

An Ergonomic Perspective on Cortisol, Cardiovascular Risk, and Anxiety in Full-Time Faculty Workers

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ABSTRACT

Human Systems Integration (HSI) and Organizational Ergonomics provide a robust framework to analyze the modern university as a complex socio-technical system. This paper expands upon the findings of a baseline study involving 90 university faculty members in Cartagena, Colombia (Alayón et al., 2025), shifting the focus from individual pathology to systemic ergonomic feedback. The data revealed that state anxiety is significantly associated with a failure in the physiological decline of cortisol at 4:00 PM, as well as with elevated triglyceride levels. From an HSI perspective, these biomarkers are identified as proactive ergonomic indicators of “systemic strain” and a lack of adequate “recovery windows” within the organizational interface. The persistence of evening cortisol is discussed as a failure in psychological detachment processes, likely resulting from high administrative workloads and the “porosity” of contemporary academic roles. Based on these indicators, the paper proposes systemic interventions grounded in the SEIPS 2.0 and Compensatory Control models, specifically the implementation of circadian-aligned work scheduling and the reduction of “cognitive friction” in bureaucratic procedures to mitigate long-term allostatic load. The study concludes that the integration of biological and psychological markers into organizational monitoring allows academic institutions to identify misalignments between system demands and human biological constraints. This proactive approach ensures the long-term sustainability of the academic system by protecting its most critical component: the human operator.

Keywords: Human systems integration, Organizational ergonomics, Cortisol, State anxiety, Academic workload, Circadian rhythms, Socio-technical systems.

INTRODUCTION

Human Systems Integration (HSI) involves the comprehensive integration of human capabilities—cognitive, physical, and sensory—into system design, from conceptualization to lifecycle management (Booher, 2003). Within this framework, the modern university can be analyzed as a complex socio-technical system (Carayon, 2006), where the performance of the organization

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depends on the synergy between its technological tools, administrative processes, and the human component.

A fundamental challenge in HSI is the empirical demonstration of how the human operator performs within the system architecture to validate its effectiveness (Folds et al., 2008). Building on this requirement for empirical validation, the objective of this paper is to expand the discussion of our previous study published in Alayón et al. (2025), which assessed cortisol levels, state anxiety, and cardiovascular risk in 90 university teachers in Cartagena, Colombia. While the original work focused on clinical findings, the present paper seeks to re-interpret these markers not only as individual health issues but as ergonomic indicators of the academic system's health. It is proposed that evening cortisol and state anxiety act as feedback signals regarding the effectiveness of organizational design and its impact on the "human operator."

METHODS AND PREVIOUS FINDINGS

The data from Alayón et al. (2025) analyzed here were gathered from a cross-sectional study of 90 full-time university faculty members in Cartagena, Colombia (47 female, 43 male), with an average age of 44.1 years. The protocol involved AM (8:00 AM) and PM (4:00 PM) serum cortisol measurements using electrochemiluminescent immunoassay (Elecsys cortisol II®), anthropometric measurements including waist circumference, fasting glycemia, and lipid profiles. Anxiety was assessed using the Spanish version of the State-Trait Anxiety Inventory (STAI), which demonstrated high internal consistency in this population ($\alpha = 0.939$).

The original findings (Alayón et al. 2025) revealed that 61.1% of individuals presented with medium-to-high state anxiety (28 males and 27 females); notably, within the high anxiety category, the percentage of females was substantially higher, accounting for 68.4% ($n=13$) of that group compared to 31.6% ($n=6$) for males. In tandem, 71.1% of participants showed moderate to high trait anxiety. Biologically, although 94.4% maintained cortisol levels within reference ranges, a significant positive correlation was found between state anxiety and evening (PM) cortisol concentrations ($r = 0.232, p = 0.028$). Furthermore, an ANOVA confirmed a significant effect of state anxiety levels on PM cortisol ($F(2.87) = 7.336, p = 0.001$), identifying that high-anxiety individuals exhibited the highest cortisol levels at the end of the day ($\bar{X} = 7.88 \mu\text{g/dL}$). Metabolic findings also showed a high prevalence of dyslipidemia (60.4%), with 68.9% of the participants exhibiting high cardiovascular risk based on waist circumference measurements. Additionally, a significant association was reported between state anxiety and elevated triglyceride levels ($t(87.999) = -2.244, p = 0.027$).

