



## **ANALYSIS OF SALIVARY CORTISOL AS A RESOURCE IN THE EVALUATION OF OCCUPATIONAL STRESS: A SYSTEMATIC REVIEW OF THE LITERATURE**

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### **ABSTRACT**

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Stress at work has long been a reason for studies and concerns. In this context, ergonomics presents itself as the science that studies the adaptations of activities in the work environment, to the physical, physiological, biomechanical and psychological characteristics of individuals (NASCIMENTO and MORAES, 2000). Recent research shows that a series of variables influence the intensity of worker stress. The present systematic review sought to verify the main results obtained in research with analysis of salivary cortisol in different occupations. A search was carried out in journals published between 2005 and 2015, in the following databases: BIREME (Virtual Health Library); MEDLINE (US National Library of Medicine); PUBMED (National Library of Medicine and The National Institute of Health); Scopus and Science Direct. Thirty-two publications met the requirements and were included in the work. We analyzed whether the authors considered the analysis of salivary cortisol effective as a measure for identifying stress levels. Few studies compared the difference between genders, but those that did, found that women, married, with children, of low purchasing power, had high concentrations of cortisol. More than half of the studies did not show a comparison between work shifts and rest days. In addition, the main category investigated consisted of health professionals. Research indicates that salivary cortisol is an important biomarker in the investigation of stress-causing agents, and its analysis, if methodologically well-founded and described, can be implemented as a resource in the ergonomic analysis of work.

**KEYWORDS:** physiology, ergonomics, stress, cortisol, work

### **1. INTRODUÇÃO**

The term "work," according to some etymological dictionaries, derives from the Latin word "tripaliare" (a torture instrument with three stakes), meaning it is associated with the concept of suffering. In a more general sense, it refers to the activity through which humans consciously

and voluntarily alter the world to satisfy their basic needs (JAPIASSÚ and MARCONDES, 2001).

According to Silva et al. (2010), since ancient times, the nature of work has been a subject of study and concern for society. The evolution of tools and the organization of work have been of great importance in the advancement of contemporary civilizations. New technologies and management methods developed in recent decades have intensified work, leading to changes in the profile of illness and suffering among workers. This change is demonstrated by the increased incidence of work-related diseases and the emergence of new stressful situations such as stress, physical and mental fatigue, and other forms of work-related suffering (BRASIL, 2001). Many risk factors, whether physical, chemical, biological, ergonomic, or psychosocial, can cause occupational diseases (MURTA, 2004).

According to Iida (2005), "ergonomics" can have various definitions, but they all emphasize its interdisciplinary nature and the objective of studying the interaction between humans and work in the human-machine-environment system. More frequently, we find the definition of ergonomics as the science that studies the adaptation of work activities in the workplace to the physical, physiological, psychological, and biomechanical characteristics of the individual. Its focus should be on the well-being and safety of the worker, with the result being professional efficiency (NASCIMENTO and MORAES, 2000).

### **1.1 FISILOGIA DO ESTRESSE**

In general, when a person is exposed to stressful conditions, the neuroendocrine systems are activated and secrete substances such as the hormone cortisol and catecholamines (adrenaline and noradrenaline), promoting physiological responses to stress. When the restoration of balance is compromised due to chronic stress, the concentration of these substances in the bloodstream is altered (PACAK and McCARTY, 2000).

According to Low et al. (2010), the pathways through which stress influences health are mediated by the hypothalamic-pituitary-adrenal (HPA) axis, which regulates the body's response to stress in both the short and long term.

In the case of short-term or acute stress, the sympathetic nervous system is dominant. In this stage, also known as the alert phase, there is a release of catecholamines throughout the body, preparing it for a fight-or-flight response. During this moment, heart rate increases, blood vessels in the muscles of the legs and arms dilate (vasodilation), the liver increases glucose production (glycogenolysis) to provide energy for muscle contraction, and various other mechanisms that prepare the body for increased activity are activated (MOLINA, 2014). If the stressor persists, the body may enter the resistance phase, during which the adrenal gland reduces the release of adrenaline and starts producing and releasing cortisol (MARTINS, 2007). The exhaustion phase occurs when the stressor persists for an extended period or when other stressors act simultaneously. In this phase, psychological and physical fatigue sets in, leading to symptoms such as insomnia, dermatological and gastrointestinal problems, emotional instability, anxiety, hypertension, hyperglycemia, and more.

