Jurnal
Metris
p-ISSN: 1411 - 3287
e-ISSN: 2808 - 4810

Jurnal Metris 24 (2023) 75 –82
http://ejournal.atmajaya.ac.id/index.php/metris

Analysis of Mental Workload on Workers in Service Department Using The Nasa-TLX Method

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Article Info

Article history:

Received
April 12, 2023

Accepted
October 20, 2023

Keywords:
Mental Workload, NASA-TLX, Workers, Service Department

Abstract

CV. Istiqomah Furniture is a company engaged in manufacturing furniture located in Klaten, Central Java. The problems that are often faced by CV. Istiqomah Furniture, namely the decrease in worker productivity and the number of final products that are not following company standards. One of the departments responsible for these problems is the service department. The high intensity of work in the service department can cause a mental burden for workers. The purpose of this study is to calculate the mental workload felt by workers, find out the dominant factors that cause this mental burden, and provide alternative improvements based on the problems faced by the company. The method used in this research is NASA-TLX (National Aeronautics and Space Administration Task Load Index). The results of this study are that the average worker has a high mental workload with a WWL value of 72.11, and the most influential factors are physical and mental needs. Based on these results, the proposed improvements provide sufficient rest time, improve worker safety and comfort, increase work motivation, provide adequate facilities, conduct medical tests, and provide good nutrition.

1. INTRODUCTION

CV. Istiqomah Furniture is a small, medium enterprise located in Klaten, Central Java, that produces various kinds of finished furniture products such as dining table sets, sideboards, dressers, various home decorations, and other appliances for housing or hotels. Istiqomah Furniture products are also shipped to multiple countries, such as Singapore and Malaysia, and it uses a make-to-order system where products are made based on consumer wishes. This type of system means that the variety and quantity of products in a specific time unit cannot be ascertained (Raundal *et al*., 2016). However, the furniture industry in developing countries is still manual, and its workers are vulnerable to musculoskeletal disorders and mental stress (Azemi and Wahyuni., 2017). Musculoskeletal disorders that can happen to the workers varied from low back pain and Osteoarthritis, a degenerative disease that occurs in the joints and is progressive (Hidayah *et al.*, 2023). Excessive workload impacts worker health, long-term illness, stress, and mental fatigue (Sartang *et al.,* 2016). Workers with a high workload will experience a decrease in performance, which can be detrimental to the company (Foy *et al.*, 2018). The reduced performance will lead to defective products and increase the likelihood of the product being a waste product (Nursanti *et al*., 2019). The increase in defect product will affect consumer utility as the cost will increase (Nugroho *et al*, 2021). Workload will also increase when the number and difficulty of tasks required to complete work increase or when the time allotted for task completion decreases (Bommer and Fendley, 2016). Complaints of Musculoskeletal disorders (MSDs) that accumulate will majorly impact bone structure disorders and muscle disorders (Pratiwi *et al.,* 2022). This problem also occurred in CV Istiqomah Furniture, where of 56 total workers, 44 are experiencing pain and stress from their work. There is also a drop in productivity in which the company usually produces about 10 pieces of furniture a week, which is reduced to about 7 pieces weekly.

Employee workload status can be measured with various methods such as Subjective Workload Assessment Technique (SWAT), Rating Scale Mental Effort (RSME), and National Aeronautical and Space Administration - Task Load Index (NASA-TLX). This paper measures workers' workload with NASA-TLX because it is sensitive to various work conditions, and it is easier and more practical to use in measuring workload. In addition, NASA-TLX has various assessment factors that can identify and provide information about various activities in carrying out work. By knowing the mental load status of workers, companies can make improvements to minimize work accidents

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(Bommer & Fendley, 2016). In addition, with evaluation and special treatment that can reduce the mental burden of workers, suitable and comfortable working conditions will be created without excessive pressure when doing work to increase work productivity, ultimately optimizing company profits (Putri & Handayani, 2017). NASA-TLX also produce stable result across various setup of experiments and samples, and the instrument shows high sensitivity even in non-critical cognitive load levels based on research that explores the cognitive workload of 107 driver and related to in-vehicle information systems (Janczewski *et al.*, 2022).

Research on the mental load of workers is carried out in the service department because this department is most responsible for the final product's quality and requires constant mental work such as inspecting, repairing, sanding, and patching products. In addition, the service department has a relatively large number of workers who will be respondents compared to other departments in the CV. Istiqomah Furniture. In addition, the selection of the service department in measuring mental load is because all workers have the same duties from one worker to another. Based on the problem of decreasing worker productivity and the number of final products that do not follow company standards, a mental workload measurement is carried out using the NASA-TLX (National Aeronautical and Space Administration - Task Load Index) method to improve existing systems.

