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ERGONOMIC ANALYSIS OF THE TACTICAL FORCE VEHICLE OF THE 11TH BATTALION OF THE MILITARY POLICE OF SÃO PAULO

Ana Carolina Russo[1]*

Abstract

The present study aimed to perform an ergonomic analysis in a police vehicle, providing better working conditions for operational officers, more specifically from the 11th Battalion of the Tactical Force of the Military Police of the state of São Paulo. Police officers must perform several operations during their shifts, including patrolling, in which they have a maximum working day of 12 hours per day, as provided by law, in 12-hour shifts by 36 hours. In more than 99% of cases, patrolling operations are performed with 3 operational officers, as per the Military Police command standard, where the officer located in the rear of the vehicle needs to cover the rear and the side of the vehicle, forcing him to twist his lumbar and neck joints by 123.79 degrees to obtain an ideal field of vision. This activity is performed at a frequency of 7 times per minute, resulting in several occurrences of low back pain. Thus, it was found necessary to adapt the work environment to the operating officer in order to provide better operational and ergonomic conditions. For the case study in question, the NIOSH, OWAS, RULA, REBA and Couto Checklist methods were used from the Ergolândia software. It was possible to simulate the officers' movements during the operation. These methods were selected in order to facilitate the understanding of the material prepared, resulting in ergonomic basis analyses for the proposed changes inside the vehicle. With such changes, an ergonomic improvement of 28.57% was obtained, providing better working conditions for the officers, and thus, returning to the issue of work, proving that it is possible to provide better working conditions for the officers of the 11th Battalion of the Military Police Tactical Force.

Keywords: Military Police, Ergonomic Analysis, Vehicle, Operations, Patrol, Field of Vision, Working Conditions, Low Back Pain, Methods, Software, Simulate.

1. INTRODUCTION

The concept of organizations that promote health at work is that organizational and personal well-being are intertwined and that there is an effective management practice to combine these two aspects. This practice emphasizes efficiency, creating an organizational climate that supports performance, effective use of human resources, and reduces obstacles. Ergonomics researchers conducted a study to identify organizational practices involved in creating an organ that promotes occupational health in conjunction with organizational efficiency, ergonomic design, and reduction of work-related stress (SAUTER et al., 1991). This institution focuses on quality, invests in employee development, participates in strategic

[1] Jorge Duprat Figueiredo Foundation for Occupational Safety and Medicine. * ana.russo@fundacentro.gov.br

planning activities, provides fair pay and awards. Several of these activities are aspects of effective management that emphasizes quality and innovation. Numerous countries have laws that specify the maximum level allowed for health risk in a job.

According to Gomes da Silva and colab., [S.d.]):

> Organizations have always had as their main objective the search for better productivity rates. Due to the phenomenon of globalization, productivity has become a great differential in the competitiveness of companies. Industrial activity, for example, grows every year, and in this segment a large number of workers directly involved in the production and clothing areas are concentrated. As a result, recent studies show an increase in employee leaves due to work-related diseases, generating in companies the need to adopt appropriate ergonomic policies for this work.

It is noted that ergonomic problems are present in diversified activities having something in common: The absence of employees due to ergonomic problems, triggering a reduction in productivity and an increase in costs on the part of the company (GOMES DA SILVA and colab., [S.d.]).

It is observed that these problems occur in many aspects, as well as with police officers who occupy highly dangerous positions, facing a series of occupational risks, when compared to other professionals. Statistics on workplace accidents are difficult to interpret. Rates are calculated differently from study to study, perspectives are restricted, and comparison with other types of professions becomes practically impractical, since there is a lack of relevant information due to insufficient data. Studies generally focus on injuries to police officers that most commonly occur on the back, hands, fingers, knees, and legs (MAYHEW and GRAYCAR, 2001). As indicated by medical statistics and data from empirical research (HELIÖVAARA, 1988), back pain is the most impactful ergonomic risk, and consequently, requires extra attention.

Thus, the present work seeks to prove that ergonomics is of paramount importance to the Stakeholders, namely: The Institution of the Military Police, the State of São Paulo, the operation officers and society; in a way that improves working conditions and satisfies the interests of organizations.

This work aims to carry out a study that allows proposing improvements in the working conditions of military police officers, in agreement with the interests of the Government of the State of São Paulo, the Military Police Institution and society; being carried out from an in-depth macro and micro ergonomic analysis at the workstation (vehicle); positioning of the operation officers inside the vehicle; analysis of the prescribed task and the activity actually performed, taking into account the limitations of the activity, both physical (of the vehicle) and financial (government spending on police officers on leave), aiming at the best use of resources

and, consequently, greater productivity, not only through the search for profit, but mainly through the search for the physical health of the police officers.

2. LITERATURE REVIEW

2.1. Working conditions of military police officers

Military police officers, in general, go through a regulated working day because they start with the reading of the agenda, that is, everything that is instructed to them so that they can carry out their respective activities according to the work schedule, such as pre-patrol operation training, the operation itself and the return to the police base; and with the long working hours of 12 hours a day at most or even shifts of 12 by 36 hours, offering great risk for the operation itself, in addition to all the psychological factors involved.

In addition, there are 3 factors that contribute to the unhealthiness of the activity. They are:

- Risk: From the moment that the individual's profession is to protect other individuals in the event of confrontation and violence, it already gains a connotation of dangerous activity. In this context, According to Bernstein (1997), police officers are treated as categories that act under high epidemiological "risk", which would be the probability of occurrence of injuries, traumas and deaths, and can bring to the operation officer, the impetus and the will to confront them.
- Physical Health: The work of a police officer requires exacerbated and repetitive movements, intense training and exposure to projectiles, triggering physical problems, muscle pain, fatigue, fractures and consequently leaves from their daily activities. In addition, the operating officers are not prepared to perform this type of activity in such proportion, because there is not enough support with regard to working conditions (DE SOUZA and MINAYO, 2004). According to Minayo and colab. (2008):

  > The soldiers complain about various situations related to medical care, diseases themselves and also underline difficulties associated with the processes of obtaining sick leave. They directly relate their health condition to the work process: lost hours of sleep, daily stress, permanent risk of life, poor diet and work intensity.

- Mental Health: Because they carry out their activity almost always under pressure, police officers tend to suffer from psychic problems, depression, high stress and even psychiatric disorders.

The reflection of Brant and Minayo-Gomez (2004) contributes to understanding the situation of the officers:

> It is important to recognize that suffering does not have a single manifestation for all individuals in the same family, culture, or historical period. What is suffering for one is not necessarily for another, even when subjected to the same adverse environmental conditions. Or again, what is suffering for someone can be pleasure for another and vice versa. An event, such as something capable of provoking astonishment, at a certain moment can mean suffering; in another, it can be experienced as satisfaction. It remains to remember that in suffering it is possible to find a mixture of pleasure and pain, simultaneously.

Thus, it is of paramount importance to have a holistic approach with regard to the mental and physical health of police officers so that they can perform their duties with excellence, minimizing the risk of the activity as much as possible and eliminating the occurrence of errors resulting from lack of support.

2.2. Ergonomic work analysis

Iida and Buarque (2016) state that the Ergonomic Analysis of Work (AET) aims to apply the concepts of ergonomics in a real work context, aiming to diagnose and correct the points that are classified as a threat to the worker's health. The AET method consists of five stages: demand analysis, task analysis, activity analysis, diagnosis and recommendations (GUÉRIN et al., 2001).

According to the Ministry of Labor, based on Regulatory Standard 17 (BRASIL, 1978), in order to assess the adaptation of working conditions to the psychophysiological characteristics of workers, it is up to the employer to carry out an ergonomic analysis of the work, which must address, at least, the working conditions. These include aspects related to the lifting, transport and unloading of materials to furniture, equipment, the environmental conditions of the workplace and the organization of work itself.

