

Analysis of Physical and Mental Workload Measurement on Container-Loading Man Power in a Finished-Goods Warehouse Using the 10-Pulse Method and the Rating Scale Mental Effort (RSME)

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Article Information

Received: August 11, 2026

Revised: October 10, 2026

Online: October 22, 2026

Keywords

10-Pulse Method, Cardiovascular Load, Container Loading, Mental Workload, Physical Workload, Rating Scale Mental Effort

ABSTRACT

Container-loading work in finished-goods warehouses combines repetitive manual handling with time pressure, yet physical and mental workload are rarely classified together for each operator. This descriptive quantitative field study assessed ten male container-loading operators at a snack-food manufacturer in Indonesia (January–March 2025). Physical workload was measured with the 10-pulse method and expressed as cardiovascular load (%CVL, numerically identical to %heart rate reserve), using an estimated maximum pulse (220 – age). Mental workload was rated on six indicators with a 0–100 questionnaire adapted from the Rating Scale Mental Effort (RSME). Mean %CVL was 31.0%, and five of ten operators exceeded the 30% threshold (highest 51.63%). Mean mental workload was 72.0 (High); all operators scored High or Very High, and three scored Very High (≥ 80). Work fatigue was the dominant indicator (19.7%), whereas work difficulty contributed least (13.0%). Cross-classifying both measures identified two operators (MP A, MP D) with simultaneously elevated physical and mental workload. Scheduled recovery breaks, pacing adjustments, and occupational safety training are proposed. Findings are descriptive, based on a small single-site sample and an estimated maximum pulse, and require validation in larger studies.



INTRODUCTION

A snack-food manufacturing company in Indonesia (hereafter, the Company) operates under high production targets, strict delivery schedules, and continuously growing consumer demand. These conditions often require the finished-goods warehouse man power (MP) responsible for container loading to work for extended, uninterrupted periods. Under these conditions, workers frequently report fatigue and reduced anticipation of hazards related to improper working posture and physical exhaustion. Workload is not a single-dimensional phenomenon: it emerges from the interaction between task demands, the work environment, the skills required, and the perceptions of the worker performing the task (Hart & Staveland, as cited in Tarwaka, 2011). When the demands placed on a worker exceed individual capacity, both physical strain and psychological strain increase, which in turn threatens productivity, safety, long-term occupational health, and job satisfaction (Inegbedion et al., 2020).

A large body of ergonomics research shows that no single measurement approach can fully capture workload, because physical and cognitive demands frequently occur simultaneously and interact with one another (Albuquerque et al., 2020; Diarra et al., 2025; Charles & Nixon, 2019; Tao et al., 2019). Heart-rate-based methods, including the 10-pulse method and the related Cardiovascular Load (%CVL) and Heart Rate Reserve (%HR Reserve) indices, are widely regarded as simple, low-cost, and sufficiently reliable indicators of physical workload in field settings where laboratory-grade equipment is unavailable (Dias et al., 2023; Amol & Pandit, 2023; Rahayu, 2020). Complementing physiological measurement with a subjective instrument such as the Rating Scale Mental Effort (RSME) allows researchers to capture the worker's own perception of mental demand, difficulty, performance, anxiety, and fatigue, which physiological signals alone cannot reveal (Malik et al., 2021; Fais et al., 2024; Azizah et al., 2025). Combining an objective physiological method with a subjective psychological method is therefore recommended as good practice in contemporary workload research (Fogelberg et al., 2025; Nugroho & Amalia, 2025; Azizy & Novita, 2024).

Workload can be defined broadly as the value or cost, expressed in physiological or psychological terms, that a worker must expend to achieve a given task target within a fixed time; when this cost is disproportionate to the worker's capacity, fatigue and performance decline follow. Two broad families of measurement approach have been used to operationalise this concept in ergonomics research. Physiological methods infer workload from measurable bodily responses, most commonly heart rate, because cardiac response scales monotonically with both aerobic demand and, to a lesser extent, cognitive and emotional demand, and because it can be recorded with minimal equipment in a working environment (Tao et al., 2019; Ding et al., 2020). The 10-pulse method, together with the derived %CVL and %HR Reserve indices, belongs to this family and has been applied in manual-handling and production settings, including warehouse and tofu-industry workers (Sufyan et al., 2024; Nugroho & Amalia, 2025). Cardiovascular load is generally reported to rise with physical demand and to be reduced when adequate recovery is provided (Dias et al., 2023; Wahlstrom et al., 2025).

Subjective methods, by contrast, ask the worker to directly report perceived demand. Multidimensional instruments such as the NASA Task Load Index (NASA-TLX; Hart & Staveland, 1988) are widely applied to production workers in Indonesia (Hermansyah & Handayani, 2022; Rachmuddin et al., 2021; Iman et al., 2025; Saputra et al., 2025). The RSME is a more parsimonious alternative: the original instrument is unidimensional and asks respondents to rate the mental effort invested in a task on a single scale (Zijlstra, 1993; Widyanti et al., 2013), which makes it fast to administer to production-floor workers while still discriminating between workload levels with acceptable sensitivity (Malik et al., 2021; Azizah et al., 2025). The RSME has also been combined with other instruments in cognitive measurement models (Adamy, 2022) and applied to employees performing multiple tasks (Sinaga & Ramdhani, 2025). Reviews of both physiological and subjective workload literature converge on the same conclusion: because physical and cognitive demands frequently load onto the same physiological channel (heart rate) while producing distinct subjective experiences (effort, difficulty, anxiety, fatigue), single-method assessments risk under- or over-estimating true workload, and pairing an objective and a subjective measure gives a more defensible picture of the worker's actual state (Charles & Nixon, 2019; Fogelberg et al., 2025; Wang et al., 2024). This study adopts that paired approach for container-loading operators, a manual-handling role in which both cardiovascular strain and time-pressured mental demand are plausible.

