(0.184) | 0.451(0.205) | 0.582(0.652) |
| T7 | (Cortisol: N = 85) (Stress: N = 87) | 9.445(2.490) | -0.032(0.017) | 0.911(0.239) | 0.621(0.190) | 0.567(0.189) | 0.426(0.217) | 0.602(0.700) |

# CHAPTER 3:

# STUDY 2

## Self-compassion, chronic age-related stressors, and diurnal cortisol secretion in older adulthood

Note. Copy edited version of this study was published in *Journal of Behavioral Medicine*, June 2018

## Abstract

Many older adults experience chronic age-related stressors (e.g., life regrets or health problems) that are difficult to control and can disturb cortisol regulation. Self-compassion may buffer adverse effects of these stressful experiences on diurnal cortisol secretion in older adulthood. To examine whether self-compassion could benefit older adults' cortisol secretion in the context of chronic and largely uncontrollable age-related stressors, 233 community- dwelling older adults reported their levels of self-compassion, age-related stressors (regret intensity, physical health problems, and functional disability), and relevant covariates. Diurnal cortisol was measured over 3 days and the average area-under-the-curve and slope were calculated. Higher levels of self-compassion were associated with lower daily cortisol levels among older adults who reported higher levels of regret intensity, physical health problems, or functional disability ($\beta$s <- .53, $p$s < .01), but not among their counterparts who reported lower levels of these age-related stressors ($\beta$s < .24, $p$s > .28). These results suggest that self-compassion may represent an important personal resource that could protect older adults from stress-related biological disturbances resulting from chronic and uncontrollable stressors.



Keywords: Aging, Cortisol, Self-compassion, Chronic stress

## Introduction

The aging population represents the fastest growing segment of the human population, typically including individuals of 60 years of age and older (United Nations, 2015). Although normative aging involves both developmental gains and losses (Baltes, 1987), research has documented an age-related increase in the amount of chronic and less controllable stressors (e.g., physical health problems, functional disabilities, or life regrets; Heckhausen et al., 2010; Wrosch et al., 2006; Wrosch et al., 2007a, b; Ebner, Freund, & Baltes, 2006; Heckhausen, Dixon, & Baltes, 1989). These stress experiences may trigger psychological distress and forecast disturbances in HPA axis regulation leading to altered patterns of cortisol release (Cohen et al., 2007; Miller, Chen, & Zhou, 2007). As such, examining patterns of cortisol dysregulation may be particularly important in older adulthood because HPA axis regulation can become compromised (Sapolsky, Krey, & McEwen, 1986) and the controllability of certain stressors frequently decrease during this life phase (Ebner et al., 2006; Heckhausen et al., 2010). As a result, cortisol levels can be higher in older adulthood (Nater et al., 2013), and these cortisol disturbances (e.g., higher area-under-the-curve [AUC] or a flatter cortisol slope) may reflect dysregulated physiological responses to stress experiences (Nater et al., 2013; Nicolson et al., 1997; Otte et al., 2005; Rohleder et al., 2002). Such patterns of cortisol dysregulation are thought to have important implications for health over time (Heim et al., 2000; Sephton et al., 2000) and have been associated with higher mortality rates in middle-aged and older adults (e.g., Kumari et al., 2011).

Although the general link between stress and health-relevant biological processes has been documented (Cohen et al., 2007), the effects of some stressors on health-related outcomes may become paramount among older adults. In particular, chronic and uncontrollable stressors

have been shown to adversely affect HPA axis activity, as they tend to be associated with higher levels and flatter slopes of cortisol outflow (Miller, Chen, & Zhou, 2007). As older adults are likely to experience an increase in these types of stressors (Ebner, Freund, & Baltes, 2006; Heckhausen, Dixon, & Baltes, 1989), their biological stress response may also be affected. Consistent with this argument, up to 90% of older adults report significant life regrets that are perceived as less controllable than young adults' life regrets (Landman, 1987; Wrosch & Heckhausen, 2002). In addition, intense regret experiences have been associated with psychological distress and enhanced cortisol output (Wrosch et al., 2005, 2007a, b). Such adverse effects of life regrets may occur in old age because the opportunities for undoing the consequences of regretted events often become sharply reduced or absent as individuals advance in age (Wrosch et al., 2005). Thus, older adults who experience intense regret may be at risk of ruminating about the regretted event without being capable of overcoming the regret, which may trigger greater distress and a disturbance of HPA axis regulation (Heckhausen, Wrosch, & Schulz, in press; Wrosch & Heckhausen, 2002).

Older adulthood is also characterized by other, frequently intractable, stressful experiences, such as an increase in physical health problems and functional disability. Indeed, both of these stressors have been related with psychological distress (e.g., Bruce, 2001) and dysregulated cortisol secretion (Heaney et al., 2012; Wrosch et al., 2007a, b). Such effects may occur in older adulthood since a loss of control over the onset and progression of physical health problems can be psychologically and physiologically distressing (Heckhausen, Wrosch, & Schulz, in press).

It is important to note, however, that chronic and uncontrollable stressors may not disturb cortisol secretion to the same extent among all individuals (Wrosch et al., 2007a, b). Whether

stressful experiences result in dysregulated HPA activity can vary considerably between individuals (Kudielka et al., 2009). Such individual difference variables can be partially independent from the experience of a stressor and determine how stressors impact important outcomes (Bolger & Zuckerman, 1995). In this regard, past research has shown that factors such as social support and physical activity can exert robust stress-buffering effects (e.g., Rimmele et al., 2007; Seeman et al., 1994). Similarly, research suggests that inter-individual differences in psychological characteristics that facilitate adjustment to, and coping with, stress are likely to moderate links between stress and cortisol (e.g., O'Donnell et al., 2008; Wrosch et al., 2007a, b). Thus, psychological characteristics that facilitate coping with stressors are likely to buffer the adverse effects that these stress experiences can exert on older adults' biological functioning (Heckhausen et al., 2010).

To determine individual difference variables that may promote effective coping with chronic and uncontrollable stressors in old age, motivational theories of life-span development provide a useful framework for identifying pathways to successful aging (e.g., Brandtstädter & Renner, 1990; Heckhausen et al., 2010, in press). These theories posit that older adults' health may benefit from a shift towards self-regulation processes that involve self-protective strategies, helping them to accept that certain problems can no longer be resolved (e.g., social comparisons or positive reappraisals; Wrosch et al., 2006). Building upon these theories, we propose that self-compassion could represent a dispositional factor that exerts such motivational function and promotes older adults' physiological regulation in the context of uncontrollable stress experiences. Self-compassion is an individual difference variable that involves treating oneself in a manner that most individuals would treat a close friend who experiences difficult life circumstances. That is, with kindness and concern, rather than self-criticism, pity, or

aggrandizing negative feelings (Neff, 2003a). Self-compassionate individuals are supportive and understanding towards themselves and maintain an open and non-judgmental attitude of oneself during difficult times. In addition, they are able to recognize that difficult life circumstances are common to the human experience (Neff, 2003b).

As a consequence, we suggest that individual differences in dispositional self-compassion may prevent biological disturbances in response to uncontrollable stressors by promoting psychological processes that reduce emotional distress (cf. Cohen et al., 2007). In circumstances when older adults experience difficulty performing certain behaviors (e.g., living independently) or have severe life regrets, some of them may engage in self-blame or self-criticism and keep trying to resolve stress experiences that are difficult or impossible to overcome (Wrosch et al., 2005). By contrast, self-compassionate individuals should be less likely to engage in such maladaptive psychological responses to encountering uncontrollable problems (Brion et al., 2014; Leary et al., 2007; Neff, 2011) and instead may be more likely to accept that their health is declining or forgive themselves for a behavior that they regret (Zhang & Chen, 2016). These motivational concomitants of self-compassion may ameliorate the psychological consequences of uncontrollable stress experiences and reduce associated cortisol output.

In support of these possibilities, research has documented that self-compassion can moderate the effects of age-related stressors, such as poor physical health, pain, and mobility on psychological well-being (Allen et al., 2012; Homan, 2016). Moreover, self-compassion can promote physical health among individuals who confront chronic disease and experience higher levels of distress (e.g., diabetes, Friis et al., 2015). Less is known, however, about whether self-compassion also benefits physiological functioning in the context of stressful experiences. Preliminary evidence from laboratory stress tasks among young adults suggests that self-

compassion could promote more adaptive biological responses to stress, such as reduced cortisol reactivity and inflammation (Breines et al., 2014a, b). However, research examining the effects of self-compassion on diurnal cortisol output in the context of older adults' naturalistic, self-relevant, and uncontrollable stress experiences is lacking. We think that such research may be warranted since associations between stress and biological dysregulation can become paramount in older adulthood (Kiecolt-Glaser & Glaser, 2001). In addition, it could help identify a psychological mechanism that influences HPA axis functioning among older adults who experience common chronic and uncontrollable age-related stressors (Adam et al., 2007; Van Eck et al., 1996).

**The Present Study**

The present study examined whether individual differences in dispositional self-compassion predict lower levels of diurnal cortisol output among older adults who experience chronic and uncontrollable age-related stressors. Using cross-sectional data from 233 older adults, we examined associations among self-compassion, specific age-related stressors (physical health problems, functional disability, and regret intensity), and diurnal cortisol secretion. Because overall daily cortisol secretion (i.e., higher AUC) and change in cortisol secretion across a day (i.e., flattened slope) have both been associated with stress experiences, morbidity, and mortality, we predicted these indicators in our analyses (Heim et al., 2000, Kumari et al., 2011; Sephton et al., 2000). In supplemental analyses, we further explored whether obtained effects were related to cortisol output at different times of day (i.e., awakening, CAR, afternoon, and evening). More specifically, we expected that higher levels of age-related stressors (physical health problems, functional disability, and regret emotions) could be associated with higher daily levels and a flattened slope of cortisol secretion. In this regard, we hypothesized that the

emergence of such an association would depend on older adults' levels of self-compassion. In particular, we predicted that the experiences of age-related stressors would exert a significant effect on cortisol secretion only among older adults who score low on self-compassion. By contrast, we hypothesized that their counterparts who are more self-compassionate would be protected from experiencing cortisol disturbances in context of higher levels of age-related stressors. To examine potential confounds of the observed effects, the analyses controlled for socio-demographic characteristics (age, sex, and socio-economic status) and health relevant covariates (BMI, smoking status).

## Methods

### Participants

Participants in this study included an age-normative sample of community-dwelling older adults who participated in the Montreal Aging and Health Study (MAHS). The MAHS is a longitudinal study that originally included 215 participants (Wrosch et al., 2007a, b). After 10 years of study, the cohort of the MAHS was refreshed and new measures that are pertinent for the present study (e.g., self-compassion) were added to the study. Therefore, only cross-sectional data from this time point were analyzed. Recruitment for this study was completed via newspaper advertisements in the Montreal area. To obtain a normative sample, the only inclusion criteria for this study was that participants were older than 60 years. Each participant provided informed consent prior to participating in the study.

In this refreshed cohort, a total of 268 participants (95 original and 173 newly recruited participants) were assessed in their homes or in the laboratory. Participants were excluded from the analysis if they did not provide at least one complete day of cortisol data (n = 30). Five additional participants were excluded for not completing the self-compassion scale. The analytic sample thus included 233 participants. Excluded participants had a significantly higher BMI

($M = 28.83$, $SD = 5.28$) than included participants ($M = 26.80$, $SD = 4.78$; $t(258) = -2.24$, $p < .03$. The excluded participants did not significantly differ on any of the other main study variables ($|ts| < 1.54$, $ps > .13$).

## Materials

**Diurnal cortisol.** To assess normative patterns of diurnal cortisol secretion, we measured cortisol on three non-consecutive days over the course of 1 week. Participants were asked to collect five saliva samples using salivettes at awakening, 30 min after awakening, 2 PM, 4 PM, and bedtime. Upon awakening participants collected the first sample and started a timer to facilitate the collection of the second saliva sample 30 min after awakening. Participants were then contacted by phone at 2 PM and 4 PM to facilitate compliance with the afternoon samples collection. The last sample of the day was collected by the participants themselves before they went to bed. The time each sample was collected was recorded by the participants. To prevent contamination with food or blood, they were instructed not to brush their teeth or eat prior to saliva collection. For each sample, participants were instructed to insert a salivette into their mouths for 30 s to collect saliva. The salivettes were stored in participants' home refrigerators until they were returned to laboratory (after 2–3 days) and frozen until study completion. Cortisol analysis was performed at the University of Trier using a time-resolved fluorescence immunoassay with a cortisol-biotin conjugate as a tracer. The inter-assay variability from these cortisol analyses performed at the University of Trier was on average 5.3% and the intra-assay variability performed in this laboratory is usually below 10%.

All cortisol scores were log-transformed to stabilize variance. Cortisol samples were excluded if they deviated three standard deviations or more from the mean cortisol level for a given time of day, as these samples could have been contaminated with food or blood. Cortisol

scores were only calculated for participants who provided at least four usable cortisol scores on each of the collection days. Daily cortisol levels were calculated using the area-under-the-curve with respect to ground (AUC) across each day separately, using the trapezoidal method based on hours after awakening (Pruessner et al., 2003). The 30-min measure was excluded from the calculation of daily cortisol level because early morning increase of cortisol has been shown to be relatively independent from overall cortisol level (Chida & Steptoe, 2009). The three AUC scores were averaged across the 3 days to obtain a reliable measure of average cortisol secretion. Cortisol slope was calculated by regressing cortisol values on time of day for each collection day (excluding the 30-min measure). The three obtained cortisol slopes were then averaged to create a reliable measure of average cortisol slope. On each of the assessment days, cortisol levels significantly declined from awakening to bedtime, $t$s > 26.43, $p$s < .001.