The ETS can be applied to any type of work, as long as it respects the 5 steps presented by it, the first three being analytical, supporting the diagnosis to make the recommendations.

According to Iida and Buarque (2016), demand analysis seeks to understand the root and dimension of the problems in a given situation under study. However, this problem is often presented in a partial way, masking others of greater relevance (SANTOS AND FIALHO, 1997). According to Iida and Buarque (2016), the analysis of the task looks for irregularities between the work described and what is actually done, while the analysis of the activity is divided between internal and external factors, with the internal factor referring to the behavior of the employee in the performance of his assigned task, his training, experience, disposition, motivation, and as an external factor there are the conditions in which this employee is exposed,

unfolding into: work organization, content (norms, rules and objectives) and technical means (machines, equipment, among others). The diagnosis formulation stage aims to identify the causes of the reported problems, relating them to the factors found in the task and activity analysis stages.

As a result of this process, ergonomic recommendations are obtained, i.e. the steps to be taken to correct the ergonomically inadequate situation, being raised indispensable steps to solve the problem, and the people, sections or departments in charge of such changes and implementations within a defined timeframe.

2.3. Consequences of the lack of ergonomics

In relation to workers, it is necessary to consider the various environmental and organizational risks to which they are exposed, due to their insertion in the work processes.

Thus, workers' health actions should be formally included in the agenda of the basic health care network. In this way, the care already offered to workers is expanded, to the extent that it starts to see them as subject to a specific illness that requires strategies – also specific – for health promotion, protection and recovery (BRASIL, 2002).

According to Mafra and Vidal (2006), in a production process there are losses such as failures in the management of health, the environment and occupational safety. In addition to patrimonial, efficiency and productivity losses, which are not always evident in management reports. In this sense, the ergonomics methodology makes the flaws and their respective losses evident. It is worth mentioning that, according to Mafra and Vidal (2006), ergonomic costs are the result of the absence of ergonomics.

That said, losses in the process, direct or related to problems related to ergonomics, are then classified as "ergonomic costs", showing that the absence of ergonomics could be characterized by economic indicators of effectiveness. In other words, by opting for ergonomics, one is not incurring or incorporating new expenses, expenditures or costs, but rather opting for investments in optimization of productive resources. It is a capital investment whose return and risks can be estimated with reasonable accuracy, like any other investment option in the company.

Thus, it was agreed to call ergonomic costs, the losses in the process due to poor ergonomics, or the absence of it. In this direction, improving the process should not be understood as spending on improvements; they are, in fact, investments because they trigger profits and bring returns and benefits in time and in time (MAFRA and VIDAL, 2006).

In military police activity, the individual is exposed to a series of factors that can interfere with his health. Many police officers carry out operational activity, in which they must carry out constant movements, carry relatively heavy artifacts, triggering overload in the spine and, as a consequence, pain in the lower back. To exemplify this statement, in the state of Bahia alone, in 2013, it recorded the expenditure of R$1,500,000.00 with salaries of police officers on leave, victims of low back pain. (TAVARES NETO and colab., 2013).

It is worth noting that due to the absence of public data provided by the State of São Paulo, an example from the State of Bahia was used only as a way to illustrate the dimension of the problem studied.

3. METHODOLOGY

3.1. Procedure for data collection

3.1.1. Informal conversations and semi-structured interviews

At first, informal conversations were held with soldiers, corporals, sergeants and lieutenants who effectively participate in the operation, in order to structure the problem in question, and collect initial data, identifying possible solutions, also measuring in a macro way what would be defined as a point to be optimized in the work as a whole. Data collected include:

- Working hours (12 hours a day in shifts of 12 x 36 hours);
- Work routine (Training, operation instruction, operation and return);
- Training (physical and psychological);
- Types of operations (in the case of the present study, only patrolling was considered).

3.1.2. Direct observation of operations and workstation

5 visits were made to the courtyard of the 11th Battalion of the Tactical Force of the Military Police, where it was possible to obtain a holistic view of the police workstation (vehicle), and for each visit a position of the officers in the vehicle was studied.

In addition, by observing more closely and in detail the operations carried out by the officers of the respective Military Police Battalion, it was possible to collect data in more detail. Data collected include:

- Movement of police officers;

- Equipment used (such as holster, belt, weaponry and vest);
- Spacing and measurements of the vehicle (Figure 1 and Figure 2).

Figure 1 - Lower side measurement of the rear door

SOURCE: Authors

Figure 2 - Rear seat side measurement

SOURCE: Authors

3.1.3. Image and video

Photos were captured from professional DSLR digital cameras, in order to observe in more detail the position of the police officers at their workstation (vehicle), as well as obtaining videos taken by the authors' cell phones, was essential for a better understanding of how the movements were carried out by the officers while they practiced their activities.

3.1.4. Questionnaire

In order to compile the requisitions of the officers, a survey was carried out through a questionnaire, shown in Appendix I, which contains 44 questions, intended for the corporation of the Tactical Force of the Military Police, more precisely in the 11th Battalion of the city of São Paulo. Data collected include:

- General information from police officers;
- General information on operations;
- General information from the 11th Battalion of the Tactical Force of the Military Police;
- Information on the reasons for the police officers' removals.

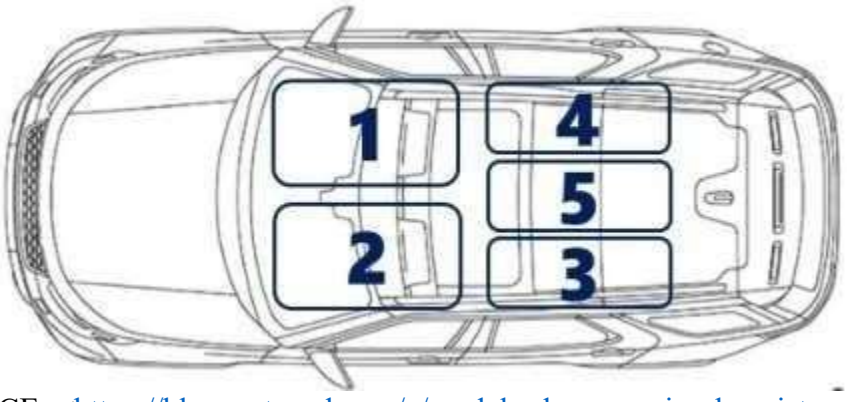
3.2. Military Operation Details

To understand the military operation, it is of paramount importance to highlight what must be considered pre-known for full understanding and interpretation of data analysis.

The military police has 84,290 operational police officers, 31.14% of which serves the Tactical Force in the state of São Paulo (ARCOVERDE, 2016) with a fleet of 420 vehicles of the Tactical Force for a population of, according to the website FIQUEM SABER (ARCOVERDE, 2016), 43,461,491, that is, 1 MP of the tactical force for every 16,557 inhabitants by estimate, since there are 105 battalions with an average of 25 officers of the Tactical Force.

During an operation, the team may work in three, four, or five officers. It was described how the five work positions perform the proper task, as shown in Figure 3:

Figure 3 - Top view of the position of the police officers at the workstation



SOURCE: <https://blocoautocad.com/e/modelo-de-carro-simples-vista-superior/>

- Position 1: Commander
- Position 2: Driver
- Position 3: Most Experienced Police Officer
- Position 4: Less Experienced Police Officer
- Rank 5: Extra Policeman

Positions one, two, and three are essential to the operation and are typically the most commonly used. The positions occupied by positions one and two are in charge of supervising the front of the vehicle and a portion of the side area via the rearview mirror. Places three and four are filled by the function of monitoring the largest portion of the car's side area and the rear through the movement of the body itself. The most experienced police officer works on a more effective action in cases of threats to civilians, operations and against the vehicle itself. Position four is intended to assist the lateral and frontal views. It is occupied by the less experienced officer and his function is more linked to the documentation of fines. Finally, position five is required in cases of CDC (Civil Disturbance Control) actions and is occupied by the less experienced officer and his function is more linked to the documentation of fines. It is also worth mentioning that, in more than 99% of cases, the police usually operate with 3 men.

