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Hair cortisol and dehydroepiandrosterone and their associations with optimism and pessimism in older people

Mariola Zapater-Fajarí [a], Isabel Crespo-Sanmiguel [a], Teresa Montoliu [a], Vanesa Hidalgo [a,b,*], Alicia Salvador [a,c]

[a] Laboratory of Cognitive Social Neuroscience, Department of Psychobiology and IDOCAL, University of Valencia, Valencia, Spain
[b] Department of Psychology and Sociology, Area of Psychobiology, University of Zaragoza, Teruel, Spain
[c] Spanish National Network for Research in Mental Health CIBERSAM, 28029, Spain

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ABSTRACT

The cumulative negative effects of prolonged Hypothalamic-Pituitary-Adrenal axis (HPA axis) activation are associated with several age-related diseases. Some psychological traits such as optimism and pessimism have been shown to be related to both health and the stress response, although their relationship with the HPA axis is inconclusive. More stable HPA axis biomarkers, such as hair samples of cortisol (HC) and dehydroepiandrosterone (HDHEA), would help to clarify the association between these psychological traits and HPA axis functioning. The main aim of this study was to test the relationships between optimism and pessimism and chronic stress biomarkers measured in hair (HC and HDHEA). Additionally, a secondary objective was to explore sex differences in HC and HDHEA levels and their relationship with these psychological traits. We measured optimism, pessimism, and their combination (dispositional optimism) using the Life Orientation Test Revised (LOT-R) and chronic stress biomarkers (HC and HDHEA) in 119 healthy participants (46 men and 73 women) between 56 and 81 years old who belonged to a university program. Regression analyses controlling for perceived stress and BMI indicated that higher dispositional optimism was related to lower HC and $HC{:}HDHEA_{ratio}$ ($\beta = -0.256$, $p = .008$ and $\beta = -0.300$, $p = .002$, respectively). More specifically, higher pessimism was related to higher HC ($\beta = 0.235$; $p = .012$) and $HC{:}HDHEA_{ratio}$ ($\beta = 0.240$; $p = .011$), whereas higher optimism was associated with a lower $HC{:}HDHEA_{ratio}$($\beta = -0.205$; $p = .031$). Moderation analyses showed no sex differences. To date, this is the first study to investigate the link between these traits and HC and HDHEA in older people. Our results confirm that positive and negative expectations about the future (i.e. optimism and pessimism) may play an important role in health due to their relationship with the HPA axis. They also strengthen the idea that the negative effects of pessimism have a greater weight than the protective effects of optimism in their relationship with HPA axis regulation.

1. Introduction

The number of older people around the world is increasing dramatically, with an anticipated population over 60 years of age of two billion in 2050. This is a problem in today's society because this age group faces various physical and mental health problems. However, older people show differences in the way they age. Whereas some older adults maintain good health until advanced ages (healthy/normal aging), others experience health problems (pathological/unsatisfactory aging) (World Health Organization, 2022a). In this regard, several personality traits have been proposed as important factors in health, given that they have been associated with the evolution or maintenance of many age-related disorders in older people, including stress pathologies and diseases (Cruitt and Oltmanns, 2018). Because stress is currently an important problem in our societies (World Health Organization, 2022b) and the stress response could be one of the mechanisms explaining the differences in the aging process, there is a clear need to study potential factors that affect this process.

An important component of the stress response is Hypothalamic-Pituitary-Adrenal (HPA) axis activation and its main product, cortisol. HPA axis dysregulation has been related to several health illnesses linked to aging, such as cardiovascular disease, Type 2 diabetes, and

* Corresponding author at: Department of Psychology and Sociology, Area of Psychobiology, University of Zaragoza, Campus Ciudad Escolar, 44003 Teruel, Spain.
E-mail address: vhidalgo@unizar.es (V. Hidalgo).

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reduced immune function (Jones and Gwenin, 2021; O'Connor et al., 2021). Generally, the functioning of the HPA axis has been studied through traditional cortisol measures (plasma or saliva) that are good at capturing the impact of acute stressors but fail to reflect long-term stress exposure, with hair cortisol (HC) being proposed as a good biomarker of chronic stress exposure (Russell et al., 2012; Stalder and Kirschbaum, 2012). Additionally, dehydroepiandrosterone (DHEA), another adrenal hormone involved in stress regulation, has shown an antagonistic effect to cortisol (Buoso et al., 2011), and it has been considered a biomarker of neuroprotective and anti-inflammatory processes (Kamin and Kertes, 2017). Interestingly, DHEA concentrations decrease with age, and so it has been suggested that an increase in DHEA may be involved in longevity and healthy aging in terms of better cognition or lower stress-related aging problems (Barrou et al., 1997; Maggio et al., 2015). DHEA levels have mostly been investigated in blood and saliva, but their measurement in hair (HDHEA), as a proxy for chronic stress, is increasing (Bürgin et al., 2020; Hennessey et al., 2020). It has been suggested that the Cortisol:DHEA ratio (Cort:DHEA$_{ratio}$), which would represent the interaction between these two hormones, might be a more accurate and physiological reflection of adrenocortical activity (Kamin and Kertes, 2017; Sollberger and Ehlert, 2016). In this regard, a higher Cort:DHEA$_{ratio}$ would be associated with increased chronic stress and poorer health (Sollberger and Ehlert, 2016). Therefore, studies that incorporate the two biomarkers and their combination in the Cort:DHEA$_{ratio}$ would be of special interest (Kamin and Kertes, 2017) in older people.