**Self-compassion**. Self-compassion was measured with the 12-item Self-Compassion Scale (Raes et al., 2011). This short-form version of the Self-Compassion Scale has shown good internal consistency (αs ≥ .86), good test–retest reliability over 5 months (α = .71; Neff, 2003a), a high correlation with the long-form scale ($r$s > .97), and self-compassion interventions have been shown to result in increases of self-compassion scores (Germer & Neff, 2013; Raes, 2011; Raes et al., 2011). This questionnaire uses 5-point Likert-type scales (*almost never* = 0 to *almost always* = 4). Participants were asked to consider how they typically act towards themselves in difficult times. Samples items include: “I try to see my failings as part of the human condition”, “When I fail at something important to me, I become consumed by feelings of inadequacy”, and “I try to be understanding and patient towards those aspects of my personality I don’t like.” To obtain an indicator of self-compassion a sum score of the 12 items was calculated after negatively formulated items were reverse coded (α = .80 in the current sample).

**Physical health problems**. Physical health problems were measured using a previously used symptom checklist of seven physical health problems (Wrosch et al., 2005). This checklist asked participants to report whether they had experienced or had been treated for any of the following health problems in the past 12 months: (a) persistent skin troubles (e.g., eczema); (b) recurring stomach trouble, indigestion, or diarrhea; (c) being constipated all or most of the time; (d) chronic sleeping problems; (e) migraine headaches; (f) asthma, bronchitis, or emphysema; and (g) thyroid disease. To obtain an indicator of physical health problems, we computed a count variable of each of these seven health problems (*Range* = 0–5, *M* = 1.24, *SD* = 1.12).

**Functional disability**. Functional disability was measured by asking participants to indicate whether or not they had difficulty or were unable to perform six basic activities of daily living (eating, using the toilet, dressing, showering, walking around the home, and getting in and out of a bed or chair), and six instrumental ADLs (heavy housework, light housework, shopping, preparing meals, managing money, and using the phone; Lawton & Brody, 1969). A count variable was computed comprising of the total number of basic and instrumental ADL difficulties (*Range* = 0–9, *M* = 1.71, *SD* = 2.20).

**Regret intensity.** Participants were asked to think about their own lives and report their most severe life regret. Consistent with past research, the majority of the sample reported having a significant life regret (82%; Bauer et al., 2008; Landman, 1987). To determine regret intensity, participants were asked to report the extent to which they experienced the following emotions during the past few months when they thought about their life regrets: sorrow, anger, desperate, irritated, helpless, and embarrassed (based on the work by Gilovich et al., 1998). Each item was rated on a 5-point Likert-type scale (*not at all* = 0 to *extremely* = 4). An index of the regret intensity was calculated by computing a sum score of the 6 items ($\alpha = .85$). Individuals who

reported not having a life regret and did not complete the regret intensity scale (n = 18) received a score of zero for this construct.

**Covariates**. Covariates included participants' sex, age, objectively measured BMI, smoking status (yes or no), and SES. These variables were selected as covariates because of their previously demonstrated associations with cortisol secretion (e.g., Hajat et al., 2010; Van Cauter et al., 1996). Sex was coded as *male* = 1 and *female* = 2. SES was indexed using three variables; highest education completed, yearly family income, and perceived social status. The three standardized SES measures were correlated ($r$s = .36 to .50, $p$s < .01) and averaged to obtain a reliable indicator of SES.

**Data Analysis**

Preliminary analyses were conducted to describe the sample (means, standard deviations, and frequencies) and explore zero-order correlations among the main study variables. The main hypotheses of this study were tested using multiple regression analysis (SPSS 23.0). A total of 9 participants had missing data on regret emotions, and 6 participants did not provide information necessary to calculate BMI. Since the proportion of missing data was less than 5%, missing scores of single constructs were replaced with the sample mean in the regression analysis (Tabachnik et al., 2013). All predictor variables were standardized prior to conducting the main analysis. In the first step of the analysis all covariates and main effects (sex, age, BMI, smoking status, SES, self-compassion, regret emotions, functional disability, and physical health problems) were included in the analysis. The final step involved testing the hypothesized interaction effects in separate models (physical health problems × self-compassion, functional disability × self-compassion, and regret emotions × self-compassion). Significant interactions were plotted to illustrate the associations between self-compassion and cortisol levels 1 SD

above, average, and 1 SD below the sample mean of physical health problems, functional disability and regret intensity, and the simple slopes were tested for significance (Aiken Leona and West Stephen 1991).

Finally, we conducted supplemental analyses to explore whether obtained, significant effects of chronic stressors on cortisol AUC and slope were related to specific times of day by predicting in separate analyses awakening levels, awakening response (CAR; sample 1 subtracted from sample 2), afternoon levels (averaged samples 3 and 4), and evening levels of cortisol as outcome variables.

## Results

### Preliminary Analyses

Sample characteristics are reported in Table 1. Participants were on average 76 years old (Median = 76, Range = 59–93). Approximately 39% of the sample was male. This sample represented a diverse socioeconomic background, approximately 33% had an income less than $34,000, 40% had an income between $34,001 and $85,000, and 16% had an income greater than $85,000. Participants reported a perceived social status that was slightly above mid-range. More than half the sample had a BMI greater than 25. A minority of participants smoked (5%).

Zero-order correlations among the study variables are reported in Table 2. Cortisol levels (AUC) were negatively associated with self-compassion and positively associated with age. Males were more likely to secrete higher cortisol levels than females. Cortisol slope was also positively associated with age. Self-compassion was negatively associated with regret intensity and positively associated with socioeconomic status. Regret intensity was negatively associated with socioeconomic status. Functional disability was positively associated with physical health problems and age and negatively associated with SES. Females reported higher levels of functional disability and physical health problems than males.

Table 5

*Means, Standard Deviations and Frequencies of Main Study Variables (N = 233)*

| Constructs | Mean (SD) or Percentage |
|---|---|
| Cortisol level (AUC in log nmol/Lxh) | 10.00 (2.46) |
| Cortisol slope | -0.04(.01) |
| Self-compassion | 41.14 (6.33) |
| Regret intensity | 4.76(5.10) |
| Physical health problems | 1.24(1.12) |
| Functional disability | 1.71(2.20) |
| Education (%) | |
| Did not complete high school | 15.02 |
| High school | 21.89 |
| College/trade | 13.30 |
| Bachelor | 25.75 |
| Masters/PhD | 16.74 |
| Income (%) | |
| Less than $17,000 | 7.30 |
| $17,001-$34,000 | 26.18 |
| $34,001-$51,000 | 21.46 |
| $51,001-$68,000 | 9.44 |
| $68,000 – 85,000 | 9.01 |
| > $85,000 | 16.31 |
| Perceived social status | 6.69(1.76) |
| Married or cohabitating (%) | 50.21 |
| Age | 75.57(7.75) |
| Female (%) | 60.94 |
| BMI | 26.80(4.78) |
| Current smoker (%) | 4.72 |

Note that that the sample size involving correlations with regret intensity, perceived social status, and BMI and were slightly reduced because of missing data for these constructs.

Table 6

*Zero-Order Correlations of Main Study Variables (N = 233).*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Cortisol level (AUC) | | | | | | | | | | |
| 2. Cortisol slope | .12 | | | | | | | | | |
| 3. Female | -.23** | -.06 | | | | | | | | |
| 4. Age | .15* | .20** | -.06 | | | | | | | |
| 5. BMI | .05 | .13 | -.07 | -.02 | | | | | | |
| 6. Smoking | .09 | -.04 | .01 | -.16* | -.13 | | | | | |
| 7. SES | -.05 | -.03 | -.19** | -.19** | -.07 | -.10 | | | | |
| 8. Self-compassion | -.14* | .00 | .04 | .03 | -.02 | .01 | .18** | | | |
| 9. Physical health problems | .08 | .03 | .14* | .08 | -.03 | .02 | -.08 | -.12 | | |
| 10. Functional disability | .00 | .12 | .17** | .28** | .07 | -.03 | -.23** | -.06 | .34** | |
| 11. Regret intensity | .09 | .12 | .02 | .07 | .00 | -.02 | -.16* | -.36** | .12 | .08 |

Note that that the sample size involving correlations with BMI and regret intensity and were slightly reduced because of missing data for these constructs.

*$p \leq .05$; **$p \leq .01$.

**Predicting Diurnal Cortisol Level**

The results of the regression analysis predicting participants' cortisol levels (AUC) are reported in Table 3. The first step of the analysis, which included all covariates and main study variables, showed a significant model effect $F(9, 232) = 3.15$, $p < .01$. Age was significantly positively associated with cortisol levels $\beta = .40$, $p = .02$. Sex was significantly negatively associated with cortisol levels $\beta = -.54$, $p < .01$, indicating that females had lower cortisol levels than males. No significant main effects of the remaining covariates or self-compassion and age-related stressors (physical health problems, functional disability, and regret emotions), were obtained for predicting participants' cortisol levels. In the final step of the analysis, three significant interaction effects emerged between self-compassion and the three age-related stressors (physical health problems: $\beta = -.52$, $p < .01$, functional disability: $\beta = -.29$, $p \leq .05$, and regret emotions: $\beta = -.44$, $p < .03$).

The significant interaction between self-compassion (1 SD above and below the sample mean) and physical health problems is plotted in the upper panel of Fig. 1, separately for participants who reported low (− 1 SD), average (sample mean), and high (+ 1 SD) levels of physical health problems. The observed pattern suggests that particularly high levels of cortisol were observed among participants who reported high levels of physical health problems and low levels of self-compassion. In addition, it indicates that to the extent participants' reported greater levels of physical health problems, self-compassion became increasingly associated with lower levels of daily cortisol. Follow-up simple slope analyses supported these interpretations. Self-compassion significantly predicted lower cortisol levels among participants who reported high levels of physical health problems $\beta = -.79$, $SE = .22$ $t = -3.54$, $p < .01$, but not among their

Table 7

*Regression analysis predicting cortisol level (AUC) and slope by covariates, self-compassion, physical health problems, functional disability, and regret emotions (N = 233).*

| | Cortisol level (AUC) | | | Cortisol slope | | |
|---|---|---|---|---|---|---|
| | $R^2$ | $\beta$ | SE | $R^2$ | $\beta$ | SE |
| Main Effects | | | | | | |
| Female | .043 | -.536** | .163 | .003 | -.001 | .001 |
| Age | .022 | .398* | .169 | .028 | .003** | .001 |
| BMI | .003 | .136 | .161 | .015 | .002 | .001 |
| Smoking | .013 | .288 | .161 | .000 | .000 | .001 |
| SES | .000 | -.052 | .170 | .001 | .001 | .001 |
| Self-compassion (SC) | .010 | -.273 | .169 | .001 | .001 | .001 |
| Physical health problems | .007 | .230 | .168 | .000 | .000 | .001 |
| Functional disability | .002 | -.127 | .177 | .005 | .001 | .001 |
| Regret intensity | .001 | .088 | .171 | .012 | .002 | .001 |
| Interactions | | | | | | |
| Physical health problems X SC | .045 | -.516** | .150 | .000 | .000 | .001 |
| Functional disability X SC | .015 | -.293* | .152 | .001 | .000 | .001 |
| Regret intensity X SC | .021 | -.438* | .188 | .011 | -.002 | .001 |

Notes. $R^2$ values represent the unique proportion of variance explained in each step of the analyses. $\beta$ represents standardized regression values in each step of the analyses. All interaction terms were tested in separate models

*$p \leq .05$ ** $p \leq .01$

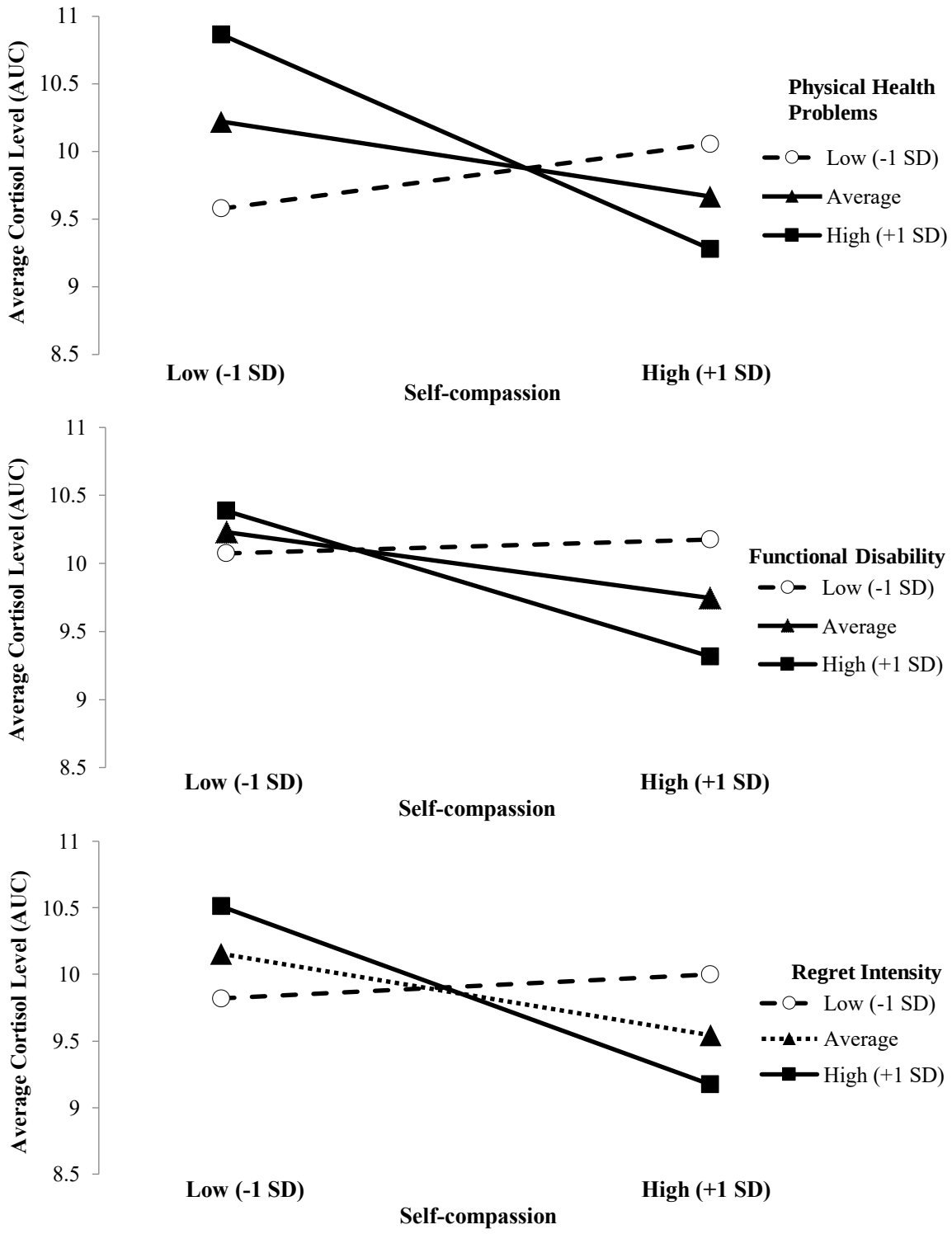


*Figure 4.* Associations between self-compassion and cortisol levels separately for: *(upper panel)* participants who reported levels of physical health problems one standard deviation above, below and mean levels of physical health problems, *(middle panel)* levels of functional disability one standard deviation above, below and mean levels of functional disability, and *(lower panel)* levels of regret emotions one standard deviation above, below and mean levels of regret emotions.

counterparts who reported either average, $\beta = -.27$, $SE = .17$, $t = -1.68$, $p = .10$, or low levels of physical health problems $\beta = .24$, $SE = .22$, $t = 1.08$, $p = .28$.