### **1.2 INFLUENCE OF CORTISOL**

Cortisol is a glucocorticoid secreted by the adrenal cortex and exerts significant effects that raise blood glucose levels. Nearly any type of physical or neurogenic stress causes an immediate and pronounced increase in cortisol secretion. Elevated levels of this hormone and catecholamines (adrenaline and noradrenaline) in the bloodstream can have detrimental effects on health, such as diabetes, obesity, hypertension, and suppression of the immune system (GOODMAN, 2009).

Currently, salivary cortisol is considered the most promising biomarker for assessing the stress response, playing an important role in occupational health research due to its potential use in evaluating the physiological response in working groups exposed to workload and occupational stress (KUDIŁKA et al., 2012).

According to Castro and Moreira (2003), saliva samples are obtained through simple, non-invasive procedures that do not cause stress and can be performed by untrained individuals. Samples can be collected multiple times a day, allowing for a dynamic assessment of free cortisol secretion. However, laboratory analysis should be critical, considering the circadian rhythm, the presence or absence of disease, and the individual's work shift (VILAR et al., 2013).

Rocha et al. (2013a) aimed to assess salivary cortisol concentration as a physiological indicator of stress levels in nurses by comparing a workday with a day off. The results suggested that on days off, stress is less evident, as salivary cortisol concentrations remain lower compared to workdays.

In a second study, Rocha (2013b) found that night shift workers experienced disruptions in their circadian rhythm on workdays, and as workers' age increased, the salivary cortisol values decreased, which was attributed to a possible adaptation to workplace stress. The analysis of salivary cortisol appears to be a useful resource in identifying work-related stress, and a systematic review of studies using this technique may not only confirm this hypothesis but also provide insights for more precise research on the subject.

## **2. METODOLOGIA**

A systematic search of journals published between 2005 and 2015 (pre-SARS-CoV-2 pandemic) was conducted. This chronology was justified by the high global prevalence of depressive and anxiety disorders (stress) due to the COVID-19 pandemic. This variable could potentially influence research outcomes since the subjects were already exposed to stressful conditions (such as social isolation, mask-wearing, and fear), which could interfere with the analysis of the work environment (SANTOMAURO et al., 2021). The search was carried out in the following databases: BIREME (Virtual Health Library), MEDLINE (US National Library of Medicine), PUBMED (National Library of Medicine and The National Institute of Health), Scopus, and ScienceDirect. The following keywords and phrases were used for the search: "workload and cortisol levels," "cortisol salivary in workers," and similar variations. Only studies conducted in humans, case studies, and studies with pre- and post-ergonomic intervention were included. Articles were selected after reviewing their respective titles and abstracts. To assess the quality of the research in terms of adequacy, clarity, and methodology details, the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology)

checklist, consisting of 22 items, was used. According to Malta et al. (2010), these items should be present in a scientific article, covering information in the title, abstract, introduction, methodology, results, and discussion. Additionally, the following aspects of the included articles were quantified:

- Number of annual publications during the specified period.
- Professions and genders studied.
- Work characteristics, such as shifts, rest days, and physical and mental workloads.
- Use of additional analyses, such as glycemic levels and others.

Evaluation by the author(s) of the effectiveness of salivary cortisol analysis as a biomarker for work-related stress. Publications that appeared in multiple databases were counted only once. Review articles were not included in this study.

During the search, 55 publications were identified. Of these, after an analysis of their respective titles, objectives, and methods, within the predefined criteria for this review, 33 investigations met the necessary requirements to be included in this study, and their full texts were read. The main reasons for excluding articles were that salivary cortisol was not the main variable analyzed (n=6), lack of relevance to the topic investigated in this study (n=6), and literature review type of research (n=10).

### 3. RESULTS AND DISCUSSION

#### 3.1 BIBLIOMETRIC INDICATORS

Considering the 33 selected articles according to the established requirements, we observed that the majority of the studies were published in the year 2014 (8 works), with notable representation for the years 2009 and 2012. The remaining years had 3 or fewer published works (Figure 1).