Older people typically present higher vulnerability to health problems, as well as a greater risk of developing stress-related disorders associated with long-term stress exposure. In this regard, HC becomes higher as people age, whereas an 80 % decline in DHEA levels has been found around 60 years of age in both men and women (Feller et al., 2014; Stárka et al., 2015; Kushnir et al., 2010). Given the beneficial effects of DHEA on neuroprotection, neurite growth, and anti-inflammatory and anti-glucocorticoid effects, and the negative effect of HC on health, it is important to study these factors and their ratio in this age population (Maggio et al., 2015). Moreover, the study of HDHEA will expand current knowledge about the more long-term role of this hormone in aging, beyond what blood or salivary sampling can provide.

A current question is the extent to which these biomarkers could be related to psychological traits and explain possible differences in the stress response of the older population (Russell et al., 2012). Determining the factors associated with HC and HDHEA concentrations would improve our understanding of the role these adrenal hormones play in normal development and psychopathology associated with the aging process (Kamin and Kertes, 2017). It has been well established that the way people experience current and future demands is an important factor in the stress response. More specifically, the *Self-Regulatory Behavior Theory* (Carver and Scheier, 2000) deals with the type of expectations and the way they affect physical and mental health. According to this theory, there will be differences between individuals who are confident and persistent in their expectations of success in achieving their goals and those who are more hesitant about success and have negative expectations (Carver et al., 2010; Scheier and Carver, 1992; Scheier et al., 1994). That is, health and stress differences will appear depending on the person's level of optimism/pessimism, understood as psychological traits that are fairly stable over time (Scheier and Carver, 2018). Positive expectations about future events make people less reactive to stress in life, which translates into more adaptive physical and psychological stress-related responses (Brydon et al., 2009; Carver et al., 2010). In this line, optimistic individuals show greater resilience to stress, and optimistic thoughts about the future in stressful situations have been proposed as an important dimension of resilience (Souri and Hasanirad, 2011; Yu and Zhang, 2007).

An important point that deserves our attention is the nature of these psychological dimensions. Although initially both optimism and pessimism were considered extremes of a unique dimension and, consequently, measured mainly through "dispositional optimism", some results, particularly in people over the age of 50, have suggested that these constructs show low shared variance and are better studied separately (Mroczek et al., 1993; Plomin et al., 1992; Robinson-Whelen et al., 1997). In addition, theoretical points of view about the independence of the two dimensions (Diener et al., 1999; Ryff and Singer, 1998) were found in some studies (e.g., Lai, 1994, 1997; Lai et al., 2005). Thus, Rasmussen et al. (2009) recommended that both dispositional optimism and the optimism and pessimism subscales should be studied separately. More recently, the Optimism/Pessimism Meta-Analytic Consortium (OPMAC) examined the different effects of the two dimensions on physical health indicators, based on their independence in several stress-coping processes and biological factors (Scheier and Carver, 2018; Scheier et al., 2021).

Regarding stress hormones, optimism has been linked to cortisol measures such as the cortisol awakening response (CAR), an index that reflects the dynamic of morning cortisol levels (Endrighi et al., 2011; Lai et al., 2005). Thus, on the one hand, higher optimism has been related to lower CAR in both healthy young (Lai et al., 2005) and older (Endrighi et al., 2011) people, although other studies failed to confirm this association in young people (Ebrecht et al., 2004). On the other hand, pessimism has not been related to cortisol secretion after a stressor in older people (Endrighi et al., 2011) or to CAR in young people (Lai et al., 2005). In two previous studies in older people, we found that optimism was related to faster recovery after a stressor (Puig-Perez et al., 2015), but not to CAR (Puig-Perez et al., 2018). Moreover, although pessimism was not related to the cortisol reactivity to stress or CAR, it was associated with worse psychological adjustment to stress and more negative affect and negative cognitions and emotions (Puig-Perez et al., 2015, 2018). Thus, we found that optimism was more related to physiological components of the stress response, whereas pessimism appeared to be more related to psychological aspects; however, we did not study associations with more chronic stress biomarkers. Hence, the question of how optimism and pessimism are related to biomarkers of chronic stress remains unanswered.

To date, only one study has investigated the relationship between optimism and HC. Specifically, optimism was associated with lower levels of HC in adolescents between 12 and 18 years old ($\beta = -0.53$, $p = .01$) (Milam et al., 2014). However, in a sample of 20-year-old young people, optimism-related factors such as resilience were negatively related to HC ($r = -0.39$, $p = .022$) (García-León et al., 2019). Bürgin et al. (2020) investigated whether some measures of resilience were related to HC, HDHEA, or the HC:HDHEA$_{ratio.}$ in a mixed-aged sample of young and older adults from 22 to 61 years of age. They found that sense of coherence (SoC) and self-care were associated with higher HDHEA levels (SoC: $\beta = 0.28$, $p = .002$ and self-care: $\beta = 0.21$, $p = .016$) and a lower HC:HDHEA$_{ratio}$ (SoC: $\beta = -0.36$, $p < .001$ and self-care: $\beta = -0.24$, $p = .005$). This study also looked for sex differences and confirmed a positive relationship between SoC and HDHEA only in women ($\beta = -0.46$, $p = .01$) (Bürgin et al., 2020). Thus, resilience and optimism, which are strongly related factors (Souri and Hasanirad, 2011), have both been associated with chronic stress biomarkers (Bürgin et al., 2020; García-León et al., 2019; Milam et al., 2014). However, no study has investigated the relationship between optimism and pessimism and chronic stress biomarkers (HC, HDHEA, and HC:HDHEA$_{ratio}$) in healthy older people.

