World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Analysis of The Mental Workload of Warehouse Workers Using The NASA-TLX Method in The Garment Industry

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World Journal of Advanced Research and Reviews, 2026, 30(03), 368-375

Publication history: Received on 21 April 2026; revised on 02 June 2026; accepted on 04 June 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.30.3.1593

Abstract

Mental workload is a critical factor affecting worker performance, especially in labor-intensive industries such as garment manufacturing. This study aims to analyze the mental workload of warehouse workers at PT App One Indonesia using the NASA Task Load Index (NASA-TLX) method. A total of 34 respondents participated through questionnaires, observations, and interviews. The results indicate that the average mental workload score is 75.10, categorized as high. A total of 31 workers fall into the high category, and 3 into the very high category. The dominant factor contributing to workload is temporal demand, followed by mental demand and physical demand. These results demonstrate that time constraints, multitasking, and physical activity largely influence work pressure. Improvement strategies include optimizing workload distribution, improving scheduling systems, standardizing work procedures, and implementing ergonomic interventions. This study provides both theoretical and practical contributions for improving workplace conditions and worker productivity in warehouse operations.

Keywords: Mental Workload; NASA-TLX; Ergonomics; Warehouse; Garment Industry

1. Introduction

Human resources play a vital role in determining organizational success, particularly in manufacturing environments where efficiency and productivity are crucial performance indicators [1]. Worker performance is influenced not only by physical workload but also by mental workload, which involves cognitive processes such as perception, decision-making, and attention [2].

Warehouse operations in the garment industry are responsible for managing the flow of materials, including receiving, storing, and distributing goods to production lines [3]. These activities require high levels of accuracy, coordination, and speed, leading to increased mental and physical demands [4].

Mental workload refers to the cognitive and psychological effort required to complete a task within certain constraints. It is influenced by task demands, time pressure, work environment, individual capacity, and organizational factors [5,6]. Excessive mental workload may reduce attention, increase fatigue, decrease performance, and increase the probability of errors [7,8]. Therefore, evaluating mental workload is important in designing safer, healthier, and more productive work systems.

One commonly used subjective method for measuring mental workload is the NASA Task Load Index, or NASA-TLX. The method evaluates workload through six dimensions: mental demand, physical demand, temporal demand, performance, effort, and frustration [9,10]. NASA-TLX has been widely applied in various work domains due to its practicality, sensitivity, and ability to represent multidimensional workload perception [11,12].

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Based on preliminary observations and interviews with warehouse workers at PT Apparel One Indonesia, workers experienced work pressure due to high material flow, strict accuracy requirements, limited rest time, and the need to complete tasks within daily operational targets. Therefore, this study aimed to analyze warehouse workers' mental workload using NASA-TLX and to identify the dominant workload dimensions to inform improvement recommendations.

2. Materials and methods

2.1. Research Design

This study used a descriptive quantitative approach supported by field observation and interviews. The research focused on measuring perceived mental workload among warehouse workers using the NASA-TLX method.

2.2. Data Collection

Data were collected from 34 warehouse workers using:

- ASA-TLX questionnaire, used to measure perceived workload across six workload dimensions.
- Observation, used to understand actual warehouse activities, work environment, material flow, and operational demands.
- Interviews, used to identify possible causes of workload and support the interpretation of questionnaire results.
- Interviews

This approach ensures both subjective and contextual data are captured [3].

2.3. NASA=TLX Dimension

NASA-TLX measures workload using six dimensions [9,10]:

1. Mental Demand: Cognitive and perceptual activity required to perform the task.
2. Physical Demand: Physical activity required to complete the task.
3. Temporal Demand: Time pressure experienced during task completion.
4. Performance: Perceived success in completing the task.
5. Effort: Mental and physical effort required to achieve task performance.
6. Frustration: Feelings of stress, insecurity, irritation, or discouragement during task performance.

2.4. NASA-TLX Score Calculation

The NASA-TLX calculation was performed through the following steps:

2.4.1. Pairwise comparison weighting

Respondents compared the six dimensions in 15 pairwise comparisons. The number of times each dimension was selected determined its weight.

