

# Application of indicators associated with mental fatigue in sanitary personnel from Heroes del Moncada Polyclinic in Cárdenas municipality, Cuba

Juan Lázaro Acosta-Prieto, Joaquín García-Dihigo, Yilena Cuello-Cuello, Yoel Almeda-Barrios & Amelia Beatriz Ulloa-Felipe

University of Matanzas, Matanzas, Cuba, [juan.acosta@umcc.cu](mailto:juan.acosta@umcc.cu), [joaquin.garcia@umcc.cu](mailto:joaquin.garcia@umcc.cu), [yilena.cuello@gmail.com](mailto:yilena.cuello@gmail.com), [yoel.barrios@umcc.cu](mailto:yoel.barrios@umcc.cu), [ulloaamelia41@gmail.com](mailto:ulloaamelia41@gmail.com)

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## Abstract

Healthcare professionals undergo frequent job stress due to exposure to high cognitive demands. The present research was carried out at the "Héroes del Moncada" polyclinic in the municipality of Cárdenas, Matanzas. The objective is to apply indicators associated to mental fatigue. The indicators applied are: Simple Reaction Time and Yoshitake Test. Statgraphic Centurion 15.0 software is used as a tool for information processing. The results of the research obtained in this study show significant differences between before and after in some of the indicators applied, which evidences the presence of mental workload at the end of the working day. When applying the Yoshitake Test after finishing the assigned activity, all the health personnel of the study sample manifested the presence of subjective sensation of fatigue, highlighting both physical and mental fatigue.

**Keywords:** health personnel; mental load; psychological indicators; psychophysiological indicators.

# Aplicación de indicadores asociados a fatiga mental en personal sanitario del policlínico Héroes del Moncada del municipio Cárdenas, Cuba

## Resumen

El personal sanitario constituye una profesión donde el estrés laboral se presenta frecuentemente por estar expuestos a elevadas exigencias cognitivas. La presente investigación se desarrolló en el policlínico "Héroes del Moncada" del municipio Cárdenas, Matanzas. El objetivo es aplicar indicadores asociados a fatiga mental. Los indicadores aplicados son: Tiempo de Reacción Simple y Prueba de Yoshitake. Se utiliza como herramienta para el procesamiento de la información el software Statgraphic Centurion 15.0. Los resultados de la investigación obtenidos en esta muestra presentan diferencias significativas entre antes y después en algunos de los indicadores aplicados lo que evidencia la presencia de carga mental al final de la jornada laboral. Al aplicar el Test de Yoshitake después de finalizar la actividad asignada, todo el personal sanitario de la muestra de estudio manifiesta la presencia de sensación subjetiva de fatiga, destacando la fatiga tanto física como mental.


**Palabras clave:** personal sanitario; carga mental; indicadores psicológicos; indicadores psicofisiológicos.

## 1 Introduction

The technological development of recent years and the increasing outsourcing of the labor world have decisively influenced the evolution of the mental workload, augmenting jobs with cognitive demands. The work currently requires

less direct contact with materials and their transformation, leaving this work in charge of advances in automation and computerization. The employee, on the other hand, is responsible for controlling the correct functioning of processes, which means having to be attentive to a series of signals, to know their meaning, and activate the

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corresponding controls to achieve the desired operation. Labor activity demands of the worker a certain effort, a mental workload which requires certain requirements of the organism. Mental workload is defined as the difference between the cognitive demands of a job or task and the attention span of the worker [1-3].

Work stress is defined as a state that occurs when an individual perceives the demands of a situation exceeds their resources [4-6]. The mentioned stressful event can increase the vulnerability of the organism to certain diseases, exerting an immunosuppressive effect, according to [6-8] which manifests itself mainly in those pathologies that are directly linked to immunological mechanisms, such as infections, autoimmune diseases and neoplasms [9-11]. Chronic stress is also well known to lead to elevated blood pressure and risk of heart attack [12,13]. Eustress must be distinguished from distress. Eustress is a neutral or pleasurable event that is thought to be "controllable." Distress can be emotionally or physically threatening, severe, prolonged, unpredictable, and "uncontrollable." [4-6].