3.3. Procedure for data analysis

3.3.1. Analysis of data acquired from informal conversations and semi-structured interviews

The first primary data were collected from informal conversations and semi-structured interviews with the following members of the Military Police: Colonel Temístocles Telmo Ferreira Araújo, Captain Luis Humberto Caparroz, Lieutenant Davi Carlos Queiroz and officers of the Tactical Force of the 11th Battalion of the Military Police (PM). These data were useful for identifying the main questions of the police officers, understanding the type of research that had been carried out, what rules the police should follow in their operations, availability of resources and was also the basis for the questionnaire elaborated.

3.3.2. Analysis of data collected through visits to the 11th Battalion of the Military Police

After 5 visits to the 11th Battalion of the Military Police, it was possible to observe the police operations, their difficulties and identification of the main restrictions of the officers in relation to the work position, thus allowing the identification of some problems.

During the period witnessed in the visitation, it is possible to abstract important facts about the daily activities carried out by the officers, especially in operations carried out in the vehicle, in this case the study exercise.

3.4. Mapping of operations vs. positioning of police officers

In order to organize the sequence of operations carried out and find the most harmful to the police officers (critical point), a kind of mapping of the operations was carried out via Excel, attributing weight (from 1 to 5, with 5 being the most weighted) by the degree of complexity of the position of the police officers in the vehicle and the frequency of their movement. For a better view, Table 1 is presented.

Table 1 - Mapping of operations vs. positioning of police officers

	Operação			
Posição	Patrulha	Farolete	Condução	Total/Posição
1° Homem	4	-	-	4
2° Homem	1	-	5	6
3° Homem	**5**	**5**	**-**	**10**
4° Homem	5	5	-	10
5° Homem	3	-	-	3

SOURCE: Authors

3.5. Analysis of the questionnaire applied

Through all the notes made in the previous items, it was possible to prepare a complete questionnaire with different aspects, encompassing general, personal and operational data related to the police officers, thus offering the consolidation of the subjects addressed so that the present work achieved the objectives so far, of identifying and structuring the main problems.

3.6. Analysis of data from bibliographies, scientific articles and government platforms

The combination of data collection from scientific bibliographies and articles with data collected from government platforms allowed the analysis between the total number of police officers in the state of São Paulo versus the number of police officers on leave due to low back

pain versus government spending on police officers on leave in accordance with the established law, with the objective of obtaining a productivity indicator.

3.7. Analysis of data collected through image and video

From the technological resources used, such as the Ergolândia software, it was possible to analyze the angle and frequency of movement of the officers, the angle of the field of vision, the angle of torsion of the neck and back, restrictions faced in the movement, vehicle spacing, internal measurements of the vehicle and thus classify them according to the methods used in the present work. These methods mentioned go through calculation and simulation software, bringing both quantitative and qualitative results that will be presented in the next chapter.

4. RESULTS AND DISCUSSIONS

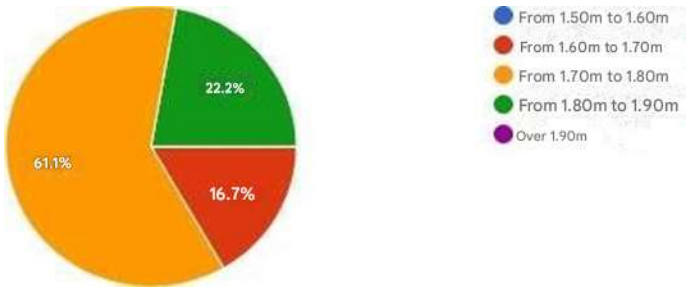
4.1. Application of the questionnaire

The questionnaire obtained 18 responses, representing 72% of all employees of the Tactical Force of the Military Police of the 11th Battalion of the state of São Paulo. The other 7 employees did not respond because they are not currently active, 2 on leave due to low back pain, 1 due to vacation and the others chose not to respond. The questionnaire was composed of 44 questions and the results obtained proved the need for ergonomic adjustments in the workplace.

All the results of the questionnaire in question are presented in Appendix I. However, there are some answers that show in a more incisive way the problems in the activities of the employees and will be described below.

As shown in Figure 4, there is a considerable height difference, since the variation is specified between 1.60m and 1.90m and should be considered for ergonomic analysis.

Figure 4 - How tall is you?



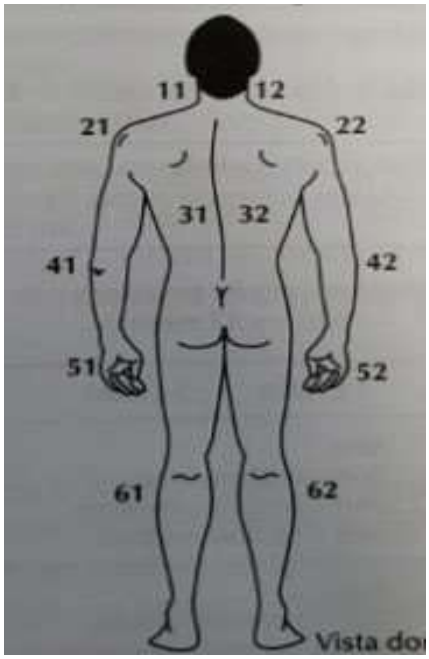
SOURCE: Authors.

Figure 5 presents a pain diagram in which the interviewees were able to answer in which regions they had already felt some discomfort due to the operation to which they are submitted daily.

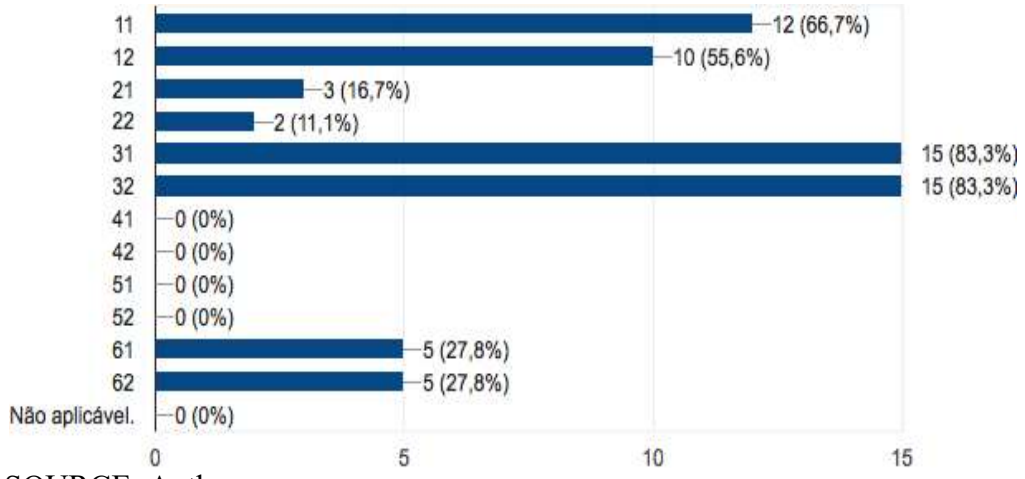
According to the answers obtained, 15 of the 18 employees who responded to the survey reported that they had already felt some discomfort in regions 31 and 32, that is, the back region close to the lumbar. Two other points of high relevance are regions 11 and 12, which obtained 12 and 10 responses, respectively, informing that the interviewees had already suffered some discomfort in these regions (Figure 6).