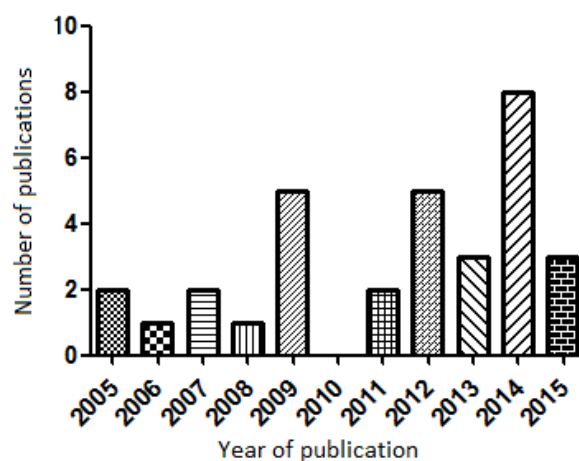


Figure 1: Number of publications considered in the study, by year, from 2005 to 2015.

According to Paschoal and Tamayo (2004), the interest in studying work-related stress has been steadily increasing in the scientific literature. One of the reasons for the rise in research on this topic is the negative impact of occupational stress on the health and well-being of workers, and consequently, on the functioning of an organization. Florentino et al. (2015) emphasize the importance of conducting research to expand the study and provide professionals with more effective mechanisms to cope with stress in the occupational environment. Research in health is an indispensable component for the advancement and development of peoples and nations. Regardless of the source of funding, health research contributes directly and indirectly, with the potential impact on economic activity, the creation and maintenance of a culture of evidence and reason (BRAZIL, 2004).

### **3.2 MAIN STUDIED PROFESSIONS**

Regarding the analysis of the study's population, it was found that the primary area of investigation consisted of healthcare professionals (34%) (Figure 2). According to Brazil (2004), there are no shortage of requirements to work in the healthcare field, as it often involves reflective work with technical, ethical, and political dimensions. Healthcare professionals, especially nurses working in hospitals, often deal with anxiety, feelings of loss, patient fragility, uncomfortable and embarrassing care procedures, invasive and painful treatments (ATHAYDE, 2005). In addition, low salaries and flexible work hours have been identified as reasons for these professionals taking on multiple jobs, subjecting themselves to overwork with shifts, increased responsibilities, which can affect their job performance (SILVA; PINTO, 2012). There were also studies on professionals in education (6%), security (6%), aviation (3%), and unspecified professions (50%), including studies with audiences from the industrial, aerospace, public sector, communication, and student sectors (Figure 2). According to Oiticica and Gomes (2004), considering the competitive demands that schools face, teachers are required to constantly and quickly update and adapt to evolving social values. However, the reality does not provide sufficient conditions for educational practices, in terms of materials, audiovisual resources, classroom physical environments, and often in terms of salaries that do not correspond to the educator's responsibilities, leading to dissatisfaction and contributing to increased stress levels. Thus, it can be said that teachers are among the professionals who experience high levels of stress (MARTINS, 2007).

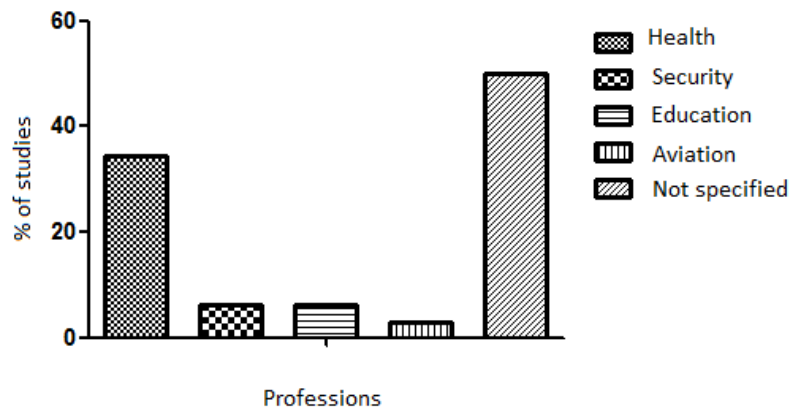


Figure 2: Main Areas of Study Focus.

As Catarina (2010) points out, the scientific literature on occupational stress indicators in police officers and their relationship with work is considered scarce. Some authors believe that this is due to a tradition where occupational health studies are primarily focused on industrial sectors (SOUZA et al., 2007). One hypothesis is that the historical relationship between intellectuals and security professionals, especially during the years of dictatorship, may have led to a disconnect between these professionals. According to Catarina (2010), it is also important to conduct occupational research with security professionals to enhance understanding and identify potential risk factors to their health.