Several field studies provide a useful benchmark for the present investigation. Using the same 10-pulse and %CVL approach, warehouse operators handling finished goods were found to carry light-to-moderate physical workload in the 1%–43.5% %CVL range (Sufyan et al., 2024). Sugar-factory shift workers assessed with RSME reported mean scores of 97–102 in the high category, driven by high company targets and hot working conditions (Malik et al., 2021); because these values exceed 100, they evidently refer to the original 0–150 range and correspond to roughly 65%–68% of the scale maximum. This combination of target pressure and physically demanding work closely resembles the conditions described for the finished-goods warehouse in this study. High mental workload has also been reported for spoon-manufacturing operators, where fatigue was a prominent indicator (Fais et al., 2024), and for automotive quality-assurance staff, whose mean RSME score of 97.52 (about 65% of a 150-point scale) was also high (Azizah et al., 2025). Multimodal studies pairing CVL with NASA-TLX in a tofu industry (Nugroho & Amalia, 2025) and FTE with RSME in a bakery (Azizy & Novita, 2024) both found normal-to-moderate physical workload coexisting with considerably higher mental workload, and the pairing of CVL with RSME has also been applied in another industrial setting (Satria et al., 2023). Whether the same divergence between physical and mental workload appears among container-loading operators is examined in this study.

Despite the demonstrated value of the multimodal approach, three gaps remain in the literature reviewed here. First, to the best of the authors' knowledge, few of these studies classify each worker on the physical and the mental dimension simultaneously; the two sets of results are usually discussed side by side or in aggregate, which conceals workers who are at risk on both. Second, evidence for container-loading operators in the finished-goods warehouses of food



manufacturers is scarce. Third, the participating company had never formally assessed the physical or mental workload of its container-loading operators, and the appropriate number of man power needed to sustain the current loading target was unknown.

The novelty of this study is therefore threefold. (1) It provides an operator-level, dual-dimension assessment in which every operator is classified by %CVL and by RSME-based mental workload; the cross-classification (Table 7) identifies operators who are simultaneously at risk, which aggregate means do not reveal. (2) It decomposes mental workload into six indicators and expresses the share of each indicator in the total rating, which shows that accumulated fatigue, rather than task difficulty, is the main psychological burden; this distinction points to rest and pacing, rather than skills training alone, as the first line of intervention. (3) It applies a low-cost, equipment-free protocol (manual 10-pulse counting and a short questionnaire) to container-loading operators in a finished-goods warehouse, a setting for which comparable evidence is limited in the literature reviewed. The study is descriptive and exploratory and does not claim statistical generalisation.

This gap motivated the present study, which sought to answer three questions: (1) what is the level of physical workload experienced by the container-loading MP; (2) what is the level of mental workload experienced by the container-loading MP; and (3) what improvement measures can be proposed if the measured physical or mental workload is found to be excessive. Accordingly, the objectives of this study were to identify the physical workload factors using the 10-pulse/%CVL method, to identify the mental workload factors using the RSME-based questionnaire, to classify each operator on both dimensions, and to formulate practical improvement proposals to reduce excessive physical and mental workload among container-loading man power.

METHODS

1. Research Design, Time, and Setting

This study used a descriptive quantitative field-measurement design combining objective physiological measurement with a subjective questionnaire. Data collection was carried out from January to March 2025 in the finished-goods warehouse of the Company, focusing on the container-loading section.

2. Participants

The respondents were ten male container-loading man power (MP A–MP J), selected because this group directly determines the loading throughput of the finished-goods warehouse and was considered the most representative unit for investigating physical and mental workload in this setting. All respondents were active operators at the time of data collection; their age and tenure characteristics are reported in Table 3.

3. Data Collection Technique

Physical workload data were collected through direct field observation: the resting pulse of each operator was measured before the work shift began, and the working pulse was measured while the operator was actively loading a container. Mental workload data were collected using a

structured questionnaire based on the Rating Scale Mental Effort (RSME; see Section 5) distributed to all ten respondents, who rated each of six indicators on a 0–100 numeric scale.

4. Physical Workload: the 10-Pulse Method

Radial pulse was felt manually at the wrist and counted for the time required to complete 10 pulse beats, timed with a stopwatch. Pulse rate in beats per minute was then obtained from Equation (1):

$$DN = \left(\frac{10 \text{ beats}}{\text{measured time (s)}} \right) \times 60 \quad (1)$$

where DN is the pulse rate. This procedure was applied separately to obtain the resting pulse (Denyut Nadi Istirahat, DNI), taken immediately before work began, and the working pulse (Denyut Nadi Kerja, DNK), taken while the operator was loading the container. Maximum pulse rate (DN Max) was estimated with the age-based formula 220 minus age for male workers (Fox et al., 1971; Tarwaka et al., 2004). This formula was used because a direct maximal-effort test is not practicable for operators during normal production, and because it is the formula conventionally applied in field applications of the 10-pulse and %CVL methods in Indonesia. DN Max obtained in this way is an estimated, population-level maximum and not a direct measurement of an individual's physiological capacity; individual variation around the estimate is considerable, and alternative equations give different values (Tanaka et al., 2001; Robergs & Landwehr, 2002). The implications for interpretation are addressed in the limitations. Cardiovascular Load was then calculated with Equation (2):

$$\%CVL = \frac{(DNK - DNI)}{(DN_{Max} - DNI)} \times 100 \quad (2)$$

In this study, %HR Reserve (Karvonen et al., 1957) was calculated from the same three quantities as %CVL, namely DNK, DNI, and DN Max, as given in full in Equation (3):

$$\%HR \text{ Reserve} = \frac{(DNK - DNI)}{(DN_{Max} - DNI)} \times 100 \quad (3)$$

Equations (2) and (3) are therefore algebraically identical, so the two indices take identical values for every operator (Table 4). They are reported under both names because %CVL is the term used, together with the classification in Table 1, in Indonesian ergonomics practice (Tarwaka et al., 2004; Tarwaka, 2011), whereas %HR Reserve is the term used in exercise physiology. Because the two indices carry no independent information, %CVL is used for classification and interpretation hereafter. Table 1 shows the five %CVL classes; a value above 30% was taken as the threshold at which work improvement is needed.