The significant interaction effect between self-compassion and functional disability is plotted in the middle panel of Fig. 1, separately for participants who reported low (− 1 SD), average (sample mean), and high (+ 1 SD) levels of functional disability. Similar to the previous interaction, the obtained pattern shows that relatively high levels of cortisol were observed among participants who reported high levels of functional disability and low levels of self-compassion. The results further suggest that to the extent participants reported higher levels of functional disability, self-compassion became increasingly associated with lower levels of cortisol levels. Simple slope analysis was consistent with this interpretation, indicating that among those participants who report higher levels of functional disability, self-compassion became more strongly associated with lower cortisol levels $\beta = -.54$, $SE = .22$, $t = -2.48$, $p = .01$, as compared to their counterparts who had either average $\beta = -.24$, $SE = .17$, $t = -1.44$, $p = .15$ or low levels of functional disability $\beta = .05$, $SE = .24$, $t = .21$, $p = .83$.

The significant interaction effect between self-compassion and regret intensity is plotted in the lower panel of Fig. 1, separately for participants who reported low (− 1 SD), average (sample mean), and high (+ 1 SD) levels of regret intensity. Similar to the previously reported interactions, the obtained pattern suggests that the highest cortisol levels appeared among those who experienced high levels of regret intensity and were relatively low in self-compassion. Self-compassion was increasingly associated with lower cortisol levels to the extent that participants experienced higher levels of regret intensity. This interpretation was supported by the simple slope analyses, demonstrating that higher self-compassion significantly predicted lower cortisol levels among participants who reported greater levels of regret intensity, $\beta = -.67$, $SE = .25$,

$t = -2.71$, $p < .01$, but not among their counterparts who reported either average, $\beta = -.31$, $SE = .17$, $t = -1.82$, $p = .07$, or low levels of regret intensity, $\beta = .09$, $SE = .23$, $t = .39$, $p = .70$.

The supplemental analyses, predicting different times of cortisol secretion during the day, showed that the obtained interaction between physical health problems and self-compassion predicted awakening levels, CAR, and evening levels of ($|\beta|$s > |.02|, $p$s < .05, $R^2$>.01), but not afternoon levels of cortisol ($\beta = -.02$, $p = .11$, $R^2 = .01$). In addition, the interaction between regret intensity and self-compassion predicted only evening levels ($\beta = -.05$ $p = .001$, $R^2 = .04$), but not awakening levels, CAR, or afternoon levels of cortisol ($|\beta|$ s < |− .02|, $p$s > .22, $R^2$< .01). Finally, the interaction between functional disability and self-compassion did not significantly predict any additional marker of cortisol ($|\beta|$s < |− .02|, $p$s > .16, $R^2$< .01).

**Predicting Cortisol Slope**

The results of the regression analysis predicting cortisol slope are also reported in Table 3. The first step of the analysis, which included all covariates and main study variables, showed a significant model effect $F(9, 232) = 2.06$, $p < .04$. Of the covariates, age was significantly positively associated with cortisol slope, $\beta = .003$, $p = .01$, indicating that older, as compared to younger, participants exhibited a more flattened cortisol slope across day. However, no additional significant associations with cortisol slope were obtained for the remaining covariates, self-compassion, or age-related stressors (physical health problems, functional disability, and regret emotions). The final step of the analysis, testing the three interaction effects between self-compassion and age-related stressors separately (physical health problems, regret emotions and

functional disability), showed that none of the three interactions significantly predicted participants' cortisol slope, all $|\beta s| < .002$, all $ps > .09$ (see Table 3).[1]

## Discussion

This study showed in a community-dwelling sample of older adults that dispositional self-compassion moderates the associations between specific chronic and uncontrollable age-related stressors (i.e., physical health problems, functional disability, and regret intensity) and higher levels of diurnal cortisol secretion. More specifically, we found that to the extent older adults reported higher levels of regret and health-related stressors, self-compassion became increasingly associated with lower levels of diurnal cortisol (AUC). These findings were not observed for participants' cortisol slope, and the obtained pattern of results was significant after controlling for a number of demographic (age, sex, SES) and health-relevant covariates (BMI, smoking).

The study's findings suggest that self-compassion represents an adaptive personal resource that is capable of buffering stress-related disturbances of older adults' cortisol secretion. These findings are consistent with motivational theories of life-span development, which document that successful aging is characterized by a shift in older adults' self-regulation attempts, from overcoming problems and striving for gains to adjusting psychologically to

[1] We note that our study also included a measure of daily perceived stress, which was assessed on 3 days and could involve both transient and addressable stressors or chronic and uncontrollable stressors. Since our theoretical approach focused on specific chronic and uncontrollable stressors, daily perceptions of stress were not considered for the study hypotheses. However, we acknowledge that supplemental analyses, using an average score of daily perceived stress, did not show significant interactions involving daily stress and self-compassion predicting cortisol level ($\beta = -.22$, $p > .05$) or slope ($\beta = -.00$, $p > .05$). In addition, there were no significant main effects of the daily stress predicting cortisol level ($\beta = .10$, $p > .05$) or cortisol slope ($\beta = .00$, $p > .05$). Further, including daily stress into the reported models as a covariate did not change any of the reported results.

relatively intractable age-related losses (Brandtstädter & Renner, 1990; Heckhausen et al., 2010, in press). In fact, certain self-protective processes (e.g., avoiding self-blame, positive reappraisals, or downward social comparisons) and goal disengagement processes (Heckhausen et al., 2010; Wrosch et al., 2006) have been shown to exert effective coping effects in the context of older adults' stress experiences. To this end, self-compassion may foster such self-protective responses to the experience of uncontrollable stressors. For example, being kind and understanding to oneself during times of stress could promote positive reappraisals of difficult life circumstances and reduce self-blame for emerging problems, rumination, or catastrophizing (Brion et al., 2014; Leary et al., 2007; Neff, 2011). In addition, appraising personal challenges in the broader context of common humanity may elicit adaptive social comparisons that may reduce negative emotional responses to pressing problems (Festinger, 1954) and prevent the HPA axis from releasing high levels of cortisol into the circulation.

Of importance, the beneficial effects of self-compassion on older adults' cortisol secretions were observed in the presence of both psychological stressors (i.e., intense life regret) and physical stressors (i.e., functional disability and physical health problem). These results suggest that self-compassion may represent a dispositional resource that can protect older adults' cortisol functioning across a variety of life stressors. Since both intense life regrets and physical health problems typically represent relatively chronic stressors that become increasingly intractable as individuals advance in age (Wrosch et al., 2005, 2006), these findings may further imply that self-compassion is adaptive particularly if individuals confront uncontrollable and chronic stressors. To this end, we note that our study also included a measure of daily perceived stress, which is thought to be different from chronic stress experiences (Almeida, 2005), and could be elicited by both stressors that are either transient and potentially controllable or by

chronic and intractable stressors. Interestingly, self-compassion did not interact with daily perceptions of stress in predicting cortisol output (see Footnote 1), which could imply that participants' daily stress experiences were relatively minor and/or potentially controllable. As a consequence, the influence of self-compassion on older adults' cortisol secretion could be stronger in the context of chronic and intractable stressors, as compared to daily perceptions of stress.

It should be noted that consistent moderation effects of self-compassion in the associations between age-related stressors and cortisol were found only for predicting cortisol AUC. By contrast, the analyses did not show the same effects for predicting cortisol slope. In addition, the supplemental analyses indicated that if cortisol secretion during different times of day were analyzed separately, buffering effects of self-compassion were either absent (i.e. for functional disability) or detected only for some times of the day (i.e., for regret experiences and physical health problems). These findings may imply that cortisol AUC is a particular promising outcome measure, which is consistent with some past research that has documented associations between stress experiences and cortisol AUC only (Ice, 2005; Wrosch et al., 2005). Such different effects may occur considering that stress experiences can enhance cortisol secretion across the entire day and thus would be particularly likely to predict cortisol AUC (Kirschbaum et al., 1995). Cortisol measures that reflect different times of day, by contrast, may fail in capturing some of the physiological effects of stressors occurring during the entire day. In addition, a flattened slope can be observed as a function of both reduced morning cortisol levels and/or greater levels of evening cortisol, and thus may be less related to stressors that increase cortisol across the entire day (Cohen et al., 2006). Another explanation that is consistent with our data (see correlations in Table 2) would be that cortisol AUC and slope can be relatively

independent from each other (Vedhara et al., 2006) and may be regulated by different mechanisms (Ice, 2005). This possibility could further explain the observed associations between self-compassion and cortisol AUC among individuals with low self-compassion, considering previous research documenting that cortisol level may be more affected by psychological traits, whereas cortisol slope may be influenced to a larger extent by variables related to the circadian rhythm (i.e., age, physical activity, sleep; Ice, 2005). We further acknowledge that the reliabilities of cortisol slope and levels during different times of day may not have been sufficiently high to detect between-person differences. Although previous research has shown that three collection days provide reliable estimates of between-person differences in cortisol level, more collection days are likely required to obtain other reliable indicators of cortisol secretion (e.g., Segerstrom et al., 2014).

Finally, we would like to acknowledge that our data did not show significant main effects of any of the age-related stressors on participants' cortisol secretion. This pattern is consistent with prominent self-regulation theories that posit that not stressors per se, but instead individuals' appraisals and behaviors, determine the health-related outcomes of stress experiences (Folkman et al., 1986). In support of this possibility, we note that other studies also did not consistently report significant main effects of stress experiences on cortisol secretion (e.g., Kudielka et al., 2009; Liu et al., 2014). As such, our data suggest that individual difference variables that facilitate adjustment to stressors, such as self-compassion, may play an important role in the physiological effects of stress experiences. In the absence of adaptive levels of self-compassion, older adults may remain vulnerable and secrete high levels of cortisol in response to intractable stress experiences.

Overall, the reported findings have important implications for research on personality, aging, and cortisol regulation. Our study extends preliminary laboratory-based research (e.g., Breines et al., 2014a) by documenting that differences in dispositional self-compassion can facilitate adaptive stress-related HPA axis responses as older adults go about their normal daily activities. These findings are particularly important given that naturalistic patterns of cortisol secretion may provide relevant information for understanding pathways to biological dysregulation and disease (Adam et al., 2007; Van Eck et al., 1996). Indeed, such indicators of dysregulated cortisol secretion have been shown to predict mortality rates among older adults specifically (Kumari et al., 2011).

The obtained findings also contribute to theories of successful aging. With advancing age, individuals typically experience an increasing number of relatively intractable stressors in a variety of life domains, which are likely to compromise their biological functioning and physical health (Wrosch et al., 2006). To this end, our results document that self-compassion buffered the effects of both psychological and physical stressors on increased cortisol output. This pattern of results adds to current motivational theories of life-span development (e.g., Heckhausen et al., 2010) by pointing to the possibility that self-compassion represents an individual difference variable that facilitates effective coping with various age-related stressors across different areas of life.

The reported study has further implications for theory and research on stress and cortisol functioning. Self-compassion buffered the effects of age-related stressors on daily cortisol levels, but not cortisol slope. This mixed pattern may imply that research on psychological factors impacting the human stress response (Ice, 2005; Wrosch et al., 2007a, b) could obtain particularly reliable results by predicting the overall level of cortisol secretion instead of

focusing on differentially increasing or decreasing cortisol levels across the day (i.e., slope). In support of this possibility, our findings suggest that cortisol AUC and cortisol slope were not significantly correlated, and future research should investigate more thoroughly the potential mechanisms underlying different associations between stress experiences, psychological factors, and cortisol indicators.

Finally, our findings may have implications for practitioners and clinicians, as they highlight the possibility that self-compassion can benefit health-relevant biological functioning in older adulthood. This conclusion points to the utility of self-compassion as a psychological variable that could be fostered in clinical settings to promote physical health among older adults experiencing a variety of age-related stressors. Indeed, specific psychological interventions that foster self-compassion (e.g., Compassion-Focused Therapy, Mindfulness-Based Stress Reduction, Mindfulness-Based Cognitive Therapy, and Acceptance and Commitment Therapy) have been developed, and a recent review of this literature suggests that such interventions can benefit psychological well-being and, in some circumstances, physical health among older adults (Geiger et al., 2016).