Such results indicate the need for a proposal to improve working conditions (which will be deepened during the course of the project), since the constant rotation carried out in the daily activities carried out by the police officers at their workstation presents a need for change.

Figure 5 - Regions of the human body



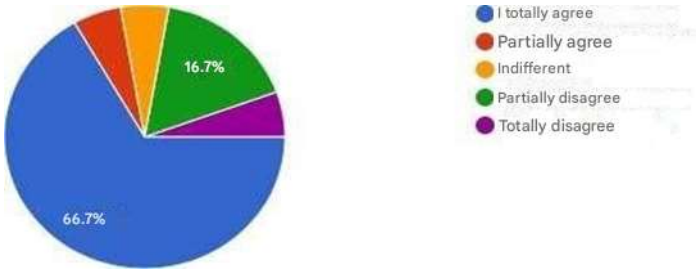
SOURCE: (IIDA and BUARQUE, 2016)



SOURCE: Authors

During the police operation, it was observed that there is a clear need to cover the entire field of vision of a car, which can cause the employee to have to rotate up to 123.79 degrees during an operation. Figure 7 proves the need to obtain visibility of the field of vision, where approximately 67% of the interviewees reported that they totally agree with the statement described.

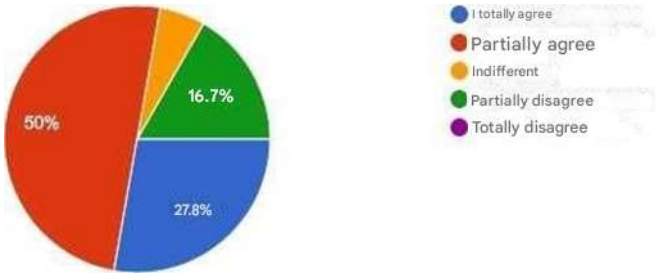
Figure 7 - Field of view is paramount for operation



SOURCE: Authors

Figure 8 shows the difficulty of movement of the police officers due to the fact that the vehicle is not adapted to the movements necessary to carry out the tasks. The results of the interviewees show that 27.8% totally agree and 50% partially agree that the vehicle hinders/limits movements.

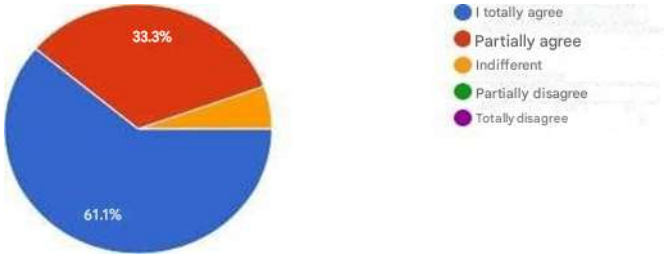
Figure 8 - vehicle limits movements



SOURCE: Authors

During the observation of the police operation, it became clear that there is excessive movement to carry out the tasks, since there is a need for employees to cover the entire field of vision. Figure 9 shows that 61.1% affirm that they totally agree with this statement and 33.3% affirm that they partially agree, confirming this fact.

Figure 9 - For an ideal field of vision, it is necessary to perform excessive movement



SOURCE: Authors

4.2. Image analysis

During the visit, the movements carried out during the period of operations were simulated. To develop the quantitative methods, the image analysis between the operating officer and the workstation was carried out using the Ergolândia software. It was observed that because the police officers occupying positions three and four need to supervise rear areas, there is a rotation of 86.8 degrees for lateral visibility and 123.79 degrees for the rear field of vision, as highlighted in Figure 10 and Figure 11, respectively.

It is worth mentioning that due to physical limitations of the workstation, it was not possible to obtain images of the officer's top view inside the vehicle. It is of paramount importance that in order to measure the angle of rotation of the operation in question, it is necessary that it be performed exclusively through the top view.

Thus, aiming at accuracy for test validation, image analysis was performed on the outside of the vehicle, simulating the same movement that the operation officer would make inside it. The test was prepared parallel to the vehicle, where the staircase illustrated below represents the limitation that the side of the door offers to the movement of police officers. Analogous to this, a reference point was used so that the simulated field of view would be faithful to that of the real operation.

Figure 10 - Rotation movement to obtain the side field of view

SOURCE: Authors

Figure 11 - Rotation movement to obtain the rear field of view

SOURCE: Authors

In addition to the evaluation of the rotation angles, the inclination of the seat is also a factor that influences the performance of the police operation, due to the fact that the individual has to exert great axial force to project forward in order to obtain an ideal field of vision for the operation. It was possible to measure the inclination as shown in Figure 12, with the value obtained of 14.96 degrees:

Figure 12 - Rear Seat Tilt from Side View

SOURCE: Authors

4.3. Current operation

Based on the Ergolândia and Ergonomics tools, it was possible to perform simulations and analysis of quantitative and qualitative scenarios in order to obtain numerical and analytical results. The results model exposes the current operation carried out by the employees of the

11th Tactical Operations Battalion of the Military Police, where all the calculated values consider the mass of the bulletproof vest added to the weapon, 5 Kg.

4.4. NIOSH

Using the quantitative NIOSH method, the result of the IL (Survey Index) was obtained as shown in Figure 8; The worst case of rotation of the back and neck was calculated to reach an angle of 123.79 degrees, considering intermittent movement of 7 times per minute.

Thus, it was possible to acquire as a Survey Index, a result classified as poor, that is, greater than 1 (Figure 13).

Figure 13- NIOSH method for load lifting

SOURCE: Authors

4.5. OWAS

Using the OWAS qualitative postural analysis method, as shown in Figure 14, the result of action category 4 was obtained: "Immediate corrections are needed".

As can be seen, the method considers the posture of the back, the posture of the arms, the posture of the legs and the effort exerted. The first is classified as inclined and twisted, the second has both arms at or above the shoulders, the third with the knees flexed and finally a load of less than 10 kg.

4.6. Rula

Figure 14- Posture analysis by the OWAS method

SOURCE: Authors

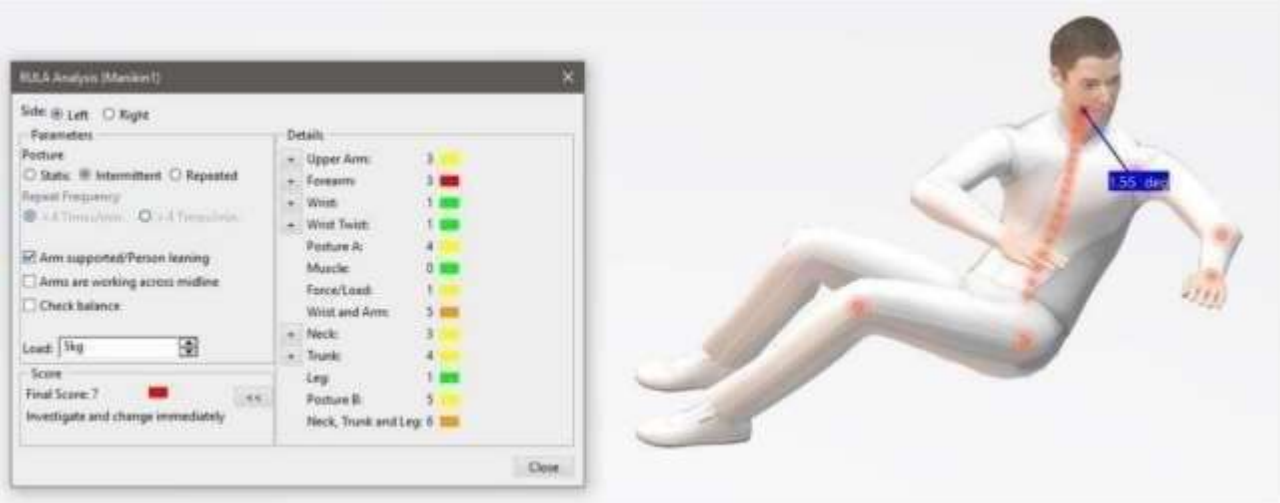
Using the RULA method, two positions were configured in the Ergonomics software for quantitative analysis. The first position presented in Figure 15 considers the police officer in a static state, that is, sitting without constant movement. It is worth mentioning that the Ergonomics software analyzes, from the chosen method, the posture of the limbs of the body and shows the fatigue that they suffer according to the movement and/or position, providing as a global result, a recommendation of what should be done from a range ranging from 1 to 7, with 7 being the worst case. In this first case, the result obtained was categorized as level 4: "Future research".