2. LITERATURE STUDY

2.1 NASA-TLX (National Aeronautical and Space Administration - Task Load Index)

The NASA-TLX is a method of measuring subjective mental workload developed by Sandra G. Hart and Lowell E. Staveland in 1988. Measuring mental workload using NASA-TLX consists of comparing each factor's scale and rating (Febiyani *et al*., 2021). NASA-TLX includes a comprehensive workload calculation based on each individual's perception of mental demand (MD), physical demand (PD), temporal demand (TD), performance (P), effort (E), and frustration level (F) (Hernandez *et al*., 2021). Chen *et al*. (2019) explained the sequence of measuring mental workload, which consists of three stages as follows:

1. Weighting

The weighting stage is carried out by conducting pairwise comparisons on each NASA-TLX indicator to determine which indicator is most dominant in influencing the mental workload of each worker when doing work. The weighting for each workload dimension is worth 0 to 5, with the provision that number 5 is the workload dimension with the most influence when doing work.

2. Rating

Ratings are determined to allocate ratings for each workload dimension. Respondents gave ratings according to the perceived workload. The value given is between 1 and 100, with the provision that 100 is the highest value that can be given

3. Score Interpretation

Interpretation of scores is done to interpret the scores obtained by respondents into workload categories. The calculation value of the respondent's score ranges from 1 to 100. The mean weighted workload score obtained is used to classify the respondent's mental workload category. The score is obtained by multiplying the weighted result with the rating value, then the total value of the result is divided by the total value of the indicators. The results of this calculation are commonly referred to as WWL or Weighted Workload (Afifah, 2021). The class of workload according to Hart and Staveland (1988) in Riono *et al.,* (2018) can be seen in Table 1 Classification of Workload Categories:

Table 1.
Workload Category Classification.

No	Value	Workload Category Classification
1	0-20	Very Low
2	21-40	Low
3	41-59	Average
4	60-79	High
5	80-100	Very High

2.2 SWAT (Subjective Workload Assessment Rating)

The Subjective Workload Assessment Technique is a subjective rating technique developed by the U.S. Air Force Armstrong Aerospace Medical Research Laboratory at Wright-Patterson Air Force Base. For each of the three workload dimensions—time load, mental effort load, and psychological stress load—SWAT employs three levels—low (1), medium (2), and high (3). It creates a single, global rating scale with interval qualities using conjoint measuring and scaling procedures. There are three basic processes involved in using SWAT. Development on a scale is the first. Twenty-seven cards contain all conceivable combinations of the three levels in each dimension. Each operator arranges the cards in a rank order corresponding to how much work they believe they must do. A scale with interval qualities is created using conjoint scaling processes. The

second phase is the event-scoring, or real evaluation of workload for a specific task or mission.

2.3 RSME (Rating Scale Mental Effort)

RSME is created by a basis point with a range of 150 points, a vertical line marked at 1-cm intervals, and nine anchor points with labels ranging from "absolutely no effort" (precisely 0 on the 0-150 point scale) to "rather much effort" (roughly 57 on the scale) to "extreme effort" (approximately 112 on the scale). Marking the line at the location that corresponds to the amount of mental effort needed to perform a job is how responses are made. In earlier work, (Johnson & Widyanti, 2011) described how the NASA-TLX and the RSME were translated into Indonesian and used to measure mental workload. The major finding in that study was that the range of ratings of subjective measures of mental workload imposed by a demanding search task (as measured by the RSME and the NASA-TLX) was more restricted among Indonesian participants than among the Dutch participants that they were compared to.