Therefore, the main aim of this study was to test the relationship between the protective and vulnerability factors of optimism and pessimism, respectively, as well as their combination (dispositional optimism), and chronic stress biomarkers measured in hair (i.e., HC and HDHEA). Some studies have suggested that there are sex differences in HC secretion, reporting higher HC levels in men than in women (for a meta-analysis: Stalder et al., 2017). Thus, it is important to address sex differences in the study of these chronic stress biomarkers in older people, in order to improve the knowledge about stress-related diseases associated with age and, perhaps, with sex. Therefore, our secondary aim was to explore sex differences in HC and HDHEA concentrations and in their relationship with optimism and pessimism. We expected that optimism would be negatively related to HC and the HC:HDHEA$_{ratio}$ (Bürgin et al., 2020; García-León et al., 2019; Milam et al., 2014) and positively associated with HDHEA (Bürgin et al., 2020). In the case of pessimism, in spite of the lack of significant relationships with the stress response and CAR, we hypothesized that there would be a positive correlation with HC and the HC:HDHEA$_{ratio}$ and a negative relationship with HDHEA, due to long-term negative expectations. Finally, we expected to find higher HC and HDHEA and a lower HC:HDHEA$_{ratio}$ in men (Bürgin et al., 2020; Goldman and Glei, 2007; Stalder et al., 2017). We also expected to find a positive association between optimism and HDHEA only in women (Bürgin et al., 2020).

2. Method

2.1. Participants

Participants belonged to a study program at the University of Valencia called "La Nau Gran", for people over 55 years of age. We recruited participants from the classes of this study program and through informative talks and posters at several faculties of the University campus (e.g., Medicine, Psychology, Philosophy, History, and others). Volunteers were interviewed by telephone to determine whether they met the study prerequisites. Inclusion criteria were: smoking <10 cigarettes a day; no present or past alcohol or other drug abuse (we asked the participants about their consumption history as well as how many glasses and what kind of beverages they drank per week; we included those with no history of past abuse story who drank <20 g/day for females and 30 g/day for males); not having been under anesthesia in the past three months; and no presence of a stressful life event during the past year (volunteers were asked about any important event considered stressful that had changed their life; e.g. widowhood, retirement, etc.).

Volunteers were also asked if they had diabetes or a neurological or psychiatric disease, or if they were taking any medication that was directly related to emotional or cognitive functioning or able to influence hormonal levels, such as glucocorticoids, psychotropic substances, or sleep medications. Six participants had Type II diabetes, although medically treated, which has not been found to affect the HPA axis stress response (Vallejo et al., 2021), 16 participants were taking medication directly related to the central nervous system (i.e. sleep medication), and three participants were taking β-blockers. Thus, medication and diseases were included as covariates in the analyses to control them. Socioeconomic status (SES) was measured with the MacArthur Scale of Subjective Social Status (Adler et al., 2000). Participants rated themselves from 1 (people with the lowest education and income and the worst jobs) to 10 points (people with the best education, income, and jobs). All the female participants were postmenopausal and had their last menstrual period more than two years prior to the testing time, and none of them were taking estrogen replacement therapy.

After an initial screening of 260 individuals, 124 participants were assessed in this study; however, three men had to be excluded because they did not have enough hair for the biochemical analyses (~3 cm length). Moreover, two women had missing data on the optimism and pessimism scales. Hence, the final sample was composed of 119 participants (46 men and 73 women) between 56 and 81 years old.

2.2. Procedure

Participants were instructed to visit the laboratory, where they filled-out self-administered psychological tests. The psychological tests were completed in the presence of an evaluator who gave the participants assistance if needed. Additionally, their height and weight and waist and hips were measured to calculate their Body Mass Index (BMI) and waist hip ratio (waist: hip), respectively. At the end of the session, 3-cm hair samples (~ 3 mm thickness) were collected from the posterior vertex region on the head. Hair was collected by the researcher using stylist's scissors, and it was cut as close to the scalp as possible (recommended by the Society of Hair Testing, 1997; Favretto et al., 2023). The samples were individually wrapped in aluminum foil and stored at room temperature until they were mailed out following the laboratory's instructions (for more details, refer to Gow et al., 2010, and Stalder and Kirschbaum, 2012). Subsequently, these data were employed to carry out cross-sectional analyses.

All the participants provided their written informed consent to participate in the study, which was conducted in accordance with the Declaration of Helsinki. The protocol was approved by the Research Ethics Committee of the University of Valencia.

2.3. Instruments

2.3.1. Perceived stress

The validated Spanish version (Remor, 2006) of the 14-item Perceived Stress Scale (PSS) (Cohen et al., 1983) was used to evaluate the degree to which people perceived their lives as stressful, uncontrollable, and unpredictable in the past month. The respondents had to answer using a 5-point Likert scale (from 0 = never to 4 = very often) where higher scores indicate higher perceived stress. Internal consistency of this scale had a Cronbach's $\alpha = 0.81$.