2.4.2. Rating assessment

Each respondent gave a rating from 0 to 100 for each dimension.

2.4.3. Product calculation

Each dimension product was calculated as:

$$Product = Weight \times RatingProduct$$

2.4.4. Weighted workload calculation

$$WWL = \sum Product$$

2.4.5. Final NASA-TLX score

NASA-TLX Score=WWL / 15

2.4.6. Workload classification

The final NASA-TLX score was classified into five categories as show in Table 1.

Table 1 Categories of final NASA-TLX score

Score	Range
0 – 20	Very Low
21 – 40	Low
41 – 60	Normal
61 – 80	High
81 - 100	Very High

2.5. Data Validation

To ensure reliability, the following tests were conducted:

2.5.1. Uniformity test

A data uniformity test was conducted to determine whether the NASA-TLX scores were within acceptable control limits. The mean, standard deviation, upper control limit, and lower control limit were calculated as follows:

$\bar{x} = \sum x / n$

$$\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

$UCL = \bar{x} + k\sigma$

$UCL = \bar{x} - k\sigma$

Data adequacy test

The data adequacy test was used to determine whether the number of observations was sufficient. The calculation used a 95% confidence level and 5% precision level. Data were considered adequate when $N' < N$

3. Results

3.1. Respondent Character

The study involved 34 warehouse workers with various job roles, including supervisor, group leader, administrative staff, receiving personnel, sample personnel, supply personnel, relax machine personnel, steam machine personnel, piping personnel, supply-to-machine personnel, and loading-to-cutting personnel. The respondents had different ages and work experience, reflecting diverse warehouse operational responsibilities.

3.2. Data Uniformity Test

The data uniformity test produced the following results:

- Mean NASA-TLX score:75.098
- Standard deviation: 3.701

- Upper control limit:86.202
- Lower control limit:63.994

3.3. The data adequacy test produced:

N′=3.42; N=34

Since N′<N, the collected data were considered adequate to represent the population of warehouse workers in this study; all NASA-TLX scores were within the lower and upper control limits. Therefore, the data were considered uniform and suitable for further analysis.

The minimum score was 65.67, while the maximum score was 81.33. Most respondents were categorized as having a high workload, while several respondents reached the very high workload category.

3.4. NASA-TLX Results

After the data is declared suitable for use, the next stage is to analyze the results of NASA-TLX processing on PT Apparel One Indonesia's warehouse department workers. Processing is done by calculating the product value, WWL, and final NASA-TLX score. The product value is obtained by multiplying weight and rating, then adding them to get WWL. The final NASA-TLX score was obtained by dividing the WWL results by 15. The score is used to determine the categories of mental workload: very low, low, medium, high, and very high. The final NASA-TLX scores of each respondent are presented in Figure 1.