Figure 15- Posture analysis using the RULA method (static position)

SOURCE: Authors

In the second case evaluated, the dynamic positioning of movement is considered, as analyzed by the NIOSH method, the largest angle of rotation being 123.79 degrees. The result obtained as shown in Figure 16 was categorized as level 7: "Investigate and change immediately".

Figure 16 - Posture analysis by the RULA method (dynamic position)



SOURCE: Authors

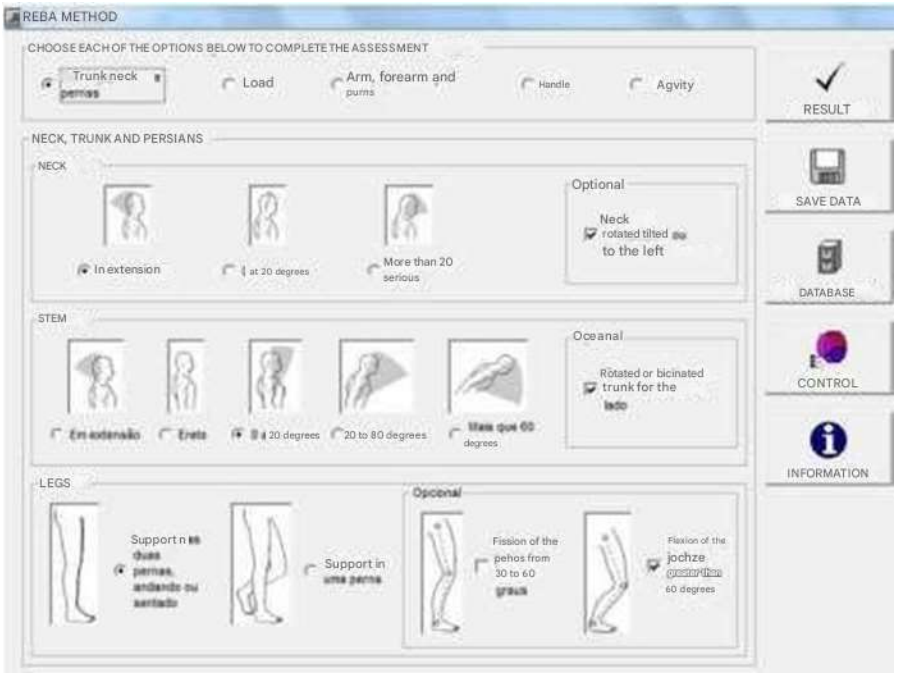
4.7. REBA

Based on the REBA method, the evaluation parameters were configured in the Ergolândia software:

- Neck, trunk and legs;
- Load;
- Arm, forearm and wrist;
- Magpie;
- Activity.

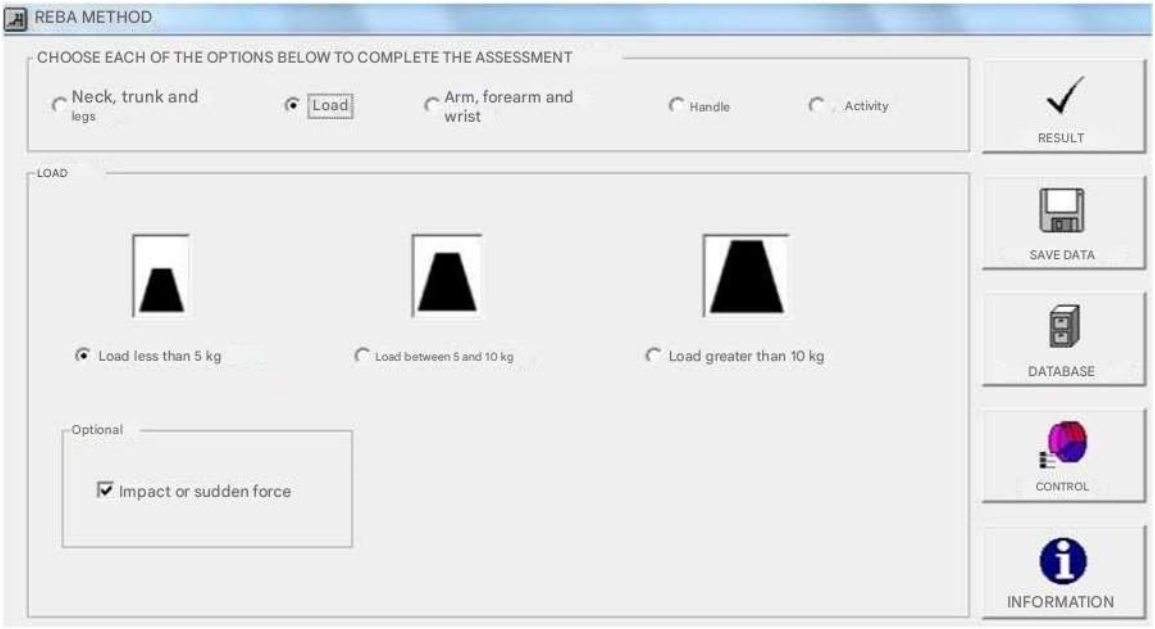
It is possible to visualize the classification of the parameters, observed in Figure 17 to Figure 22