2.3.2. Life orientation test revised

The validated Spanish version (Ferrando et al., 2002; Otero et al., 1998) of the Life Orientation Test Revised (LOT-R) (Scheier et al., 1994) was used to address optimism and pessimism. This is a 10-item scale rated on a 5-point Likert scale. It provides a measure of optimism and pessimism or a total score of dispositional optimism, depending on whether it is considered a one-dimensional or two-dimensional measure, respectively. Three items measure optimism (i.e. 'In uncertain times, I usually expect the best'), three other items measure pessimism (i.e. 'If something can go wrong for me, it will'), and the last four items are distractors. To calculate dispositional optimism, the pessimism scale is reversed, obtaining a total score from 0 to 24. Several studies have confirmed the two-dimensional measure (Carver et al., 2010; Ferrando et al., 2002; Mroczek et al., 1993; Robinson-Whelen et al., 1997), and the use of the separate scores in addition to the total score has been recommended, especially in older people (Rasmussen et al., 2009; Puig-Perez et al., 2015, 2018). Internal consistency for this scale was $\alpha = 0.75$.

2.3.3. Hair cortisol and DHEA

Hair samples were prepared and analyzed in the laboratory of Prof. Kirschbaum (Department of Psychology, Technische Universität Dresden, Germany), following the protocol described in detail in Kirschbaum et al. (2009). Analysis was performed on the proximal 3 cm of hair, which, based on a hair growth rate of 1 cm/month, represents cumulative steroid hormone secretion over a period of 3 months (Russell et al., 2012). Hair samples were incubated in 1800 μl methanol for 18 h at 45 °C (see Stalder and Kirschbaum, 2012, for more details) and the levels of cortisol and DHEA were then analyzed using the immunoassay technique with chemiluminescence detection (CLIA, IBL-Hamburg, Germany), (Kische et al., 2023). Results are in fluid units and were converted to pg/mg hair.

2.4. Statistical analyses and data management

Because the HC, HDHEA, and HC:HDHEA$_{ratio}$ values did not show normal distributions, they were log transformed. The HC:HDHEA$_{ratio}$ was calculated by dividing HC by HDHEA values.

Student's *t*-tests for independent samples were performed to evaluate the differences between the sexes in the sociodemographic variables, perceived stress, dispositional optimism, the optimism and pessimism subscales, HC, HDHEA, and the HC:HDHEA$_{ratio}$. Chi-square tests (X^2) were calculated to evaluate sex differences in educational level. Correlation analyses were performed to investigate the relationships between the sociodemographic variables, perceived stress, dispositional optimism, optimism and pessimism subscales, HC, HDHEA, and the HC:HDHEA$_{ratio}$. Based on the results of Pearson's correlation analyses, PSS and BMI were included as covariates in all the analyses because they were significantly correlated with HC or dispositional optimism and its subscales. To investigate the association between chronic stress biomarkers and psychological traits, first, separate linear regression analyses were performed, with each trait as independent variable and HC, HDHEA, or the HC:HDHEA$_{ratio}$ as dependent variables. To do so, we conducted hierarchical analyses with two models. Model 1 included PSS and BMI as covariates (Step 1) and each psychological trait (dispositional optimism or its optimism or pessimism subscale) (Step 2) (e.g., Step 1: PSS and BMI ($HC = \beta_0 + \beta_1 * PSS + \beta_2 * BMI + \varepsilon_1$); and Step 2: Dispositional optimism ($HC = \gamma_0 + \gamma_1$ * Dispositional optimism $+ \gamma_2 * PSS + \gamma_3 * BMI + \varepsilon_2$)). Model 2 also included age, sex, SES, waist:hip ratio, medication and disease in Step 1, due to their effects on HPA-axis activity (Bürgin et al., 2020; Stalder et al., 2017) and each psychological trait in Step 2 (e.g., Step 1: ($HC = \beta_0 + \beta_1 * PSS + \beta_2 * BMI + \beta_3 * age + \beta_4 * sex + \beta_5 * SES + \beta_6$ * waist:hip ratio $+ \beta_7$ * medication$+ \beta_8$ * disease $+ \varepsilon_1$); and Step 2: ($HC = \gamma_0 + \gamma_1$ * Dispositional optimism $+ \gamma_2 * PSS + \gamma_3 * BMI + \gamma_4 * age + \gamma_5 * sex + \gamma_6 * SES+ \gamma_7$ * waist:hip ratio $+ \gamma_8$ * medication $+ \gamma_9$ * disease $+ \varepsilon_2$)). All the covariates were continuous, except sex (coded as men = 0; women = 1), and medication and disease (both variables coded as no = 0, yes = 1) (Table 3).