In the case of aviation professionals, it is notable that the growth of air transportation in recent decades underscores the significance of this sector for the economy, both in passenger and cargo transport. Along with this development, changes in organizational and management practices are required (ITANI, 2009). According to Silveira et al. (2011), the need for quick and precise decision-making in a complex activity like flying further emphasizes the importance of the topic, as stress and fatigue can affect the decision-making process. Therefore, research on working conditions in aviation should shed light on how health is managed and considered in management practices (ITANI, 2009).

### 3.3 QUALITY OF OBSERVATIONAL STUDIES

Regarding the information that should be present in the papers, according to the STROBE initiative, it can be observed that, in general, the research is adequate in terms of clarity and detail in the studies (Table 1). However, for such an important item as the description of objectives and hypotheses, a relatively low percentage was observed (64.7%). Table 1: Percentage of STROBE checklist items addressed in studies published between 2005 and 2015.

Item	Recommendation	Not applicable	Not described	Described
1a	Include the study design in the title or abstract using the commonly used term.	0 (0.0)	4 (17,6)	28 (82,3)
1b	Provide an informative and balanced summary in the abstract of what was done and found.	0 (0.0)	2 (11,7)	30 (88,2)
<b>Introduction</b>				
2	Explain the scientific and rational basis for the investigation.	0 (0.0)		32 (100)
3	.Describe the specific objectives, including any pre-existing hypotheses.	0 (0.0)	10 (35,2)	22 (64,7)
<b>Methods</b>				
4	Present key elements related to the study design at the beginning of the article.	0 (0.0)	3 (14,7)	29 (85,3)
5		1 (3,0)	7(26,5)	24 (70,5)
	Describe the locations.			
5		0 (0.0)	12 (41,2)	20 (58,8)
	Describe recruitment dates.			
5		0 (0.0)	10 (35,3)	22 (64,7)
	Describe follow-up periods.			
6a	Present the eligibility criteria.	0 (0.0)	3(14,7)	29 (85,3)
6a		0 (0.0)	9 (32,3)	23 (67,6)
	Describe the follow-up methods.			
6b		0 (0.0)	9(32,3)	23 (67,6)
	Present corresponding criteria.			
6b	Present the number of exposed and unexposed individuals in the study.	0 (0.0)	4 (17,6)	28 (82,3)
7		0 (0.0)	6 (23,5)	26 (76,4)
	Clearly define all outcomes.			
7	Clearly define all exposures.	0 (0.0)	6 (23,5)	26 (76,4)
7	Clearly define all predictors.	0 (0.0)	6 (23,5)	26 (76,4)
7	Clearly define all potential factors.	0 (0.0)	10 (35,2)	22 (64,7)
7	Clearly define all effect modifiers.	0 (0.0)	8 (29,4)	24 (70,5)
8	Present the data sources.	0 (0.0)	4 (17,6)	28 (82,3)
8	Measurement method	0 (0.0)	0 (0,0)	32 (100)
9	Describe any efforts to address potential sources of bias.	0 (0.0)	10 (35,3)	22 (64,7)
10	Explain how the study size was determined.	0 (0.0)	8 (29,4)	24 (70,5)
11	Explain how quantitative variables were handled in the analysis.	0 (0.0)	5 (20,5)	27 (79,5)
12a	Describe all statistical methods.	0 (0.0)	3 (8,8)	29 (91,2)
12a	Describe the statistical software used.	0 (0.0)	3 (8,8)	29(91,2)
12b	Describe any methods used to examine subgroups and interactions.	4 (11,7)	4 (11,7)	24 (76,6)
12c	Explain how missing data was addressed	0 (0.0)	13 (44)	19 (56)
12d	Explain how loss to follow-up was addressed.	1 (3,0)	7 (26,5)	24 (70,5)
12e	Describe sensitivity analysis.	32(100)		
<b>Results</b>				
13a	Present the number of individuals in each phase of the study.	0 (0.0)	4 (17,6)	28 (82,3)
13b	Present reasons for non-participation at each phase.	2 (5,8)	5 (20,5)	25 (73,5)
13c		26 (82,3)	0 (0,0)	6 (17,6)
	Consider the use of a flow diagram.			
14a	Present the characteristics of the study participants.	1 (3,0)	1 (3,0)	30 (94)
14b	Indica o número de participantes com falta de dados para cada variável de interesse	1 (3,0)	12 (41,2)	19 (55,8)
14c	Summarize the follow-up time.	1 (3,0)	11 (38,2)	20 (55,8)
15	Report the results or summarize the measurements.	0 (0.0)	3 (8,8)	29 (91,2)
16a	Present unadjusted estimates.	4 (11,7)	24 (73,5)	4 (14,7)
16a	Present estimates adjusted for confounding.	0 (0.0)	3 (14,7)	29 (85,3)
16b	Present estimates with confidence intervals.	0 (0.0)		32 (100)
16c		0 (0.0)	4 (17,6)	28 (82,3)
	Consider relative risk and absolute risk estimates			
17	Provide information about any other analyses conducted.	1 (3,0)	12 (41,2)	19 (55,8)
<b>Discussion</b>				
18	Summarize the main results with reference to the study objectives.	0 (0.0)	1 (3,0)	31 (97)
19	Discuss study limitations.	0 (0.0)	6 (23,5)	26 (76,4)
20	Provide a cautious interpretation of the results in consideration of the objective.	0 (0.0)	2 (5,8)	30 (94,2)
20	Explain the results of similar studies.	0 (0.0)	2 (8,8)	30 (91,2)
21	Discuss the generalizability of the study results.	0 (0.0)	4 (11,7)	28 (88,2)
<b>Other information</b>				
22	Present the source of funding and the role of the funders.	0 (0.0)	15 (44,1)	17 (47)