3. RESERCH METHOD

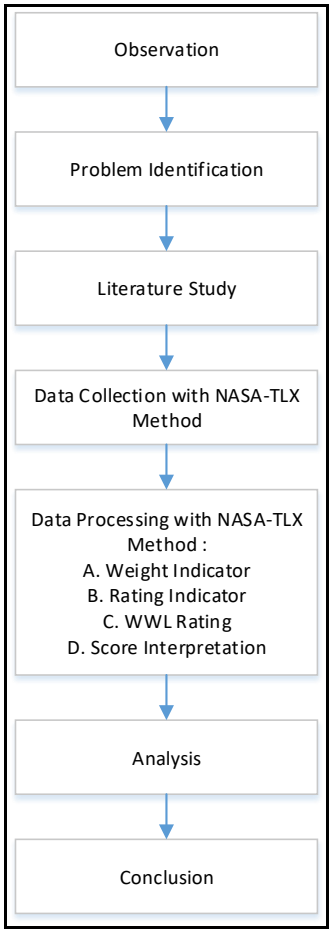

Figure 1.
Research Flowchart

Research conducted at CV. Istiqomah Furniture located in Dukuh Gombang Alas RT 05 RW 03, Gombang Village, Cawas District, Klaten Regency, Central Java Province. The research was conducted for one month, from 02 August 2021 to 01 September 2021. The steps taken by researchers so that the research runs systematically will be detailed below:

a. Observation

Observation is the activity of observing and reviewing the conditions in the CV. Istiqomah Furniture. The aim is to look for existing problems that become obstacles for the company when carrying out its business processes. In addition to observing the company's condition, observation activities were also carried out by interviewing the company, specifically the workers in the service department.

b. Problem Identification.

The problem identification stage is a step to determine specific problems from the company that will become the topic of research discussion. The problem chosen by the researcher is regarding the workload workers feel when doing work.

c. Literature Studies

Search for company data and documents, research journals related to workload, and workload measurement methods, including NASA-TLX. These sources are selected that are relevant to the research being conducted to make it easier for researchers to solve the problems they face.

d. Data Collection

The type of data used by researchers in conducting the research is primary data taken by the researchers and obtained from observations, interviews, and the distribution of NASA-TLX questionnaires to all 9 workers in the service department. Tools used during the data collection, such as paper questionnaires and pens.

e. Data Processing

Data processing was carried out with the help of Microsoft Excel software to calculate the value of the questionnaire results to get the NASA-TLX score. Stages in data processing include calculating weight values to determine the value of each workload indicator, multiplying the weight by the rating value of each workload indicator, and dividing the workload categories of respondents according to their values.

f. Data Analysis

Data analysis is carried out after obtaining results from existing data processing, aiming to make existing data more useful.

g. Conclusion and Suggestion.

Conclusions and suggestions regarding the topics discussed in the research will be described in

the last step according to the results of the analysis that has been carried out.

4. RESULTS AND DISCUSSION

Simulasi The subject of this research has consisted of 9 workers in the service department of CV. Istiqomah Furniture has a range of ages from 38 to 56 years old. All of the workers are experienced with a minimum of one year experience in this company. The detailed results of the workers will be explained below:

4.1 NASA-TLX Analysis

4.1.1 Weighting

The weighting value is an integer between 0 and 5, and the total value of all indicators is 15 (Sampei *et al*., 2016). In the first step, workers who are respondents are asked to choose one of the two more dominant indicators that influence them when doing work. The results of filling in workers can be seen in Table 2 Service Department Worker Weighting Data below.

Table 2.

Service Department Worker Weighting Data

No	Name	Age (Year)	Weight						Accumulation
			MD	PD	TD	P	F	E	
1	Agus Margana	38	3	5	1	4	0	2	15
2	Joko	45	5	3	1	4	0	2	15
3	Pardiem	56	3	5	1	0	2	4	15
4	Parti	55	4	5	2	1	0	3	15
5	Rahayu	42	0	5	2	4	1	3	15
6	Sagiem	47	4	5	0	3	1	2	15
7	Triyatno	41	3	5	1	4	0	2	15
8	Warsini	49	4	5	1	2	0	3	15
9	Yani	48	2	5	3	4	0	1	15
Accumulation			28	43	12	26	4	22	135
Average			3,11	4,78	1,33	2,89	0,44	2,44	15

Based on the respondents' assessment results at the weighting stage, which can be seen in Table 2 Service Department Worker Weighting Data, the workload indicator with the highest value is Physical Demand, with an average weighting of 4,78. This shows that the respondent requires a high Physical Demand when doing his job. The physical needs are the physical activity needed to push, pull, control, and or activate tools.

