Journal Sport Area
http://journal.uir.ac.id/index.php/JSP
Vol. 11. No. 2. August, (2026)

Development and preliminary evaluation of a mobile-based assessment system for BMI, perceived workload, and subjective fatigue

Nur Iffah[1abcd,*], Joan Rhobi Andrianto[1abcd], Nurmala Hindun[2abde], Loso Judijanto[3cde], & Subhanjaya Angga Atmaja[4bde]

Universitas PGRI Jombang, Indonesia[1]
Universitas Insan Budi Utomo, Indonesia[2]
IPOSS Jakarta, Indonesia[3]
Universitas Kebangsaan Republik Indonesia, Indonesia[4]

Received 17 December 2025; Accepted 12 August 2026; Published 30 August 2026
Ed 2026; *11*(2): 255-265

ABSTRACT

Background: Physical condition, workload, and fatigue are important considerations among workers engaged in repetitive and physically demanding activities. However, practical mobile-based systems integrating these indicators into a single assessment workflow remain limited. **Objectives:** This study aimed to develop and preliminarily evaluate a mobile-based assessment system for BMI, perceived workload, and subjective fatigue and examine their associations among industrial workers. **Methods:** A research and development design using the ADDIE framework was followed by a cross-sectional evaluation of 77 industrial workers recruited through convenience sampling. The application assessed BMI, perceived workload, and subjective fatigue using the Fatigue Assessment Scale. Associations among variables were examined using Pearson's chi-square test and Cramér's V. **Results:** The application demonstrated favorable preliminary expert and user evaluations, with scores of 87.11% for material validity, 92.90% for media validity, and 91.58% for user practicality. Among 77 workers, 51.9% reported moderate workload and 35.1% had high fatigue. Perceived workload was significantly associated with subjective fatigue, whereas BMI was not. High fatigue was more prevalent among workers with high workload (56.0%) than low workload (8.3%) and among those with obesity (62.5%) than normal BMI (25.0%). **Conclusion**: The developed mobile-based system provides an integrated digital workflow for assessing BMI, perceived workload, and subjective fatigue and demonstrated favorable preliminary expert and user evaluations. The observed distribution of fatigue across workload and BMI categories warrants further investigation using larger samples, longitudinal designs, objective physiological measures, and standardized usability assessments.

Keywords: Mobile health; occupational fatigue; body mass index; workload; industrial workers

https://doi.org/10.25299/sportarea.2026.vol11(2).26378

Nur Iffah, Department of Physical Education, Faculty of Teacher Training and Education, Universitas PGRI Jombang, Jombang, East Java, Indonesia
nur91iffah@gmail.com

How to Cite: Iffah, N., Andrianto, J. R., Hindun, N., Judijanto, L., & Atmaja, S. A. (2026). Development and preliminary evaluation of a mobile-based assessment system for BMI, perceived workload, and subjective fatigue. *Journal Sport Area*, *11*(2), 255-265. https://doi.org/10.25299/sportarea.2026.vol11(2).26378

Authors' Contribution: a – Study Design; b – Data Collection; c – Statistical Analysis; d – Manuscript Preparation; e – Funds Collection

INTRODUCTION

Physical activity, body composition, and health-related fitness are important determinants of health and human performance, particularly among populations exposed to sustained physical demands. Regular physical activity contributes to the maintenance of physical capacity and functional health, whereas insufficient or poorly managed physical activity may increase the risk of adverse health outcomes and impaired physical functioning (Bourke et al., 2024). In occupational settings, however, physical activity performed as part of work should not automatically be considered health-enhancing physical activity, as repetitive and physically demanding tasks may impose substantial physiological demands without necessarily improving health-related fitness (Mänttäri et al., 2021). Individual body characteristics, workload, fatigue, and functional capacity may therefore be relevant to understanding physical demands and human performance. From a sport science and health-promotion perspective, understanding these factors is important because sustained performance depends on the balance between individual capacity, task demands, and recovery. Previous research has also emphasized the importance of physical activity, nutrition, adequate recovery, and healthy behavioral practices in maintaining physical condition and reducing fatigue-related consequences (Chang de Pinho et al., 2024; Yin et al., 2025). Consequently, systematic assessment of body characteristics, workload, and fatigue may provide useful information for health promotion and performance maintenance among individuals exposed to physically demanding activities.