The overall item "discussion" had the highest compliance percentage with an average of 89.4% in its sub-items. In this item, the sub-item that was least addressed was related to discussing the limitations of the study, which can be considered essential in this type of approach because

most studies have confounding factors or limitations inherent to the methodology. For example, in some studies, there was an omission of methodological descriptions related to participants, such as population characteristics, and a description of the statistical methods.

According to Bosi (2012), critical evaluation of studies means discerning the validity of their results and understanding how potential study defects affect the results. This critical evaluation includes the relevance of the study, that is, clinical significance, as well as internal and external validity of the research.

In scientific research, validity is the extent to which a measure accurately represents the study's concept. Therefore, issues such as study design, paradigms, theoretical concepts, researcher expectations, methodological and analytical procedures, and presentation and discussion of results should be part of the validity verification (GIANDONI et al., 2012).

The STROBE initiative is suggested by the Department of Science and Technology of the Ministry of Health as a tool to guide the construction of observational epidemiological studies and systematic reviews. It can also be used as supporting literature for undergraduate and postgraduate students in researcher training (BRAZIL, 2013).

An important component of a comprehensive systematic review is, therefore, a primary assessment of the methodological quality of the research. It is important, however, to distinguish between the quality of reporting and the quality of what was actually done in the design, implementation, and analysis of a study. According to Sanderson et al. (2007), a high-quality report ensures that all relevant information about a study is available to the reader, but it does not necessarily reflect a low susceptibility to bias.

Malta et al. (2010) suggest that the STROBE initiative should be seen as an ongoing process open to revisions, recommendations, criticism, and new evidence.

### **3.4 VARIABLES CONSIDERED IN THE STUDIES**

As presented in Table 2, regarding the analyzed variables, it is observed that 78% of the studies did not compare between genders, 60% did not present a comparison between work shifts, and 69% did not correlate working days with days off. Furthermore, although 60% analyzed the physical or mental workload, 72% did not mention whether they considered salivary cortisol as an effective measure in the analysis of occupational stress, as shown in Table 2.

#### **3.4.1 GENDER COMPARISONS**

According to Eller et al. (2006), the sensation of stress, assessed by cortisol release, exhibits a positive exponential curve in the early hours of the day, with a drop after eight hours, in both men and women. However, the feeling of pressure combined with high effort appears to influence women more.

In athletes, higher cortisol concentrations were also observed in women, but this increase was not considered statistically significant (SEGATO et al., 2010).



In a study by Susoliakova et al. (2014), the authors sought to assess salivary cortisol levels in two different occupations (teachers and firefighters), where it was observed that the pattern of salivary cortisol throughout the workday seemed to be similar in both genders.

Levi (1999) found that certain groups had a higher risk of occupational stress, and among the determinants for this occurrence, he mentioned the combination of being female, having excessive workload, and a less favorable economic situation.

Areias and Guimarães (2004) demonstrated that married women with children are more susceptible to work overload and occupational demands, which can contribute to a high level of stress. Other authors have also found that women report more negative job characteristics than men.

The investigated population attributed this to differences in learning opportunities and job monotony (MATTHEWS et al., 1998).