Figure 17 - Evaluation of the limbs: neck, trunk and legs using the REBA method



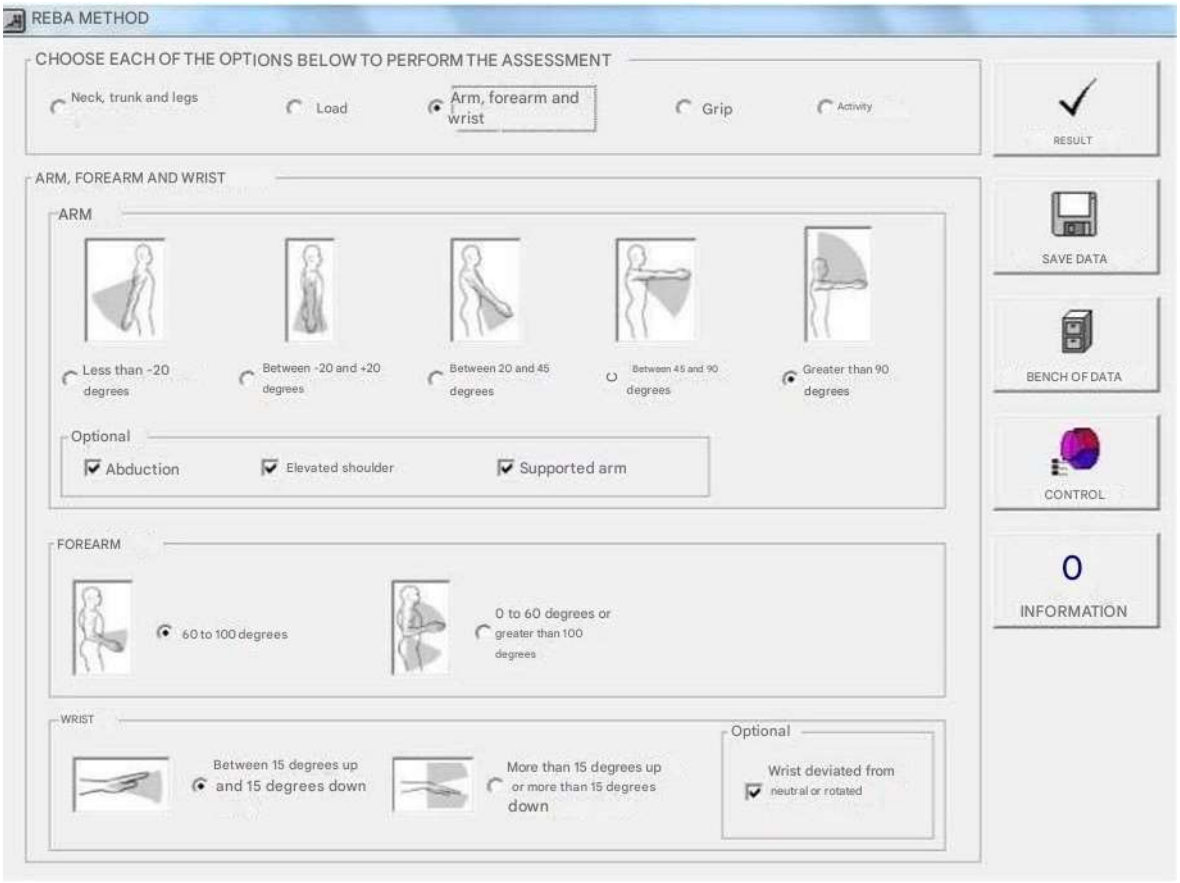
SOURCE: Authors

Figure 18 - Load Evaluation from the REBA Method



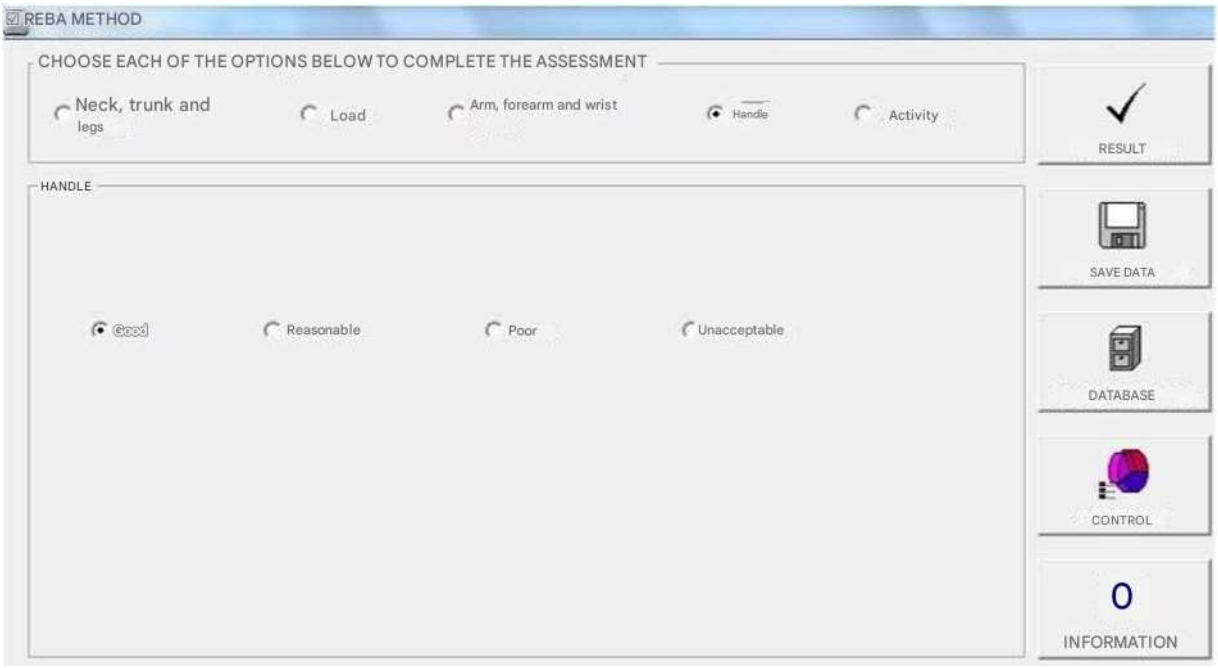
SOURCE: Authors

Figure 19 - Evaluation of the arm, forearm and wrist using the REBA method



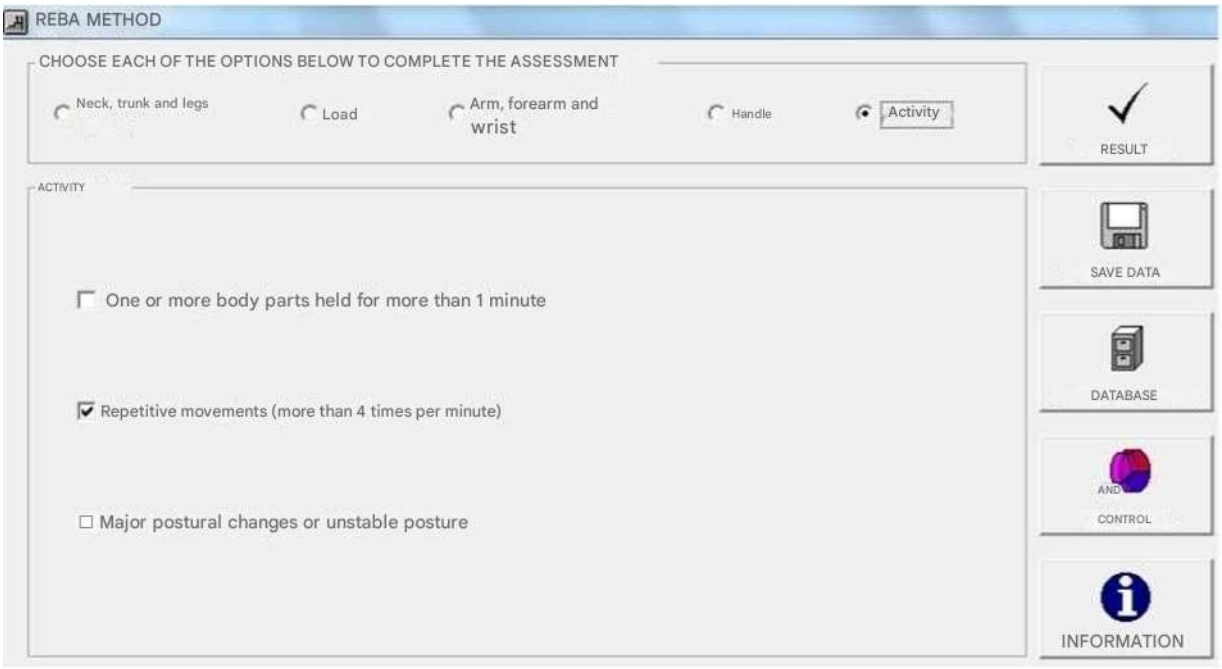
SOURCE: Authors

Figure 20 - Evaluation of the grip from the REBA method



SOURCE: Authors

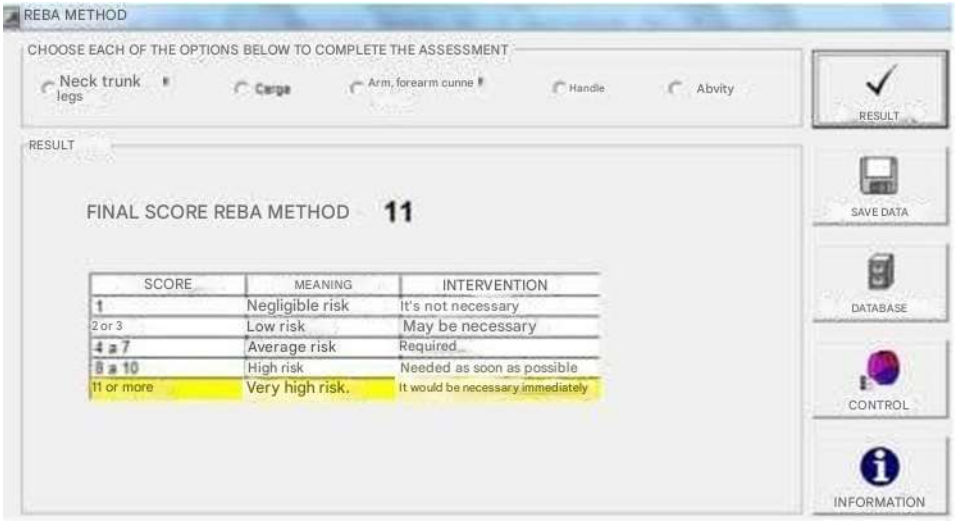
Figure 21 - Evaluation of the activity based on the reba method



SOURCE: Authors

The result presented in Figure 17, after inserting the parameters, obtained a final score of 11 or more, indicating a very high risk and the need for immediate intervention.

Figure 22- Result of the posture analysis from the REBA method



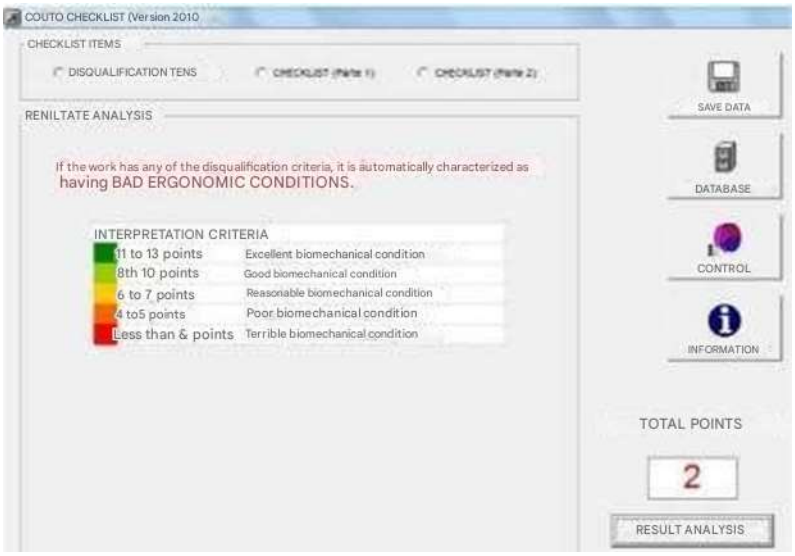
SOURCE: Authors

4.8. Checklist of couto

The Couto checklist was evaluated to measure the risk for work-related musculoskeletal disorders of the upper limbs.

The result obtained from this method was 2 points, indicating a very poor biomechanical condition; See Figure 23:

Figure 23 - result of the couto CHECKLIST



SOURCE: Authors

4.9. Hypotheses for solution

Through the analysis of the operation, the questionnaire, visits, informal conversations and semi-structured interviews, the proposed problem to be solved subjectively was verified. After the analysis of the Image, NIOSH, OWAS, RULA, REBA and Couto's Checklist, it was proven the need to adapt the vehicle to the activities of the police officers at the workplace, due to the fact that each police officer works in an intensified patrol of 12 hours (at most) per day, provided for by law.

Taking into account the criticality of the position, since the necessary torsion of the body in the activity to cover the entire field of vision is very high and because more than 99% of the operations occur with three police officers, the focus on solving the problem specifically considered position 3 as the critical point, described above.

The definition of the critical point of analysis also considered Table 3, through a mapping of operations and the respective positions of the police officers at the workplace.

Thus, a parameter ranging from 1 to 5 was created from Table 1 of item 3.6.3 regarding the degree of movement in relation to the responsibility of the operation in front of the field of