There are several limitations of this study that should be addressed in future research. First, while it is a strength of our study to examine associations between self-compassion and cortisol secretion in a naturalistic setting, the analyses were based on a relatively small sample of community-dwelling older adults, and thus may not generalize to the entire aging population. Second, the study used cross-sectional data and thus precludes any causal interpretation. As a consequence, we cannot determine the time-related associations between stressors, self-compassion, and cortisol output. Third, although our analysis showed convergent associations between self-compassion and stress-related cortisol output for three different stressors (i.e.,

functional disability, physical health problems, and life regrets), other stress experiences that frequently arise in old age were not assessed in our study (e.g., social losses or support reductions). Fourth, the study did not consider other psychological factors that could be associated with self-compassion and may protect older adults during the experience of age-related stressors (e.g., control strategies or goal disengagement capacities; Wrosch et al., 2005, 2006). Fifth, our study examined how dispositional variation in self-compassion could buffer the effects of age-related stressors, and did not examine state levels of self-compassion in response to specific stressors. Future research should thus further explore whether self-compassion as an active behavioral choice, independent of general individual differences in self-compassion, can also influence the physiological response to specific age-related stressors. Finally, the reported study did not examine clinical health outcomes, and thus could not conclude whether the protective effects of self-compassion on stress-related cortisol disturbances can optimize older adults' physical health over time. Future research should address these limitations by examining larger samples of older adults over an extended period of time. Such research should cover a wider range of age-related stressors, potentially protective psychological factors, and physical health outcomes. Research along these lines may illuminate the psychological and biological mechanisms that enable older adults to manage age-related stressors and protect their quality of life.

**Conclusion**

The present study identifies self-compassion as an individual difference variable that is associated with adaptive cortisol functioning in the context of older adults' chronic and uncontrollable stress experiences. The reported results may have implications for clinical

interventions that foster self-compassion in older adulthood as a way to cope with common age-related stressors.

# CHAPTER 4:

# STUDY 3

## Self-compassion as predictor of daily physical symptoms and chronic illness across older adulthood

Abstract

This study examined whether self-compassion could benefit daily physical symptoms and chronic illness particularly in early and advanced old age. The hypotheses were evaluated in a 4-year longitudinal study of 264 older adults. Results showed that self-compassion predicted lower levels of daily physical symptoms across the study period in advanced, but not early, old age (*T-ratio* = -1.93, $p = .05$). In addition, self-compassion was associated with fewer increases in chronic illness in advanced, but not early, old age (*T-ratio* = -2.45, $p < .02$). The results of this study suggest that self-compassion may be particularly adaptive towards the end of life.

Key words: self-compassion; chronic illness; daily physical symptoms; aging; advanced old age

Note. Copy edited version of this study has been published in *Journal of Health Psychology*, March 2021.

## Introduction

While the length of the human life span has increased substantially, the health of older adults during these added years has not kept up proportionally. Older adults generally experience a decline in their health that can be due to the rise of both daily physical symptoms and chronic health problems (Gerstorf, Ram, Lindenberger, & Smith, 2013; Wrosch & Schulz, 2008). The prevalence of physical health problems generally increases as individuals shift from early to advanced old age. In early older adulthood, for example, less than half of older adults in Canada report having at least one chronic illness, but by age 71 and greater, over 80% of older adults report having at least one chronic illness (Statistics Canada, 2009). Daily physical symptoms may be a sign of manifesting disease or a precursor of developing chronic illness and these health problems can lead to a multitude of negative downstream consequences associated with poor psychological well-being, disability, or mortality (Freund & Baltes, 2000; Williamson, & Schulz, 1995; Wrosch & Schulz, 2008). It is therefore important to focus on psychological factors that could protect health as older adults advance in age (Baltes, & Smith, 2003; Smith, Borchelt, Maier, & Jopp, 2002).

One area of theory and research addresses psychological factors that may facilitate coping with age-related stressors. To this end, motivational theories of life-span development provide a theoretical context to understand which psychological variables are potentially adaptive as individuals advance in age (e.g., Brandtstädter & Renner, 1990; Freund, & Baltes, 2000; Heckhausen, Wrosch, & Schulz, 2019). With increasing age, people experience a decline in internal resources, opportunities, and control available to overcome stressors (Heckhausen et al., 2019). As a consequence, older adults may need to increasingly rely less on processes that involve attempts at overcoming stressors and attaining those goals that have become

uncontrollable or unattainable (e.g., persistence, Wrosch, Lachman, & Heckhausen, 2000). Instead, as older adults move from early to advanced old age, they may need to shift towards self-protective strategies that aim to regulate negative emotions and promote disengagement from unattainable goals (e.g., positive reappraisals; Heckhausen et al., 2019; Jobin, & Wrosch, 2016; Wrosch et al., 2006).

Self-compassion may represent one of these self-protective factors that we theorize may become increasingly adaptive during older adulthood. Self-compassion can be conceptualized as a dispositional factor that involves treating yourself in the same kind, caring, and compassionate manner that a person would treat a close friend or loved one who experiences stress (Neff, 2003a). To be self-compassionate involves being able to recognize the experience of stress or failure in a mindful manner without criticizing, blaming or excessively ruminating on the experience (Neff, 2003b). Self-compassionate individuals are also less likely to feel alone in their experiences of stress and failure as they are more likely to contextualize problematic experiences as common to the human condition (Neff, 2003b). These psychological concomitants of self-compassion are likely to support health-relevant processes, such as well-being, among older adults who experience stressful life circumstances. In support of this assumption, a recent meta-analysis indicated that self-compassion is associated with better psychological well-being in older adults (Brown, Huffman, & Bryant, 2019).

Research has also studied whether self-compassion may benefit physical health. For example, a recent meta-analysis of mostly adult samples suggested that higher self-compassion does generally predict better physical health (Phillips & Hine, 2019). In addition, self-compassion has been related to objective biological markers of health. A cross-sectional study from our laboratory has shown that self-compassion may protect older adults who report age-

related stressors from enhanced daily cortisol output (Herriot, Wrosch, & Gouin, 2018). In addition, a randomized controlled trial of adult patients with diabetes demonstrated that promoting self-compassion buffered the effects of stress on metabolic indicators of diabetes control (Friis, Johnson, Cutfield, & Consedine, 2015).

Self-compassion may promote better health through a variety of pathways. For example, self-compassion is likely to facilitate more positive health behaviors in the context of stressors, such as better eating behavior, sleep habits, physical activity, and medication compliance (Terry & Leary, 2011). The association between self-compassion and health behavior, however, seems to become less pronounced in older adulthood (Phillips & Hine, 2019). Self-compassion may also improve health by reducing the severity of stress experiences. For example, self-compassion has been shown to be associated with more adaptive coping responses (e.g., Allen & Leary 2010), which could facilitate more adaptive biological reactivity to stress (e.g., cortisol and inflammation; Breines et al., 2014a, b; Herriot et al., 2018). Since dysregulated cortisol secretion can influence other health-relevant bodily systems (e.g., immune function, Cohen, Janicki-Deverts, & Miller, 2007), it is plausible to assume that self-compassion may also slow down the development of a number of daily physical symptoms and chronic diseases in older adulthood (cf. Wrosch, Schulz, & Heckhausen, 2004). As a consequence, the pathway linking self-compassion to better health could be related to processes that promote stress-reduction in older adulthood.

One limitation of the extant literature is its reliance on cross-sectional research, and the limited exploration of these associations during older adulthood. As such, there is a paucity of work on the association between self-compassion and changes in physical health among older adults. To date, no research has studied whether self-compassion could predict the longitudinal

development of either daily or chronic health problems among older adults. In addition, this literature has focused on older adults collectively, and there is a lack of research exploring possible age differences in the effects of self-compassion among people in early versus advanced old age (e.g., Phillips & Hine, 2019). As discussed previously, motivational life-span theories would assume that individual difference factors that support self-protection and facilitate disengagement from unattainable goals are sensitive to a person's age-related context and become particularly adaptive in advanced old age, when desired goals become frequently unattainable and individuals confront an increasing number of uncontrollable stressors (Baltes & Smith, 2003; Heckhausen et al., 2019). In early old age, by contrast, when many individuals still have sufficient opportunities to overcome stress experiences, processes other than self-compassion (e.g., persistence, Heckhausen et al., 2019) may be more important for health-related functioning, and the health effects of self-compassion could be comparatively reduced. Consistent with this assumption, research has shown that the beneficial effects of self-protective factors on preventing depressive symptom and physical disease increased from early to advanced old age (e.g., Jobin & Wrosch, 2016). Since self-compassion may exert similar buffering effects, it may thus also become paramount for protecting physical health in advanced old age.

To study this possibility, the present study used longitudinal data from a community-dwelling sample of older adults to test if self-compassion can predict levels and trajectories of common physical health outcomes over time, such as daily physical symptoms and chronic illness (Gerstorf et al., 2013). Given that self-compassion may be health-protective particularly when individuals confront an increasing number of uncontrollable stressors and unattainable goals, we further hypothesized that beneficial effects of self-compassion on physical health outcomes would be enhanced in advanced, as compared to early, old age.

## Method

### Participants

Data for this study involved community-dwelling older adults from the Montreal Aging and Health Study (MAHS). Participants were recruited via newspaper advertisements in the Montreal area. At T1 215 participants were originally assessed, and at T6 the sample was refreshed to include a total of 268 participants (95 original and 173 new participants). Only those who participated at T6 were considered for participation given that the primary measure of interest (i.e., self-compassion) was not assessed in the study until T6. As a result, we only used data from T6 onward, which was considered baseline for the purpose of analysis. Four participants did not report self-compassion data (across T6-T8) and were not included in the study. The final sample therefore included 264 older adults. Following the assessment of self-compassion, participants were assessed every two years for a total of 3 waves (Two years later: $N$ = 226; Four years later: $N$ = 176). Study attrition was due to death ($N$ = 17), lost contact ($N$ = 24), refusing to participate (N = 36), sickness ($N$ = 6), unable to follow directions ($N$ = 3), personal reasons ($N$ = 1), or unknown reasons ($N$ = 1). Informed consent was obtained from all participants in the study prior to participation. The distribution of sociodemographic and health variables of the sample was within the normative range of older Canadians residing at home (National Advisory Council on Aging, 2006; see also Table 1).

### Materials

**Self-Compassion.** Self-compassion was measured using the 12 item self-compassion scale at each wave (Raes et al., 2011). The scale asked participants to think about how they typically act during difficult times. Example items include: “When I fail at something important to me, I become consumed by feelings of inadequacy” or “I try to see my failings as part of the

human condition." Participants recorded their responses on a 5-point Likert type scale ranging from *almost never* = 0 to *almost always* = 4. A total self-compassion score was obtained for each wave by computing a sum score of the 12 items after negatively formulated items were reverse coded. Across T6-T8 the scale showed satisfactory reliability ($\alpha$ = .80 to .82). Self-compassion scores were significantly correlated across waves (*r*s > .70, *ps* < .001). Further, across all participants self-compassion generally increased over the course of the study (*coefficient* = 0.17, *SE* = 0.09, *T-ratio* = 2.00, $p < .05$). To obtain the most reliable measure of individual differences in self-compassion, we averaged self-compassion scores across all waves to compute an average measure of self-compassion across the study. Note that hypotheses-related significant effects, reported later, remained significant if we conducted analyses with only T6 scores of self-compassion (*N* = 261; three participants did not report self-compassion at T6).

**Daily Physical Symptoms.** At each wave participants completed a three-day daily survey that included a 12-item checklist of daily physical symptoms (e.g., stomach pain, headaches, constipation; Wrosch & Schulz, 2008). The number of symptoms was counted each day and averaged across the three days for an indicator of daily physical symptoms for each wave. During the three days of the first analyzed wave (i.e., T6), 32.6% of participants reported a daily average of zero physical symptoms, 28.0% between 0 and 1 symptoms, 19.3% between 1 and 2 symptoms, 8.7% between 2 and 3 symptoms, and 11.4% more than 3 symptoms.

**Chronic Illness.** Chronic illness was assessed at each wave using a 17-item checklist of different chronic illnesses (e.g., cardiovascular problems, arthritis, diabetes, high blood pressure; Wrosch & Schulz, 2008). At each wave the number of chronic illnesses reported was counted to represent a total score of chronic illness. In the first analyzed wave, 10.6% had zero chronic

illness, 19.7% had one chronic illness, 23.5% had two chronic illnesses, 22.0% had three chronic illnesses, 11.0% had four chronic illnesses and 13.3% had 5 or more chronic illnesses.

**Covariates.** We included different sociodemographic and health-relevant covariates: sex, age, SES, and BMI. Sex was coded as 1 = Male and 2 = Female. SES was indexed using highest education completed, yearly family income, and perceived social status. The three standardized variables were significantly correlated ($r$s > .33; $p$s < .001) and were averaged together to create a composite SES variable. Research assistants objectively measured weight and height to calculate BMI.

**Data Analyses**

Preliminary analyses were conducted by calculating descriptive statistics and frequencies of the main study variables and their zero-order correlations (see Table 1). The main hypotheses were tested in two separate growth-curve models, predicting trajectories of daily physical symptoms and chronic illness over 4 years (using HLM 6.0, Raudenbush, 2004). The reported effects are based on models using restricted maximum likelihood estimation and robust standard errors. At Level 1 we estimated variance in participants' daily physical symptoms and chronic illness across 4 years as function of an intercept, person-centered scores of time in the study and a residual term. In this case, the intercept represented participants' average levels of daily physical symptoms and chronic illness across 4 years, while the time slope coefficient represents the yearly changes in daily physical symptoms and chronic illness from baseline to four years later.

