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Predictors of hair cortisol concentrations in older adults

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Summary People at older ages are at increased risk for developing stress-related diseases associated with chronically elevated cortisol secretion. However, the main factors contributing to such endocrine alterations in this age group are still largely unknown. This cross-sectional study examined patterns of long-term integrated cortisol secretion, as assessed in hair, in a sample of 654 participants in middle and old adulthood (mean age: 65.8 years; range: 47—82 years) from the German cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC) study in Potsdam. Hair cortisol concentrations (HCC) were determined from the first scalp-near 3 cm hair segment and several sociodemographic, lifestyle, anthropometric, disease-related, and psychological parameters were assessed. In simple linear regressions, HCC were found to increase with participants' age and to be higher in men compared to women. HCC also showed positive associations with waist-to-hip ratio, waist circumference, smoking, prevalent type 2 diabetes mellitus, mental health, daytime sleeping, and being unemployed or retired—as well as a negative association with diastolic blood pressure. After full mutual adjustment, only age and smoking remained independent predictors of HCC. The association between prevalent type 2 diabetes mellitus and HCC was attenuated but still persisted independently in women. Similar, a positive relationship between HCC and alcohol consumption was found in women. The current results confirm previous evidence of positive associations of HCC with age, sex, alcohol consumption, and type 2 diabetes mellitus and add new knowledge on factors—such as smoking—that may contribute to elevated cortisol levels in people at older ages.

1. Introduction

Long-term changes to the secretion of the glucocorticoid hormone cortisol, such as under conditions of chronic stress,

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are well-known to be associated with a range of diseases, including cardiometabolic and autoimmune diseases, as well as mental disorders (Chrousos, 2009). This particularly applies to older people who are at increased risk for these conditions and have often been found to exhibit chronically elevated cortisol levels (e.g. Laughlin and Barrett-Connor, 2000; Larsson et al., 2009). Previous research has identified a number of potential determinants of age-associated hypercortisolism in the elderly, including health status (e.g. Adam et al., 2006), physical functioning (Kumari et al., 2010), lifestyle-related factors (e.g. Badrick et al., 2008), central adiposity (Steptoe et al., 2004), as well as a wide range of psychosocial factors, including depressive symptoms (Penninx et al., 2007), loneliness (Hackett et al., 2012), sadness, anger, or lack of control (Adam et al., 2006).

Previous endocrine research in middle and old adulthood has mostly relied on cortisol assessments in saliva and blood. While these methods accurately reflect acute changes in cortisol levels, they are not well-suited for capturing long-term cortisol alterations as their results are easily confounded by situational factors or insufficient compliance with sampling times (e.g. Kudielka et al., 2003). As age-associated factors are likely to manifest in persistent long-term changes to cortisol secretion, the use of a more stable assessment method may be advantageous. Here, recent evidence on the measurement of cortisol in human hair is of particular interest. Through continuous incorporation of cortisol into growing hair, hair cortisol concentrations (HCC) are assumed to mainly reflect integrated cortisol secretion over periods of several months (see Russell et al., 2012; Stalder and Kirschbaum, 2012). Considerable evidence now supports the general validity (Kirschbaum et al., 2009; Thomson et al., 2010; Manenschijn et al., 2011a) and test–retest reliability (Stalder et al., 2012b) of this method as well as its robustness to a range of hair-related factors (Dettenborn et al., 2012).

To date, only a small number of studies have examined HCC in relation to aging. Evidence for increasing HCC with older age has emerged from a study covering a wide range of ages (Dettenborn et al., 2012) and from a recent investigation in a large sample of working people (Stalder et al., 2013) but was not observed by other research (e.g. Raul et al., 2004; Dettenborn et al., 2010; Manenschijn et al., 2011a; Stalder et al., 2012a). Similarly, previous investigations into the role of participants' sex on HCC, as an important factor associated with endocrine functioning as well as with health risk, were mostly conducted in younger populations, revealing no sex differences in HCC (e.g. Raul et al., 2004; Thomson et al., 2010; Manenschijn et al., 2011a; Stalder et al., 2013) or suggesting lower HCC in women than in men (Dettenborn et al., 2012; Manenschijn et al., 2013). Interestingly, Dettenborn et al. (2012) found sex differences in HCC only in middle-aged adults but not in the elderly, pointing toward a potential role of changing sex steroid levels with aging. By contrast, a recent investigation found lower HCC in women within an older study sample (Manenschijn et al., 2013).

Research examining other correlates of HCC was also frequently carried out in younger populations, potentially limiting transferability of these findings to older people. Here, particularly associations of HCC with body fat-related anthropometric measures (Manenschijn et al., 2011a, 2011b; Stalder et al., 2012a, 2013), the metabolic syndrome (Stalder et al., 2013), cardiovascular risk (Manenschijn et al., 2013), or myocardial infarction (Pereg et al., 2011) have been highlighted. Findings have been more inconsistent regarding HCC relationships with psychosocial stress, with most evidence pointing toward elevations of HCC in persons exposed to stressful conditions (Staufenbiel et al., 2013) but showing less consistent associations with self-reported stress (see Stalder and Kirschbaum, 2012). Finally, previous research has not found HCC to be related to smoking status, oral contraceptive use or overall medication intake (Dettenborn et al., 2012).

Within the framework of the above evidence, the current study set out to investigate age-related changes of HCC in a large population of middle and old adulthood. To gain insight into determinants of long-term cortisol secretion in older age, relationships of HCC with a range of sociodemographic, lifestyle, disease-related, and psychological parameters were examined.

2. Methods

2.1. Study population, design and procedure

The present sample was drawn from a substudy of the German cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC) study, a large multi-center prospective cohort study investigating associations between diet, lifestyle and chronic disease risk (German EPIC cohort: Boeing et al., 1999; EPIC: Riboli et al., 2002). The current substudy was conducted between the years 2010 and 2012 and employed a cross-sectional design. For this study, individuals residing in the wider Potsdam area were randomly selected from the main cohort with attention being paid to maintain an approximately uniform sample spread and sex-distribution across the examined age range. Individuals were invited to visit the study center at the German Institute of Human Nutrition where hair samples were obtained and physical examinations as well as inquiries on diet, physical activity, and psychosocial factors were conducted. These data were obtained from a total of 815 individuals. Of these, participants were excluded if they exhibited hair shorter than 3 cm at the posterior vertex region at the back of the head ($n = 80$), reported recent use of glucocorticoid-containing treatments ($n = 44$), refused to provide a hair sample ($n = 1$) or provided a hair strand of insufficient volume for cortisol analysis ($n = 10$). Thus, the final sample (prior to statistical exclusion; see below) comprised 680 participants (369 women) aged between 47 and 82 years. The study protocol was approved by the ethics committee of the Medical Association of the State of Brandenburg and written informed consent was obtained from all participants.

2.2. Hair cortisol analysis

Hair strands of a diameter of approximately 3 mm were taken as close as possible to the scalp from a posterior vertex position using fine scissors. Cortisol concentrations were determined from the first 3 cm hair segment proximal to the scalp. Based on a hair growth rate of ~1 cm/month (Wennig, 2000), this hair segment is assumed to reflect hair growth over the three-month period prior to hair sampling. Washing and steroid extraction followed the protocol