Job demands and DHEA-S levels: a study on healthcare workers

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Background: The intricate interplay between work-related stress and its physiological impact has drawn extensive research attention. Dehydroepiandrosterone sulphate (DHEA-S) emerges as a potential biomarker reflecting stress-related endocrine changes.

Aims: This cross-sectional study aimed to examine the association between job demands and DHEA-S levels among healthcare workers. The study also explored potential correlations between DHEA-S levels and psychophysical symptoms commonly linked to work-related stress.

Methods: A sample of 488 healthcare workers from a local health authority participated. Job demands were measured using the Demands scale of the Health and Safety Management Standards Indicator Tool. DHEA-S levels and symptom prevalence were assessed through serum analysis and questionnaires, respectively.

Results: Workers exposed to high job demands exhibited significantly lower DHEA-S levels compared to those with low job demands. Psychophysical symptoms, including sleep disorders, depression, and headache, were more prevalent in the high-demands group. DHEA-S levels showed significant negative correlations with the prevalence of all considered symptoms.

Conclusions: The study shows the inverse relationship between job demands and DHEA-S levels among healthcare workers, indicating that high job demands correlate with reduced DHEA-S secretion and increased symptom prevalence. The findings suggest DHEA-S as a potential biomarker for assessing the physiological consequences of work-related stress. Proactive interventions in managing job demands are crucial for promoting employee well-being and productivity in demanding work environments. By recognizing DHEA-S as a stress biomarker, organizations can effectively address stress-related health risks and implement targeted interventions for enhancing employees' overall health and work performance.

INTRODUCTION

The intricate interplay between stress and its impact on human physiology has captivated researchers in various scientific disciplines. As a complex and pervasive phenomenon, stress arises from the interplay between an individual and their environment, encompassing a diverse array of physical, psychological and social stressors [1]. While stress responses are adaptive and essential for survival, prolonged or chronic stress can exert detrimental effects on human health, contributing to the development of numerous disorders, such as anxiety, depression, cardiovascular diseases and immune dysfunction [2,3].

Identifying reliable and sensitive biomarkers is crucial to comprehensively understanding the stress response and its consequences on health [4]. Biomarkers, particularly those reflecting alterations in endocrine function, have the potential to provide valuable insights into the physiological processes underlying the stress response. One such candidate that has garnered increasing attention is dehydroepiandrosterone sulphate (DHEA-S), a naturally occurring steroid hormone that is the most abundant circulating steroid in humans. DHEA-S is predominantly produced by the adrenal glands, with additional contributions from the gonads and brain [5]. Long recognized for its role as a precursor in the synthesis of sex hormones [6], it has also been implicated in various non-reproductive physiological processes, including immune regulation and stress modulation. Indeed, DHEA-S is known to have anabolic and neuroprotective effects, indicating protective and regenerative roles [7,8], and has been found to counteract the effects of corticosteroids, such as cortisol [8–12].

DHEA-S levels have been associated with different health issues and outcomes. High DHEA-S levels have been associated with positive outcomes, including better physical health, improved immune function, more positive mood states, and improved emotional well-being [13]. Conversely, low DHEA-S levels have been associated with conditions such as depression and anxiety [14] and with increased risks of cardiovascular diseases, including hypertension and atherosclerosis [15], and back pain and osteoporosis, particularly in postmenopausal women [16, 17].

Over the years, researchers have also explored the association between DHEA-S levels and both acute and chronic

Key Learning Points

What is already known about this subject:

- Stress's impact on health and the need for reliable stress biomarkers were recognized.
- Associations between job demands, stress and health outcomes were explored but lacked robust biomarker evidence.

What this study adds:

- Demonstrates a link between high job demands and lowered dehydroepiandrosterone sulphate levels in healthcare workers.
- Highlights dehydroepiandrosterone sulphate as a potential biomarker for assessing physiological effects of work-related stress.
- Underlines the significance of managing job demands for employee well-being and productivity.