ACADEMIC ENVIRONMENTAL STRESSORS

The contemporary academic environment has evolved from a space focused on knowledge management into a high-pressure socio-technical system, where organizational design demands often exceed the individual's biopsychosocial

recovery capacities. From a Human Systems Integration (HSI) perspective, environmental stressors in academia should not be viewed as isolated variables or challenges to be dealt with only on the individual level. They represent systemic breakdowns where the organizational architecture fails the human operator.

Longitudinal and comparative studies have established that higher education staff experience significantly higher stress levels and lower job satisfaction compared to the general population and other professional sectors (Winefield et al., 2003). This disparity suggests that there are intrinsic factors within the academic system's design that act as chronic stressors. Over the last decade, an increasing trend in work-life interference has been observed, limiting the recovery periods necessary to maintain physiological homeostasis (Kinman and Wray, 2013).

The main ergonomic failures identified by the literature are workload and bureaucracy. Colacion-Quiros and Gemora (2016), for instance, suggest that these non-pedagogical demands function as organizational stressors that trigger anxiety and hypertension responses, interfering with the educator's core mission. This administrative burden, often invisible yet omnipresent, is directly linked to the deterioration of mental health, providing evidence that current academic work structures may be misaligned with the cognitive and temporal capacities of professors (Urbina-Garcia, 2020).

Under the Job Demands-Resources (JD-R) model, occupational burnout emerges when system requirements systematically exceed available institutional resources (Mudrak et al., 2018). The lack of organizational support and the scarcity of technical resources to manage large student volumes and administrative procedures predict not only a decline in work engagement and psychological wellbeing but also a measurable biological response (Sabagh, Hall and Saroyan, 2018).

Teaching itself can be significant adaptive challenge from a physiological standpoint. For example, Filaire et al. (2011) founded that high-demand tasks—such as lecturing to large audiences of 200 students—can act as strong acute stressors. Their work identified immediate and measurable spikes in salivary cortisol and cytokine levels following these sessions. This response points to an elevated activation of the Hypothalamic-Pituitary-Adrenal (HPA) axis. While these biological responses are initially adaptive, their chronic repetition in environments that lacks adequate “recovery windows” may transform these acute spikes into a state of sustained allostatic load and systemic strain.

This biological narrative is supported by the subjective psychological toll reported by educators, which suggests clear gaps in organizational ergonomics. Slišković and Seršić (2011) have identified a high prevalence of self-reported occupational stress, described as a multidimensional phenomenon driven by chronic workloads, poor technical conditions, and a negative institutional climate. Notably, their findings suggest that female faculty and those in middle-ranking positions appear particularly vulnerable, reporting significantly higher exposure to these specific stressors. This is consistent with recent systematic evidence confirming that work overload, role ambiguity, and unfavorable organizational conditions remain pervasive

psychosocial risks that trigger chronic exhaustion and burnout within educational settings (Echeverry Saldarriaga & García Rodríguez, 2025).

When viewed together, this framework allows for the interpretation of elevated evening cortisol and state anxiety—as noted in Alayón et al. (2025)—not merely as individual clinical pathologies, but potentially as indicators of a systemic imbalance. If organizational design fails to respect the biological necessity of circadian recovery, the academic system might essentially fail in its support role, potentially transforming the work environment itself into a significant cardiovascular and metabolic risk factor.