Physical workload is an important determinant of physiological strain and may be closely related to fatigue because repeated or prolonged demands require continuous regulation of energy expenditure, muscular activity, and recovery. From an exercise physiology perspective, repeated physical loading without adequate recovery may impair performance and contribute to fatigue accumulation (Orejel Bustos et al., 2021). Workload is also multidimensional and may encompass physical demands, cognitive requirements, time pressure, and emotional demands, which can collectively influence perceived fatigue (Iman et al., 2025; Kenny & Fluck, 2023). Previous research has reported associations between higher workload and greater fatigue or reduced functional capacity in occupational populations (Cho et al., 2022; Hassanzadeh-Rangi et al., 2023). Similar workload–recovery principles are recognized in sport, where repeated exercise without sufficient recovery may be accompanied by declining performance and increased fatigue or overuse-related problems (Orejel Bustos et al., 2021). These principles may also be relevant to industrial workers who routinely perform repetitive movements, prolonged postures, and sustained physical tasks. Accordingly, examining perceived workload alongside individual body characteristics may provide additional information for understanding patterns of subjective fatigue.

Fatigue is a multifactorial phenomenon that may emerge when task demands interact with an individual's capacity to sustain performance and recover adequately. Contemporary perspectives on fatigue and human performance emphasize the interaction of physiological capacity, task demands, psychological factors, and recovery processes (Behrens et al., 2023). Repeated exposure to demanding activities without sufficient recovery may be accompanied by reduced physical and cognitive performance, impaired concentration, and increased perceived exhaustion (Cho et al., 2022; Orejel Bustos et al., 2021). Body characteristics may also contribute to individual differences in fatigue, as greater body mass can increase the energetic demands of movement and physical activity. In this context, BMI provides an accessible anthropometric indicator that can be assessed alongside perceived workload and subjective fatigue, although it should not be regarded as a comprehensive measure of physical fitness. The relationship among workload, body characteristics, and fatigue is particularly relevant to workers whose daily activities involve repetitive and physically demanding tasks. From a human-performance perspective, maintaining functional capacity requires an appropriate balance between task demands, individual capacity, and recovery. Integrated assessment of these factors may therefore provide a more comprehensive description of fatigue-related patterns in applied settings.

Advances in mobile health technology provide opportunities to integrate health and fatigue-related assessments into accessible and practical digital systems. Mobile applications can facilitate the collection, processing, and presentation of health-related information while potentially reducing the limitations associated with fragmented or periodic assessment approaches (Brick et al., 2020). Previous studies have demonstrated the potential of mobile applications for supporting health-related behavior, monitoring body-related indicators, and addressing fatigue-related problems (Bonvanie et al., 2020; Gultom et al., 2022; Scarry et al., 2022). Within sport science, exercise physiology, and physical activity and health research, such technologies may extend conventional assessment approaches by providing accessible tools for recording indicators related to body characteristics, workload, and fatigue. For individuals exposed to physically demanding activities, an integrated mobile-based assessment system may facilitate more systematic assessment and provide accessible information for health and recovery management. Although mobile applications have increasingly been applied to health assessment, existing approaches have commonly focused on individual indicators or specific health outcomes. A platform integrating body characteristics, perceived workload, and subjective fatigue may therefore offer a more comprehensive approach to assessing these interrelated factors in applied settings.

Despite growing interest in mobile health technologies and fatigue assessment, a gap remains in the integration of body characteristics, perceived workload, and subjective fatigue within a single mobile-based assessment framework. Previous research has examined occupational fatigue, physical workload, physical activity, and mobile health applications largely as separate domains (Anwar & Sari, 2021; Brambilla et al., 2023; Kang et al., 2021). Moreover, although existing mobile-based approaches demonstrate the feasibility of assessing specific health indicators, limited research has operationalized concepts from exercise physiology, physical activity and health, and fatigue science within an integrated assessment workflow for individuals exposed to sustained physical demands. This gap is particularly relevant in industrial environments, where repetitive tasks and varying workload demands may be associated with differences in perceived fatigue and functional performance. The need is therefore not simply for another health application, but for a practical assessment system that integrates complementary indicators of body characteristics, perceived workload, and subjective fatigue and enables their relationships to be examined in an applied population. Addressing this gap may extend the application of exercise physiology and sport science beyond conventional athletic populations while demonstrating the potential of mobile technology for integrated physical activity and health assessment in real-world occupational settings.