Table 1. Classification of Cardiovascular Load (%CVL)

%CVL	Classification
$\leq 30\%$	No fatigue occurs
$> 30\% - \leq 60\%$	Improvement needed
$> 60\% - \leq 80\%$	Improvement needed in the short term
$> 80\% - \leq 100\%$	Action is required immediately
$> 100\%$	Work activity is not permissible

Source: adapted from Tarwaka et al. (2004) and Tarwaka (2011).

5. Mental Workload: the Rating Scale Mental Effort (RSME)

Mental workload was assessed with a questionnaire based on the Rating Scale Mental Effort (RSME). The original RSME is a unidimensional instrument in which respondents indicate the mental effort invested in a task on a single 0–150 scale with verbal anchors (Zijlstra, 1993; Widyanti et al., 2013). Two adaptations were made in this study. To avoid ambiguity, the scale is stated explicitly here: a 0–100 scale was used throughout the study, in the abstract, methods, and results.

First, rather than a single global rating, respondents rated six indicators: Work Load (Beban Kerja, BK), Work Difficulty (Kesulitan Kerja, KK), Work Performance (Performasi Kerja, PK), Mental Effort (Usaha Mental Kerja, UMK), Work Anxiety (Kegelisahan Kerja, KgK), and Work Fatigue (Kelelahan Kerja, KLK). The indicators were selected to cover the facets through which workload is expressed in the definition adopted in the Introduction, namely task demand (BK, KK), task outcome (PK), invested effort (UMK), and strain responses (KgK, KLK) (Hart & Staveland, as cited in Tarwaka, 2011), and because RSME questionnaires with several work-related indicators have been used in Indonesian industrial studies (Malik et al., 2021; Fais et al., 2024; Septiani et al., 2024).

Second, each indicator was rated on a 0–100 numeric scale instead of the original 0–150 range. This range was adopted (i) for consistency with the 0–100 ratings of the NASA-TLX, which is widely applied to production workers in Indonesia and for which unweighted (raw) 0–100 ratings have been shown to be valid (Hart & Staveland, 1988; Hart, 2006; Said et al., 2020; Hermansyah & Handayani, 2022; Iman et al., 2025; Saputra et al., 2025); (ii) because a percentage-type scale is easier to explain to production-floor respondents; and (iii) because it allows each respondent's mean score to be matched directly with the 0–100 classification bands in Table 2. Scores from this adapted instrument are therefore not directly interchangeable with 0–150 RSME values; when results from studies that used the 0–150 range are compared, they are expressed as a percentage of the scale maximum.

Each respondent's mean score was obtained by averaging the six indicator ratings, and the mean score was then matched against the classification bands in Table 2. The bands follow the overall-workload categories commonly used for 0–100 workload scores in Indonesian studies (Hart & Staveland, 1988; Hermansyah & Handayani, 2022; Iman et al., 2025). They were developed for

NASA-TLX and have not been validated specifically for RSME, which is acknowledged as a limitation.

Table 2. Classification of Mental Workload Score

No	Category	Score range
1	Low	0 - 9
2	Moderate	10 - 29
3	Somewhat High	30 - 49
4	High	50 - 79
5	Very High	80 - 100

Source: adapted from Hart and Staveland (1988); Hermansyah and Handayani (2022); Iman et al. (2025).

6. Data Analysis

Data were processed descriptively. For the physical workload data, resting and working pulse, maximum pulse, pulse increase (NK), %CVL, and %HR Reserve were calculated for each operator and averaged across the sample; worked examples are given with Table 4. For the mental workload data, the mean RSME score was calculated for each operator and classified (Table 5), and the relative contribution of each of the six indicators was calculated as the indicator's total rating divided by the grand total of all ratings, multiplied by 100 (Table 6), in order to identify the dominant source of mental workload.

RESULTS

1. Respondent Characteristics

All ten container-loading operators were male, with ages ranging from 20 to 31 years (mean 26.2 years) and tenure ranging from six months to four years. Tenure was six months for one operator, one year for five operators, three years for two operators, and four years for two operators (Table 3).

Table 3. Characteristics of Respondents

No	Operator	Age (yrs)	Tenure	Sex
1	MP A	29	4 years	Male
2	MP B	27	3 years	Male
3	MP C	23	1 year	Male
4	MP D	28	1 year	Male
5	MP E	24	1 year	Male
6	MP F	31	6 months	Male



7	MP G	20	1 year	Male
8	MP H	30	4 years	Male
9	MP I	24	1 year	Male
10	MP J	26	3 years	Male

2. Physical Workload: Pulse Measurement and %CVL

Table 4 presents the resting pulse (DNI), working pulse (DNK), estimated maximum pulse (DN Max), pulse increase (NK), and the resulting %CVL and %HR Reserve for each operator. DNI and DNK were converted from the time needed to count 10 pulse beats using Equation (1); DN Max was obtained as 220 minus the age listed in Table 3; NK is DNK minus DNI; and %CVL and %HR Reserve were calculated with Equations (2) and (3).