Humans are exposed to stress from birth, but it must be recognized that a certain amount of stress is beneficial to life. This allows you to effectively face some important challenges, providing the necessary excitement and energy required in certain situations. Stress becomes dangerous when it is of excessive proportions, which overwhelm the individual's adaptive capacities or when it accumulates without adequate exit, installing frustration [12,13].

Fatigue has repercussions on three different essential levels, highlighting its unity of action [14,15]:

1. Physiological level, with its decrease in the activity of the body and decline in performance in the work plane. Sweating, muscle tension, palpitations, tachycardia, muscle tremors, stomach discomfort, breathing difficulties, dry lips, swallowing difficulties, headaches, dizziness, feeling nauseous, among others.
2. Psychological level, with a feeling of discomfort accompanied by a courtship of functional alterations, which develop symptoms of worry, fear, insecurity, difficulty deciding, negative thoughts, difficulties in thinking, studying, or concentrating.
3. Psychophysiological level, considered as an intermediate state between the previous two.

As a consequence of the above mentioned effects, alterations to physical and mental health can occur, as well as implications in the work environment, ranging from problems of interpersonal relationships, absenteeism, accidents and dissatisfaction at work up to death.

According to a recent report by the European Agency for Safety and Health at Work, between 50% and 60% of absences from work per year are caused by stressful situations [16].

Due to the importance given to the issue of cognitive demands demanded by jobs and the development of diseases caused by them, The International Ergonomic Association declares Cognitive Ergonomics as one of the domains of specialization within the discipline of ergonomics. It is related to mental processes, such as perception, memory, reasoning, and motor response, when they affect interactions between humans and other elements of a system [17].

Relevant topics include mental work, decision-making, experienced performance, human-computer interaction, human reliability, work stress and training as these can relate to the design of the human-system.

There are several indicators to assess mental work that have been used by several researchers, applied more frequently in the groups listed below [18-21]:

- Physiological indicators: heart rate (HR), heart rate variability (HRV), Respiratory rate variation, hormonal changes, evoked potentials, blood pressure, pupillary diameter, blinking frequency, electroencephalogram.
- Psychophysiological indicators: tactile discrimination threshold (TDT), critical fusion frequency, simple reaction time (SRT), complex reaction time, redundant simple reaction time, chromatic discrimination frequency, depth perception (DP), cutaneous galvanic resistance, manual dexterity.
- Psychological indicators: Yoshitake test, Cooper-Harper scale, SWAT (Subjective Work Load Assessment Technique), NASA-TLX (Task Load Index), WP (Workload Profile), Double Task Method, Subjective Mental Load Scale (ESCAM).
- Biomolecular indicators: variation in cholesterol, triglyceride, glucose and apolipoprotein B levels.

Despite the use of physiological, psychophysiological, psychological and biomolecular indicators in research such as [18-21] there has not been a stable behavior with respect to the variations between before and after the development of an activity that requires cognitive demands as is the case of jobs such as teachers, process controllers, health professionals, professional drivers, among others, where both significant and negligible variations have been obtained, a homogeneous trend has not been achieved in individuals who have a mental workload.

The population of health personnel is interested to evaluate indicators of mental load since they constitute one of the professional groups in which stress and exhaustion occur most frequently due to exposure to high cognitive demands, so that psychic effects such as anxiety, depression, psychosomatic diseases and neurotic disorders occur, motivated by the severity of the patients. Healthcare overload, emergencies, rotating shifts and the critical situation of patients generates intense anxiety and stress which are some of the professional risks in the hospital environment.

It should be noted that this profession is prone to develop the Burnout Syndrome that is generated above all by the institutional dynamics: organization of work, dictatorial leadership, constant increase in care pressure and responsibility, to which is added the lack of autonomy and decision of the doctor.

Although burnout rates may vary depending on specific organizational contexts and populations, all data indicate high prevalence rates in the medical population. The consequences of work stress are broad and important and affect mental health, physical health, quality of life and professional effectiveness of health personnel. This situation raises the need to develop prevention and intervention programs that help control and alleviate such effects since the

psychological well-being of workers.

The health personnel of the polyclinic "Heroes del Moncada" of the municipality of Cárdenas due to the life and death situations to which they are subjected daily, the continuous hours spent in the diagnosis of diseases that require their focus, concentration and knowledge, as well as exposure to the error that in this case puts human lives at risk can trigger emotional problems in the population under study, cognitive and physiological.