4.1.2 Rating

Rating values are given by respondents with a value of 1 to 100 for each mental workload indicator. The value given is in accordance with the conditions and the respondent's feelings when doing the job. The results of filling in workers can be seen in table 3 Data on the Rating of Service Department Workers below:

Tabel 3

Service Department Worker Rating Data

No	Name	Rating					
		MD	PD	TD	P	F	E
1	Agus Margana	75	90	40	80	30	70
2	Joko	90	75	60	80	55	70
3	Pardiem	80	90	60	55	75	85
4	Parti	70	80	45	40	35	50
5	Rahayu	30	80	50	70	35	45
6	Sagiem	75	80	40	65	50	55
7	Triyatno	70	90	50	80	40	60
8	Warsini	75	80	30	50	25	65
9	Yani	45	85	50	70	35	40
Rata-rata		67,78	83,33	47,22	65,56	42,22	60

Based on the results of respondents' assessments at the rating stage, which can be seen in Table 3, Data on Service Department Worker Ratings, it is found that the indicator that has the highest value is Physical Demand, with an average rating of 83,33.

4.1.3 WWL Value Calculation and Score Interpretation

The WWL (Weight Workload) value is calculated by multiplying the weighting result against the rating value; then, the total result is divided by the total indicator value. The score interpretation stage is carried out to interpret the scores obtained by respondents into workload groups. The formula for finding WWL can be seen

in Equation 2.1, and the WWL calculation results can be seen in Table 4.

Table 4.
WWL Calculation Result (Weight Workload)

No	Name	WWL Calculation						Total	WWL Value
		MD	PD	TD	P	F	E		
1	Agus Margana	225	450	40	320	0	140	1175	78,33
2	Joko	450	225	60	320	0	140	1195	79,67
3	Pardiem	240	450	60	0	150	340	1240	82,67
4	Parti	280	400	90	40	0	150	960	64
5	Rahayu	0	400	100	280	35	135	950	63,33
6	Sagiem	300	400	0	195	50	110	1055	70,33
7	Triyatno	210	450	50	320	0	120	1150	76,67
8	Warsini	300	400	30	100	0	195	1025	68,33
9	Yani	90	425	150	280	0	40	985	65,67
Rata-rata		232,78	400	64,44	206,11	26,11	152,22	1081,67	72,11

WWL values obtained from the weighting values and ratings of the respondents can be seen in Table 4 WWL (Weight Workload) Calculation Results. Meanwhile, to know the interpretation of the WWL value results can be seen in Table 5. Interpretation of the Workload Assessment below.

Table 5.
Interpretation of Workload Assessment

No	Name	WWL Value	Categories
1	Agus Margana	78,33	High
2	Joko	79,67	High
3	Pardiem	82,67	Very High
4	Parti	64	High
5	Rahayu	63,33	High
6	Sagiem	70,33	High
7	Triyatno	76,67	High
8	Warsini	68,33	High
9	Yani	65,67	High
Average		72,11	High

Respondents' WWL assessment can be seen in Table 5. Interpretation of Workload Assessment obtained the highest value of 82,67, included in the high workload category. Based on the results of the mental workload calculation above, it can be seen that 8 workers are in the high category, and 1 worker is in the very high category. This result shows the average mental workload of workers in the service department at CV. Istiqomah Furniture is classified as high, with an average WWL of 72,11.

Figure 2 Comparison of NASA-TLX Indicators compares the six NASA-TLX indicators consisting of mental demand, physical demand, temporal demand, performance, effort, and frustration level, which aims to determine which indicators are most influential in causing workers' mental workload.

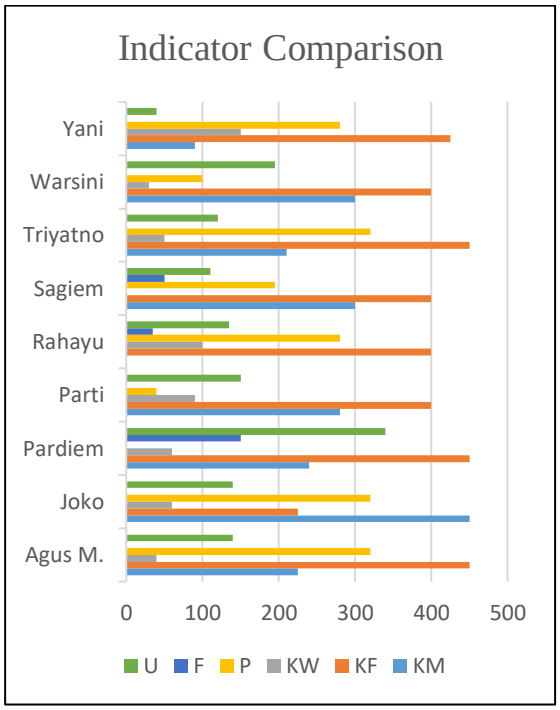

Figure 2.
NASA-TLX Indicator Comparison

4.2 DISCUSSION

Based on the calculation of the weighted workload owned by the respondents, the results obtained from the six workload indicators tested. The indicator with the highest average value is Physical Demand (PD), with a value of 400, followed by MD (MD), with a value of 232,78, and Performance, with a value of 206,11. At the same time, Effort (E) is the next rank with a value of 152,22, the following indicator is Temporal Demand (TD) with a value of 64,44, and the last is the level of Frustration (F) with a value of 26,11.