To investigate whether the relationship between psychological traits and chronic stress biomarkers were moderated by sex, moderation analyses were performed following Preacher et al. (2007). Moderation occurs when the relationship between two variables is contingent upon a third variable. This model allowed us to determine whether the relationships between the psychological traits and chronic stress biomarkers were different for men and women. We included the psychological traits (dispositional optimism or its optimism or pessimism subscale) as independent variables, each chronic stress biomarker (HC, HDHEA, or HC:HDHEA$_{ratio}$) as dependent variable separately, and sex as a moderator controlling for PSS, BMI, age, SES, waist:hip ratio, medication and disease. We used standardized values to perform the moderation analyses. Bias-corrected bootstrapping 95 % intervals were conducted to assess the moderating effects using 5000 bootstrap iterations. Confidence intervals that do not contain zero are considered statistically significant. We used Hayes' PROCESS macro model number 1 (Preacher et al., 2007) with SPSS (version 26; IBM Corporation, Armonk, NY, USA).

For the main analyses (linear regression), we estimated a sample size of 55 participants for a medium effect size ($f^2 = 0.15$, alpha = 0.05 and power = 0.80). However, because we also analyzed sex differences, we needed a total of 120 participants for a medium effect size (d = 0.50, alpha = 0.05 and power = 0.80). As has been previously mentioned, the screened sample composed by 124 participants was reduced by impossibility to obtain hair samples and missing data. Additionally, standardized residuals were used to detect multivariate outliers (± 3 SD). Specifically, one man was excluded because he was an outlier in the relationship between HC and psychological traits. Thus, for these specific analyses, the final sample contained 118 participants.

To perform the statistical analyses, version 26.0 of SPSS was used (IBM Statistics, Chicago, IL, USA). All *p* values were two-tailed, and the level of significance was taken as $p < .05$. All analyses in this study are cross-sectional in nature.

3. Results

3.1. General sample characteristics

Descriptive data for the complete sample and for men and women are reported in Table 1. Sex differences in age and the waist:hip index (*all* $p < .029$) were found, as well as a significant tendency on perceived stress ($p = .057$). Men were older and had a higher waist:hip index but lower perceived stress. No significant differences were found between men and women in SES, BMI, educational level, Dispositional Optimism, Optimism, Pessimism, HC, HDHEA, or the HC:HDHEA$_{ratio}$ (*all* $p > .05$).

3.2. Unadjusted correlation analyses

Table 2 shows unadjusted correlations among all the variables included in the study. Dispositional Optimism was negatively correlated with perceived stress ($p < .001$), HC ($p = .009$), and the HC:HDHEA$_{ratio}$ ($p = .001$). The Optimism subscale was also negatively correlated with perceived stress ($p = .005$) and the HC:HDHEA$_{ratio}$($p = .029$). In contrast, Pessimism was positively correlated with perceived stress ($p = .004$), HC ($p = .020$), and the HC:HDHEA$_{ratio}$ ($p = .006$).

3.3. Regression analyses

3.3.1. Relationship between Dispositional Optimism and chronic stress biomarkers

Linear regression analyses indicated that Dispositional Optimism was negatively associated with HC (β = −0.256; $p = .008$) and the HC:HDHEA$_{ratio}$ (β = −0.300; $p = .002$), but it was not related to HDHEA (β

Table 1
Sample characteristics for the total sample and for men and women.

	Total sample (*N* = 119)	Men (*n* = 46)	Women (*n* = 73)	*t*/ χ^2	*p* value
Age (years)	67.40 (5.32)	68.74 (4.94)	66.56 (5.42)	2.21	0.029
SES	6.00 (1.29)	6.27 (1.21)	5.83 (1.32)	1.79	0.077
BMI *(kg/m2)*	26.60 (3.82)	27.10 (2.99)	26.29 (4.26)	1.21	0.227
Waist:hip	0.89 (0.09)	0.96 (0.06)	0.85 (0.08)	8.05	<0.001
Educational Level (%)				9.52	0.090
Without studies	1 (0.8)	0	1 (1.4)		
Primary school	19 (16)	3 (6.5)	16 (21.9)		
Secondary school	30 (25.2)	11 (23.9)	19 (26)		
Graduate (3 years)	33 (27.7)	13 (28.3)	20 (27.4)		
Graduate (5 years)	35 (28.4)	18 (39.1)	17 (23.3)		
PhD	1 (0.8)	12 (0.2)	0		
PSS	17.29 (6.29)	15.91 (5.45)	18.16 (6.66)	−1.92	0.057
LOT-R					
Dispositional Optimism	22.45 (3.27)	22.67 (2.87)	22.31 (3.51)	0.61	0.562
Optimism	11.72 (1.95)	11.70 (1.82)	11.74 (2.04)	−0.12	0.905
Pessimism	7.28 (2.20)	7.04 (1.76)	7.42 (2.44)	−0.99	0.325
HC (pg/mg)	4.07 (7.41)	4.44 (10.66)	3.84 (4.32)	0.01	0.990
HDHEA (pg/mg)	15.30 (16.78)	14.88 (14.30)	15.56 (18.25)	0.65	0.517
HC:HDHEA$_{ratio}$	0.41 (0.56)	0.37 (0.60)	0.44 (0.54)	−0.55	0.585

Abbreviations: SES = Subjective Socioeconomic Status; BMI = Body Mass Index; Waist: hip = Waist hip index; PSS = Perceived Stress; LOT = Life oriented test; HC = Hair cortisol concentration; HDHEA = Hair dehydroepiandrosterone concentration; HC:HDHEA$_{ratio}$ = Cortisol to DHEA ratio in hair. Data represent means, with the corresponding standard deviations in parentheses. For educational level, data represent the number of participants, with the corresponding % in parentheses. *T* values are presented for the differences between men and women for all variables except educational level, where χ^2 are presented.