vision for each police officer. The First Man responsible for the passenger's front field of vision and right side was classified at level 4, and performs a high attention and moderate torsion activity on patrol. The Second Man, in this case the driver, has as priority the driving of the vehicle, as placed at level 5. However, it participates in front and side patrolling by the rearview mirror, thus being classified as level 1. The Third and Fourth Men have the same function, classified as the most critical due to the effort made in the patrol and also in night activities for the operation, thus being classified with the highest level. Finally, the fifth Man was classified as level 3, due to the fact that he was in the central rear part and did not act with the same vehemence in relation to rotation and intensity of movements. The critical point can be identified in Figure 24, Figure 25 and Figure 26:

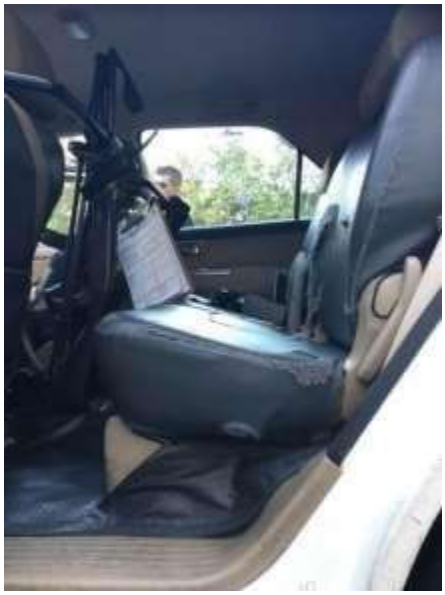
Figure 24 - Front view of the rear seat of the vehicle

Source: Authors

Figure 25 - Diagonal view of the rear seat of the vehicle

Source: Authors

Figure 26 - Side view of the rear seat of the vehicle



Source: Authors

After the fifth visit to the 11th Battalion of the Military Police, the brainstorm phase began to define possible hypotheses for solving the problem. In addition to ergonomic feasibility, some other factors were taken into account relating the economic and technical feasibility of the hypothesis, as well as the understanding of the activities, needs of the workstation and feasibility of the operation.

The first hypothesis considered was to invert the rear seat 180 degrees, like the seat of a van, subway or bus shown in the example in Figure 27, so that the police officers who are active in the rear seat would have visibility from the rear without excessive effort due to the fact that they are positioned to the rear.

This hypothesis was disregarded because such a change implies changes in the structure of the car, which makes the implementation time and a financial investment in a new car project unfeasible.

Figure 27- Inverted Bench Model

SOURCE: http://negociol.com/p342322-banco-reclinvel-lugares.html

The second hypothesis analyzed dealt with the removal of one of the rear seats, allowing the two side seats to be rotated 45 degrees, positioning them in a "V" shape as highlighted with the red line in Figure 28, where it would be possible to make only two seats available for the hypothesis. This would reduce the load on the spine, since the need to cover the rear field of vision would induce a lower rotation of the body, ergonomically adjusting the position of the police officer in the vehicle.

