



Associations between hair cortisol concentration, income, income dynamics and status incongruity in healthy middle-aged women



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ARTICLE INFO

Article history:

Received 16 December 2015

Received in revised form 9 February 2016

Accepted 10 February 2016

Keywords:

Hair cortisol

Stress biomarkers

Income

Education

Status incongruity

ABSTRACT

A body of research demonstrates that financial disadvantage is associated with general health inequalities and higher mortality rates. Most studies make use of cross-sectional analyses, although income can also be viewed as a dynamic concept. The use of endocrine-markers as proxies for health can provide information about the pathways involved in these associations. Hair cortisol analysis has been developed as a method for assessing sustained cortisol output as it provides an estimate of cumulative cortisol secretion over a prolonged time. The present study assessed income and income trajectory over a 4-year period in 164 working women (aged 26–65) in relation to hair cortisol in a longitudinal design. A negative association between hair cortisol and concurrent income was found ($p = 0.025$) and hair cortisol and changes in income over 4 years ($p < 0.001$), after adjustment for age, BMI, smoking status, hair treatment and country. Status incongruity, a mismatch between educational status and income group, was related to higher cortisol levels compared with status congruity ($p = 0.009$). These findings suggest that psychoneuroendocrinological pathways might partially explain the relationship between lower socio-economic status and adverse health outcomes. Future longitudinal research using hair cortisol analysis is warranted to clarify the time course of social mobility in relation to long-term cortisol, to investigate other underlying psychosocial factors implicated in these associations, and to determine the exact health implications of the neuroendocrine perturbations in individuals with limited economic resources.

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1. Introduction

During the past three decades, widening income inequality in many developed countries has become a major problem. Highlighting the importance of socio-economic factors in relation to health, research in various European countries demonstrates that financial disadvantage leads to many types of health inequality, including higher mortality and morbidity rates (Marmot, 2002). Financial stability is a critically important life domain as many essential daily activities and opportunities for education, realisations and achievements are dependent on existing financial resources. Self-report measures of health outcomes and status have often been used to evaluate the link between income and health, but they might underestimate the true negative socioeconomic

inequalities of health (Baker et al., 2004). Research has shown that there can be striking discrepancies between subjectively reported health outcomes and objectively measured biological markers or health conditions, and that education and income may contribute to erroneous reporting of health outcomes (Johnston et al., 2009; Mackenbach et al., 1996). The use of more objective measures, such as endocrine, metabolic or immune markers as proxies for health may improve the reliability of such findings and provide information about the pathways mediating these associations.

Most studies have examined income as a static phenomenon, making use of cross-sectional data (Gunasekara et al., 2011). However, income status can also be regarded as a dynamic entity, and the effect of changes over time might further inform the relationship between accumulated economic adversity, exposure to stressors and health. Cumulative socioeconomic disadvantage and social downward mobility over the life course have been shown to be related to cardiovascular disease mortality, but the underlying pathways between these factors are poorly understood (Johnson-Lawrence et al., 2015). Further, changes in the labour market, including job insecurity and downward social

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mobility, have created the phenomenon of status incongruity. People whose occupational position is lower than might be expected from their educational attainment and those whose status is greater than might be expected from their education can be regarded as experiencing status incongruity. Status incongruity has long been established to be linked to health outcomes (Braig et al., 2011). Longitudinal studies making use of objective biomarkers offer the possibility of investigating the effects of cumulative socioeconomic disadvantage, income trajectories and status incongruity on health.

One mechanism potentially linking socioeconomic status (SES) and health is the psychoneuroendocrine pathway and the involvement of stress-related cortisol responses (Lupien et al., 2001). A body of research has suggested a link between lower income and higher salivary and urinary cortisol levels (Dowd et al., 2009; Jimenez et al., 2015). Lower income and education have also been associated with elevated diurnal cortisol values and with flatter diurnal rhythms in a graded fashion (Cohen et al., 2006). But although low income has been found to be predominantly associated with elevated cortisol, there are contradictory findings, partly due to variations in methodology and cortisol assessments, i.e. cortisol reactivity levels, diurnal levels or morning values (Dowd et al., 2009).