Despite the existing situation in the entity, a study has not been carried out to assess the behavior of the indicators associated with mental workload in the health personnel of the "Heroes del Moncada" polyclinic of Cárdenas municipality.

General objective: to analyze the behavior of indicators related to mental load in health personnel of the polyclinic "Heroes del Moncada" of the municipality of Cárdenas.

In the present research, the empirical method prevails, based on the development of an experiment. Among the tools and techniques, a general physical examination and the Eysenck Test are used as a psychological examination for the selection of the sample. The indicators applied are: Simple Reaction Time and Yoshitake Test. The Statgraphic Centurion 15.0 software is used as a tool for information processing through the analysis of the comparison of paired samples, using the t-tests for the mean and that of the signs.

## 2 Materials and methods

Based on the analysis of the procedures used by [18,20] the procedure shown in Fig 1 is proposed for the development

of this research. It differs from the previous ones in that for the selection of the sample a physical examination and a psychological test are applied, in addition to controlling the environmental conditions such as noise, lighting and work microclimate, thus eliminating external variables that may affect the values of the indicators.

The research aims at assessing the behavior of the selected indicators related to mental load in health personnel, which is subject to the presence of cognitive demands in the period of an eight-hour workday. The following describes how the aforementioned effect is achieved:

The evaluation method consists of the initial measurement of the indicators selected in the sample under study, then the development of the proposed cognitive activity and finally the measurement of the indicators at the end of the activity.

In this way, the behavior of the selected indicators before and after the end of the eight hours of the working day is obtained, which fulfills the assumption of the presence of mental load.

The procedures used to select the sample under study are the physical and psychological evaluation, where a general physical examination is applied by the doctor of the office where the individual resides and the psychological test Eysenck Personality Inventory respectively.

All applicants who present a cardiovascular functioning disorder, chronic or acute disease at the time of the experience, or mismatch of an emotional balance, in another sense, psychological disorders such as mixed neurosis, hypochondriacs, hysterical reactions are eliminated from the experience.