The data obtained by Areias and Guimarães (2004) show that mental health and support factors are interrelated, and that psychosocial risk factors for stress are higher for female participants. However, the author mentioned that further research should be conducted to address the effects of other variables on gender-specific issues.

Laberg et al. (2020) argue that the evaluation and quantification of the impact of the production process in the workplace should consider gender analysis in decision-making and ergonomic interventions. According to Fulvio et al. (2021), the organizational analysis of work is a variable that should be considered and adjusted to reduce exposure to physical and psychosocial stress factors in this population.

### **3.4.2 SHIFT COMPARISONS**

Shift work has significant implications for health in terms of physical, emotional, and social aspects. According to Simões et al. (2010), shift work disrupts the circadian rhythm, leading to negative implications for self-regulation biological processes, notably sleep disorders.

The most common occupational losses associated with sleep disorders are absenteeism, reduced work quality, decreased productivity, and an increased risk of accidents (LITTNER et al., 2003).

Carev et al. (2011), evaluating anesthesiologists' shifts, identified that sleep deprivation-induced stress can result in increased sympathetic activity, blood pressure, and disruption of the circadian rhythm.

A study exploring the differences in salivary cortisol profiles between nurses working night shifts and regular shifts found that nurses working at night took at least four days to adjust their circadian cortisol secretion rhythm (NIU et al., 2015).

### **3.4.3 WORKDAY VS. DAY OFF COMPARISONS**

In an effort to investigate how shift work influences cortisol rhythms, Bostock and Steptoe (2013) identified that working days, regardless of the shift, were associated with higher stress and fatigue when compared to days off. These results are similar to those of Da Rocha et al.

(2013), who observed that salivary cortisol concentrations on a day off remained lower when compared to working days among nurses. However, the author emphasizes the importance of complementing physiological results with stress questionnaires.

Only a third of the studies correlated salivary cortisol on working days with days off, indicating the need for further research to support and possibly emphasize the hypothesis of the cortisol-occupational stress relationship.

#### **3.4.4 CORRELATION WITH PHYSICAL OR MENTAL WORKLOAD**

According to Frutoso and Cruz (2005), the term "workload" is a theoretical construct resulting from the need to understand that, for a given work situation, there is a constant tension between the demands of the process and the biological and psychological capacities of the workers to meet them. Workload plays a prominent role in discussions about health and job satisfaction.

Workload can generally be divided into two dimensions: mental and physical. The mental dimension pertains to subjective aspects such as feelings, affects, emotions, motivations, and cognition. The physical dimension is related to postures (static and dynamic), gestures, and movements (FRUTOSO and CRUZ, 2005).

There are three groups of measures to assess workload: performance measures (efficiency and productivity), physiological measures, and subjective measures (typically questionnaires) (FRUTOSO and CRUZ, 2005).

According to Cardoso and Gontijo (2012), the complexity of tasks can interfere with worker performance and the mental demands imposed by the job, justifying theoretical and methodological studies on the mental and physical workload imposed by work, particularly because in Brazil, there are still few studies investigating these characteristics in real situations based on ergonomic research.

As mentioned earlier and shown in Figure 2, the most researched professional group is healthcare professionals. Research can also be observed in the fields of security, education, communication, public service, and sectors of the food and automotive industries.

It was noted that, in addition to salivary cortisol, variables such as mood, sleep, fatigue, stress, circadian rhythm, among others, were analyzed in various studies included in this review, as shown in Table 3.

#### **3.4.5 OTHER CONSIDERED VARIABLES**

The response to stress results from the interaction between individual characteristics and environmental demands, that is, the disparities between the external and internal environments. This response includes cognitive, behavioral, and physiological aspects, aiming to process available information and select appropriate behaviors for the organism. Margis et al. (2003) mentions that different stress-inducing situations and responses to them vary among individuals and in their presentation, and it is therefore interesting to consider other variables in the analysis of stress.