Therefore, this study aimed to develop and preliminarily evaluate a mobile-based assessment system integrating BMI, perceived workload, and subjective fatigue and to examine the associations among these variables in industrial workers. Specifically, the study sought to (i) develop an integrated mobile-based assessment workflow; (ii) evaluate its preliminary feasibility through expert appraisal and user assessment; and (iii) examine the associations among BMI, perceived workload, and subjective fatigue.

METHODS

Study Design and Development Procedure

This study employed a research and development (R&D) design based on the ADDIE framework, comprising five stages: Analysis, Design, Development, Implementation, and Evaluation. The study aimed to develop a mobile-based assessment system integrating body mass index (BMI), perceived workload, and subjective fatigue. The overall study flow and development procedure are presented in **Figure 1**, illustrating the sequential process from the initial analysis and system design through application development, implementation, and evaluation. Following the development phase, a preliminary field evaluation was conducted among industrial workers to assess the practicality of the system and examine the associations among BMI, perceived workload, and subjective fatigue.

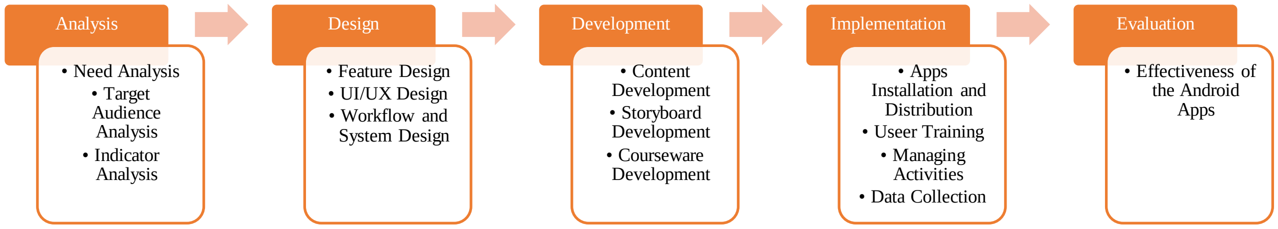

Figure 1. Research Flow

Participants

The study was conducted at PT HM Sampoerna, Jombang, Indonesia, from September to November 2025. The target population comprised 334 production workers. A sample of 77 workers was determined using the Slovin formula with a 10% margin of error and recruited through convenience sampling. Eligible participants were active production workers aged ≥18 years who were willing to participate and able to complete the assessment. Participants with incomplete data or who withdrew from the study were excluded.

Assessment Measures

The mobile application incorporated three assessment components: body mass index (BMI), perceived workload, and subjective fatigue. The study variables, assessment instruments, indicators, scoring procedures, and corresponding sources are summarised in **Table 1.** BMI was determined from body weight and height using the BMI formula (kg/m²) and classified into underweight, normal weight, overweight, and obesity categories. Subjective fatigue was assessed using the 10-item Fatigue Assessment Scale (FAS), with total scores ranging from 10 to 50, with higher scores indicating greater fatigue. Perceived workload was assessed using a 15-item questionnaire covering five dimensions: physical workload, mental workload, emotional workload, time pressure, and task variety.

Table 1. Study Variables and Assessment Procedures

Variable	Assessment indicator/instrument	Scoring/classification	Source
BMI	Body weight and height	BMI = weight (kg)/height² (m²); underweight, normal, overweight, and obesity categories	World Health Organization
Subjective fatigue	Fatigue Assessment Scale (10 items)	Total score 10–50; higher scores indicate greater fatigue	Michielsen et al. (2003)
Perceived workload	Workload assessment questionnaire	Specify the validated/adapted scoring system and non-overlapping categories	Hakim & A.P., (2024); Kjønø et al. (2022)

Expert and User Evaluation

The developed application underwent preliminary evaluation by experts and users. The assessment domains, item distribution, and response scale for the expert and user evaluations are presented in **Tables 2** and **3**, respectively. The expert evaluation assessed four aspects of the application: interface design, content accuracy, clarity and ease of use, and system performance and compatibility (**Table 2**). The user evaluation assessed ease of use, perceived functionality, interface satisfaction, and user acceptance (**Table 3**). Both evaluation instruments consisted of 20 items and used a four-point Likert-type response scale, ranging from 1 (strongly disagree) to 4 (strongly agree).