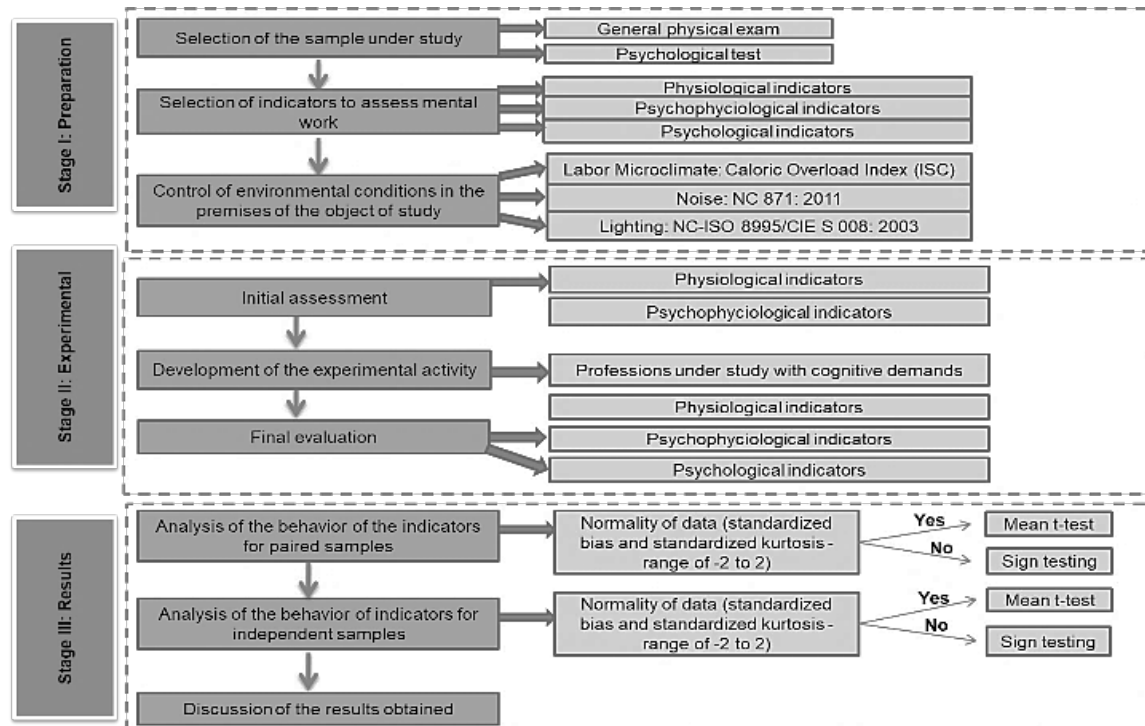


Figure 1. Proposed procedure to assess the behavior of indicators related to mental load.

Source: The Authors.

For the control of the environmental conditions in the room where the experiment is performed, the following aspects are considered:

- Microclimatic conditions: The Caloric Overload Index (ISC) is applied to evaluate microclimatic conditions. The microclimatic variables that are measured are balloon temperature (bt), using the balloon thermometer and the dry bulb and wet bulb temperatures by the suction psychrometer, the water vapor pressure is obtained in the psychrometric chart from the air velocity (ay), the dry bulb (dbt) and wet bulb temperatures (wbt). In the matter of the value of metabolism (M) is taken 100 W / m<sup>2</sup> and light manual work such as writing.
- Noise control: The sound pressure level existing in the premises under study is measured with an integrator-averaging type I sound level meter and the evaluation of the conditions according to CN 871: 2011.
- Lighting control: To carry out the measurement procedure, a luxmeter is used as a light intensity measurement equipment, with which the lighting levels are recorded in the premises under study. The assessment is based on NC-ISO 8995/CIE S 008:2003.

To assess mental work, indicators are applied before and after subjecting the individual to cognitive demands that may or may not cause the presence of mental load, that is, an experimental design with pre-test and post-test is established.

The initial evaluation of the indicators was carried out in the morning schedules, starting at 8:00 am and ending at 9:00 am, the start time of the experimental activity.

The activities culminated after 4 hours and from 1:00 pm, time to end the activity until 2:00 pm the final evaluations were made.

For the selection of the indicators, some limitations of the indicators applied to assess mental work are analyzed, for instance: to respond to other demands of the organism such as physical effort, pathological states, variations in environmental conditions and emotional factors; difficulties in experimental control; because they are techniques that limit the normal development of the activity and require specialized technology; for not having the equipment for its measurement in optimal conditions and for not adjusting to the conditions of the investigation. The indicators to be used are defined as:

- Psychophysiological indicators

Simple reaction time (TRS): The reaction time is able to show the functional deficit produced as a result of prolonged activities with high emotional load and with the participation of the visual analyzer. For the application of the indicator, software is used that facilitates its measurement, so it allows the activity to be fast and dynamic when collecting the information. With this reaction time, the margin of error that can exist in tests of complex reaction time and redundant simple reaction time is reduced because the precision of the individual is eliminated when accepting to press the button according to the stimulus that is shown (light or sound), so that with the simple reaction time more real and reliable values will be obtained.

- Psychological indicators

Yoshitake test: one of the tests that gives rise to the

emergence of this topic, where the subject self-evaluates the subjective sensations of the negative effects of the workload, that is possible with the application of a survey where the subject refers his subjective appreciation about the feeling of tiredness. It is an instrument of quick application and easy handling thanks to its dichotomous scale for the evaluation of the level of fatigue present in the population under study from its 30 items.

The behavior of each of the indicators applied before and after the execution of the activity that demands cognitive demands is recorded in an Excel sheet.

The statistical processing of the data is carried out in the Statgraphic Centurion 15.0 software. The Comparison of Paired Samples procedure is designed to compare data in 2 numerical columns where the values in each row are paired, correspond to the same subject or experimental unit, in this case the behavior of the indicator to assess mental work before and after developing the experimental activity for each sample. The main reason for such a comparison is typically to determine whether the factor differentiating the columns has an effect on the data.

To define whether the data come from a normal distribution it is necessary to start from the analysis that the standardized bias and standardized kurtosis are in the range of -2 to +2, which can be used to determine if the sample comes from a normal distribution and then a comparison of paired samples is made with the aim of defining whether there are significant differences between the before and after, for which a hypothesis test is developed.