Table 4. Pulse Measurement, %CVL, and %HR Reserve of Container-Loading Operators

No	Operator	DNI	DNK	DN Max	NK	%CVL	%HR Reserve
1	MP A	84.5	118.8	191	34.3	32.21	32.21
2	MP B	74.25	105.45	193	31.2	26.27	26.27
3	MP C	34.26	80.42	197	46.16	28.36	28.36
4	MP D	80.21	137.93	192	57.72	51.63	51.63
5	MP E	80.75	101.2	196	20.45	17.74	17.74
6	MP F	84.86	111.73	189	26.87	25.8	25.8
7	MP G	61.85	106.57	200	44.72	32.37	32.37
8	MP H	63.69	93.02	190	29.33	23.22	23.22
9	MP I	59.23	104	196	44.77	32.73	32.73
10	MP J	64.79	116.05	194	51.26	39.67	39.67
Mean		68.84	107.52	193.80	38.68	31.00	31.00

Note: DNI = resting pulse; DNK = working pulse; DN Max = estimated maximum pulse (220 - age); NK = pulse increase (DNK - DNI). Values in beats/minute except %CVL and %HR Reserve.

Worked example (MP A, age 29 years). The time to count 10 beats was 7.10 s at rest and 5.05 s during loading, giving $DNI = (10/7.10) \times 60 = 84.5$ beats/min and $DNK = (10/5.05) \times 60 = 118.8$ beats/min (Equation 1). $DN\ Max = 220 - 29 = 191$ beats/min and $NK = 118.8 - 84.5 = 34.3$ beats/min. Then $\%CVL = (118.8 - 84.5)/(191 - 84.5) \times 100 = 34.3/106.5 \times 100 = 32.21\%$, and %HR Reserve takes the same value, 32.21% (Equation 3). Because 32.21% exceeds 30%, MP A falls in the "improvement needed" class (Table 1). The same procedure was applied to the other nine operators.

The average %CVL and %HR Reserve across the ten operators were both 31.0% (Table 4), placing the group, on average, just above the 30% threshold at which improvement is recommended (Table 1). Individually, five operators, namely MP A (32.21%), MP D (51.63%), MP G (32.37%), MP I (32.73%), and MP J (39.67%), exceeded the 30% threshold and fell into the "improvement needed" category, while the remaining five operators (MP B, MP C, MP E, MP F, MP H) recorded %CVL of 30% or below and were classified as experiencing no measurable physical fatigue. MP D recorded the highest physical workload (%CVL = 51.63%), associated with the largest pulse increase in the sample (NK = 57.72 beats/minute). The group means in the last row of Table 4 are the arithmetic means of the ten individual values; for example, mean DNI = $688.39/10 = 68.84$ beats/minute.

3. Mental Workload: RSME Scores

Table 5 shows the RSME rating given by each operator on the six mental-workload indicators together with the resulting mean score and classification. Each operator rated the six indicators (BK to KLK) on the 0–100 scale in the questionnaire. The Mean column is the arithmetic mean of the six ratings, the Category column is obtained by matching this mean with the bands in Table 2, and the bottom row gives the mean of each column across the ten operators.

Table 5. RSME Ratings and Classification by Operator

No	Operator	BK	KK	PK	UMK	KgK	KLK	Mean	Category
1	MP A	100	70	80	70	90	80	81.67	Very High
2	MP B	50	40	50	100	70	100	68.33	High
3	MP C	100	50	70	30	40	80	61.67	High
4	MP D	90	70	90	80	80	100	85	Very High
5	MP E	80	70	90	80	50	70	73.33	High
6	MP F	70	70	90	80	90	90	81.67	Very High
7	MP G	70	50	80	50	30	60	56.67	High
8	MP H	60	40	80	70	60	90	66.67	High
9	MP I	80	50	70	80	60	90	71.67	High
10	MP J	70	50	80	80	70	90	73.33	High
Mean		77.0	56.0	78.0	72.0	64.0	85.0	72.0	High

Note: BK = Work Load; KK = Work Difficulty; PK = Work Performance; UMK = Mental Effort; KgK = Work Anxiety; KLK = Work Fatigue; each rated 0-100.

Worked example (MP A). MP A rated BK = 100, KK = 70, PK = 80, UMK = 70, KgK = 90, and KLK = 80. The mean score is $(100 + 70 + 80 + 70 + 90 + 80)/6 = 490/6 = 81.67$. Because 81.67 lies within the 80–100 band, MP A is classified as "Very High" (Table 2). The bottom row is obtained in the same



way across operators; for example, the mean BK rating is $770/10 = 77.0$, and the overall mean of 72.0 equals $4,320/60$ ratings.

All ten operators fell into the High or Very High mental workload categories; none scored below the High band. Three operators, namely MP A (81.67), MP D (85.00), and MP F (81.67) were classified as Very High, while the remaining seven operators recorded High mental workload, with a range of 56.67 (MP G) to 73.33 (MP E and MP J). The overall mean RSME score across the sample was 72.0, corresponding to the High category.

4. Distribution of RSME Mental Workload Indicators

To identify which aspect of mental demand contributed most to the overall workload, the ratings for each of the six RSME indicators were summed across all ten operators and expressed as a percentage of the grand total (4,320 points). Each indicator total in Table 6 is the sum of the ten operators' ratings for that indicator in Table 5 (the column sums), and the share (%) is the indicator total divided by the grand total, multiplied by 100. For Work Load (BK), for example, the total is $100 + 50 + 100 + 90 + 80 + 70 + 70 + 60 + 80 + 70 = 770$, and the share is $(770/4,320) \times 100 = 17.8\%$. The indicators were then ranked by share (Table 6).

Table 6. Total Score and Percentage Contribution of Each RSME Indicator

Indicator	Total score	Share (%)	Rank
Work Fatigue (KLK)	850	19.7%	1
Work Performance (PK)	780	18.1%	2
Work Load (BK)	770	17.8%	3
Mental Effort (UMK)	720	16.7%	4
Work Anxiety (KgK)	640	14.8%	5
Work Difficulty (KK)	560	13.0%	6
Total	4,320	100%	-

Work Fatigue (KLK) was the largest contributor to perceived mental workload (19.7%), followed by Work Performance (18.1%), Work Load (17.8%), Mental Effort (16.7%), and Work Anxiety (14.8%). Work Difficulty (KK) contributed the smallest share (13.0%), 6.7 percentage points below Work Fatigue.