Table 2. Media Expert Evaluation Instrument

Aspect	Items	Response Scale
Interface design	1–5	1–4
Content accuracy	6–10	1–4
Clarity and ease of use	11–15	1–4
System performance and compatibility	16–20	1–4

Table 3. User Evaluation Instrument

Aspect	Items	Response Scale
Ease of use	1–5	1–4
Functionality perception	6–10	1–4
Interface satisfaction	11–15	1–4
User acceptance	16–20	1–4

Note. 1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree.

Data Analysis

Descriptive statistics were used to summarise participant characteristics and the distribution of BMI, perceived workload, and subjective fatigue. Cross-tabulations were performed to examine the distribution of the categorical variables. Pearson's chi-square test was used to assess associations among BMI, perceived workload, and subjective fatigue, with statistical significance set at $p < .05$. Cramér's V was used to estimate the strength of significant associations.

Ethical Approval

Ethical approval was obtained from the Academic Integrity Committee, Universitas PGRI Jombang, through Academic Integrity Approval Letter No. 029/TKIA/KL/2025, issued on September 1, 2025. Before data collection, participants were informed about the study objectives, procedures, voluntary participation, confidentiality, and their right to withdraw. Verbal informed consent was obtained from all participants. All collected data were treated confidentially and used solely for research purposes.

RESULTS AND DISCUSSION

Results

Participant Characteristics

A total of 77 industrial workers participated in the field evaluation. As shown in **Table 4**, 50 participants (64.9%) were male and 27 (35.1%) were female. Most participants were aged 36–45 years (62.3%) and had more than 10 years of work experience (48.0%). Regarding BMI, 28 participants (36.3%) were classified as having normal weight, 25 (32.5%) as overweight, and 24 (31.2%) as obese. No participants were classified as underweight.

Table 4. Participant Characteristics

Characteristic	Category	n	%
Sex	Male	50	64.9
	Female	27	35.1
Age (years)	18–25	4	5.2
	26–35	13	16.9
	36–45	48	62.3
	46–55	12	15.6
Work experience (years)	<5	15	19.5
	5–10	25	32.5
	>10	37	48.0
BMI category	Underweight	0	0.0
	Normal weight	28	36.3
	Overweight	25	32.5
	Obesity	24	31.2
Total		**77**	**100.0**

Preliminary Expert and User Evaluation

The developed mobile-based assessment system underwent preliminary appraisal by a material expert, a media expert, and users. The results are presented in **Table 5.** The material expert evaluation yielded an overall score of 87.11%, with scores of 88.00% for BMI assessment accuracy, 87.60% for subjective fatigue assessment accuracy, and 85.75% for workload evaluation indicators. The media expert evaluation yielded an overall score of 92.90%, with scores ranging from 88.95% to 98.00% across the assessed domains. The overall user practicality score was 91.58%, with individual domain scores ranging from 89.00% to 93.00%.

Table 5. Results of Preliminary Expert Appraisal and User Evaluation

Evaluation	Aspect	Score (%)	Criterion
Material expert	BMI assessment accuracy	88.00	Valid
	Subjective fatigue assessment accuracy	87.60	Valid
	Workload evaluation indicators	85.75	Quite valid
	Overall material expert	87.11	Valid
Media expert	Interface design	95.00	Valid
	Content accuracy	89.90	Valid
	Clarity and ease of use	98.00	Valid
	System performance and compatibility	88.95	Valid
	Overall media expert	92.90	Valid
User evaluation	Ease of use	93.00	Very practical
	User perception	91.83	Very practical
	Perception	92.50	Very practical
	Interface satisfaction	89.00	Very practical
	Overall practicality	91.58	Very practical

Distribution of BMI, Perceived Workload, and Subjective Fatigue

The distribution of BMI, perceived workload, and subjective fatigue is presented in **Table 6**. Of the 77 participants, 28 (36.3%) had normal BMI, 25 (32.5%) were overweight, and 24 (31.2%) were obese. Perceived workload was classified as low in 12 participants (15.6%), moderate in 40 (51.9%), and high in 25 (32.5%). Regarding subjective fatigue, 21 participants (27.3%) reported low fatigue, 29 (37.7%) moderate fatigue, and 27 (35.1%) high fatigue. Thus, moderate workload and moderate fatigue were the most frequently observed categories.