At level 2 the intercept and slope of daily physical symptoms and chronic illness was predicted as a function of average self-compassion and covariates (sex, age, SES, BMI). All Level 2 main effect predictors were standardized prior to conducting the analyses. An interaction

term between self-compassion and age was added in a second step of the models. Significant interaction effects were followed up by calculating simple slopes of the effects of self-compassion on changes in daily physical symptoms and chronic illness over time for those in early old age (-1 SD; 67.40 years) and advanced old age (+1 SD; 83.10 years). Since HLM is capable of handling missing data at Level 1 (i.e., daily physical symptoms and chronic illness), missing data in these variables were not replaced. There was a small amount of missing data of main predictors variables (BMI: $N = 6$), which were replaced with the sample mean (Tabachnick, Fidell, & Ullman, 2007).

## Results

### Preliminary Analyses

Sample characteristics are displayed in *Table 1*. More than half the sample were female (60.2%). Participants were on average 75 years old (Range = 59 – 93). Participants had an average of 2.59 chronic illnesses, and 1.23 daily physical symptoms. The average BMI of the sample was 27.10. There was a diverse socioeconomic background among our sample, approximately 33.3% had an income less than $34,000 CAD, 22.7% had an income between $34,001 – 51,000 CAD, 18.2 % had an income between $51,001 - $85,000 CAD, and 16.7% had an income greater than $85,001 CAD (approximately 9% of the sample did not provide income information). Education was also diverse across our sample, 36.7% completed high school or less, 38.3% completed college or a bachelor's degree, and 17.8% completed a master's degree or above (approximately 7% of the sample did not provide education information). Participants reported an average perceived social status of 6.67 which is slightly above mid-range.

Zero-order correlations among the main study variables are reported in *Table 2*. Self-compassion was associated with less daily physical symptoms and higher SES. Having more

Table 8

*Means, Standard Deviations, Frequencies and Zero-Order Correlations of Main Study Variables (N = 264).*

| Construct | Mean (SD) or % | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| 1.Self-compassion (average) | 41.30 (5.85) | | | | | | |
| 2.Chronic Illness (average) | 2.59 (1.92) | -.04 | | | | | |
| 3.Daily Physical Symptoms (average) | 1.23 (1.28) | -.15* | .52** | | | | |
| 4.Age | 75.25 (7.85) | .02 | .26** | .18** | | | |
| 5.Female | 60.2% | .02 | -.01 | .17** | -.05 | | |
| 6.BMI[a] | 27.10 (4.84) | -.03 | .15* | .08 | -.04 | -.08 | |
| 7.SES | -0.01 (0.79) | .15* | -.20** | -.19** | -.18** | -.16** | -.11 |

[a] N is slightly reduced for this construct due to missing data ($N$ = 258).

*$p \leq .05$; **$p \leq .01$.

Table 9

*Results of Growth-Curve Analysis Predicting Chronic Illness and Daily Physical Symptoms by Self-Compassion, Age and Covariates (N = 264).*

| | Chronic Illness | | | | Daily Physical Symptoms | | | |
|---|---|---|---|---|---|---|---|---|
| | Intercept (Average levels) | | Slope (Time) | | Intercept (Average levels) | | Slope (Time) | |
| | Coefficient (SE) | T-Ratio | Coefficient (SE) | T-Ratio | Coefficient (SE) | T-Ratio | Coefficient (SE) | T-Ratio |
| Level 1 ($\beta_0$; $\beta_1$)[a] | 2.58 (0.12)** | 22.25 | 0.04 (0.04) | 1.17 | 1.22 (0.08)** | 15.58 | 0.01 (0.02) | 0.46 |
| Level 2: Main effects and covariates | | | | | | | | |
| Self-Compassion | -0.03 (0.11) | -0.29 | -0.01 (0.03) | -0.27 | -0.17 (0.07)** | -2.53 | -0.00(0.02) | -0.11 |
| Age | 0.45 (0.11)** | 4.20 | 0.04 (0.03) | 1.27 | 0.23 (0.07)** | 3.27 | 0.03 (0.02) | 1.55 |
| Female | -0.00 (0.11) | -0.02 | 0.02 (0.04) | 0.53 | 0.22 (0.07)** | 3.11 | -0.00 (0.02) | -0.23 |
| BMI | 0.27 (0.11)* | 2.41 | 0.03 (0.03) | 1.01 | 0.12 (0.08) | 1.47 | 0.02 (0.02) | 1.43 |
| SES | -0.26 (0.13)* | -1.94 | -0.04 (0.04) | -1.04 | -0.12 (0.08) | -1.53 | 0.01 (0.02) | 0.35 |
| Level 2: Interaction effect | | | | | | | | |
| SC X Age | -0.16 (0.11) | -1.40 | -0.08 (0.03)* | -2.45 | -0.15 (0.08)* | -1.93 | 0.03 (0.02) | 1.28 |

chronic illnesses were associated with more daily physical symptoms, being older, a higher BMI, and lower SES. Having more daily physical symptoms was associated with being older, being female and lower SES. Being older and female was associated lower SES.

**Predicting Daily Physical Symptoms**

The Level 1 model predicting daily physical symptoms showed a significant effect of the intercept, indicating that participants' average daily physical symptoms across waves were significantly different from zero (see Table 2). The time slope of daily physical symptoms was not significantly different from zero, indicating that daily physical symptoms did not significantly change over 4 years across all participants. The results from the Level 1 model for daily physical symptoms showed significant variance around participants' average intercept, $\chi^2 = 1687.95$, $df = 231$, $p < .001$, but not slope, $\chi^2 = 265.82$ $df = 231$, $p = .057$.

The Level 2 model predicted the observed variance in the intercept and time slope of daily physical symptoms as a function of self-compassion, age, and the covariates. Of the covariates, being female and older age significantly predicted higher average daily physical symptoms. No covariates significantly predicted the time slope of daily physical symptoms. However, self-compassion significantly predicted the intercept (but not the time slope) of daily physical symptoms. Participants with higher, as compared to lower, self-compassion scores reported lower average levels of daily physical symptoms. Self-compassion explained an additional 1.93% of the variance in average daily physical symptoms.

In the next step we included an interaction term between self-compassion and age. The interaction term significantly predicted the intercept (but not the time slope) of daily physical symptoms. To illustrate the significant interaction, we used recommended growth-curve techniques (Preacher et al., 2006) and plotted the average levels of daily physical symptoms

separately for those with low (-1 SD) and high (+1 SD) self-compassion in early (-1SD; 67.40 years) and advanced old age (+1 SD; 83.10 years) in *Figure 1*. The observed pattern suggests that being older was increasingly associated with more daily physical symptoms among participants with low self-compassion. In addition, the highest average levels of daily physical symptoms were observed among participants in advanced old age with lower self-compassion. Simple slope analyses supported this interpretation. Self-compassion significantly predicted average levels of daily physical symptoms among participants in advanced old age (*coefficient* = -0.35, *SE* = 0.13, *T-ratio* = -2.76, $p < .01$), but not among their counterparts in early old age (*coefficient* = -0.06, *SE* = 0.08, *T-ratio* = -0.71, $p = .48$). Including the interaction between self-compassion and age in the model explained an additional 1.13% of variance in average daily physical symptoms (controlling for main effects and all covariates).

**Predicting Chronic Illness**

The Level 1 model predicting chronic illness showed a significant effect of the intercept, indicating the average chronic illness across all participants were significantly different from zero. The time slope of chronic illness was not significantly different from zero, suggesting that across all participants chronic illness did not change over time. Finally, the Level 1 model displayed significant variance around participants' average intercept, $\chi^2 = 1810.34$, $df = 231$, $p < .001$, and slope, $\chi^2 = 368.23$, $df = 231$, $p < .001$.

The Level 2 model attempted to predict the variance in the intercept and slope of participants' chronic illness as a function of self-compassion, age, and covariates. Of the covariates, higher BMI, lower SES, and being older was significantly associated with higher intercept values (i.e., average levels) of chronic illness across all waves. No other covariates or self-compassion significantly predicted the intercept or time slope.

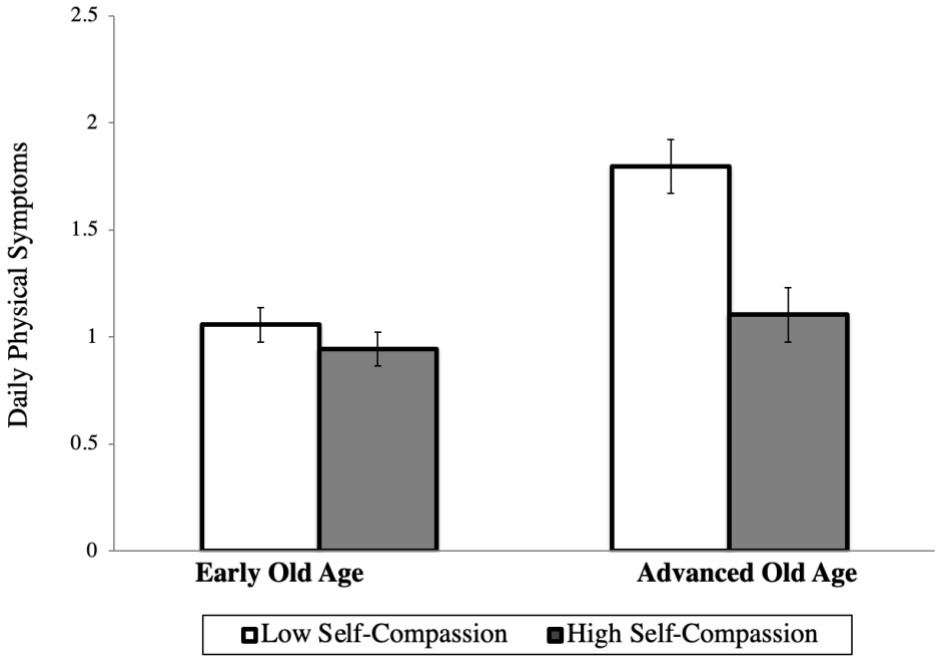


*Figure 5.* Average levels of daily physical symptoms across four years as a function of self-compassion and chronological age. Results for early versus advanced old age were plotted for 67.40 versus 83.10 years, respectively. Error bars represent the standard error.

For the final step of the analysis, we added the self-compassion and age interaction term to the model. The interaction term significantly predicted the time slope, but not the intercept, of chronic illness. To examine the interaction of self-compassion and age on the time slope of participants' chronic illness, we plotted the trajectories of chronic illness across waves separately for participants with high (+ 1 SD) and low self-compassion (-1 SD) in early (-1 SD; 67.40 years) and advanced old age (+1 SD; 83.10 years). As depicted in *Figure 2*, levels of chronic illnesses were comparable at the beginning of the study period for young-old and older-old participants with high versus low self-compassion. However, simple slope analyses of the obtained interaction showed that chronic illness increased over four years among participants in advanced old age who reported low self-compassion (*coefficient* = 0.20, *SE* = 0.07, *T-ratio* = 2.79, $p < .01$). By contrast, chronic illness did not significantly increase among participants in advanced old age with high self-compassion (*coefficient* = -0.02, *SE* = 0.09, *T-ratio* = -0.23, $p = .82$). Among participants in early old age, chronic illness did not significantly change for those with either low (*coefficient* = -0.05, *SE* = 0.04, *T-ratio* = -1.13, $p = .26$) or high (*coefficient* = 0.05, *SE* = 0.06, *T-ratio* = 0.87, $p = .39$) self-compassion. The addition of the self-compassion by age interaction to the model explained additional 3.83% of variance in the time slope of participants' chronic illness (controlling for main effects and all covariates).

## Discussion

The present study showed that self-compassion can predict levels and trajectories of daily physical symptoms and chronic health problems in older adulthood. More specifically, self-compassion was associated with fewer daily physical symptoms on average over four years across the entire sample. This result was moderated by age such that self-compassion predicted higher average levels of daily physical symptoms among people in advanced, but not early, old

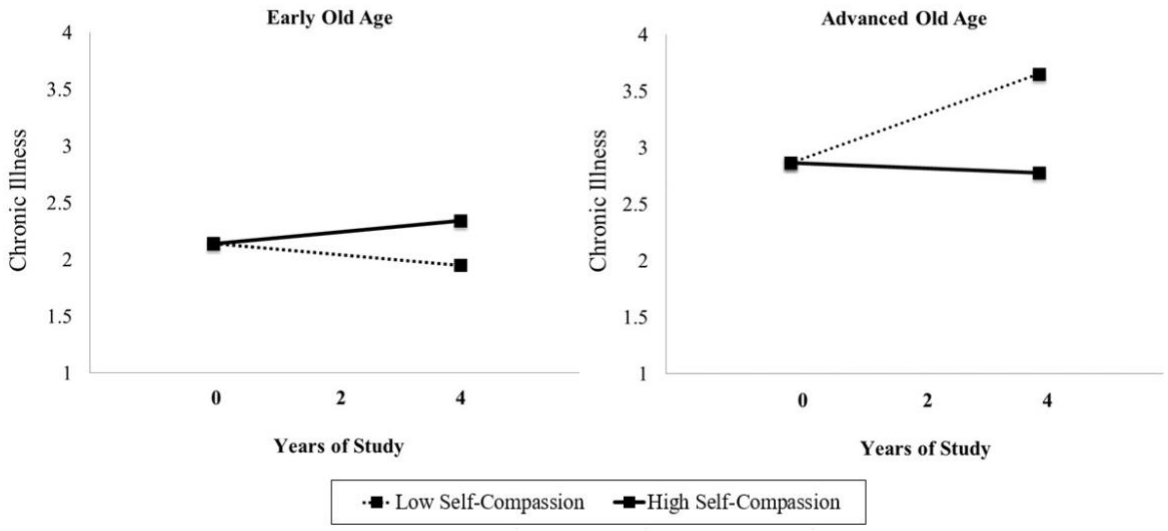


*Figure 6.* Changes in levels of chronic illness over four years as a function of self-compassion and chronological age. Results for early versus advanced old age were plotted for 67.40 versus 83.10 years, respectively.

age. In addition, the results showed that lower, as compared to higher, self-compassion was associated with increases in chronic disease over four years among participants in advanced, but not early, old age. These age effects were independent of sociodemographic and health relevant covariates (sex, BMI, SES), and explained substantial variance in the age-related levels and longitudinal trajectories of daily physical symptoms and chronic health problems over time.