5. Combined Physical and Mental Workload Classification

Table 7 cross-tabulates each operator's physical (%CVL-based) and mental (RSME-based) workload classification. The mental workload category of each operator was taken from Table 5 (based on the bands in Table 2), and the physical workload category was derived from the %CVL values in Table 4 using the classes in Table 1: %CVL of 30% or below is "No fatigue", and above 30% up to 60% is "Improvement needed". No operator exceeded 60%, so no other class occurs.

Table 7. Combined Physical and Mental Workload Classification by Operator

No	Operator	Mental workload	Physical workload
1	MP A	Very High	Improvement needed
2	MP B	High	No fatigue
3	MP C	High	No fatigue
4	MP D	Very High	Improvement needed
5	MP E	High	No fatigue
6	MP F	Very High	No fatigue
7	MP G	High	Improvement needed
8	MP H	High	No fatigue
9	MP I	High	Improvement needed
10	MP J	High	Improvement needed

Five operators (MP A, MP D, MP G, MP I, MP J) simultaneously required physical-workload improvement, and two of these five (MP A and MP D) also fell into the Very High mental workload band. Conversely, MP F fell into the Very High mental workload band without a physical-workload classification requiring improvement.

6. Relationship Between Tenure and Workload

Cross-referencing Table 3 with Tables 4 and 5 shows no consistent pattern between tenure and either workload dimension in this sample (no inferential test was performed because of the small sample size). The two longest-serving operators (MP A and MP H, four years each) differ in physical-workload classification: MP A required improvement (%CVL = 32.21%) while MP H did not (%CVL = 23.22%). MP F, the most recently assigned operator in the sample (six months of tenure), recorded no physical fatigue (%CVL = 25.80%) but a Very High mental workload score (RSME = 81.67). MP D, who recorded the highest %CVL (51.63%) and the highest mean RSME score (85.00), had one year of tenure; among the five operators with one year of tenure (MP C, MP D, MP E, MP G, and MP I), MP C and MP E recorded %CVL below 30%, while MP G and MP I recorded values only marginally above 30% (32.37% and 32.73%).

DISCUSSION

The physical workload results show that container-loading operators at the Company experience, on average, cardiovascular load at the boundary of the "no fatigue" and "improvement needed" categories (mean %CVL = 31.0%), with half of the sample exceeding the 30% threshold. This finding is consistent with field studies of manual loading and warehouse tasks using the same 10-pulse and %CVL approach, which typically report %CVL in the light-to-moderate range for lifting



and moving activities but identify a meaningful subset of workers who cross into the "improvement needed" band during peak loading (Sufyan et al., 2024; Rahayu, 2020; Satria et al., 2023). The pattern also mirrors broader occupational cardiovascular-load literature showing that sustained manual handling without adequate recovery elevates relative heart-rate reserve above recommended limits (Dias et al., 2023; Wahlstrom et al., 2025; Amol & Pandit, 2023). MP D, who recorded the highest %CVL (51.63%) and the largest pulse increase in the sample, illustrates how individual variation, potentially related to physical conditioning, task pacing, or momentary workload intensity, can produce disproportionately high cardiovascular strain even within a small, homogeneous group of young male operators.

The mental workload results indicate a more uniform pattern: every operator reported High or Very High scores, with a group mean of 72.0 on the 0–100 scale. When the scores of studies that used the original 0–150 range are expressed as a percentage of the scale maximum (97–102 in Malik et al. (2021), about 65%–68%; 97.52 in Azizah et al. (2025), about 65%), the present result falls in the same High band as RSME findings from other target-driven production environments, including sugar-factory shift workers (Malik et al., 2021), spoon-manufacturing operators (Fais et al., 2024), horizontal-directional-drilling crews (Septiani et al., 2024), and automotive quality-assurance staff (Azizah et al., 2025). Such comparisons are indicative only, because the instruments differ in scale and indicator set. The dominance of the Work Fatigue (KLK) indicator (19.7% of total ratings) in the present sample echoes the sugar-factory finding that excessive company targets and demanding physical conditions manifest primarily as fatigue rather than task difficulty (Malik et al., 2021), and is consistent with RSME studies in which fatigue was a prominent indicator (Fais et al., 2024; Septiani et al., 2024). That Work Difficulty (KK) received the lowest share (13.0%) suggests that, from the operators' own perspective, the loading task itself is not cognitively complex; the burden appears to stem more from its pace, repetition, and the accumulation of fatigue from sustained, target-driven work.

Taken together, the two methods offer complementary rather than redundant information. Operators such as MP F reported Very High mental workload despite an acceptable %CVL (25.80%, "no fatigue"), while operators such as MP G and MP I recorded only High (not Very High) mental workload alongside a physical %CVL that required improvement. This divergence is expected: heart rate responds to the combined physical and cognitive demands of a task, whereas RSME captures the worker's own appraisal of mental effort, difficulty, and fatigue, and the two are not always statistically aligned (Fogelberg et al., 2025; Diarra et al., 2025). Similar complementary patterns between cardiovascular and subjective workload indices have been reported when CVL was paired with NASA-TLX in a small-scale tofu industry (Nugroho & Amalia, 2025) and when FTE was paired with RSME in a bakery setting (Azizy & Novita, 2024), reinforcing the recommendation that physiological and subjective instruments should be used together rather than as substitutes for one another (Charles & Nixon, 2019; Tao et al., 2019; Ding et al., 2020).