If the data comes from a normal distribution, the t-test is applied for the mean. The t-test evaluates the hypothesis that the mean of paired samples is equal to 0.0 versus the alternate hypothesis that the mean of paired samples does not equal 0.0. If the P-value for this test is greater than or equal to 0.05, the null hypothesis cannot be rejected, with a confidence level of 95.0%.

If the distribution from which the differences come is not normal, it may be of greater interest to test a hypothesis about the population median rather than the mean. The sign test is based on comparing the number of differences below the hypothetical median with the number of differences above it. A large discrepancy leads to the rejection of the null hypothesis. The sign test evaluates the hypothesis that the median of paired samples is equal to 0.0 versus the alternate hypothesis that the median of paired samples is not equal to 0.0. Based on counting the number of values above and below the hypothetical median. If the P-value for this test is greater than or equal to 0.05, the null hypothesis cannot be rejected, with a confidence level of 95.0%. Of primary importance are the Values of P. Values of P below 0.05 if working at the level of significance of 5% lead to the rejection of the null hypothesis.

## 1 Results and discussion

### 1.1 Development of Stage I of the proposed procedure

#### 1.1.1 Selection of the sample under study

The Heroes del Moncada university polyclinic is located in the municipality of Cárdenas, province of Matanzas. Its social purpose is to provide medical and stomatological,

specialized and nursing care to the population, carrying out comprehensive health activities that include prevention, promotion, treatment and rehabilitation.

The investigation was carried out on health personnel based in the Heroes del Moncada polyclinic in the municipality of Cárdenas. The selected population is located in six main departments: Department of Human Resources, Department of Education, Emergency Department Stomatology, Allergology and Librarianship.

For the development of the research, 13 workers were randomly selected, of which one of them is invalidated for presenting neuroses according to the Eysenck Personality Inventory. After applying the medical examination to each worker, the most common diseases are osteoarthritis, allergy, scoliosis and arterial hypertension. Tests to measure indicators of mental load are applied to a total of 12 people.

A survey is applied on the most relevant aspects of the life and health habits of the staff with the aim of analyzing whether the staff meets the required health expectations. The results, in general, indicate that they often feel exhausted during or after the end of the working day, frequently present sleep disorders and digestive disorders, 16.7% argue to have presented cardiovascular disorders, 50% dermatological diseases and 66.7% have frequently manifested the presence of anxiety crises or depression, all these are symptoms associated with work stress. On the part of the organizational climate, workers sometimes do not have freedom to make decisions, they do not feel compensated according to the activity they perform, where it is associated that 17% of individuals are the economic support of their home.

The sample is made up of 3 nurses of the Emergency Department, 1 First degree Specialist in Allergology, 2 Dental Practitioner and 6 General Practitioner. In the course of the research, 25% of the sample under study developed their activity during a 24-hour working day and the rest 8 hours per day. Fig 2 shows the years of experience in the current job.

### 1.1.2 Selection of indicators to assess mental work

The following indicators are defined to assess mental work:

- Psychophysiological indicators: Simple Reaction Time (SRT).

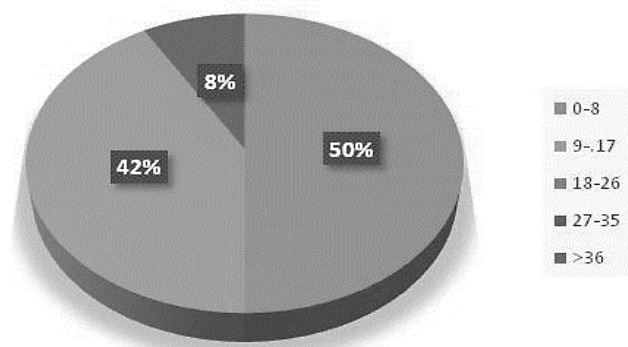


Figure 2. Number of years of experience in the current job.  
Source: The Authors.

Table 1.

Registration of microclimatic variables in the premises where activities of the object of study are carried out.

Local	General exam room
Dry bulb temperature (°C)	31
Wet bulb temperature (°C)	28.4
Balloon temperature (°C)	30
V air (m/s)	1
PVa (KPa)	3.724
ISC (%)	24

Source: The Authors.