Psychoneuroendocrinological research has predominantly used saliva, blood and urine for cortisol assessment. Assays of cortisol from these sources reflect momentary cortisol concentrations at the time of sampling rather than sustained levels and are influenced by timing, the collection method and handling plus a variety of situational factors such as diet, sleep patterns, environmental stressors, acute psychological states and participant adherence (Hansen et al., 2008; Kudielka et al., 2003). In the last decade, there has been a steep rise in studies using hair as a source for cortisol analyses, with many results mirroring findings from the saliva cortisol literature and thus demonstrating its utility as a measure of HPA axis function (Raul et al., 2004; Stalder and Kirschbaum, 2012; Staufenbiel et al., 2013). Hair cortisol has been associated with numerous adversities or stress-related conditions, such as pregnancy (D'Anna-Hernandez et al., 2011), chronic pain (Van Uum et al., 2008), dementia caregiving (Stalder et al., 2014) or unemployment (Dettenborn et al., 2010), with chronic illnesses, such as diabetes (Feller et al., 2014), asthma (Kamps et al., 2014) and also obesity (Veldhorst et al., 2014). Studies relating hair cortisol with psychiatric illnesses and perceived stress have produced somewhat inconsistent results (Herane Vives et al., 2015; Sharpley et al., 2012; Staufenbiel et al., 2013).

The relationship between financial status (income) and hair cortisol is not well studied. The only study to date reported elevated hair cortisol in participants earning less than the minimum wage in different communities in sub-Saharan Africa (Henley et al., 2014). Some mixed evidence also exists for the effect of parental income on children's hair cortisol levels (Bosma et al., 2015). While one study found support for a negative association between parental income and pre-schooler's hair cortisol levels, another study found lower maternal and paternal education but not income per se to be linked with elevated hair cortisol levels, supporting the notion that different measures of SES might associate differently and that methodological variations lead to heterogeneous findings (Henley and Koren, 2014; Vaghri et al., 2013). Trajectories over time in income have not been studied at all, although our group previously showed changes in salivary cortisol in relation to changes in financial strain over 3 years (Steptoe et al., 2005). The protective effect of upward social mobility on different health outcomes, including cardiovascular disease mortality risk, is well documented, but no study has evaluated this phenomenon in relation to hair cortisol. There is therefore a sound rationale for exploring socioeconomic factors in relation to this long-term cortisol marker. The aims of the study were therefore to investigate hair cortisol concentration in relation to concurrent income, income change over a 4 year period,

education and status incongruity in a healthy sample of women. We hypothesised that lower income and a negative shift in income over four years would predict higher hair cortisol levels, and that lower education and status incongruity would also show an association with elevated hair cortisol.

2. Method

2.1. Participants, procedure and study design

The Daytracker Study involved healthy working women aged 26–65 years employed at the University College London (UCL) and neighbouring institutions in London and at Semmelweis University in Budapest. The study involved assessment of a range of psychosocial factors, emotional experience and biomarkers in two contrasting cultures, and data were collected in 2007–2008. Participants were re-contacted via email, telephone, LinkedIn and Facebook four years later in 2012 for the present follow-up study by the study researchers at both sites. Exclusion criteria were pregnancy, chronic or acute medical conditions, e.g. cardiovascular disease or cancer, or regular intake of steroid medication, as these factors are known to affect cortisol secretion. Of the 199 London sample, 68 women took part in the follow-up assessment (33 were excluded due to missing baseline information or contact details and 14 because of ineligibility upon contact, 4 refused, 10 could not be scheduled and 70 were otherwise not contactable due to invalid e-mail addresses, non-delivery of e-mails or non-responsiveness). Of the 202 Budapest sample, there were 97 women who were followed-up (20 were excluded because of ineligibility upon contact, 7 refused, 11 could not be scheduled, 1 person died and 66 were not contactable). Participants did not differ from those who did not take part on any of the socio-demographic (education, income), health-related and anthropometric factors (smoking, BMI) except in age, since follow-up participants were slightly older than those who did not take part. Participants received an honorarium for their involvement, and the study was approved by relevant Research Ethics Committees in London and Budapest.

Both at baseline and at follow-up, participants reported income in 8 categories, educational attainment and demographic characteristics (age and smoking status) and anthropometric measures were recorded. At follow-up, hair samples were taken for the assessment of cortisol.

2.2. Hair sample collection and analyses

A scalp hair strand of 3 cm was collected from the posterior vertex position by cutting the hair as close to the scalp as possible with fine medical scissors. These were placed onto aluminium foil, stored in a dry, dark place, until shipped to the Technical University of Dresden, Germany. The wash procedure and steroid extraction were undertaken using high performance liquid chromatography–mass spectrometry (LC/MS), as described by Kirschbaum et al. (2009), with a minimum of 10 mg $\pm$ 0.5 mg of hair, cut from each 3 cm hair segment. Based on an average monthly hair growth of approximately 1 cm, the scalp-nearest hair segment of 3 cm represents averaged cortisol accumulated over an approximate timespan of three months prior to sampling. Hair-specific factors that could affect hair cortisol concentration (washing frequency, hair colour, product use and hair treatment/dyeing) were assessed by self-report.

2.3. Measures and statistical analyses

Data from the two study sites were combined to improve statistical power for the analyses. Income data were obtained

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