Table 2
Pearson's correlation values between all the factors used.

	BMI	Waist:hip	SES	Med	Dis	HC	HDHEA	HC: $HDHEA_{ratio}$	PSS	D-OP	OP	PES
Age	0.110	0.210*	−0.026	0.040	0.110	−0.095	−0.050	−0.041	−0.173	0.011	0.042	0.020
BMI		0.362**	−0.214*	0.004	−132	0.181*	−0.015	0.167	0.082	0.057	0.095	−0.001
Waist:hip			−0.145	−0.057	0.134	0.003	0.038	−0.029	0.118	0.016	0.003	−0.017
SES				−0.056	0.056	−0.063	0.154	−0.180	−0.184*	−0.004	−0.114	−0.094
Med					−0.125	−0.121	−0.117	−0.009	0.071	0.123	0.015	−0.170
Dis						0.086	−0.102	0.158	−0.074	−0.020	−0.025	0.007
HC							0.294**	0.621**	0.080	−0.239**	−0.164	0.213*
HDHEA								−0.567**	−0.056	0.101	0.072	−0.082
HC:$HDHEA_{ratio}$									0.116	−0.289**	−0.200*	0.250**
PSS										−0.331**	−0.255**	0.263**
D-OP											0.756**	−0.813**
OP												−0.234*

Abbreviations: SES = Subjective socioeconomic status; BMI = Body Mass Index; Waist: hip = Waist hip index; PSS = Perceived Stress; Med = Medication; Dis = Disease; D-OP=Dispositional Optimism; OP = Optimism; PES = Pessimism; HC = Hair cortisol concentration; HDHEA = Hair dehydroepiandrosterone concentration; HC: $HDHEA_{ratio}$ = Cortisol to DHEA ratio in hair . *$p < .05$. **$p < .01$. $N = 119$.

=0.114; p = .252). The direction of the results did not change after including medication, disease, age, sex, SES, BMI, waist:hip ratio, and PSS as covariates, confirming that Dispositional Optimism was negatively associated with HC (β = −0.251; p = .013) and the HC:$HDHEA_{ratio}$ (β = −0.273; p = .007) (Table 3). Despite not finding a significant interaction between Sex and Dispositional Optimism in all the aforementioned relationships (all $p > .05$), Dispositional Optimism was negatively related to HC (β = −0.329; p = .008) and HC:$HDHEA_{ratio}$ (β = −0.332; p = .004) in women, but not in men (all $p > .05$)(Supplementary Table 1).

3.3.2. *Relationship between Optimism and chronic stress biomarkers*

The results showed that Optimism was negatively associated with the HC:$HDHEA_{ratio}$ (β = −0.205; p = .031). Optimism was not significantly related to HC (β = −0.145; p = .127) or HDHEA (β =0.079; p = .418). Results, after including medication, disease, age, sex, SES, BMI, waist: hip ratio, and PSS as covariates, showed similar significance, except that the relationship between optimism and the HC:$HDHEA_{ratio}$ did not remain significant (β = −0.183; p = .064) (Table 3). No interaction between Sex and Optimism was found in all the aforementioned relationships (all $p > .05$) (Supplementary Table 1).

3.3.3. *Relationship between Pessimism and chronic stress biomarkers*

The results showed that Pessimism was positively associated with HC (β = 0.235; p = .012) and the HC:$HDHEA_{ratio}$ (β = 0.240; p = .011), but not with HDHEA (β = −0.085; p = .379). Although the estimates changed, the direction of the results did not change when adding medication, disease, age, sex, SES, BMI, waist:hip ratio, and PSS as covariates, thus confirming that pessimism was positively associated with HC (β = 0.222; p = .021) and the HC:$HDHEA_{ratio}$ (β = 0.260; p = .007)(Table 3). Although no interaction between Sex and Pessimism was found in the aforementioned relationships (all $p > .05$), Pessimism was positively related to HC (β = 0.276; p = .017) and HC:$HDHEA_{ratio}$ (β = 0.251; p = .020) only in women, and not in men (all $p > .05$) (Supplementary Table 1).

4. Discussion

Studying the relationship between protective/ vulnerability factors and chronic stress biomarkers can have important implications for health, especially in older people, given that chronic stress has been related to a maladaptive aging process and age-related diseases (Yegorov et al., 2020). In this study, we investigated the relationship between optimism and pessimism, as well as dispositional optimism,

Table 3
Linear regression analyses with stress biomarkers (HC, HDHEA, and HC:HDHEAratio) as dependent factors and Dispositional Optimism, Optimism, or Pessimism as independent factors, including PSS and BMI as covariates (Model 1) and medication, disease, age, sex, SES, BMI, waist:hip ratio, and PSS as covariates (Model 2).