What impact this may have on practice or policy:

- Encourages proactive interventions to manage workplace stress and maintain optimal dehydroepiandrosterone sulphate levels.
- Supports considering dehydroepiandrosterone sulphate as a screening tool to identify at-risk employees.
- Impels policy-makers to consider dehydroepiandrosterone sulphate assessment in occupational health strategies to promote worker well-being and productivity.

stress in diverse populations and under various stressors. Preliminary evidence suggests that DHEA-S may undergo dynamic changes in response to stress. DHEA-S exerts anti-glucocorticoid effects [18], which can help buffer the impact of excess cortisol, promoting a more balanced stress response. Indeed, increased DHEA-S levels are found as a consequence of acute stress [9,19]. However, chronic stress or prolonged exposure to stressors can reduce the capacity to produce DHEA-S, impacting the body's ability to modulate the stress response effectively [20]. Chronically stressed individuals, such as the caregivers of patients with Alzheimer's disease [21], patients with chronic urticarial [22] and patients with clinical burnout [23], have lower DHEA-S levels than nonchronically stressed individuals. As a specific form of prolonged stress, work-related stress has also been associated with reduced DHEA-S levels. For example, perceived stress at work has been negatively associated with reduced DHEA-S secretion [24,25], and decreased DHEA-S levels were also found in a longitudinal study exploring the consequences of stress due to organizational change [26].

The Job Demands-Resources (JD-R) model [27] provides a conceptual framework to understand the interplay between job demands and resources in the work environment and their impact on employees' well-being. Job demands refer to physical, psychological, social or organizational aspects requiring sustained effort (e.g. high workload, time pressure and emotional demands). According to this model, chronic job demands exhaust workers' mental and physical resources and may lead to energy depletion and health problems [28,29]. Indeed, there is evidence that job demands are strongly related to emotional exhaustion and burnout [30,31] and health complaints such as musculoskeletal pain and anxiety–depression symptoms [32,33]. It has been hypothesized that psychobiological processes through central nervous system activation of autonomic, neuroendocrine and immune responses mediate the association between job demands and the development of physical illness [27]. Due to its pivotal role in stress regulation, DHEA-S holds promise as a potential biomarker for gaining deeper insights into the physiological implications of job demands.

Therefore, this cross-sectional study aims to investigate whether DHEA-S secretion differs between healthcare workers exposed to different job-demands levels. Specifically, we hypothesized that workers exposed to prolonged high job demands would show a reduced ability to produce DHEA-S and, thus, a lower DHEA-S level than workers with low job demands. Finding an association between high job demands and DHEA-S production would help understand the intricate interplay between job demands, stress response and health outcomes, and provide further support for using DHEA-S as a biomarker of work-related stress.

METHODS

The study was approved by the Ethical Committee of Friuli-Venezia Giulia (ID: 16810; 7 October 2022) and was conducted according to the Helsinki Declaration. The STROBE guidelines were used to ensure the reporting of this study.

From 1 October 2022 to 31 March 2023, all consecutive healthcare workers (physicians, nurses, social workers and technicians) employed in the local health authority who underwent routine preventive occupational medicine consultation were asked to take part in the study.

Serum DHEA-S levels and questionnaire measures were collected in single sessions between 07:00 and 10:00. The subjects had fasted overnight. The blood samples were collected in a serum separator clot activator tube containing a barrier gel at its bottom. The specific gravity of this material lies between the blood clot and the serum. Serum was separated by centrifugation (15 minutes at 3500 rpm), and the sample was analysed on the same day as collection. The serum DHEA-S concentration was measured using a quantitative chemiluminescent immunoassay with paramagnetic particles. A four-parameter ponderated logistic curve with six calibration points was used, and the DHEA-S level was determined by photon production. Therefore, high levels of total bilirubin, triglycerides and hemolysis do not interfere with DHEA-S measurement. The test's total imprecision is ≤10% at ≥20 μg/dL.

Job demands were measured through the Demands scale of the Health and Safety Management Standards Indicator Tool (HSE-MS IT), a widely used assessment tool designed to help organizations identify and assess psychosocial risks in the workplace related to work-related stress [34,35]. The Demands scale comprises eight items that evaluate workers' exposure to job demands (e.g. task difficulty, strict deadlines and high work pace) in the previous 6 months. Cronbach's alpha for this sample was 0.83.

The questionnaire also included eight items measuring the prevalence of eight psychophysical symptoms (palpitations, sleep disorders, depression, irritability, anxiety, physical and mental tiredness, headache, and osteoarticular pain) commonly associated with work-related stress [32,33,36] using a five-point scale (from never to always). Participants were also asked to provide some basic demographic information (age, sex, job tenure and smoking habits). Participants returned the completed questionnaires in a closed urn to ensure anonymity, and their weight and height were measured by well-trained medical professionals for body mass index (BMI) calculation.