This hypothesis was not feasible for implementation because it makes the CDC (Civil Disturbance Control) operation unfeasible, where 5 police officers are needed to be available to perform the task.

Figure 28 - Representation of the "v" bank model

SOURCE: http://4.bp.blogspot.com

The third hypothesis evaluated was the implementation of a rotating bench, as shown in Figure 29, in which the bench would have the flexibility to follow the movement of the police officer, resulting in a much lower rotation of the neck and back.

This hypothesis would be the best possible scenario, however the economic, technological, operational feasibility and elaboration time make this model unfeasible.

Figure 29 - Representation of a rotating bench

SOURCE: http://4.bp.blogspot.com

Finally, it was possible to conclude the hypothesis used in this work. Considering short-term implementation needs, economic and structural viability of the car, feasibility of police operations and ease of implementation, a simpler solution model was developed that met the requirements, that is, without modifying the current operation.

The hypothesis considered a remodeling of the rear seat and the door, thus obtaining a greater spacing between the seat and the door, offering greater rotational mobility for the police officer within his workstation. In addition to these changes, it was necessary to propose a modification in the structure of the belt with a height adjustment bias, since the sample studied is composed of a height variation of 30 cm.

Finally, it was possible to suggest a change in the angle of inclination of the rear seat, seeking to favor activities and operations, from a kind of "filling".

The proposed changes can be found in Figure 30, Figure 31 and Figure 32, indicated by the blue arrows:

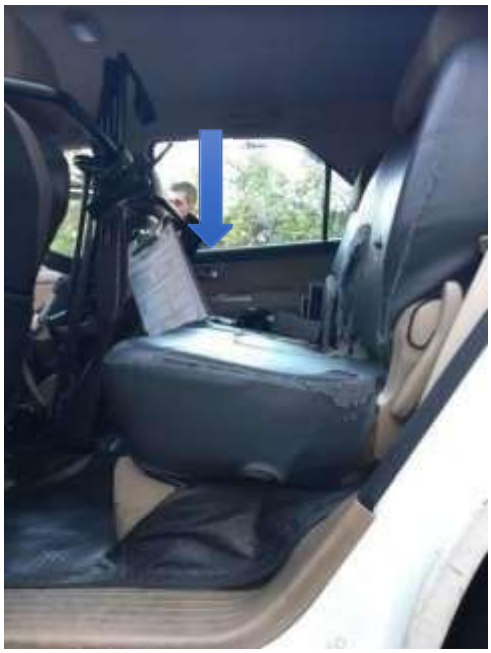
Figure 30 - Proposed front view

Source: Authors

Figure 31- Proposed diagonal view

Source: Authors

Figure 32 - Proposed side view



Source: Authors

4.10. Improvements obtained from the proposed model

Through the simulation and analysis tools, Ergonomics and Ergolândia respectively, it was possible to find quantitative improvements in the proposed model. However, there was no significant result in relation to the qualitative methods to the point of presenting a change in status in the operation, that is, classified as: "immediate actions must be taken."

4.11. Image analysis

From the proposed change, where it was feasible to increase the spacing between the seat and the side of the door by 15 cm, with these 6.15 cm being extracted from the seat upholstery and 8.75 cm removed from the material on the side of the door, greater freedom was obtained for the rotational movement of the police officers in the workplace.

The result obtained for the lateral visibility angle was a decrease from 86.8 degrees to 40.65 degrees, as well as the rear viewing angle went from 123.79 degrees to 92.06 degrees as shown in Figure 33 and Figure 34, which required a lower effort to obtain the same field of view.

Figure 33- Proposed rotation for lateral field of view

SOURCE: Authors

Figure 34- Proposed rotation for rear field of view

SOURCE: Authors

4.12. Improvement from the NIOSH method

Based on the established proposal, considering the greatest angle of rotation, the NIOSH method presented the result of IL (Survey Index) less than or equal to 1, that is, a result classified as good; see Figure 35.

Figure 35- Improvement obtained for load lifting

Source: Authors

To obtain the improvement in quantitative factors, equation (3) was used: Percentage of Improvement = 1 - (IL f/ IL i)(3), This being:

- IL f = Final survey index, after proposal
- IL i = Initial survey index, before the proposal The result obtained was an improvement of 14.47%.

4.13. Improvement from the RULA method

Based on the proposal defined for the bench, it was necessary to reduce the angle of inclination so that the effort on the legs and fatigue of the police officers could be mitigated in order to obtain greater efficiency in the visibility of the operation. As shown in Figure 36, a reduction in the angle from 14.96 degrees to 8.11 degrees was obtained.

Figure 36 - Improvement obtained in relation to the inclination of the bench

Source: Authors

Associated with the modifications of the seat, considering the greater rotation angle of the operation, it was possible to simulate through the Ergonomics software, the movement of the officers through the 3 changes applied.

The simulated result was proven in Figure 37, where a final classification of 5 was achieved, that is: "Investigate and change soon".

Figure 37 - Improvement in posture obtained from the RULA method

Source: Authors

To prove the improvement in quantitative factors, equation (4) was used: Percentage of Improvement = 1 - (Rf/ Ri) (4)

This being:

Rf = Final value obtained by RULA, after the proposal

Ri = Initial value obtained by RULA, before the proposal The result obtained was an improvement of 28.57%.

4.14. Clearances

As mentioned, low back pain is one of the problems that most causes police officers to be absent from their routine activities. On average, in the battalion analyzed, 2 out of 25 police officers are removed per year, bringing several consequences for stakeholders; These are:

- The police officer himself, because he develops a health problem caused by his intense physical effort;
- The police corporation because it has fewer resources in its operations, making it difficult to protect society;

To the government, which according to Law No. 10,261, of October 1968, must reimburse the public servant on leave for the period he is away due to activities practiced at work.

Note: the details of the law of the public servant and the working hours of the military police can be found in Annexes A and B respectively.

It is notorious that all interested parties have to lose with this scenario. This gets worse when this number is extrapolated to the 105 battalions, with an average of 25 police officers dedicated to the Tactical Force, who are subject to operations that cause low back pain.

Therefore, it was possible to estimate the following situation:

- 2 out of 25 police officers, represents 8% of leaves;
- 105 battalions multiplied by 25 police officers results in 2625 police officers dedicated to the operation of the Tactical Force.

Thus, considering the percentage of leaves for all battalions in a conservative analysis, an annual leave of absence is obtained in the state of São Paulo of 210 police officers who are prevented from carrying out their activities, triggering government spending.

It can be said that the present study aimed to reduce this number of leaves from simulations of the movement of police officers and found an improvement of 28.57%, thus representing the greater longevity of the police officer until he started to have problems with low back pain.

5. FINAL CONSIDERATIONS

It was perceived, through the study, that there is coherence between the factors studied, to the extent that, within the police groups, the factors are interrelated. In addition, some risk factors are directly opposed to the other factors initially mentioned, which only ratifies their classification in this way.

In this sense, the indications that can numerically slow down the number of police leaves due to low back pain are included in this study, which, at the study site, once again was certified to be in too high a quantity; however, being ergonomically reduced by 28.57%.

It is also worth remembering that such factors, to the extent that they are related to working conditions, require a cultural change in the institution, in the sense of valuing more the

workers who compose it, giving them subsidies for a dignified, decent work that satisfies the need for its operation, and that, at the same time, is not harmful to those who perform the tasks.

It is also worth mentioning the importance of job satisfaction, a point so much discussed by ergonomics, which applies intimately to the health area, a fact well marked by the final considerations of this study, which aimed to provide better working conditions to the police officers of the 11th Battalion of the Military Police of the state of São Paulo.

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