Dependent Variable: HC	**Model 1**				**Model 2**			
	R^2	**Adj R^2**	**R^2 change**	**Beta**	**R^2**	**Adj R^2**	**R^2 change**	**Beta**
Dispositional Optimism	0.113	0.089	0.058	−0.256*	0.165	0.092	0.052	−0.251*
Optimism	0.075	0.050	0.019	−0.145	0.132	0.056	0.019	−0.145
Pessimism	0.107	0.083	0.051	0.235*	0.154	0.091	0.044	0.222*
Dependent Variable: DHEA	**Model 1**				**Model 2**			
	R^2	**Adj R^2**	**R^2 change**	**Beta**	**R^2**	**Adj R^2**	**R^2 change**	**Beta**
Dispositional Optimism	0.015	−0.011	0.011	0.114	0.058	−0.023	0.006	0.088
Optimism	0.009	−0.017	0.006	0.079	0.054	−0.027	0.003	0.055
Pessimism	0.010	−0.016	0.007	−0.085	0.053	−0.017	0.007	−0.090
Dependent Variable: HC:HDHEAratio	**Model 1**				**Model 2**			
	R^2	**Adj R^2**	**R^2 change**	**Beta**	**R^2**	**Adj R^2**	**R^2 change**	**Beta**
Dispositional Optimism	0.118	0.095	0.079	−0.300*	0.167	0.095	0.061	−0.273*
Optimism	0.077	0.052	0.039	−0.205*	0.135	0.060	0.029	−0.183
Pessimism	0.092	0.068	0.053	0.240*	0.164	0.101	0.060	0.260**

Abbreviations: D-Optimism = Dispositional Optimism; HC = Hair cortisol concentration; HDHEA = Hair dehydroepiandrosterone concentration; HC:$HDHEA_{ratio}$ = Cortisol to DHEA ratio in hair. Beta represents the beta standardized coefficients. *$p < .05$. $N = 119$, except for regressions between HC and psychological variables (N = 118).

and the hair stress biomarkers HC, HDHEA, and HC:HDHEA$_{ratio}$. To date, this is the first study to investigate psychological traits and chronic stress biomarkers in a sample of healthy older individuals. We observed that higher levels of dispositional optimism and lower levels of pessimism were associated with lower HC and a lower HC:HDHEA$_{ratio}$. Additionally, we found that higher scores on the optimism subscale were only linked to a lower HC:HDHEA$_{ratio}$. Furthermore, we did not find any significant sex interactions.

Linear regressions showed that higher dispositional optimism was related to less long-term cortisol exposure (i.e., the previous three months) and lower HC:HDHEA$_{ratio}$ concentrations measured in scalp hair. In contrast, higher pessimism was associated with greater HC and HC:HDHEA$_{ratio}$ concentrations. As mentioned above, according to the *Self-Regulatory Behavior Theory* (Carver and Scheier, 2000), anticipating that good things are going to happen leads to engaging in different coping strategies and drawing on different sources to cope with stress (Carver et al., 2010). Thus, optimistic people have lower perceived stress (Endrighi et al., 2011; Milam et al., 2014), and they use positive or active coping strategies, which are considered more adaptive, to deal with stressors (Nes and Segerstrom, 2006). Positive or adaptive coping strategies include a wide range of sources, such as dealing with the stressor or the emotions stemming from it (Carver et al., 2010). Thus, optimism can lead to better adjustment to stressful situations and, in turn, more adaptive HPA regulation. In contrast, pessimistic individuals, given their greater doubts about achieving their goals and their lower expectations, tend to withdraw their efforts in stressful situations and use avoidant coping strategies. These avoidant coping strategies are also understood as maladaptive coping strategies, which make people more vulnerable to stress and health problems such as stress-related diseases (Carver et al., 2010). Additionally, optimistic people tend to have larger social networks and attend more social activities than pessimists (Scheier and Carver, 2018), all of which have been related to better coping with stress and greater well-being (Taylor, 2007).

The results for dispositional optimism were consistent with Milam et al. (2014), who found that higher dispositional optimism was related to lower HC in young adults. Likewise, García-León et al. (2019) and Bürgin et al. (2020) found that resilience was negatively related to HC in young people (García-León et al., 2019), and that resilience factors (sense of coherence and self-care) were negatively related to HC:HDHEA $_{ratio}$ concentrations, due to the positive association with HDHEA, in mixed-aged samples (Bürgin et al., 2020). Overall, optimism can be understood as a resilience-related factor because these two traits have been strongly correlated with each other, and optimism is a factor included in the definition of resilience (Souri and Hasanirad, 2011; Yu and Zhang, 2007). Sense of coherence can be understood as one's perception of life as comprehensible, manageable, and meaningful, whereas self-caring behavior can be described as specific health behaviors (e.g., participating in sports, sleeping enough, balancing nutrition). In this regard, based on their definitions, these two variables can be understood as components of optimism, given the close relationship between positive expectations and health and healthy behaviors found in optimistic individuals (Carver et al., 2010). In contrast, no previous study has analyzed the relationship between pessimism and chronic stress biomarkers (HC or HC:HDHEA$_{ratio}$ concentrations) in young or older people. However, previous studies have suggested that pessimism is related to a higher stress perception (Endrighi et al., 2011), and that people who score high on pessimism perceive more effort and difficulty after a laboratory induced stressful situation (Puig-Perez et al., 2015) and present more negative affect and negative cognitions and emotions (Puig-Perez et al., 2018).