These results suggest that self-compassion is a beneficial psychological factor in promoting physical health among older adults. While the literature on self-compassion and psychological well-being is well established (Brown et al., 2019), the link between self-compassion and older adults' physical health has been examined less and extant findings are largely cross-sectional (Phillips & Hine, 2019). This study therefore extends this literature by providing longitudinal evidence, documenting that self-compassion can not only relate to older adults' physical health concurrently, but that it may also play a role in preventing development of physical health problems over time.

The study further supported our hypotheses by showing evidence for an enhanced importance of self-compassion for protecting physical health outcomes in advanced old age. Different from individuals in early old age, high, as compared with low, self-compassion was associated in advanced old age with generally lower levels of daily physical symptoms and fewer increases in the number of chronic illnesses. Although we predicted that self-compassion would also exert some health benefits in early old age, and increase its adaptive function during older adulthood, there was little evidence for differences in health as a function of self-compassion in early old age. One explanation for this pattern of findings is that other personality variables, which support counteracting stress-experiences, could play a more important role in early old age

(e.g., optimism or goal engagement, Barlow, Wrosch, Heckhausen, Schulz, 2016; Wrosch, Jobin, & Scheier, 2017).

Overall, the obtained findings are consistent with motivational theories of life-span development, which highlight that the adaptive value of certain self-regulation factors is age-dependent and becomes increasingly important in advanced old age (Heckhausen et al., 2019; Jobin & Wrosch, 2016). During old age, many individuals experience an increase in often irrevocable losses and uncontrollable stressors (Baltes & Smith, 2003; Heckhausen et al., 2019), which are likely to contribute to poor health outcomes over time (Wrosch, Dunne, Scheier, & Schulz, 2006; Barlow, Wrosch, Heckhausen, Schulz, 2016). As such, it is particularly important how older adults cope with an age-related shift in these life experiences. Older adults who experience a decline in their resources and opportunities to overcome pressing challenges may not be able to effectively address some of their problems, which could reduce the effectiveness of psychological mechanisms that support goal attainment (e.g., persistence or optimism; Wrosch, Jobin, & Scheier, 2017; Wrosch, Lachman, & Heckhausen, 2000). In such circumstances, the use of self-protective strategies that promote acceptance and disengagement from unattainable goals may be more beneficial (Jobin & Wrosch, 2016). Self-compassion represents such a psychological factor that has been shown to promote the use of self-protective strategies (Allen & Leary, 2010; Perez-Blasco, Sales, Meléndez, & Mayordomo, 2016). It may therefore increase its adaptive health-related function in advanced old age.

Note that the health benefits deriving from self-compassion could also accrue through other pathways. For example, self-compassion may not only promote adaptive coping, but could also facilitate positive health behaviors and reduced biological stress reactivity (Allen, & Leary, 2010; Terry & Leary, 2011; Breines et al., 2014a, b; Friis et al., 2015). In advanced old age,

however, engagement in some health behaviors, such as physical activity, can become increasingly difficult (Bijnen, Feskens, Caspersen, Mosterd, & Kromhout, 1998). Consistent with this possibility, a meta-analysis has demonstrated that the association between self-compassion and health behaviors is reduced as individuals age (Phillips & Hine, 2019). As such, it seems more likely that self-compassion promotes physical health towards the end of life via adaptive coping and reduced stress reactivity. In fact, research on self-compassion interventions in older adult populations has demonstrated increases in self-protective coping strategies, such as positive reappraisal and a reduced negative self-focus (Perez-Blasco et al., 2016). As a consequence, self-compassion could help older adults to accept that certain problems can no longer be resolved and facilitate disengagement from unattainable goals. The psychological benefits of such self-regulation behaviors (Heckhausen, Wrosch, & Schulz, 2019; Wrosch & Scheier, 2020), in turn, could exert downstream consequences on the regulation of hormonal and immune processes that underlie the development of disease (e.g., cortisol or inflammation, Breines et al., 2014a, b; Herriot et., 2018; McEwen, 1998).

We further acknowledge that the predictive patterns observed for older adults' daily physical symptoms and chronic illness were not identical. First, in advanced old age, self-compassion was cross-sectionally associated with fewer daily physical symptoms, but not chronic illnesses, across the 4-year study period. Second, self-compassion predicted fewer longitudinal increases in advanced old age only for chronic illness, but not for daily physical symptoms. To explain these differences in the patterns observed, it may be important to consider that daily physical symptoms may not only reflect manifest chronic illnesses, but can also represent early and sub-clinical signs of a developing disease that could take time before it manifests fully or is diagnosed (Wrosch & Schulz, 2008). With these considerations in mind, it

would be possible that individual differences in self-compassion had an earlier effect on older participants' daily physical symptoms, which plateaued during the observed study period. Further, such earlier and high levels of daily physical symptoms could have contributed to increasing levels of chronic disease during the observed study period, among participants in advanced old age with low self-compassion. This possibility could explain the observed chronically elevated levels of daily health symptoms among individuals in advanced old age with low self-compassion, and their steadily increasing levels of chronic illness.

We also acknowledge that the percentage of variance explained in health outcomes by individual differences in self-compassion was relatively small (1.13 – 3.83 %). However, we would like to note that the difference between low versus high self-compassion in advanced old age translated into one daily physical symptom across the entire study period (see *Figure 1*) and one additional chronic illness after four years of study (see *Figure 2*). Chronic illnesses, such as cardiovascular problems, arthritis, or diabetes, represent pressing health problems and can induce significant distress and disability that can impair an individual's quality of life (Freund & Baltes, 2000; Williamson, & Schulz, 1995; Wrosch & Schulz, 2008). We therefore feel that although the amount of explained variance is relatively small, it could be clinically relevant. In addition, we would like to note that small effects may be a result of the relatively short follow-up of four years. As a result, it would be possible that these effects could be larger when examined over longer periods of time (e.g., ten years) which could provide stronger clinical relevance for supporting health in old age.

Overall, the reported findings have important implications for theories of successful aging. They bolster life-span developmental theories and research, which posit that the function of self-protective psychological factors is age-dependent and becomes increasingly important in

advanced old age (Heckhausen et al., 2019; Jobin & Wrosch, 2016). To this end, our study highlights that a modifiable psychological variable, self-compassion, may be beneficial for both daily and chronic health outcomes as older adults advance in age. Given that daily and chronic illness can further jeopardize older adults' quality of life by eliciting additional distress and causing disability (Freund & Baltes, 2000), our findings point to the importance of fostering adaptive self-regulation factors, like self-compassion, particularly among individuals in advanced old age. Indeed, there is accumulating evidence that older adults experience sharp declines across different areas of life, including physical health, as they approach the end of their lives (Baltes & Smith, 2003; Gerstorf et al., 2013). However, little is known about the psychological factors that could slow down or prevent such losses. To this end, our findings could inform much needed intervention research to improve quality of life in aging populations and reduce exorbitant health care spending currently dedicated to managing daily physical symptoms and chronic health conditions.

While there are many strengths of this study, such as the use of a longitudinal design and a community dwelling older adult sample, there are also some limitations that should be addressed in future research. First, the sample size is relatively small and may not be generalizable to all older adults. Therefore, research should aim to replicate these findings in larger and more diverse samples. Second, we acknowledge that this study focused on self-compassion as a predictor of physical health, and did not examine other broader, potentially protective personality constructs. Since individual difference variables, such as emotional stability, could also contribute to maintaining health in old age (Lahey, 2009), future research should examine a wider array of personality variables. Third, our analysis did not address the mechanisms by which self-compassion promotes physical health. It will be important for future

research to illuminate how self-compassion could promote better health over time. For example, it would be interesting to examine whether certain behaviors in response to stress experiences (e.g., coping or health behaviors) and accruing emotional states could explain the documented associations between self-compassion and physical health outcomes. In addition, changes in biological markers of developing disease (e.g., cortisol or chronic inflammation) could mediate the relations between self-compassion and older adults' daily and chronic health problems. Fourth, although our study controlled for a number of health-relevant covariates (e.g., sex, BMI, or SES), there are additional factors that were not included in our study but could influence physical health. For example, differences in race or ethnicity may play and important role (Mays, Cochran, & Barnes, 2007). From our perspective, it may be the most vulnerable segments of the population that could benefit from self-compassion in old age. Finally, the correlational design of our study cannot determine causality in the association between self-compassion and physical health. Given that self-compassion is a modifiable psychological variable (e.g., Friis, Johnson, Cutfield, & Consedine, 2016; Neff, & Germer, 2013), we think that there is merit for intervention studies to conduct research to help elucidate the causal pathways linking self-compassion and physical health in old age.

## Conclusions

The present study highlights self-compassion as an important psychological factor for older adults' physical health over time. By comparing people in early and advanced old age, the study's results suggest that self-compassion becomes important for protecting daily and chronic health outcomes particularly in advanced old age. These results add to motivational theories of lifespan development and successful aging and have implications for interventions that promote self-compassion as a way to improve the health of the aging population.

# CHAPTER 5:

# GENERAL DISCUSSION

This dissertation aimed to explore the impact of stress experiences on older adults' physical health, and the protective benefits of the psychological factor self-compassion. To accomplish this, three studies were conducted. First, Study 1 (Chapter 2) examined how levels and changes in chronic stress experiences predicted trajectories of diurnal cortisol (AUC and slope) over 12 years. Second, Study 2 (Chapter 3) investigated cross-sectional associations between age-related stress experiences and diurnal cortisol (AUC and slope). Further, this study explored the moderating role of self-compassion as an adaptive stress-buffering factor in older adulthood. Finally, Study 3 (Chapter 4) sought to study the longitudinal health benefits of self-compassion for acute and chronic health problems. In addition, given that motivational life span theories posit that psychological factors which foster self-protection have more adaptive value among those in advanced old age, this study assessed the adaptive value of self-compassion from early to advanced old age. Overall, the described studies represent significant empirical and theoretical contributions towards the literature on successful aging.

## Summary of Research Findings

The three studies in this dissertation provide substantial insight towards the objectives outlined in this introduction. The first objective was "*To examine how acute and chronic stress experiences influence diurnal cortisol patterns.*" Study 1 addressed the associations between chronic stress experiences and longitudinal trajectories of diurnal cortisol (AUC and slope). The results showed that both levels and changes in stress experiences predicted longitudinal trajectories of diurnal cortisol levels and slopes. Older adults who reported higher levels of stress displayed relatively enhanced cortisol at the beginning of the study which declined at a rate

greater than those with lower levels of stress. By the end of the study period, those older adults with higher stress experiences had the lowest cortisol levels. This pattern is consistent with previous meta-analytic research which has shown that more recent/concurrent stress is associated with higher daily cortisol levels, and over longer periods of chronic stress the HPA axis seems to rebound such that cortisol levels (AUC) decline to lower than normal levels (Miller et al., 2007). With regards to cortisol slope, higher stress levels were associated with generally flatter cortisol slopes. Further, individuals with generally high stress levels who also exhibited increases in stress over the course of the study were found to have increasingly flatter cortisol slopes over time. These findings are consistent with past work that have found associations between chronic stress and flatter cortisol slopes (e.g., Hiem et al., 2000; Young et al., 2019) These results represent some of the first longitudinal research that helps understand the direction that chronic stress influences diurnal cortisol patterns long term.

Study 2 also examined cross-sectional associations between various age-related stressors (physical health problems, functional limitations, and regret emotions) and diurnal cortisol. Contrary to our hypotheses, we did not find any main effects of these age-related stressors on participant's cortisol patterns. Compared to our findings in Study 1, this suggests that the acute effects of stress experiences may be less pronounced at a singular time-points, and reliable associations may require longitudinal investigations (e.g., Study 1) to elucidate the influence of stress of diurnal cortisol patterns. Another possible explanation may be that the objective stress (e.g., number of physical health problems/functional limitations) may show less reliable associations with diurnal cortisol, compared to the individual's appraisal of the stressor which may play a larger role in determining the health-related outcomes of stress experiences (Folkman et al., 1986). However, we did conduct supplemental analyses with perceived stress indicators

and did not find associations between daily stress perceptions and diurnal cortisol (See Footnote 1; Study 2). Limitations with this approach still exist, given that such measures of stress perceptions could represent transient stress experiences and/or more chronic stress perceptions that cannot be disentangled in these cross-sectional analyses. Overall, it seems that longer-term studies of stress experiences and diurnal cortisol are required (e.g., Study 1) to elucidate links between stress experiences and diurnal cortisol patterns.

Further, it's possible that short term studies of stress experiences and cortisol may require that researchers include individual difference variables related to self-regulation in tandem with stress perceptions (See obj. 3) which may represent a more sensitive predictor of concurrent stress appraisals (e.g., Kudielka et al., 2009; Liu et al., 2014). As demonstrated in Study 2, self-compassion buffered the effects of age-related stressors on diurnal cortisol levels (AUC) but not cortisol slope. The finding that only high daily cortisol levels were related to stress and self-compassion, but not slope (T6 – MAHS), is consistent with what is observed in baseline values seen in Figure 1-2 (Study 1; T1 – MAHS). In Study 1, higher stress was associated with increased diurnal cortisol levels at baseline, whereas there did not appear to be a discernable difference between cortisol slopes for those with low or high stress levels at baseline. This is similar to the results in Study 2, where cross-sectional effects were found for AUC but not slope. As a reminder, these cross-sectional associations from Study 1 and Study 2 occur at different time points of the MAHS (T1 vs. T6), and only share an overlap of about half the sample. While additional research with larger and more diverse older adult samples will be required, together Study 1 and 2 suggest that concurrent associations between stress may be more likely to be observed with measures of diurnal cortisol levels (AUC), but not slopes. Therefore, the influence of stress on cortisol slopes may be less sensitive and require longer term chronic stress

experiences to produce noticeable changes in the rate that cortisol declines across the day (e.g., longitudinal results from Study 1).