- Psychological indicator: Yoshitake test

### 1.1.3 Control of environmental conditions in the premises where the activities of the object of study are carried out

Next, measurements are performed to check the exposure to extreme temperatures, in this case the heat, for this the ISC for interiors was used. The results obtained in the place where the activities of the object of study are carried out are shown in Table 1.

The ISC value is in the range of 10-30% which indicates light to moderate thermal stress, correct for jobs involving higher intellectual functions, dexterity and vigilance.

- Evaluation of the existing sound pressure level

For the premises, 85 db-A is taken as recommended, because a communication activity is carried out and this is the maximum admissible value for any job. With the use of an integrator-integrator type I sound level meter, due to the fact that the noises in these facilities are not constant, the instrument offers the direct value of the continuous equivalent sound level existing in the premises where the activities will be developed from the slow response of the sound level meter. For the premises, a value of 76.5 db-A was recorded, which when compared with NC 871:2011, it recommends 85-A db so it is considered adequate.

- Evaluation of the existing lighting level

The NC-ISO 8995/CIE S 008: 2003 for the premises of general examinations of a health center defines a value of 500 lux and in the place where the working day takes place there is 682.11 lux so it complies with the recommended.

## 1.2 Development of Stage II of the proposed procedure

The initial evaluation of the indicators was carried out in the morning schedules, starting at 6:00 am and ending at 7:00 am, the start time of the experimental activity for both the staff working 8 hours and 24 hours. At the end of the working days, the final evaluations were carried out.

## 1.3 Development of Stage III of the proposed procedure

During the application of the experiment corresponding to the selected indicators that assess the presence of mental load, measurements were taken from 12 people, before and after the development of the working day.

### 1.3.1 Analysis of the behavior of indicators for paired samples

Next, each of the indicators selected from the comparison of paired samples is analyzed, which allows us to infer

whether or not there are significant differences between the before and after the development of the working day.

66.7% of the individuals subjected to the activity comply with the premise that before exposure to mental work the TRS tends to increase, where average values are obtained before starting the working day a TRS of 0.29 sec, after culminating 0.34 sec and a variation of 0.024 sec.

These values are processed with the help of the Stargraphics Centurion 15.0 software to know if there are significant differences between before and after the activity developed. When analyzing the values of standardized bias and standardized kurtosis are 0.123 and 0.281 respectively, so being in the range of -2 to 2 the data come from a normal distribution. The t-test of the mean is analyzed, which rejects the null hypothesis because the P-value equals 0.00000265129, less than 0.05, so it can be concluded that there are significant differences, therefore, the measurements taken before and after the activity carried out show that the sample was mentally charged during the course of the working day.

The Yoshitake Test is applied to the sample group moments after completing the assigned activity.

The 12 people in the sample group manifested the presence of subjective feelings of fatigue, highlighting both physical and mental fatigue. Fig 3 summarizes the symptoms presented during or after the end of the working day of the sample group, highlighting the heaviness in the head, fatigue in the legs, confusion, lightheadedness and back pain.

In a study conducted on mental health complaints of health care workers from 1998 to 2008 [22], nurses and members of the nursing team, as well as physicians, psychologists, health care technicians, dentists, among others, were included. These workers presented pictures of occupational and chronic stress, suffering and physical and

psychological complaints in general, as a consequence of the work process. Excessive work, represented by long working hours, multiple jobs, double or triple shifts, are elements that may favor psychological/mental health problems in health care workers. In addition to overwork, other factors such as inadequate work environments, the way work activities are organized, low worker valorization, unsatisfactory participation in work decisions, excessive work demands, low salaries, high work complexity, including undesirable working conditions, with multiple occupational hazards, may favor these aggravations to the mental health of workers. It is a profession in which stressors such as shortage of personnel, which implies work overload, shift work, dealing with problematic users, direct contact with illness, pain and death, lack of specificity of functions and tasks, which implies role conflict and ambiguity, lack of autonomy and authority at work to be able to make decisions, have a special impact.