Our research showed that the dispositional optimism scale and the pessimism subscale had stronger relationships with the chronic stress biomarkers than the optimism subscale. These differences found between the subscales support studying the optimism and pessimism subscales as two separate dimensions in people over 50 years of age, given that, although negatively and strongly related, multicollinearity tests showed that these variables were independent (Herzberg et al., 2006; Puig-Perez et al., 2015; Rasmussen et al., 2009). The greater effect of pessimism on chronic stress biomarkers is consistent with a previous study by our group showing that pessimists tended to report more negative events, cognitions, and emotions than positive ones, whereas optimism was not related to past life review (Puig-Perez et al., 2018). Recently, the greater importance of pessimism over optimism has been emphasized by Scheier et al. (2021), at least for physical health. These authors have indicated that the absence of pessimism is more strongly related to physical health outcomes than the presence of optimism, highlighting the need to study the association with stress-related factors and psychological health outcomes in greater depth. Pessimism increases the focus on negative aspects of life and, thus, may have greater involvement in pathological aging processes and HPA axis regulation (Puig-Perez et al., 2018). Our results may strengthen the notion that the negative effects of pessimism have a greater weight than the protective effects of optimism in the relationship with HPA axis regulation (Scheier and Carver, 2018; Robinson-Whelen et al., 1997). Overall, the results of our study could suggest that the effects found between dispositional optimism and the HPA axis could be mainly due to the pessimism subscale, given its stronger association when studying the subscales separately. More precisely, the results for the HC:HDHEA$_{ratio}$ could mainly be due to HC levels, possibly because, on the subscales, pessimism is significantly related to HC, whereas optimism is not. The association between dispositional optimism and pessimism and HC could also explain why we found a relationship with the HC:HDHEA$_{ratio}$ and not with HDHEA.

We failed to find associations between the optimism and pessimism measures and DHEA hair cortisol concentrations. To our knowledge, this is the first study to investigate the associations between these psychological traits and HDHEA concentrations. Our results differ from Bürgin et al. (2020), who found associations between resilience factors and HDHEA levels. However, their sample was younger than ours ($M = 35.20$ vs. $M = 67.36$, respectively), and the authors did not study optimism per se. Further studies need to determine whether the relationship between optimism and HDHEA levels differs depending on age and study the relationship between HDHEA and pessimism in populations of young and older people.

The models including sex as a moderator in the relationships between these protective/vulnerability factors and chronic stress biomarkers (HC, HDHEA, HC:HDHEA$_{ratio}$) were not significant. The models' limited significance may stem from unequal group distribution (46 men vs. 73 women), potentially impacting our results. However, besides the lack of interaction between Sex and Dispositional Optimism and Pessimism, we found that these two variables were significantly related to HC and HC:HDHEA$_{ratio}$ in women, but not in men. Again, only one study looked for sex differences, and it found a positive relationship between sense of coherence and HDHEA only in women (Bürgin et al., 2020). However, the only study that looked for associations between optimism and HC did not address sex differences. Additionally, sex differences in HC remains ambiguous, several studies have failed to find differences between men and women in HC concentrations (Dettenborn et al., 2012; Gao et al., 2010; Manenschijn et al., 2011; Raul et al., 2004; Thomson et al., 2010), although sex differences have also been found (for a meta-analysis see: Stalder et al., 2017). There also appears to be limited research on sex differences in DHEA levels measured in hair. Only one study has been identified that investigated this aspect, conducted by Kintz et al. (1999), and it did not find any significant differences between men and women. In fact, the question of whether the sex variable is associated with HC or HDHEA is still unclear, and future studies should address sex differences in the relationship between optimism or pessimism and chronic stress biomarkers.

Our study has some strengths, such as using HC and HDHEA concentrations as well as the ratio, all of which seem to be potential indicators of chronic stress exposure that would be better than saliva samples, which need rigorous methodological control (e.g., adherence problems). Thus, it may be interesting to take HC and HDHEA measures into consideration when studying the relationship between vulnerability/protective factors and long-term stress exposure. However, our results should be viewed with some limitations in mind. It would be advisable to replicate these results in larger samples, specifically to confirm the role of sex in the relationships between optimism or pessimism and chronic stress biomarkers. Given the cross-sectional nature of our study we could not test causality, and so longitudinal studies should shed light on the causality of the relationships. Moreover, it would be useful to include other variables, such as coping or social networks, to study the moderators between optimism/pessimism and the HPA axis more in depth. Finally, we studied a sample of healthy older people who belonged to a University program, and so some bias may have been present in our results. Therefore, any generalization should be made with caution.

5. Conclusions

In sum, our results contribute to clarifying the role of dispositional optimism, optimism, and pessimism in relation to chronic stress biomarkers. These results show the interest of dispositional optimism in the association with the HPA axis through lower levels of HC and the HC:HDHEA ratio, and they highlight the role of pessimism as a negative trait related to a maladaptive HPA axis response. It is important to study the psychological factors of vulnerability and coping in relation to physiological variables related to health, especially in the older population, in order to promote healthy aging. More interventions should focus on the weight of positive and negative expectations about the future in health outcomes.

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CRediT authorship contribution statement

Mariola Zapater-Fajarí: Conceptualization, Formal analysis, Investigation, Writing – original draft. **Isabel Crespo-Sanmiguel:** Data curation, Investigation. **Teresa Montoliu:** Data curation, Investigation. **Vanesa Hidalgo:** Conceptualization, Methodology, Writing – review & editing. **Alicia Salvador:** Conceptualization, Methodology, Resources, Writing – review & editing.

Declaration of competing interest

The authors report no conflicts of interest.

Data availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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