Table 6. Distribution of BMI, Perceived Workload, and Subjective Fatigue

Variable	Category	n (%)
BMI	Underweight (<18.5)	0 (0.0)
	Normal weight (18.5–24.9)	28 (36.3)
	Overweight (25.0–29.9)	25 (32.5)
	Obesity (≥30.0)	24 (31.2)
Perceived workload	Low	12 (15.6)
	Moderate	40 (51.9)
	High	25 (32.5)
Subjective fatigue	Low	21 (27.3)
	Moderate	29 (37.7)
	High	27 (35.1)
Total		**77 (100.0)**

Associations Among BMI, Perceived Workload, and Subjective Fatigue

The associations among BMI, perceived workload, and subjective fatigue were examined using Pearson's chi-square tests. The cross-tabulation results are presented in **Table 7.**

BMI and Perceived Workload

The distribution of perceived workload was relatively similar across BMI categories. Among participants with normal BMI, 17.9% reported low workload, 50.0% moderate workload, and 32.1% high workload. Corresponding proportions among overweight participants were 16.0%, 52.0%, and 32.0%, respectively, whereas among participants with obesity they were 12.5%, 54.2%, and 33.3%, respectively. Based on the frequencies presented in the table, no statistically significant association was observed between BMI category and perceived workload.

BMI and Subjective Fatigue

The distribution of subjective fatigue differed descriptively across BMI categories. Among participants with normal BMI, 25.0% reported high fatigue, compared with 32.0% among overweight participants and

62.5% among participants with obesity. However, the observed descriptive pattern should not be interpreted as evidence of a statistically significant association without reference to the verified inferential test.

Perceived Workload and Subjective Fatigue

A clear descriptive gradient was observed between perceived workload and subjective fatigue. Among participants reporting low workload, 8.3% had high fatigue. This proportion increased to 30.0% among those with moderate workload and 56.0% among those with high workload. Thus, higher perceived workload was accompanied by a greater proportion of participants classified as having high subjective fatigue.

Table 7. Cross-Tabulation of Study Variables

BMI and Perceived Workload				
BMI category	**Low workload**	**Moderate workload**	**High workload**	**Total**
Underweight	0 (0.0)	0 (0.0)	0 (0.0)	0
Normal weight	5 (17.9)	14 (50.0)	9 (32.1)	28 (100.0)
Overweight	4 (16.0)	13 (52.0)	8 (32.0)	25 (100.0)
Obesity	3 (12.5)	13 (54.2)	8 (33.3)	24 (100.0)
Total	**12 (15.6)**	**40 (51.9)**	**25 (32.5)**	**77 (100.0)**
BMI and Subjective Fatigue				
BMI category	**Low fatigue**	**Moderate fatigue**	**High fatigue**	**Total**
Underweight	0 (0.0)	0 (0.0)	0 (0.0)	0
Normal weight	9 (32.1)	12 (42.9)	7 (25.0)	28 (100.0)
Overweight	6 (24.0)	11 (44.0)	8 (32.0)	25 (100.0)
Obesity	3 (12.5)	6 (25.0)	15 (62.5)	24 (100.0)
Total	**21 (27.3)**	**29 (37.7)**	**27 (35.1)**	**77 (100.0)**
Perceived Workload and Subjective Fatigue				
Perceived workload	**Low fatigue**	**Moderate fatigue**	**High fatigue**	**Total**
Low	8 (66.7)	3 (25.0)	1 (8.3)	12 (100.0)
Moderate	10 (25.0)	18 (45.0)	12 (30.0)	40 (100.0)
High	3 (12.0)	8 (32.0)	14 (56.0)	25 (100.0)
Total	**21 (27.3)**	**29 (37.7)**	**27 (35.1)**	**77 (100.0)**

Effect Sizes

Cramér's V was used to quantify the strength of association between the categorical study variables. **Table 8** presents the Pearson's chi-square statistics, *p* values, and corresponding Cramér's V coefficients for the associations among BMI, perceived workload, and subjective fatigue. The magnitude of the associations was interpreted based on the Cramér's V criteria specified in the Methods section.

Table 8. Associations and Effect Sizes Among Study Variables

Variable relationship	Pearson's χ^2	p	Cramér's V	Interpretation
BMI–Perceived workload	1.585	.124	.10	Weak
BMI–Subjective fatigue	6.342	.175	.20	Weak
Perceived workload–Subjective fatigue	8.128	.087	.23	Weak

Note. Cramér's V was used to describe the strength of association between categorical variables. Statistical significance was evaluated at $p < .05$.

Discussion

This study developed and preliminarily evaluated a mobile-based assessment system integrating body mass index (BMI), perceived workload, and subjective fatigue among industrial workers. The findings indicate different patterns across the assessed variables. While BMI showed a descriptive pattern with subjective fatigue that did not reach statistical significance, perceived workload was associated with subjective fatigue. These findings highlight the potential value of integrating individual body characteristics and task-related demands when assessing fatigue among workers exposed to sustained physical demands.