BIOMARKERS AND ANXIETY AS FEEDBACK FOR THE ERGONOMIC SYSTEM

Based on the findings, both state anxiety and afternoon cortisol may serve as an “ergonomic indicator” within educational organizations. In light of the HSI perspective, such markers are not merely indicators of illness or clinical symptoms but also possible manifestations of the allostatic load of the teacher (McEwen, 1998), that is, the “biological cost” assumed by the teacher to maintain performance in a high-demand environment.

The correlation found between state anxiety and higher 4:00 PM cortisol levels suggests that teachers may struggle to achieve psychological detachment (Sonnetag, 2012). From a human system design perspective, an ideally adapted work interface implies a natural physiological reduction of cortisol towards evening time in human operators. Nonetheless, results gathered from the selected group of Cartagena teachers demonstrate persistence of HPA axis activation that can be associated with the lack of ‘windows of recovery’ designed in the human system interface.

Integrating biological monitoring into this framework aligns with a growing body of evidence that shows how specific academic stressors can reshape human physiology. Kinman and Wray (2013), for instance, have highlighted how the increasing “porosity” of academic life—that blurring of boundaries between the professional and the personal—acts as a persistent barrier to true recovery. This is further supported by the work of Filaire et al. (2011), who used salivary cortisol to track how teaching large student cohorts triggers sharp adrenal peaks; their findings suggest that biological responses serve as sensitive barometers for systemic pressure.

When viewed through the lens of the Compensatory Control Model (Hockey, 1997), it becomes clear that maintaining high-level performance under heavy demands and a rhythm that doesn’t allow for sufficient recovery is never “free”—it requires a significant, extra regulatory effort from the faculty member. The findings of the baseline study suggest a potential physical cost. Specifically, with 68.9% of participants exhibiting metabolic risk indicators—measured by waist circumference—alongside observed instances of hormonal dysregulation. These markers may serve as an indication that the biological system is struggling to adapt to the persistent demands of the organizational environment.

These biomarkers allow to look beyond simple individual stress management and instead evaluate the core of organizational design. By reframing cortisol and state anxiety as early detection tools, we offer universities a way to pinpoint “systemic strain” in real-time. This allows institutions to intervene before these imbalances translate into chronic illness or a permanent decline in the performance of the university system itself.

PROPOSALS FOR SYSTEMIC INTERVENTION AND MODIFICATION

The transition from identifying systemic strain to implementing ergonomic modifications requires a paradigm shift: moving beyond individual-centered coping strategies toward deep organizational redesign. Based on the evening cortisol levels and state anxiety data, these interventions aim to optimize the health of the academic environment by managing recovery windows and simplifying the administrative interface.

As previously noted, high-demand tasks such as lecturing trigger acute physiological responses (Filaire et al., 2011). When recovery windows are absent, these repeated responses likely transition into a state of sustained allostatic load. This failure to disconnect by 4:00 PM suggests a state of systemic strain within the academic work system that’s misaligned with the physiological ‘switch-off’ that’s essential for maintaining homeostasis.

In order to effectively address these risks, one viable path involves rethinking academic schedules through the lens of circadian logic. As Costa (2010) highlights, when professional demands and biological rhythms drift out of sync—often due to fragmented hours or late-evening sessions—it can truly become a significant driver for metabolic and cardiovascular disorders. From a Human Systems Integration (HSI) standpoint, a more effective strategy might actually prioritize high-intensity cognitive tasks and face-to-face teaching during the morning. This timing works in harmony with the natural morning peak of baseline cortisol, potentially offering a better fit between institutional requirements and the teacher’s biological reality. However, it is worth noting that this model likely only succeeds if paired with institutional guarantees of “low-demand” periods in the late afternoon. These windows are essential for the psychological detachment needed to trigger hormonal deactivation and ensure the full physiological recovery of the faculty member.