Since DHEA-S levels were non-normally distributed (Skewness = 1.27, Kurtosis = 2.45, Kolmogorov–Smirnov and Shapiro–Wilk tests, $P < 0.001$), square-root-transformed DHEA-S levels were used in the analyses to improve the normality of their distributions [37,38]. Participants were divided into two groups (high-demands versus low-demands) based on the 50th percentile of the Demands scale distribution. Chi-square tests and *t*-tests were used to check for possible differences in sex, age, job tenure, smoking habits and BMI between the two groups, which are all factors that could influence DHEA-S levels.

Differences in DHEA-S levels between the high- and low-demands groups were assessed using an analysis of covariance (ANCOVA) with DHEA-S levels as the dependent variable, job demands (high versus low) as the predictor, and age group and sex as covariates.

Differences in the psychophysical symptoms between the two groups were assessed using *t*-tests. Pearson's correlations were calculated to evaluate the association between DHEA-S levels and the prevalence of psychophysical symptoms. Missing data were minimal (approximately 1%), and list-wise deletion of cases was used. Statistical analyses were conducted using SPSS Statistics 23 (IBM Corporation, USA).

RESULTS

A total of 491 participants provided written informed consent and were initially included in this study. Three participants out of the initial sample were excluded from the analysis due to excessive missing data in the questionnaire. As a result, the final sample size for this study was 488.

The 50th percentile of the Demands scale distribution was 3.38 (mean [*M*] = 3.35, standard deviation [SD] = 0.62); therefore, participants with scores lower than this value were included in the high-demands group and participants with scores equal or higher in the low-demands group (in the HSE-MS IT, lower scores indicate an increased exposure to organizational stressors and vice versa [35]). Table 1 shows that the considered demographic characteristics did not differ significantly between the high- and low-demands groups.

The ANCOVA results showed that DHEA-S levels were significantly lower in the high-demands group ($M = 151.93$ μg/dL, SD = 90.21 μg/dL) than in the low-demands group ($M = 173.07$ μg/dL, SD = 109.61 μg/dL), after controlling for sex and age group ($F_{(1,482)} = 4.18$, $P < 0.05$).

In addition, all psychophysical symptoms were reported significantly more frequently in the high-demands group than in the low-demands group (Table 2).

Table 1. Demographic characteristics of the high- and low-demands participants

	Low demands	High demands	*P*
Sex (M/F)	85/168	61/174	NS
Age group[a] (<30/30–40/41–50/51–60/>61)	35/55/60/87/15	30/60/54/81/9	NS
Job tenure (years)[*,b]	2.68 (1.35)	2.77 (1.29)	NS
Smoker (no/yes)[c]	186/59	166/63	NS
BMI (kg/m^2)[*,d]	24.35 (4.30)	24.40 (4.54)	NS

[*]Data are presented as mean (standard deviation).
[a]One missing value in the low-demands group and one in the high-demands group.
[b]One missing value in the low-demands group and two in the high-demands group.
[c]Eight missing value in the low-demands group and six in the high-demands group.
[d]One missing value in the low-demands group and six in the high-demands group.

Table 2. Incidence of psychophysical symptoms in both groups

	Low demands	High demands	*P*
Palpitations	1.98 (1.04)	2.22 (1.08)	<0.05
Sleep disorders	2.71 (1.25)	3.07 (1.17)	0.001
Depression	1.99 (1.09)	2.55 (1.08)	<0.001
Irritability	2.27 (0.96)	2.83 (1.02)	<0.001
Anxiety	1.94 (1.04)	2.33 (1.10)	<0.001
Physical and mental tiredness	2.71 (1.08)	3.34 (0.99)	<0.001
Headache	2.15 (1.09)	2.48 (1.20)	<0.01
Osteoarticular pain	2.09 (1.22)	2.35 (1.26)	<0.05

Data are presented as mean (standard deviation). The *P* levels refer to the Student's *t*-test. Very similar results were obtained using the Mann–Whitney test (all *P*s < 0.05).

DHEA-S levels displayed significant negative correlations with all psychophysical symptoms, ranging from small to moderate in magnitude (Table 3). Pearson's correlation coefficients ranged from −0.09 (anxiety symptoms) to −0.35 (osteoarticular pain).