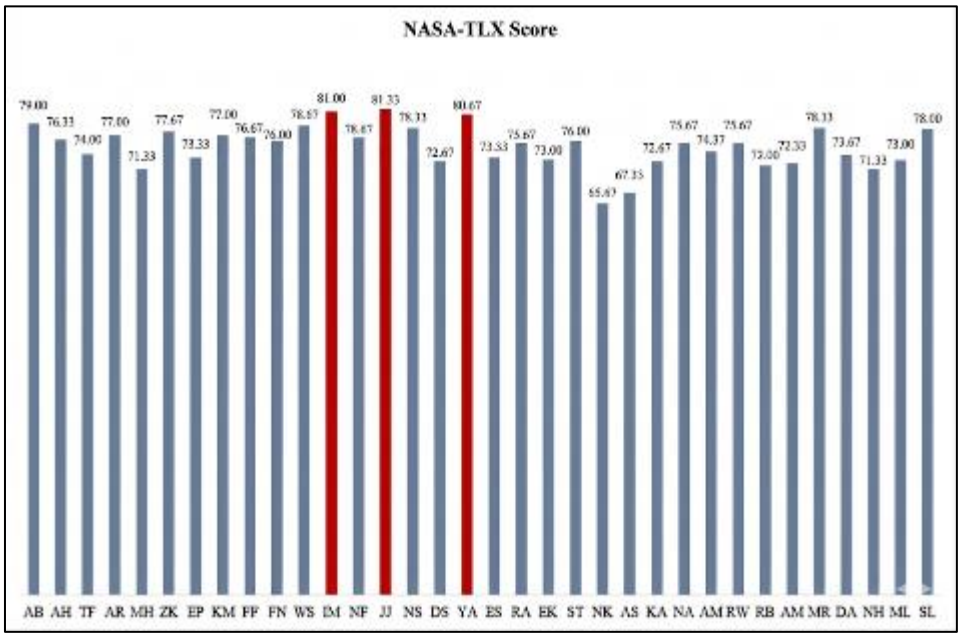

Figure 1 NASA-TLX Score of the respondents

Figure 1 shows the results of the final NASA-TLX score, which is divided into two categories: high (blue) and very high (red). Based on the recapitulation results, the lowest score was 65.67 for NK respondents, while the highest was 81.33 for JJ respondents. A total of 31 workers are in the high category, and 3 workers are in the very high category. These results show that workers' mental workload is relatively high, indicating the need for improvements to reduce the risk of performance decline, work errors, and mental fatigue. To analyze the score comparison of each indicator to find out

the indicator that has the most effect on the mental workload. Figure 2 is the score of each indicator presented in the bar chart.

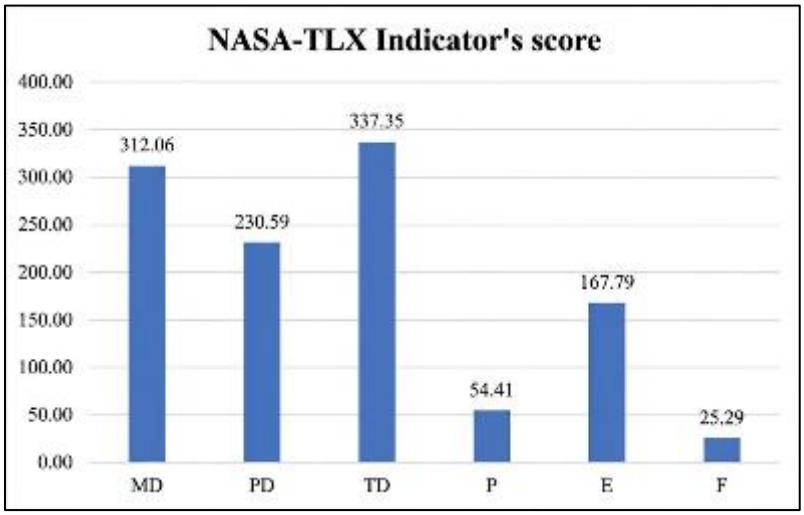

Figure 2 NASA-TLX Score of indicators

Figure 2 shows the comparison of scores on each mental workload indicator. The temporal demand (TD) indicator received the highest score of 337.35, making it the most dominant factor influencing workers' mental workload. This shows that there is pressure related to time constraints in completing work. Meanwhile, the frustration (F) level indicator obtained the lowest score of 25.29, indicating that workers do not experience significant emotional distress or frustration at work. The other indicator scores are mental demand (MD) of 312.06, physical demand (PD) of 230.59, performance (P) of 54.41, and efforts (E) of 167.79.

3.5. Final NASA-TLX Score

The final NASA-TLX scores showed that the average mental workload score was $\bar{x}$ = 75.098. Based on the NASA-TLX classification, this score falls into the high workload category.

4. Discussion

The study found that warehouse workers at PT Apparel One Indonesia experienced a high mental workload, with an average NASA-TLX score of 75.098. This result indicates that warehouse activities impose substantial cognitive, physical, and time-related demands on workers. In manufacturing environments, high workload may arise from task complexity, operational targets, production pressure, and the need for continuous coordination between departments [5,7].