Table 2: Frequency of Variables Considered in the Analyzed Articles

Analyzed variables					
Authors	Gender comparisons	Shift Comparisons	Comparison between workday vs. day off	Correlation with the Physical or Mental Workload	Evaluation of the Effectiveness of Salivary Cortisol Analysis as a Measure of Stress
Amirian et al. (2015)	No	Yes	No	Yes	Not reported
Anjum et al. (2011)	No	Yes	No	No	Yes
Atri et al. (2015)	No	No	No	Yes	Not reported
Bostock; Steptoe (2013)	No	Yes	Yes	Yes	Not reported
Campos; David (2014)	No	Yes	No	No	Yes
Carev et al. (2011)	No	Yes	No	Yes	Yes
Da Rocha et al. (2013)	No	No	Yes	No	Yes
Dahlgren et al. (2005)	No	No	Yes	Yes	Not reported
Dahlgren et al. (2009)	No	No	Yes	Yes	Not reported
De Schipper et al. (2009)	No	No	No	No	No
Eller et al. (2006)	Yes	No	Sim	No	Yes
Eller et al. (2012)	Yes	No	No	No	Not reported
Griefahn; Robens (2008)	No	Yes	No	Yes	Not reported
Hansen et al. (2012)	No	No	Yes	No	Not reported
Harris et al. (2007)	No	Yes	No	Yes	Yes
Hébert; Lupien (2009)	No	No	No	No	Yes
Lindholm et al. (2012)	No	Yes	No	No	Not reported
Marchand et al. (2014)	Yes	No	No	Yes	Not reported
Marrelli et al. (2014)	No	No	No	Yes	Not reported
Martinez De Tejada et al. (2013)	No	Yes	Yes	Yes	Not reported
Metzenthin et al. (2009)	No	Yes	No	Yes	Not reported
Minelli (2014)	No	No	No	No	Yes
Neylan et al. (2005)	No	No	No	No	Not reported
Niu et al. (2015)	No	Yes	Yes	No	Not reported
Rai et al. (2012)	No	No	No	Yes	Not reported
Rai; Kaur (2012)	No	No	No	Yes	Yes
Scholey et al. (2009)	No	No	No	No	Not reported
Sjörs et al. (2014)	Yes	Yes	Yes	Yes	Not reported
Stokholm et al. (2014)	No	No	No	Yes	Not reported
Susoliakova et al. (2014)	Yes	No	No	Yes	Not reported
Uhde et al. (2007)	No	Yes	Yes	Yes	Yes
Vangelova; Stanchev (2014)	No	No	No	Yes	Not reported
Total	No (78%)	No (60%)	No (69%)	No (40%)	Not reported
	Yes (22%)	Yes (40%)	Yes (31%)	Yes (60%)	Yes (28%)

Table 3: Main fields of activity, additional variables analyzed in relation to salivary cortisol analysis, and types of interventions.

Authors	Area of Expertise	Variables considered in addition to salivary cortisol					Intervention	Variables considered in addition to salivary cortisol
		Mood	Sleep	Fatigue or Stress	Circadian Rhythm Disruption (yes, no, or not reported)	Others		
Amirian et al. (2015)	Health	Yes	-	-	NR	Pain and Melatonin	NA	-

Anjum et al. (2011)	Health	-	Yes	-	Yes	PA e FC	NA	-
Atri et al. (2015)	Unspecified	-	-	Yes	NR	Periodontitis	NA	-
Bostock; Steptoe (2013)	Aviation	Yes	Yes	Yes	NR	-	NA	-
Campos; David (2014)	Health	-	-	Yes	NR	-	NA	-
Carev et al. (2011)	Health	-	Yes	Yes	NR	PA	NA	-
Da Rocha et al. (2013)	Health	-	-	Yes	NR	-	NA	-
Dahlgren et al. (2005)	Unspecified	-	Yes	Yes	sim	-	NA	-
Dahlgren et al. (2009)	Health	-	Yes	Yes	NR	-	NA	-
De Schipper et al. (2009)	Education	-	-	-	-	Service Quality	NA	-
Eller et al. (2006)	Unspecified	-	-	-	NR	Psychosocial Factors	NA	-
Eller et al. (2012)	Public Administration	-	Yes	-	NR	Melatonin	NA	-
Griefahn; Robens (2008)	Students	-	Yes	-	Yes	-	NA	-
Hansen et al. (2012)	Public Servant o	-	Yes	-	NR	-	NA	-
Harris et al. (2007)	Health	-	-	Yes	NR	Quality of Life, Job Demands, Job Control	NA	-
Hébert; Lupien (2009)	Unspecified	-	-	-	NR	Noise	NA	-
Lindholm et al. (2012)	Communication.	-	Yes	Yes	NR	-	NA	-
Marchand et al. (2014)	Unspecified	-	-	Yes	NR	-	NA	-
Marrelli et al. (2014)	Health	-	-	Yes	NR	Salivary Immunoglobulin A	NA	-
Martinez De Tejada et al. (2013)	Health	-	-	Yes	NR	Catecholamines , FC	NA	-
Metzenthin et al. (2009)	Health	-	-	Yes	Yes	Quality of Life	NA	-
Minelli (2014)	Unspecified	-	-	Yes	NR	-	Meditation	Yes
Neylan et al. (2005)	Security	-	-	Yes	NR	Post-Traumatic Stress Disorder	NA	-
Niu et al. (2015)	Health	-	Yes	Yes	Yes	-	NA	-
Rai et al. (2012)	Space Industry	Yes	Yes	-	NR	VO2, Workload	NA	-
Rai; Kaur (2012)	Space Industry	-	-	-	NR	-	NA	-
Scholey et al. (2009)	Unspecified	Yes	-	-	No	Cognitive Performance	Chewing Gum	Yes
Sjörs et al. (2014)	Unspecified	-	-	Yes	NR	-	NA	-
Stokholm et al. (2014)	Industry	-	-	-	No	Noise	NA	-
Susoliakova et al. (2014)	Safety and Education	-	-	-	NR	-	NA	-
Uhde et al. (2007)	Automotive Industry	-	Yes	Yes	No	Effort and Reward	NA	-
Vangelova; Stanchev (2014)	Unspecified	-	-	Yes	Yes	Visual Symptoms and Muscular Complaints	NA	-