DISCUSSION

The study demonstrates a significant association between job demands and DHEA-S levels in healthcare workers. Those facing high job demands exhibit lower DHEA-S levels and a greater prevalence of stress-related psychophysical symptoms compared to peers with lower demands. Workers with high job demands had, on average, 12% lower serum DHEA-S levels than those with low job demands. These results are consistent with existing studies showing reduced DHEA-S levels in individuals exposed to prolonged stress [9,22,23] and suggest that prolonged exposure to high work-related stress may disrupt the delicate balance of the stress response, leading to reduced DHEA-S secretion. Since DHEA-S plays a vital role in modulating the stress response and promoting resilience [18,19], its depletion may make individuals more vulnerable to the detrimental effects of chronic stress on physical and mental health.

While the study benefits from a substantial sample size and comprehensive measurement approach, some limitations of this

Table 3. Pearson's correlations between DHEA-S levels and psychophysical symptoms

	Pearson's correlation coefficient	*P*
Palpitations	−0.19	<0.001
Sleep disorders	−0.18	<0.001
Depression	−0.17	<0.001
Irritability	−0.12	0.01
Anxiety	−0.09	<0.05
Physical and mental tiredness	−0.18	<0.001
Headache	−0.20	<0.001
Osteoarticular pain	−0.35	<0.001

study should be acknowledged to provide a thorough interpretation of the findings. First, the use of self-report measures to assess job demands and psychophysical symptoms could have introduced response bias and potential inaccuracies in reporting. While efforts were made to ensure participants' honesty and accuracy, objective measures or data from multiple sources could enhance the validity of the results. Second, as the primary focus of this study was on job demands, a brief set of eight psychophysical symptoms was used to assess the prevalence of health problems. Future research aiming to delve deeper into specific health outcomes should instead consider the use of established and validated measures, such as the Beck Depression Inventory [39] and the Generalized Anxiety Disorder scale [40]. Additionally, data on participants' perceived stressors in other life domains were not collected. Therefore, the potential for a spill-over effect, wherein stressors from personal life may exacerbate stress at work [41], cannot be ruled out. Lastly, the study focused on a specific population of healthcare workers employed by a local health authority. As a result, caution should be exercised when generalizing the findings to other occupational groups or industries. Future research with diverse samples from various work settings is warranted to establish broader applicability.

Overall, these findings underscore the importance of considering DHEA-S as a potential biomarker for assessing the physiological impact of job demands on employees' stress response systems. The use of a biomarker offers significant advantages over conventional self-report measures of work-related stress. First, it provides an objective measurement, offering a direct physiological insight into the body's response to stressors, as opposed to self-reporting based on subjective perceptions. This approach enables the early detection of stress-related changes, so that physiological changes can potentially be identified before individuals consciously recognize them. In addition, it mitigates biases associated with self-reporting, such as social desirability, presenting a more impartial reflection of stress levels. While, in this study, we measured serum DHEA-S levels using blood samples, alternative non-invasive methods like salivary tests are available [42]. These tests are relatively easy to administer, making them practical for regular screening in organizational settings, such as during routine preventive occupational medicine consultations. This may prove more feasible than relying solely on periodic retrospective self-assessments. Essentially, a combined approach of DHEA-S assessment and self-report measures could provide a comprehensive strategy for understanding and monitoring stress in the workplace, for example, for identifying employees at risk of stress-related health problems and for evaluating the effectiveness of interventions aimed at mitigating job demands.

In conclusion, our findings provide further insight into the relationship between job demands, DHEA-S levels and health outcomes, and advocate DHEA-S as a potential biomarker for assessing the physiological effects of work-related stress. Despite these contributions, the precise mechanisms underlying these associations require further exploration. For example, it is conceivable that chronic stress may influence DHEA-S production, heightening vulnerability to health issues. At the same time, chronic stress could directly increase the risk of health problems such as depression, which, in turn, could contribute to reduced DHEA-S secretion. To fully understand this complex interplay, further research is needed to investigate the temporal dynamics and possible mediating factors. Longitudinal studies examining changes in DHEA-S levels in response to different job demands over time could shed light on the temporal dynamics of DHEA-S changes. Furthermore, assessing whether interventions targeting job demands can restore DHEA-S balance and mitigate stress-related health risks, represents an important avenue for future exploration.

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COMPETING INTERESTS

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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