As Segura Martinez [23] refers in a research on work stress in rotating medical interns, it was confirmed through a literature review that among the consequences it can cause are psychosomatic effects: it manifests with weakness and general discomfort, which results in functional alterations of different body systems, such as cardiac, respiratory, digestive, reproductive, nervous; behavioral: refers to the impossibility of leading a relaxed life, adopting certain behaviors and sudden changes in mood; emotional: refers to emotional exhaustion that manifests itself as affective distancing, anxiety, impatience, frustration, depression; social and interpersonal relationships: characterized by negative attitudes towards life in general, affecting personal life, couple and family problems.

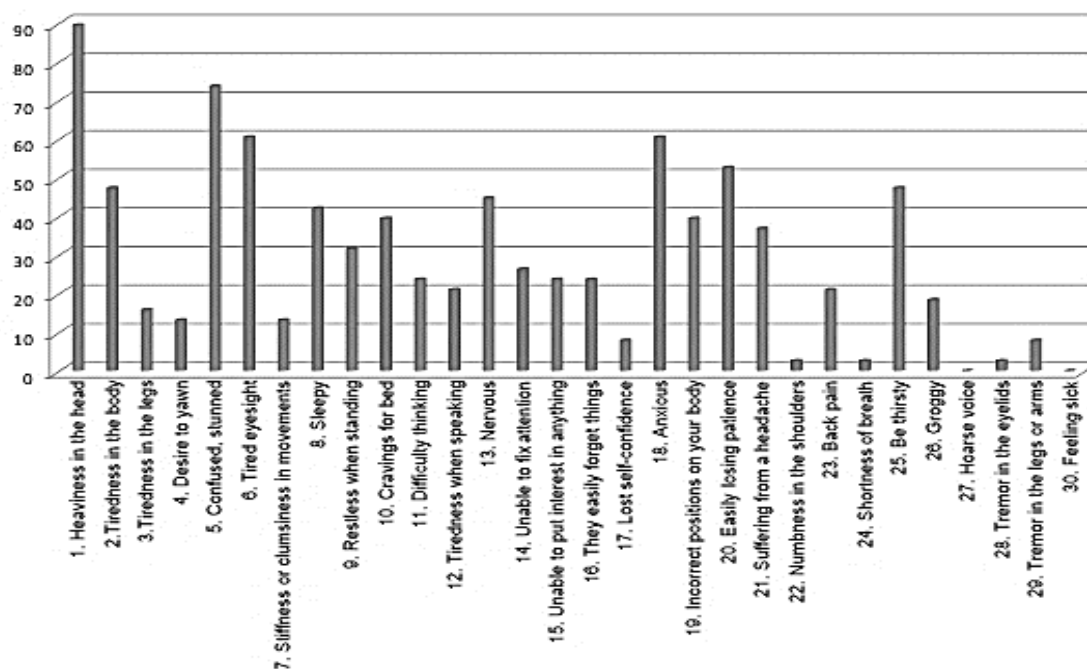


Figure 3. Behavior in % of the sample in the Yoshitake Test  
Source: The Authors.

The results of these investigations are similar to the results of the health personnel selected as the study sample, where all of them show physical and mental fatigue, with increasing values of the indicators applied.

With respect to the behavior of the indicators used, the similarity of previous studies by other researchers is corroborated [24-26]. The first studies carried out by Almirall [27] evaluated 60 subjects by means of the psychophysiological indicator TRS. They exposed healthy subjects to various conditions that demanded mental effort, in the simple reaction time (SRT) there is a significant difference between before and after, as the values of the measurement increases gradually at the conclusion of the task in the face of high mental demands.

Very similar results have been described by Ormazá Murillo [28] who studied the level of mental workload of professors of the Public Administration career of the Escuela Superior Politécnica Agropecuaria de Manabí, using the methodology of Jo Carvalho [24], which is one of those taken into account when designing the procedure shown in the present research. He uses among the indicators the simple reaction time, and the Subjective Feelings of Fatigue survey. The result obtained was that during the administrative hours they maintain the same level of concentration and at the end of the class hours four out of six teachers had a decrease in their attention and have a high level of mental workload. The Subjective Fatigue Feeling Test showed that at the end of the workday 85% of the teachers felt tiredness in the body and legs, 57% wanted to go to bed, 43% felt tired when talking and their attention was dispersed.