Regarding tenure, the descriptive cross-reference in the Results (Section 6) shows no consistent association between tenure and workload. The Very High mental workload of MP F

despite an acceptable %CVL may reflect the additional cognitive demand of still becoming familiar with the pacing and routine of the loading task, although this was not measured and remains a hypothesis. The wide spread of workload among operators with the same tenure (MP C, MP D, MP E, MP G, and MP I) suggests that individual pacing and momentary task intensity during the specific loading cycle measured may be more strongly associated with workload than tenure alone, and that both new and experienced operators can be exposed to elevated combined workload. Given the small sample, these explanations are tentative and should be tested in larger samples.

From a managerial standpoint, the combined classification in Table 7 identifies MP A and MP D as the highest-priority operators, since both simultaneously exceeded the physical-workload threshold and fell into the Very High mental-workload band. For physical workload, the most directly actionable intervention is the introduction of short, scheduled recovery breaks between loading cycles. For example, a rest of five to ten minutes after each completed container is proposed to allow heart rate to return toward resting levels; the adequacy of this duration was not tested in the present study and should be verified by post-intervention pulse measurement. For mental workload, because Work Fatigue and Work Performance were the dominant indicators rather than task difficulty, interventions that address pacing and recovery are likely to be more effective than additional skills training alone; nevertheless, structured motivational support and occupational safety and health training, including correct lifting technique, injury prevention, and posture maintenance, remain warranted, consistent with recommendations from comparable manual-handling and warehouse workload studies (Azizy & Novita, 2024; Septiani et al., 2024; Rosyada & Harnikova, 2026). Cross-training and, where feasible, additional staffing to redistribute the container-loading workload during peak periods would further reduce the frequency with which individual operators are exposed to both elevated %CVL and Very High RSME scores simultaneously.

For plant and warehouse management, three practical implications follow from these findings. First, because physical workload was concentrated in an identifiable subset of operators rather than the whole workforce, targeted rather than blanket intervention is likely to be more cost-effective: a rotating micro-break schedule tied to container-completion events, prioritised for the five operators exceeding the %CVL threshold, would address the physical dimension without disrupting overall loading throughput. Second, because mental workload was uniformly high across the entire sample and was driven primarily by fatigue and performance concerns rather than task difficulty, purely instructional interventions (for example, additional technical training) are unlikely on their own to resolve the mental-workload problem; pacing, staffing levels, and recovery time are the more direct levers, consistent with recommendations from comparable garment- and drilling-industry studies (Rosyada & Harnikova, 2026; Septiani et al., 2024). Third, the combined classification in Table 7 offers a simple screening tool that the company can reuse periodically, for example at the start of each peak season, to track whether operators move between categories over time and to verify whether implemented improvements (rest breaks, motivational support, safety training)



measurably reduce the proportion of operators in the "improvement needed" and "Very High" categories.

This study has several limitations. First, the sample was limited to ten male operators aged 20–31 years from a single company and a single warehouse section, which restricts the generalisability of the findings to the wider warehouse workforce (including female and older workers) and precluded formal inferential testing of associations between age, tenure, %CVL, and RSME score. Second, DN Max was estimated with the 220 – age formula rather than measured. This formula has considerable individual variability, and alternatives such as $208 - 0.7 \times \text{age}$ give somewhat different values (Fox et al., 1971; Tanaka et al., 2001; Robergs & Landwehr, 2002). As a sensitivity check, recalculating %CVL with the $208 - 0.7 \times \text{age}$ formula raised the mean %CVL from 31.0% to 32.1% and did not change the classification of any operator (the same five operators exceeded 30%, and MP C remained just below the threshold at 29.3%); nevertheless, %CVL values remain estimates, particularly for operators near the 30% cut-off. Third, pulse was measured manually rather than with continuous heart-rate monitoring, which, while consistent with standard 10-pulse field practice (Rahayu, 2020; Sufyan et al., 2024), cannot capture within-shift variation in cardiovascular load. Fourth, the mental workload questionnaire is an adapted six-indicator, 0–100 version of the RSME that was not separately validated, its classification bands were originally developed for NASA-TLX, and the scores are self-reported and not directly comparable with 0–150 RSME values (Zijlstra, 1993; Widianti et al., 2013). Fifth, data were collected at a single time point rather than across multiple shifts or seasons, so the results should be interpreted as a snapshot of workload under the production conditions observed during January–March 2025 rather than a stable, year-round estimate. Future research should extend this multimodal protocol to a larger and more heterogeneous sample, incorporate continuous heart-rate monitoring and measured or validated maximum heart rate, validate the questionnaire and its classification bands, and examine whether the proposed rest-break and training interventions measurably reduce %CVL and RSME scores over time.

CONCLUSIONS

This study measured the physical and mental workload of ten container-loading man power at a snack-food manufacturing company in Indonesia using the 10-pulse/%CVL method and an RSME-based questionnaire (0–100 scale). Three conclusions follow from the results. First, the mean physical workload was %CVL = 31.0% and %HR Reserve = 31.0% (the two indices are algebraically identical), indicating that, on average, the group required workload improvement; five of the ten operators (MP A, MP D, MP G, MP I, MP J) individually exceeded the 30% threshold. Second, mental workload was uniformly high, with a mean score of 72.0 across all ten operators; three operators (MP A, MP D, MP F) were classified as Very High and the remaining seven as High, and Work Fatigue (KLK, 19.7%) was the most dominant contributing indicator, followed by Work Performance (18.1%) and Work Load (17.8%), while Work Difficulty (KK, 13.0%) contributed least. Third, the proposed improvements are, for physical workload, scheduled five-to-ten-minute recovery breaks



between container-loading cycles, and, for mental workload, attention to pacing and recovery together with structured motivational support and occupational safety and health training covering correct lifting technique and posture maintenance; their effectiveness remains to be evaluated. Combining an objective physiological measure with a subjective psychological measure was feasible for characterising workload among container-loading man power, and the operator-level cross-classification identified MP A and MP D as the highest-priority cases. It is recommended that the company give priority attention to operators identified as high-risk on both dimensions, that future studies apply an additional method such as NASA-TLX for cross-validation, and that the proposed improvements be implemented and re-evaluated to confirm their effectiveness in reducing workload.