The most dominant NASA-TLX dimension based on weighting was temporal demand. This finding suggests that time pressure is the primary contributor to perceived workload. Warehouse workers must complete receiving, checking, recording, and distributing materials within specified timeframes to prevent production delays. High temporal demand is frequently associated with increased stress, reduced attention, and higher risk of human error, particularly in tasks requiring accuracy and rapid decision-making [6,8].

The high mental demand rating indicates that warehouse tasks require sustained concentration, memory, information processing, and accuracy. Workers must ensure that material quantities, types, and destinations are correct. Mistakes in material handling or recording may disrupt production flow and affect downstream processes. This aligns with previous studies showing that cognitive workload increases when workers must handle multiple information sources, maintain accuracy, and make decisions under time constraints [11,13].

The relatively high frustration rating also indicates psychological pressure in warehouse operations. Frustration may arise from urgent material requests, communication barriers, unexpected changes in production needs, and accumulated workload. Previous ergonomic studies have shown that excessive demands, low control, and insufficient recovery time can increase psychological strain and reduce work performance [14,15].

The data uniformity test showed that all data were within control limits, indicating that the workload scores were consistent and no extreme data points were found. The data adequacy test also confirmed that the sample size was sufficient. These results strengthen the validity of the workload analysis and support the interpretation that high workload was a general condition among warehouse workers in the observed department.

From an ergonomics perspective, workload improvement should focus on both technical and organizational interventions. Technical improvements may include visual management, clearer material labeling, better warehouse layout, digital inventory support, and standardized work instructions. Organizational improvements may include task rotation, workload balancing, rest scheduling, workforce evaluation, and improved communication between the warehouse and production departments [16,17].

The use of NASA-TLX in this study provided a practical and comprehensive evaluation of workload perception. However, NASA-TLX is a subjective method; therefore, future studies may combine it with objective measures such as heart rate variability, eye-tracking, reaction time, error rate, or productivity data to obtain a more complete workload profile [18,19].

5. Conclusion

Based on the results of data processing and analysis, the following conclusions can be drawn:

The mental workload of workers in the warehouse department of PT Apparel One Indonesia is in the high to very high category. Of the 34 respondents, 31 were in the high category, and 3 were in the very high category. This condition indicates considerable mental workload pressure and has the potential to cause fatigue, reduce concentration, and increase the risk of work errors.

The most dominant indicators affecting workers' mental workload are time, mental, and physical needs. This shows that time pressure, the demands of concentration and precision, and physical activity in operational work are the main factors affecting workers' mental state.

Proposed improvements focus on balancing workloads, improving work system efficiency, and enhancing the work environment. This step is expected to reduce mental workload, increase work productivity, and reduce the risk of errors in operational processes.

Limitation

This study has several limitations. First, the analysis was limited to workers in the warehouse department and did not include other production or support departments. Second, the NASA-TLX method is subjective and depends on workers' perceptions. Third, the study provided improvement recommendations but did not evaluate post-implementation effects. Future research should combine NASA-TLX with physiological, behavioral, and performance-based workload indicators and evaluate the effectiveness of implemented interventions.

Compliance with ethical standards

Acknowledgments

The authors would like to express their sincere gratitude to PT App One for providing the facilities and equipment used in this study. The authors also thank all participants who volunteered for the experiment and contributed their time and effort to this research. Appreciation is also extended to colleagues and laboratory assistants who supported data collection and helped ensure the smooth execution of the experiment.

Disclosure of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Statement of ethical approval

This study was conducted in accordance with applicable ethical standards for research involving human participants. All participants were informed about the purpose, procedures, potential risks, and benefits of the study before

participation. Participation was voluntary, and informed consent was obtained from all participants before data collection. Participants were also assured of the confidentiality of their personal information and could withdraw from the study at any time without penalty.

Statement of informed consent

Informed consent was obtained from all participants before their involvement in the study. Participants were provided with clear information regarding the study objectives, experimental procedures, potential risks and benefits, data confidentiality, and their right to withdraw from the study at any time without consequences. Only participants who voluntarily agreed to participate were included in the research.

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