Beyond the physiological markers, the observed link between state anxiety and metabolic indicators highlights what can be identified as a need to rebalance the modern academic environment. Current organizational structures quite often allow administrative “red tape”—ranging from heavy paperwork to relentless quality auditing—to displace the faculty’s core mission of research and teaching. This imbalance can indeed create high levels of cognitive friction, where non-pedagogical demands trigger increased state anxiety by systematically demanding more time and cognitive resources than the ones available. The “porosity” of academic work mentioned earlier can also be connected with this imbalance; administrative burdens often permeate personal time, transforming what should be “recovery windows” into periods of sustained mental load and “work rumination”.

The proliferation of administrative tasks—frequently misaligned with academic vocation and specialized training—can induce a state of low perceived competence and diminished motivation among faculty members. This vocational misalignment can generate a high cognitive load that contributes to sustained neuroendocrine activation, maintaining in this manner elevated cortisol levels throughout the workday. At the same time, this systemic imbalance can be further exacerbated by role porosity, largely as a consequence of an unoptimized and intrusive administrative burden that blurs the boundaries between professional and personal life. This porosity actively prevents the psychological detachment (Sonnentag, 2012) essential for downregulating the Hypothalamic-Pituitary-Adrenal (HPA) axis and achieving a physiological hormonal nadir.

The university's procedural architecture needs to be simplified, then, if one wants to mitigate the long-term allostatic load assumed by the faculty (McEwen, 1998). This proposal aligns with the SEIPS 2.0 model (Holden et al., 2013), which posits that the specific configuration of work system components—Tasks, Tools, and Organization—is indeed the primary determinant of health and safety outcomes. Redesigning administrative workflows to eliminate “cognitive friction” and ensuring that digital tools function as supportive interfaces rather than supplementary stressors is essential to safeguarding the physiological homeostasis and long-term sustainability of the human operator.

Ultimately, these interventions from a Human Systems Integration (HSI) perspective basically seek to ensure the sustainability of the university system. By integrating the physiological constraints of the teacher into the design of schedules and processes, the institution not only protects the well-being of its human component but also optimizes total system performance. The monitoring of biomarkers, therefore, ceases to be exclusively a clinical measure and becomes a human factors management tool that allows for the dynamic and preventive adjustment of organizational design.

FUTURE DIRECTIONS

Given the exploratory and cross-sectional nature of the baseline study (Alayón et al., 2025), future research aiming to refine human systems integration (HSI) models could integrate objective quantitative workload metrics. In light of these specific findings, it is crucial to include critical variables such as specific class schedules, student-to-teacher ratios (class size), and administrative task volume. The incorporation of these data would allow for a more precise identification of how the temporal configuration of the workday and the size of pedagogical audiences influence the teacher's allostatic load.

Furthermore, it is suggested to expand the psychological assessment spectrum to incorporate cognitive ergonomics indicators, such as perceived mental workload and organizational support. Finally, the development of quasi-experimental designs will be essential to determine whether the proposed interventions—specifically circadian-aligned scheduling and the simplification of bureaucratic processes—effectively restore cortisol homeostasis and reduce cardiovascular risk among the faculty population.

CONCLUSION

The intersection of mental health and biochemical markers represents a critical frontier for Applied Human Factors and Organizational Ergonomics. By expanding upon the findings of Alayón et al. (2025), this paper recontextualizes elevated state anxiety, evening cortisol, and metabolic risk as signals of a systemic imbalance rather than isolated medical issues. From an ergonomic perspective, the failure in physiological recovery at the end of the workday serves as a feedback loop, indicating a misalignment between organizational demands and the biological constraints of the human operator.

Implementing Human Systems Integration (HSI) strategies is essential to transition from individual-centered coping mechanisms toward a robust organizational redesign. As discussed, interventions such as circadian-aligned scheduling and the reduction of “cognitive friction” in administrative processes can effectively mitigate allostatic load. Ultimately, recognizing biomarkers as proactive ergonomic indicators allows institutions to identify systemic strain early, ensuring both the long-term well-being of the faculty and the overall performance and sustainability of the university system.

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