ACKNOWLEDGMENT

The authors would like to thank the management and finished-goods warehouse staff of the participating company for granting research access and facilitating the data collection process, and the ten container-loading man power who participated as respondents in this study. Appreciation is also extended to the academic supervisors and colleagues for their guidance and constructive feedback throughout the research process.

REFERENCES

- Adamy, M. R. (2022). RSI (Relative Stress Index) based cognitive measurement model with NASA-TLX, RSME (Rating Scale Mental Effort Index) and GHQ-12 methods (case study: sales marketing). *PROZIMA (Productivity, Optimization and Manufacturing System Engineering)*, 6(2). <https://doi.org/10.21070/prozima.v6i2.1582>
- Albuquerque, I., Tiwari, A., Parent, M., Cassani, R., Gagnon, J., Lafond, D., Tremblay, S., & Falk, T. (2020). WAUC: A multi-modal database for mental workload assessment under physical activity. *Frontiers in Neuroscience*, 14. <https://doi.org/10.3389/fnins.2020.549524>
- Amol, & Pandit, S. (2023). Physiological workload assessment with the help of heart rate and perceived exertion rating on handcart pullers of wholesale trade markets of Delhi. *National Medical Journal of India*, 36, 89–92. <https://doi.org/10.25259/NMJI.855.20>
- Azizah, F. N., Rinaldi, D. N., & Al-Muqaffa, F. W. (2025). Assessing mental workload of automotive factory employees using NASA-TLX and RSME methods. *Jurnal Ilmiah Teknik Industri*, 24(1). <https://doi.org/10.23917/jiti.v24i01.8363>
- Azizy, A. R., & Novita, R. (2024). Workload analysis using the Full-Time Equivalent and Rating Scale Mental Effort methods in the production division. *Journal La Multiapp*, 5(1). <https://doi.org/10.37899/journallamultiapp.v5i1.1587>
- Charles, R., & Nixon, J. (2019). Measuring mental workload using physiological measures: A systematic review. *Applied Ergonomics*, 74, 221–232. <https://doi.org/10.1016/j.apergo.2018.08.028>



- Diarra, M., Theurel, J., & Paty, B. (2025). Systematic review of neurophysiological assessment techniques and metrics for mental workload evaluation in real-world settings. *Frontiers in Neuroergonomics*, 6. <https://doi.org/10.3389/fnrgo.2025.1584736>
- Dias, M., Silva, L., Folgado, D., Nunes, M. L., Cepeda, C., Cheetham, M., & Gamboa, H. (2023). Cardiovascular load assessment in the workplace: A systematic review. *International Journal of Industrial Ergonomics*, 96, 103476. <https://doi.org/10.1016/j.ergon.2023.103476>
- Ding, Y., Cao, Y., Duffy, V., Wang, Y., & Zhang, X. (2020). Measurement and identification of mental workload during simulated computer tasks with multimodal methods and machine learning. *Ergonomics*, 63, 896–908. <https://doi.org/10.1080/00140139.2020.1759699>
- Fais, M., Ayu, G., Deviyanti, S., Tjandra, S., Mohamad, S., Lapai, Y., & Syahrir, M. (2024). Evaluation of employee mental workload using the Rating Scale Mental Effort and KAUPK2 method in the production process of spoon making PT. VRIZ. *Jurnal Optimalisasi*, 10(2). <https://doi.org/10.35308/jopt.v10i2.9911>
- Fogelberg, E., Cao, H., & Thorvald, P. (2025). Cognitive ergonomics: Triangulation of physiological, subjective, and performance-based mental workload assessments. *Frontiers in Industrial Engineering*. <https://doi.org/10.3389/fieng.2025.1605975>
- Fox, S. M., Naughton, J. P., & Haskell, W. L. (1971). Physical activity and the prevention of coronary heart disease. *Annals of Clinical Research*, 3(6), 404–432.
- Hart, S. G. (2006). NASA-Task Load Index (NASA-TLX); 20 years later. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 50(9), 904–908. <https://doi.org/10.1177/154193120605000909>
- Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P. A. Hancock & N. Meshkati (Eds.), *Human mental workload* (pp. 139–183). North-Holland. [https://doi.org/10.1016/S0166-4115\(08\)62386-9](https://doi.org/10.1016/S0166-4115(08)62386-9)
- Hermansyah, M. S. A., & Handayani, N. U. (2022). NASA-TLX assessment of mental workload in manufacturing industry. *Spektrum Industri*, 20(2), 1–14. <https://doi.org/10.12928/si.v20i2.43>
- Iman, N., Firmansyah, N. A., & Himayati, A. I. (2025). The evaluation of mental workload using the NASA Task Load Index (NASA-TLX) method on production department employees. *Sainteks: Jurnal Sain dan Teknik*, 7(1). <https://doi.org/10.37577/sainteks.v7i01.858>
- Inegbedion, H., Inegbedion, E., Peter, A., & Harry, L. (2020). Perception of workload balance and employee job satisfaction in work organisations. *Heliyon*, 6(1), e03160. <https://doi.org/10.1016/j.heliyon.2020.e03160>
- Karvonen, M. J., Kentala, E., & Mustala, O. (1957). The effects of training on heart rate: A longitudinal study. *Annales Medicinae Experimentalis et Biologiae Fenniae*, 35(3), 307–315.
- Malik, R., Afiah, I. N., Dahlan, M., Hw, Z., Nur, T., & Iswandi, R. (2021). Analysis of Rating Scale Mental Effort (RSME) to determine the mental workload of workers at sugar factory in South Sulawesi. *Prosiding Seminar Nasional PASTI*, 130–136. <https://doi.org/10.22441/pasti.2021.v15i2.002>