In Acosta Prieto's research [25] similar results were found, since he evaluated the behavior of indicators related to mental workload in Industrial Engineering students of the University of Matanzas. In the TRS it was obtained that 62.5% of the individuals who were not exposed to mental workload have an increase in the values of the measurements at the end of the task and 89.47% of the individuals submitted to the test comply with the premise that when exposed to mental work TRS tends to increase. The application of the Yoshitake test showed that 47% had heaviness in the head, 73.68% felt confused and dazed, 60.53% felt tired eyes and were anxious, 52.63% stated that they lose patience easily under cognitively demanding situations.

This study is of great importance since there is a tendency in the workplaces to increase cognitive demands and therefore there is a greater incidence in mental work, so it is necessary to establish mechanisms to follow the behavior of workers and create workplaces that guarantee the quality of life and prevent occupational risks and diseases related to mental work.

#### 4. Conclusions

1. The hypothesis test in the comparison of paired samples evidences that there are significant differences between before and after for the selected object of study according to the t-student test in the simple reaction time indicator.
2. When applying the Yoshitake test 100% of the personnel under study manifest the presence of subjective

sensation of fatigue, highlighting both physical and mental fatigue and the symptoms presented during or after the end of the working day of the object of study with the presence of heaviness in the head, fatigue in the legs, confusion, lightheadedness and back pain.

3. The present investigation allows confirming the high mental workload in health personnel by presenting the expected behavior of the applied indicators TRS and Yoshitake test, showing similarities with studies carried out focused on this work position and the application of valiative indicators of mental work.

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**J.L. Acosta-Prieto**, is BSc. Eng. in Industrial Engineer from the University of Matanzas, Cuba, graduated as a title of and award for scientific merit. MSc. in Ergonomics and Occupational Health and Safety, and in 2021 he obtained the National CITMA award as a research student, in 2021 the Forjadores del Futuro Seal. In 2020 he was vice dean of the Faculty of Business Sciences at the University of Matanzas, Cuba, and in 2021 to date Director of the Municipal University Center of Cárdenas, Cuba. He is studying the master's in business administration, service management module, enrolled in the doctoral training program in Technical Sciences of Industrial Engineering in the line of research of Cognitive Ergonomics. ORCID: 0000-0003-1390-2380

**J. Garcia-Dihigo**, is BSc. Eng. in Industrial Engineer. Dr. of Technical Sciences in 1988 and Dr. of Science in 2017. He has taught different subjects related to occupational health and safety, ergonomics and the environment. He is a tenured professor at the University of Matanzas, Cuba. He has published 63 articles in journals from different countries, 17 of them indexed in group 1 and group 2 databases. He has participated in 103 national and international events in different Latin American countries. He is a methodologist at the Rectory of the University of Matanzas where he holds the position of Attention to the International Center of Havana, which is an auditing and consulting company. He has tutored 10 Doctors in Technical Sciences and 80 Masters in different branches of science. ORCID: 0000-0002-8791-5830

**Y. Cuello-Cuello**, is BSc. Eng. in Industrial Engineer from the University of Matanzas, Cuba. She belongs to the Cognitive Ergonomics Student Scientific Group, in which he has developed theoretical and practical research on mental work in the Municipal Administration of Cárdenas. ORCID: 0000-0003-4589-8670

**Y. Almeda-Barrios**, is BSc. Eng. in Industrial Engineer with a gold degree in 2015. MBA with a mention in Production and Services Management. MSc. in Ergonomics and Safety and Health at Work 2022, Dr. of Technical Sciences 2022. Industrial Property Representative of the University of Matanzas, Cuba, from 2018 to date. ORCID: 0000-0002-3423-4011

**A.B. Ulloa-Felipe**, is Industrial Engineering student at the Municipal University Center of Cárdenas, University of Matanzas, Cuba. She belongs to the Cognitive Ergonomics Student Scientific Group, in which he has developed theoretical and practical research on mental work in various sectors, such as health personnel at the Héroes de Moncada polyclinic, professors and students of the University of Matanzas and workers at the "Operations" office at the Juan Gualberto Gómez airport. As an achievement, both personal and student, she has published an article in the Ciencia Digital Magazine and is the main author of the book "Estudio de las ondas" published in the Editorial Académica Española. ORCID: 0000-0002-4434-5006