The second objective was "*to examine the longitudinal trajectories of diurnal cortisol in older adulthood."* In other words, this objective aimed to explore how diurnal cortisol patterns may change as a function of age. Study 1 accomplished this aim by utilizing data involving 7 waves in which three non-consecutive days of diurnal cortisol (AUC and slope) were measured. This study found that daily cortisol levels declined on average across all participants over the course of the study. This finding would suggest then that as individuals age, cortisol levels are likely to decrease. However, correlations in Study 1 and 2 (in Study 2—approximately half the participants were not in Study 1, therefore only partial overlap) suggest being older is associated with higher cortisol levels and flatter cortisol slopes. The longitudinal and correlational findings appear to be contradictory to one another. A possible explanation for these disparate findings could be related to the fact that the longitudinal time difference (12 years) is much shorter than the cross-sectional age range (> 35 years). As a result, we could still possibility expect to see a flattening of cortisol slopes if we were to observe these individuals for longer periods of time. Further, an increase of diurnal cortisol may be more likely to occur alongside new stress experiences which are expected to increase in advanced old age (Miller et al., 2007; Heckhausen et al., 2019). As a result, while we may be observing a general decline in cortisol levels related to chronic stress experiences, it does not rule out the possibility that cortisol levels may be enhanced in the future as individuals progress into advanced old age. This could potentially explain why cortisol levels are generally higher in advanced, as compared to early old age, yet both age segments exhibit declines as stress experiences become more chronic. In summary, there is consistency in the correlational associations found in Study 1 and Study 2, which suggest

that diurnal cortisol tends to exhibit enhanced levels and flatter slopes with increasing age. Future research will need longer follow-up and more intensive stress measurements to disentangle the effects of aging (independent of stress experiences) on diurnal cortisol trajectories over time.

The third objective "*To explore the health benefits of self-compassion among older adults, and whether the benefits of self-compassion increase from early to advanced old age*" was explored in Study 2 and 3. First, Study 2 examined cross-sectional associations between self-compassion and diurnal cortisol, as well as the role of self-compassion as a moderator in the association between age-related stressors and diurnal cortisol (AUC and slope). There were no significant main effects of self-compassion predicting diurnal cortisol (AUC or slope). However, Study 2 demonstrated that self-compassion buffered the association between age-related stressors and diurnal cortisol AUC (levels), but not cortisol slope. Study 3 found that across the sample, self-compassion was related to fewer daily physical symptoms.

Study 3 also addressed the latter component of objective 3, which aimed to addressed whether the benefits of self-compassion vary across older adulthood. This component of the objectives was inspired by motivational theories of life-span development (Brandtstädter & Renner, 1990; Freund, & Baltes, 2000; Heckhausen et al., 2019) which posit that shifting self-regulation approaches from strategies which require sufficient opportunities, resources, and energy (e.g., persistence, engagement) to self-protective strategies (e.g., positive reframing, self-compassion) promote adaptation to uncontrollable stressors common in older adulthood (Heckhausen et al., 2019; Jobin, & Wrosch, 2016; Wrosch et al., 2006). Study 3 found that self-compassion was associated with generally less daily physical health symptoms for those individuals in advanced, but not early, old age. In addition, self-compassion protected older

adults in advanced old age (but not early old age) from increases in chronic health problems over two years. Taken together, Study 2 and Study 3 suggest that self-compassion is a beneficial psychological factor for protecting health in older adulthood, and the benefits of self-compassion show enhanced effects in advanced compared to early old age.

While this dissertation did not address the mechanisms in which self-compassion exerts health benefits, such pathways will briefly be considered. Much research has demonstrated that self-compassion promotes positive health behaviours, an association that may be reduced in older adulthood (Phillips & Hine, 2019). Therefore, it's more likely that self-compassion may have facilitated adaptive coping strategies in response to stress, such as acceptance and disengagement of unattainable goals (Allen & Leary, 2010; Perez-Blasco, Sales, Meléndez, & Mayordomo, 2016; Miyagawa, Taniguchi, & Niiya, 2018). Older adults may therefore be more likely to accept that certain problems are unable to be resolved and enhance engagement in reappraisal or disengagement from unattainable goals. This may lead to reduced reactivity to stressful experience that could have downstream consequences on biological processes (e.g., hormonal or immune) that reduce development of disease (Breines et al., 2014a, b; McEwen, 1998).

**Contributions to Theory, Research, and Clinical Applications**

The three presented studies in this dissertation have several implications for theory, research and practice. First, findings from Study 1 extend the present knowledge base on research on stress and cortisol. While past research has found mixed associations between stress and diurnal cortisol levels (e.g., Carroll et al., 2017; Heim et al., 2000; Vedhara et al., 2002; Hiem et al., 2000; McEwen, 1998). There has been some evidence from a meta-analysis which demonstrates the chronicity of stress experiences play a role. This meta-analysis of mostly cross-

sectional research found that cortisol levels were higher in samples that were exposed to concurrent/recent stress experience and rebounded to be below normal in samples that experiences more chronic stressors (Miller et al., 2007). Results from Study 1 provide the first empirical support of this theoretical claim using longitudinal data. Therefore, this study represents a significant contribution to our understanding of how chronic stress experiences can shape diurnal cortisol patterns over time.

This dissertation also added to the literature on cortisol and aging. Previous research on how cortisol patterns change as individuals advance in age have been mixed (e.g., Adam et al., 2006; Dmitrieva et al., 2013; Evans et al., 2011; Gaffey et al., 2016; Nater et al., 2013 Brandtstädter et al., 1991; Evans et al., 2011; Heaney et al., 2012). The discussion of obj. 2 (Study 1 and Study 2) provided some preliminary evidence that diurnal cortisol tends to exhibit increases in levels and flatter slopes with increasing age. However, there were conflicting longitudinal findings that will require more extensive and long-term studies to fully elucidate the influence of aging on diurnal cortisol patterns. Study 1 also has significant clinical health related implications for aging. Research has shown that older adults are more likely to display HPA axis dysregulation that is believed to influence cognitive decline, depression, morbidity, and mortality (Conrad & Bimonte- Nelson, 2010; Murri et al., 2014; Heim et al., 2000, Kumari et al., 2011; Gaffey et al., 2016; Nater et al., 2013; Nicolson et al., 1997; Otte et al., 2005). Given that Study 1 has shown the marked effects that stress can have on cortisol dysregulation this research highlights the importance of targeting at-risk older adults to prevent stress-related health problems from developing.

This research also adds significantly to the motivational life-span development theories and research on successful aging. These theories highlight that the adaptive nature of certain self-

regulation factors exhibits an age-dependent relationship. When individual's age there is an increase in uncontrollable stressors and a reduction of resources and opportunities to overcome these stressors (Brandtstädter & Rothermund, 2002; Heckhausen et al., 2019; Freund & Baltes, 2000). Not only do we notice these changes as individuals reach early old age (i.e., 60+), but the experience of intractable stressors continues to increase even more so well into advanced old age (85+). These changes can contribute to poor and declining health among those in the oldest age groups. However, there is a paucity of work which has explored how those in the oldest-old age groups can prevent these adverse changes (Baltes, & Smith, 2003). The present research informs this area by suggesting that strategies which involve self-protection (e.g., positive reframing, acceptance, disengagement) are more adaptive in this life phase. Study 2 and 3 add to this literature by supporting the benefits of self-compassion as a form of self-protection that is generally more adaptive for the types of stressors experienced in old age (Allen & Leary, 2010; Perez-Blasco, Sales, Meléndez, & Mayordomo, 2016). In addition, this theory highlights that across old age, such factors become more adaptive in advanced old age compared to early old age (Heckhausen et al., 2019). Study 3 found support for this theory, self-compassion is increasingly beneficial for health among those in advanced, compared to early old age. These findings are consistent with other research that has found similar changes in the benefits of self-regulation factors in older adulthood (Wrosch, Jobin, & Scheier, 2017; Wrosch, Heckhausen, & Lachman, 2000).

Finally, Study 2 and 3 highlight the clinical and practical implications of self-compassion for protecting older adult's health. Older adulthood is characterized by a decline in physical health (Baltes & Smith, 2003; Gerstorf et al., 2013). Research studying the psychological factors that promote adaption to the irrevocable losses and declines in older adulthood is understudied

and deserves more attention. Self-compassion represents such a factor that promotes successful aging and is a modifiable psychological factor that can be increased with clinical intervention (Neff & Germer, 2013). Therefore, the next step will be for research to conduct clinical interventions of self-compassion to determine potential causal influences on protecting health in older adulthood. Until then, this dissertation still provides evidence warranting the promotion of self-compassion among at-risk older adults for practitioners who work with older adults.

**Limitations and Future Directions**

While there are several strengths of the research presented in this dissertation there are limitations of the present research that should be acknowledged. First, the research conducted involves a moderately small sample of community-dwelling older adults collected from Montreal, QC. Therefore, the generalizability of these findings may not extend to all older adults. Future research should collect larger samples involving diverse (i.e., racial, ethnic, and socioeconomic) demographics. For example, there could be cultural differences that the present research was unable to elucidate given the smaller sample size and largely Caucasian sample.

Another strength of Study 1 and 3 was the use of longitudinal data. However, it is also important to note the second limitation of this dissertation which relates to the attrition that occurred in both of these studies. This is an unfortunate common occurrence in research among older adults due to the relatively higher rates of significant illness, cognitive declines, and mortality that occur in this population. As a consequence, it is also possible therefore that older adults in our study may be more likely to represent “happy survivors” that limits that generalizability of our research findings to the older adult population (Segerstrom et al., 2016). Future research should aim to examine differential mortality curves by imputing data for deceased participants to explore whether trajectories of health for those with early mortality.

Another limitation that is relevant to Study 1 and Study 2, is related to our measure of stress. Although perceptions of stress (Study 1), and indicators of age-related stress experiences (Study 2) are useful in determining an individual's circumstance, it would be important to include more detailed measures of stress which identify characteristics of the stress experience that are known to exacerbate the effects of stress. For example, including measures of stress severity, controllability, and constraints would allow for more comprehensive measures of an individual's stress experience. We would expect that stressors with higher amounts of severity, uncontrollability, and reduced constraints would be those most likely to trigger dysregulation of cortisol rhythms and lead to poor health long-term (Miller et al., 2007; Heckhausen et al., 2019). In addition, adding measures that help determine relative start and end dates of stress experiences could add to assessing the relatively chronicity of the stress experience (Miller et al., 2007).

A final limitation of this dissertation is the use of a self-report scale measuring self-compassion which can only determine associations between self-compassion and health on a correlational basis (Study 2 and 3). Without an intervention aimed at changing self-compassion levels, we are unable to determine a causal relationship between self-compassion and health. To provide more causal evidence it will be important for future research to conduct randomized controlled trials assessing effects of self-compassion interventions among older adult populations. Interventions among young-middle aged populations have been able to produce significant increases in self-compassion (see Neff & Germer, 2013). Such research could provide causal evidence of the benefits of self-compassion in older adulthood which could be translated into practical applications for the general older adult population.

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# APPENDIX A

## Consent Form – Montreal Aging and Health Study

# CONSENT FORM TO PARTICIPATE IN RESEARCH

This is to state that I agree to participate in a program of research being conducted by Dr. Carsten Wrosch of the Psychology Department of Concordia University.

**A. PURPOSE**

I have been informed that the purpose of the research is to study older adults' goal management, wellbeing,
and health.

**B. PROCEDURES**

This research will involve a questionnaire and 15 salivary cortisol samples collected over the course of three typical days. It also involves collecting some blood drops. A research assistant will go to the participant's home to administer part of a questionnaire on goal management, well-being and health, explain the saliva collection procedure, and collect the blood drops. The rest of the questionnaire will be filled in by the participant while alone and should take approximately one hour to complete. The saliva collection will involve chewing a provided cotton swab for one minute before placing it in its salivette. The saliva collection will be performed five times a day at specific times. The participant will receive phone calls from the research assistant to remind him/her to take a salivary cortisol sample. The blood drops will be collected by the trained research assistant using a finger-prick with a small lancet. The participant will receive $70 for participating in the study.

There should be no risks or discomfort involved in answering the questions or collecting the salivary cortisol samples. Collection of the blood drops should also involve no risk and should not be painful. The participant's name will not be attached to the questionnaire, although the signatures and names on the consent forms will be collected and stored separately by the supervising professor. The participant is free to refuse to participate in any portion of the study or to answer any question that makes him or her uncomfortable.

**C. CONDITIONS OF PARTICIPATION**

• I understand that I am free to withdraw my consent and discontinue my participation at anytime without negative consequences. Even if I discontinue my participation, I will receive $70.

• I understand that my participation in this study is CONFIDENTIAL (i.e., the researcher will know, but will not disclose my identity)

• I understand that the data from this study might be published.

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY.

NAME (please print) _____

SIGNATURE _____

WITNESS SIGNATURE _____ DATE _____

# APPENDIX B

## Assessment of Sociodemographic Variables

# Personal information

1. **Sex :** Female Male

2. **Age** yrs.