- Nugroho, A., & Amalia. (2025). Study of physical and mental workload in the small-scale tofu industry: An ergonomic perspective using cardiovascular load and NASA-TLX. *MORFAI Journal*, 5(1). <https://doi.org/10.54443/morfai.v5i1.2653>
- Rachmuddin, Y., Dewi, D. S., & Dewi, R. S. (2021). Workload analysis using Modified Full Time Equivalent (M-FTE) and NASA-TLX methods to optimize engineer headcount in the engineering services department. *IOP Conference Series: Materials Science and Engineering*, 1072(1), 012036. <https://doi.org/10.1088/1757-899X/1072/1/012036>
- Rahayu, M. (2020). Analisis beban kerja fisiologis mahasiswa saat praktikum analisa perancangan kerja dengan menggunakan metode 10 denyut. *Unistek*, 7(1), 16–20. <https://doi.org/10.33592/unistek.v7i1.463>
- Robergs, R. A., & Landwehr, R. (2002). The surprising history of the “HRmax = 220 – age” equation. *Journal of Exercise Physiology Online*, 5(2), 1–10.
- Rosyada, Z., & Harnikova, C. N. (2026). Analysis of the mental workload of warehouse workers using the NASA-TLX method in the garment industry. *World Journal of Advanced Research and Reviews*, 30(3). <https://doi.org/10.30574/wjarr.2026.30.3.1593>
- Said, S., Gozdzik, M., Roche, T. R., Braun, J., Rossler, J., Kaserer, A., Spahn, D. R., Nothiger, C. B., & Tscholl, D. W. (2020). Validation of the raw National Aeronautics and Space Administration Task Load Index (NASA-TLX) questionnaire to assess perceived workload in patient monitoring tasks: Pooled analysis study using mixed models. *Journal of Medical Internet Research*, 22(9), e19472. <https://doi.org/10.2196/19472>
- Saputra, R., Rahdiana, N., & Karnadi, K. (2025). Analysis of employee mental workload using the NASA-TLX method (case study at PT. ABC). *G-Tech: Jurnal Teknologi Terapan*, 9(1). <https://doi.org/10.70609/gtech.v9i1.6536>
- Satria, D., Tiara, T., & Widjajanto, T. (2023). Analisis beban kerja fisik menggunakan metode Cardiovascular Load dan beban kerja mental menggunakan metode Rating Scale Mental Effort pada PT Citra Abadi Sejati Bogor. *Jurnal Teknologi dan Manajemen*, 21(1), 25–34. <https://doi.org/10.52330/jtm.v21i1.77>
- Septiani, W., Rusy, R. I. P. R., & Adisuwiryo, S. A. (2024). Minimize mental workload and fatigue of horizontal directional drilling worker using Rating Scale Mental Effort and Swedish Occupational Fatigue Inventory methods. *Jurnal Teknik Industri*, 14(2). <https://doi.org/10.25105/jti.v14i2.21084>
- Sinaga, S., & Ramdhani, A. Y. (2025). Analysis of employees mental workload with multiple tasks in halal product process assistance services using the Rating Scale Mental Effort (RSME) method at BBSPJIKB Yogyakarta. *Dinamika Kerajinan dan Batik: Majalah Ilmiah*, 42(2). <https://doi.org/10.22322/dkb.v42i2.8750>
- Sufyan, A. A. S., Mulyana, Y., Kusumadewi, A., & Santang, I. E. (2024). Physical and mental workload measurement on warehouse division operators of PT.X using objective workload and subjective workload assessment. *Sainteks: Jurnal Sain dan Teknik*, 6(2). <https://doi.org/10.37577/sainteks.v6i2.786>



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Vol. 01, No. 1, June 2026

- Tanaka, H., Monahan, K. D., & Seals, D. R. (2001). Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology*, 37(1), 153–156. [https://doi.org/10.1016/S0735-1097\(00\)01054-8](https://doi.org/10.1016/S0735-1097(00)01054-8)
- Tao, D., Tan, H., Wang, H., Zhang, X., Qu, X., & Zhang, T. (2019). A systematic review of physiological measures of mental workload. *International Journal of Environmental Research and Public Health*, 16(15). <https://doi.org/10.3390/ijerph16152716>
- Tarwaka. (2011). *Ergonomi industri: Dasar-dasar pengetahuan ergonomi dan aplikasi di tempat kerja*. Harapan Press.
- Tarwaka, Bakri, S. H. A., & Sudiajeng, L. (2004). *Ergonomi untuk keselamatan, kesehatan kerja dan produktivitas*. UNIBA Press.
- Wahlstrom, V., Abtahi, F., Forsman, M., Yang, L., Ohrner, P., Tornevi, A., Stjernbrandt, A., Lewis, C., & Slunga Jarvholm, L. (2025). Cardiovascular load and physical capacity in older workers engaged in physically demanding occupations. *International Archives of Occupational and Environmental Health*. <https://doi.org/10.1007/s00420-025-02161-8>
- Wang, P., Houghton, R., & Majumdar, A. (2024). Detecting and predicting pilot mental workload using heart rate variability: A systematic review. *Sensors*, 24(12). <https://doi.org/10.3390/s24123723>
- Widyanti, A., Johnson, A., & de Waard, D. (2013). Adaptation of the Rating Scale Mental Effort (RSME) for use in Indonesia. *International Journal of Industrial Ergonomics*, 43(1), 70–76. <https://doi.org/10.1016/j.ergon.2012.11.003>
- Zijlstra, F. R. H. (1993). *Efficiency in work behaviour: A design approach for modern tools* [Doctoral dissertation, Delft University of Technology]. Delft University Press.