Physical needs are the most dominant indicator affecting the mental burden of workers, as evidenced by the highest WWL value. Physical needs have the highest value because many work activities require physical activity when workers do their jobs. Physical activities in question, such as controlling tools to sand, smooth and patch components, and pushing and pulling components, which require workers to maximize their physicality

at work, can cause workers to experience fatigue. Mental Needs are also an indicator of workload that has a high value. Mental factors that can affect the workload of workers in the service department include looking for deficiencies in a component and fixing it, thinking and deciding that components and or products have the appropriate standards, and activities to see and look for product surfaces that are still imperfect. Meanwhile, the Temporal Demand and Frustration (F) indicators do not affect workers when they do their work according to the WWL calculations that have been done. This is because workers have a lot of time to do their work, and there are no demands or targets from the company related to the total quantity of products produced in a particular time unit. Likewise, with the level of frustration, workers are safe, comfortable, and calm in doing their work, so there is no excessive feeling of stress felt by workers in the CV service department. Istiqomah Furniture.

After measuring all workers in the service department of CV. Istiqomah Furniture, by weighing indicators, giving ratings, and calculating WWL, the results of interpreting WWL values for each operator are based on the mental load category, which states that 8 workers are in the high category and 1 worker is in the very high category. Based on these data, it can be concluded that the workload experienced by operators is high, so over time, it will affect and have a negative effect on operators, work productivity, product quality produced, and the work performed; therefore, improvements are needed in several aspects that aim to reduce the mental burden felt by workers when doing their work.

Alternative suggestions for improvement according to the problems in the CV service department. Istiqomah Furniture is as follows:

a. Reducing the physical burden on workers by providing sufficient rest time and eliminating flexible work systems, namely systems where loose workers immediately do other work.
b. Improving worker safety and comfort by providing occupational health and safety equipment such as masks, goggles, and gloves.
c. Increasing employee motivation and responsibility by imposing a reward and punishment system in accordance with each worker's performance, productivity, and work ethic.
d. Arranging and providing good work facilities, space, and equipment by creating air circulation, updating and inspecting work tools every certain period, and providing ergonomic chairs and work desks to support workers in completing their tasks.
e. Conduct health checks for workers regularly to ensure they are in good and prime physical condition and do not interfere with the work process.
f. Providing good nutritional intake to workers through snacks or heavy meals to support work success and maintain ideal body condition for workers.
g. This research also concluded that NASA-TLX could give an insight into workers' mental workload and a valuable method for the company.

This research also has several limitations, such as:

a. This research only consisted of 9 workers and did not factor in other workers from the company. The result may vary if the research is conducted with all department workers. This opens opportunities to compare workers' conditions with other departments.
b. This research also only consisted of 1 mental workload assessment method, namely NASA-TLX. Future research can include other methods, such as RSME and SWAT, and compare various methods' results.

5. CONCLUSION

The conclusions that can be given based on the results of data processing that have been obtained in this study are as follows:

a. Based on the results of mental workload calculations using the NASA-TLX method, it can be seen that 8 workers are in the high category, and 1 worker is in the very high category. This shows that the average mental workload is high, with an average workload weight of 72,11.
b. Based on the calculation of the weighted workload, the indicator rating from the most dominant to the least impactful on the mental workload of workers is physical demand (PD) of 400, mental demand (MD) of 232,78, performance (P) of 206,11, effort (E) of 152,22, temporal demand (TD) of 64,44, and frustration level (F) of 26,11.
c. Proposed improvements made to reduce the workload on employees in the service department are by providing sufficient rest time, increasing worker safety and comfort, increasing work motivation and responsibility, providing adequate facilities and equipment, conducting medical tests, and providing enough nutritional intake.

Acknowledgment

Researchers would like to acknowledge Muhammadiyah Surakarta University and CV

Istiqomah Furniture for the opportunities and facilities provided.

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