3. **Family Status?**

   married
   live with partner but not married
   single
   divorced; please indicate since when _____
   widowed; please indicate since when _____

4. **Working status:** Retired Still working Never worked outside the house

5. **Profession (before retirement) _____**

6. **Current Family income (per year):**

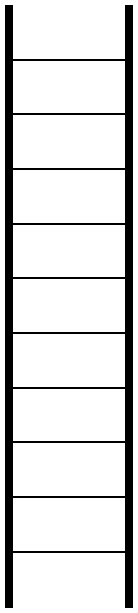
| | | |
|---|---|---|
| Less than 17 000$ | 17 001$ - 34 000$ | 34 001$ - 51 000$ |
| 51 001$ - 68 000$ | 68 001$ - 85 000$ | more than 85 000$ |

7. **Height:** _____

8. **Body weight:** _____

# SES and Finances

1. **Think of this ladder as representing where people stand in our society. At the top of the ladder are the people who are the best off, those who have the most money, most education, and best jobs. At the bottom are the people who are the worst off, those who have the least money, least education, and worst jobs or no job. Please, place an X on the rung that best represents where you think you stand on the ladder?**



2. **Using a scale from 0 to 10 where 0 means " the worst possible financial situation" and 10 means " the best possible financial situation," how would you rate your financial situation these days?**

**Worst**

**Best**

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

# APPENDIX C

## Assessment of Health Variables

**Acute Physical Symptoms**

Please check the box in the column "Yes" if you experienced the symptom often in the last month, **"**No" if you did not.

| **During the past month, have you often been bothered by…….** | **YES** | **NO** |
|---|---|---|
| 1. Stomach pain | | |
| 2. Back pain | | |
| 3. Pain in your arms, legs or joints (knees, hips, etc.) | | |
| 4. Pain or problems during sexual intercourse | | |
| 5. Headaches | | |
| 6. Chest pain | | |
| 7. Dizziness | | |
| 8. Fainting Spells | | |
| 9. Feeling your heart pound or race | | |
| 10. Shortness of breath | | |
| 11. Constipation, loose bowels, or diarrhea | | |
| 12. Nausea, gas or indigestion | | |

**Chronic Illness**

# Physical Health

Please answer the following questions about your physical health.

| | **NO** | **YES** | **NOT SURE** |
|---|---|---|---|
| 1. Do you currently have high blood pressure? | | | |
| 2. Do you currently have problems with an irregular heartbeat or chest pain? | | | |

| | | | |
|---|---|---|---|
| 3. Have you ever been told that you have coronary heart disease or coronary artery disease? | | | |
| 4. Have you ever had a heart attack? | | | |
| 5. Have you ever been treated for congestive heart failure? | | | |
| 6. Have you ever had major surgery?<br>(IF YES:) What? _____ | | | |
| 7. Have you ever had a stroke? | | | |
| 8. Do you currently have osteoarthritis, fibromyalgia, osteoporosis, or any other serious muscular or bone problem? | | | |
| 9. Do you currently have asthma, emphysema, chronic bronchitis, chronic obstructive lung disease, or any other serious respiratory problems? | | | |
| 10. Do you currently have stomach ulcers, irritable bowel syndrome, or any other serious problems with your stomach or bowels? | | | |
| 11. Do you have diabetes? | | | |
| 12. Do you currently have problems with your kidneys? | | | |
| 13. Do you have cirrhosis or any other serious liver problems? | | | |
| 14. Do you currently have cancer?<br>(IF YES:) What type? _____ | | | |
| 15. Do you currently have rheumatoid arthritis, lupus, acquired immune deficiency syndrome, multiple sclerosis, scleroderma, or any other autoimmune problem? | | | |

# Physical Health (cont'd)

| | NO | YES | NOT SURE |
|---|---|---|---|
| 16. Do you currently have problems with blood circulation in your legs, hemophilia, or any other blood-related problems? | | | |
| 17. Do you have epilepsy or any other neurological problems? | | | |

| | | | |
|---|---|---|---|
| 18. Do you currently have an overactive or underactive thyroid, or any other thyroid problems? | | | |
| 19. Do you currently have any problems with your vision or hearing? | | | |
| 20. Do you currently have asthma, bronchitis, or emphysema? | | | |
| 21. Do you currently have persistent skin trouble (e.g., eczema)? | | | |
| 22. Do you currently have recurring stomach trouble, indigestion, or diarrhea? | | | |
| 23. Do you currently have migraine headaches? | | | |
| 24. Are you constipated all or most of the time? | | | |
| 25. Do you have chronic sleeping problems? | | | |
| 26. Do you currently have any other health problems that I have not asked you about?<br>(IF YES:) What? _____ | | | |

# APPENDIX D

## Assessment of Diurnal Cortisol – Salivary Collection Times

# DAY 1

Date: _____

Please record the exact time when you took your saliva sample.

| |
|---|
| **1st Saliva Sample:** ***(Label: 1-1)*** <br> I woke up at _____ h _____ min |
| **2nd Saliva Sample:** ***(Label: 1-2)*** <br> Exact time : _____ h _____ min |
| **3rd Saliva Sample:** ***(Label: 1-3)*** <br> Exact time : _____ h _____ min |
| **4th Saliva Sample:** ***(Label: 1-4)*** <br> Exact time : _____ h _____ min |
| **5th Saliva Sample:** ***(Label: 1-5)*** <br> Exact time : _____ h _____ min |

*After the last saliva sample of the day, please respond to the questions on the back of this page.*

# DAY 2

Date: _____

Please record the exact time when you took your saliva sample.

| |
|---|
| **1st Saliva Sample:** ***(Label: 2-1)*** <br> I woke up at _____ h _____ min |
| **2nd Saliva Sample:** ***(Label: 2-2)*** <br> Exact time : _____ h _____ min |
| **3rd Saliva Sample:** ***(Label: 2-3)*** <br> Exact time : _____ h _____ min |
| **4th Saliva Sample:** ***(Label: 2-4)*** <br> Exact time : _____ h _____ min |
| **5th Saliva Sample:** ***(Label: 2-5)*** <br> Exact time : _____ h _____ min |

*After the last saliva sample of the day, please respond to the questions on the back of this page.*

# DAY 3

Date: _____

Please record the exact time when you took your saliva sample.

| |
|---|
| **1st Saliva Sample:** ***(Label: 3-1)*** <br> I woke up at _____ h _____ min |
| **2nd Saliva Sample:** ***(Label: 3-2)*** <br> Exact time : _____ h _____ min |
| **3rd Saliva Sample:** ***(Label: 3-3)*** <br> Exact time : _____ h _____ min |
| **4th Saliva Sample:** ***(Label: 3-4)*** <br> Exact time : _____ h _____ min |
| **5th Saliva Sample:** ***(Label: 3-5)*** <br> Exact time : _____ h _____ min |

# APPENDIX E

## Assessment of Daily Stress

# DAY 1 (cont'd)

To what extent did you experience each of the following emotions today? Check the appropriate box next to the emotion.

| | Very slightly or not at all | A little | Moderately | Quite a bit | Extremely |
|---|---|---|---|---|---|
| 1. Lonely | | | | | |
| 2. Stressed | | | | | |
| 3. Sad | | | | | |
| 4. Upset | | | | | |
| 5. Hostile | | | | | |
| 6. Isolated | | | | | |
| 7. Overwhelmed | | | | | |
| 8. Unhappy | | | | | |
| 9. Angry | | | | | |

# DAY 2 (cont'd)

To what extent did you experience each of the following emotions today? Check the appropriate box next to the emotion.

| | Very slightly or not at all | A little | Moderately | Quite a bit | Extremely |
|---|---|---|---|---|---|
| 1. Lonely | | | | | |
| 2. Stressed | | | | | |
| 3. Sad | | | | | |
| 4. Upset | | | | | |
| 5. Hostile | | | | | |
| 6. Isolated | | | | | |
| 7. Overwhelmed | | | | | |
| 8. Unhappy | | | | | |
| 9. Angry | | | | | |

# DAY 3 (cont'd)

To what extent did you experience each of the following emotions today? Check the appropriate box next to the emotion.

| | **Very slightly or not at all** | **A little** | **Moderately** | **Quite a bit** | **Extremely** |
|---|---|---|---|---|---|
| 1. Lonely | | | | | |
| 2. Stressed | | | | | |
| 3. Sad | | | | | |
| 4. Upset | | | | | |
| 5. Hostile | | | | | |
| 6. Isolated | | | | | |
| 7. Overwhelmed | | | | | |
| 8. Unhappy | | | | | |
| 9. Angry | | | | | |

# APPENDIX F

## Assessment of Self-Compassion

# Describe Yourself

The questions in this scale ask you how you typically act towards yourself in difficult times. Please read each statement carefully before answering and indicate for each item how often you behaved in the stated manner

| **How I typically act towards myself in difficult times …** | **Never** | **Almost Never** | **Some-times** | **Fairly Often** | **Very Often** |
|---|---|---|---|---|---|
| 1. When I fail at something important to me, I become consumed by feelings of inadequacy. | | | | | |
| 2. I try to be understanding and patient towards those aspects of my personality I don't like. | | | | | |
| 3. When something painful happens, I try to take a balanced view of the situation. | | | | | |
| 4. When I'm feeling down, I tend to feel like most other people are probably happier than I am. | | | | | |
| 5. I try to see my failings as part of the human condition. | | | | | |
| 6. When I'm going through a very hard time, I give myself the caring and tenderness I need. | | | | | |
| 7. When something upsets me, I try to keep my emotions in balance. | | | | | |
| 8. When I fail at something that's important to me, I tend to feel alone in my failure | | | | | |
| 9. When I'm feeling down, I tend to obsess and fixate on everything that's wrong. | | | | | |
| 10. When I feel inadequate in some way, I try to remind myself that feelings of inadequacy are shared by most people. | | | | | |
| 11. I'm disapproving and judgmental about my own flaws and inadequacies. | | | | | |
| 12. I'm intolerant and impatient towards those aspects of my personality I don't like. | | | | | |

# APPENDIX G

## Assessment of Activities of Daily Living

# Activities of Daily Living

Please answer the following questions regarding your daily chores. Place a check under "No" if you do not experience any difficulty with the specific chore. If you do experience some difficulty with that chore, we would like you to first evaluate the amount of: **1)** difficulty completing the chore; **2)** physical strain involved; **and 3)** emotional strain experienced with this chore, using the scale below. Please write the corresponding number under each of the "yes" columns.

**1 = very slightly or not at all**
**2 = a little**
**3 = moderately**
**4 = quite a bit**
**5 = extremely**

| **Because of health or physical problems, do you have any difficulty or are you unable:** | No | **Yes** | | |
|---|---|---|---|---|
| | | **Difficulty** | **Physical strain** | **Emotional strain** |
| 1. to eat, including feeding yourself? | | | | |
| 2. to dress yourself? | | | | |
| 3. to bathe or shower? | | | | |
| 4. to use the toilet including getting to the toilet? | | | | |
| 5. to walk around the home? | | | | |
| 6. to get in and out of a bed or a chair? | | | | |
| 7. to do heavy housework, like scrubbing floors or washing windows, or yard work, like raking leaves or mowing? | | | | |
| 8. to do light housework? | | | | |
| 9. to do shopping for personal items? | | | | |
| 10. to prepare meals? | | | | |
| 11. to manage money, such as paying bills? | | | | |
| 12. to use the phone? | | | | |

# APPENDIX H

## Assessment of Life Regrets

# Life Regrets

*People make a lot of important decisions during their lives and they sometimes think that they should have done something differently than they did. For example, a person may believe that she/he would be better off today if she/he had behaved in a different way in the past. In such situations, people might regret their behaviours. In addition, they often want the negative consequences of their behaviours to be undone.*

Life regrets might result from things that people <u>have done</u> (e.g., having pursued a fruitless goal) and from things that people <u>have not done</u> (e.g., not having pursued a certain goal) across a number of different life domains (e.g., work, family, spouse, health). Regrets are related to decisions in people's daily lives (e.g., not having visited a friend) and to people's long-term development (e.g., having pursued inappropriate career goals).

Please think for a moment about your life. Is there anything in your life that you regret having done or not having done? Please think about your regrets and write down your most severe life regret.

_____

_____

**1.** We would like to ask you some specific questions concerning the regret that you have noted.

1. Does the regret that you have noted relate to a behaviour ☐ that you have done ☐ that you have *not* done
2. When did the behaviour occur that has lead to the regret? (please try to indicate the exact number of months and years ago that the event occurred)

   _____ months ago _____ years ago
3. How likely is it that the negative consequences of the event <u>can</u> in fact be undone?

| **Very Unlikely** | | | | **Very Likely** |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |
| 1 | 2 | 3 | 4 | 5 |

4. How likely is it that the negative consequences of the event <u>will</u> in fact be undone?

| **Very Unlikely** | | | | **Very Likely** |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |
| 1 | 2 | 3 | 4 | 5 |

5. How much effort do you invest in undoing the negative consequences of the event?

| **No Effort at all** | | | | **A Lot of Effort** |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |
| 1 | 2 | 3 | 4 | 5 |

6. How strongly are you committed to undoing the negative consequences of the event?

| **Not at all Committed** | | | | **Very Much Committed** |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |
| 1 | 2 | 3 | 4 | 5 |

# Life Regrets (cont'd)

**2.** People usually experience different emotions when they think about their regrets. We would like to ask you to what extent you usually experienced the following emotions **during the past few months** when and if you thought about the regret that you noted.

| | **Not at all** | **A little** | **Somewhat** | **Quite a bit** | **Extremely** |
|---|---|---|---|---|---|
| 1. Sorrow | | | | | |
| 2. Angry | | | | | |
| 3. Sentimental | | | | | |
| 4. Desperate | | | | | |
| 5. Irritated | | | | | |
| 6. Nostalgic | | | | | |
| 7. Helpless | | | | | |
| 8. Embarrassed | | | | | |
| 9. Contemplative | | | | | |

**3.** Below is a list of comments made by people who experienced life regrets. Please indicate how frequently these comments were true for you **during the past few months** by checking the appropriate box.

| | **Not at all** | **Rarely** | **Sometimes** | **Often** |
|---|---|---|---|---|
| 1. I had trouble falling asleep because I couldn't stop thinking about the regret. | | | | |
| 2. I woke up at night thinking about the regret. | | | | |
| 3. I had difficulty concentrating on my work or daily activities because thoughts about the regret kept entering my mind. | | | | |
| 4. Once I start thinking about the regret I find it hard to think about (focus my attention on) other things. | | | | |
| 5. Thoughts about the regret interfered with my ability to enjoy social or leisure activities. | | | | |