According to Navarro and Navarro (2011), excess cortisol can cause insomnia and markedly elevate or depress mood. Hypercortisolism is involved in the genesis of depressive disturbance. According to Pinto (2010), patients with depression show an increase in cortisol release, but not all patients with hypercortisolism are depressed.

Sleep also seems to influence stress and cortisol levels. Sadir et al (2010) reports that in industrialized countries, the percentage of workers performing night work that extends into the next day has been constantly increasing. According to the author, the human organism is adapted to work during the day (ergotropic phase) and adapts to rest and energy replenishment (trophotropic phase). Changes in this cycle can affect the circadian rhythm and consequently the cortisol release phase (LOW, 2010).

Sapolsky (2001) suggests that elevated cortisol levels propose models for the pathogenesis of depression by increasing the intensity of affective symptoms (depressive mood, anhedonia).

In addition to cortisol, sleep, stress, and circadian rhythm, variables such as pain, noise, melatonin, catecholamines, and salivary immunoglobulin A have also been found as complements to the studies (table 3).

These variables were assigned in their respective studies because it is known that excess cortisol (glucocorticoids in general) can disturb some physiological activities such as reducing the release of central nervous system hormones, ion retention, hypertension, depression of the immune system, skin thinning, peripheral insulin resistance, and hyperglycemia (LOW 2010).

According to Goodman (2009), cortisol raises blood glucose concentration and, for reasons not yet entirely understood, reduces the sensitivity of many tissues, especially skeletal muscle and adipose tissue, to the stimulating effects of insulin on glucose uptake and utilization. This condition is called "Adrenal Diabetes," which can evolve into Type II Diabetes.

Clinical observations in patients with excess or deficiency of glucocorticoids (cortisol, corticosterone) revealed that the brain is an important target tissue for these hormones, and depression, euphoria, psychosis, apathy, and lethargy are important manifestations (LOW et al 2010). Glucocorticoids cause neuronal death, notably in the hippocampus, which may be related to neurodegenerative diseases such as Alzheimer's.

According to JOSEPH and HURRELL (2011), chronic stress, whether physical, psychological, or intellectual, is a factor that, when not managed, poses ergonomic risks because the homeostatic imbalance of a series of physiological variables often silently impacts the body, potentially causing future diseases.

In conclusion, studying and researching the functions of the body and all the physiological factors that can be influenced by work are relevant for understanding the genesis of occupational diseases and promoting intervention strategies.

#### **4. FINAL CONSIDERATIONS**

Ergonomics is a science that has been increasingly explored by professionals and researchers from various fields. Therefore, understanding the physiological phenomena of the human body is extremely important in order to act as a health and work organization interventionist.

With this study, we can observe that salivary cortisol is an important biomarker in investigating stress-inducing agents. Its analysis, if methodologically well-founded and described, can be implemented as a resource in ergonomic work analysis. As ergonomics professionals are the ones who analyze, quantify, diagnose, and intervene in potential health risks for workers, this

becomes an important tool because it provides objective and reliable data for decision-making in favor of the worker.

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