The association between BMI and subjective fatigue was not statistically significant, although a descriptive gradient was observed across BMI categories. Participants with obesity had a higher proportion of high fatigue (62.5%) than those with normal BMI (25.0%). This pattern should be interpreted cautiously because BMI is an anthropometric indicator and does not directly represent physical fitness or physiological capacity. Greater body mass may increase the energetic demands of movement and physical activity, potentially influencing perceived exertion and fatigue during physically demanding (Grevendonk et al., 2021; Phoemsapthawee & Phoemsapthawee, 2025). Previous research has also reported relationships among physical activity, fatigue, and physical condition (Hanif et al., 2024). Nevertheless, the absence of a statistically significant association in the present study indicates that BMI alone may be insufficient to explain individual differences in subjective fatigue. Future studies should therefore examine BMI alongside direct measures of physical fitness, physical activity, and physiological capacity.

In contrast, perceived workload was significantly associated with subjective fatigue. Participants reporting high workload had a substantially greater proportion of high fatigue (56.0%) than those reporting low workload (8.3%). This finding is consistent with workload frameworks in which fatigue may arise from the accumulation of physical, cognitive, temporal, and emotional demands (Bennett, 2019). Sustained exposure to demanding tasks may increase physiological and cognitive strain and limit opportunities for recovery (Cho et al., 2022; Vitoulas et al., 2022). Similar workload–recovery principles have been described in exercise and sports settings, where repeated loading without adequate recovery can negatively affect performance and contribute to fatigue (Bustos et al., 2021). In the present occupational context, these principles may also be relevant to workers performing repetitive movements, prolonged postures, and sustained physical tasks. However, because the present study used a cross-sectional design, the observed association should not be interpreted as evidence that higher workload causes fatigue.

The distribution of fatigue across workload categories also suggests that workload intensity is unlikely to be the sole determinant of fatigue. Although high workload was accompanied by the greatest proportion of high fatigue, moderate workload was also associated with substantial proportions of moderate and high fatigue. Individual differences in work schedules, task characteristics, recovery opportunities, and physical capacity may contribute to variation in fatigue responses (Anjani & Ariesyady, 2022; Hassanzadeh-Rangi et al., 2023). From a human-performance perspective, fatigue may therefore reflect the interaction between task demands, individual capacity, and recovery rather than a single occupational or anthropometric factor (Behrens et al., 2023). The present findings support the value of assessing workload and individual characteristics together, while recognizing that the relative contribution of each factor requires further investigation.

The developed mobile application provides a practical framework for integrating BMI, perceived workload, and subjective fatigue within a single digital workflow. This integration translates established concepts from exercise physiology, physical activity and health, workload assessment, and fatigue research into an accessible assessment format. Previous studies have highlighted the potential of mobile technologies for health self-management, body-condition monitoring, and fatigue-related applications (Bonvanie et al., 2020; Brick et al., 2020; Gultom et al., 2022; Scarry et al., 2022). The favorable preliminary evaluations obtained from experts and users suggest that the system has potential for initial field use. However, these findings represent preliminary appraisal and practicality rather than evidence of full usability, diagnostic accuracy, predictive performance, or intervention effectiveness. The application should therefore be regarded as an assessment and recording tool rather than a validated real-time fatigue-monitoring or risk-prediction system.

The main contribution of this study is the integration of BMI, perceived workload, and subjective fatigue within a mobile-based assessment framework for industrial workers. Rather than treating fatigue as an outcome of a single factor, the proposed framework enables individual body characteristics and perceived task demands to be considered simultaneously. The findings provide preliminary evidence that perceived workload may be more closely related to subjective fatigue than BMI in this sample, while the descriptive BMI pattern indicates a potentially relevant area for further investigation. The application also demonstrates how concepts from exercise physiology and human performance can be operationalized within a digital assessment platform for a non-athletic population exposed to sustained physical demands.

Several limitations should be considered when interpreting these findings. First, the cross-sectional field evaluation does not permit causal inference regarding the relationships among BMI, workload, and fatigue. Second, participants were recruited using convenience sampling, which may limit the generalizability of the findings to other occupational groups or industrial settings. Third, perceived workload and subjective fatigue were assessed using self-reported measures and may therefore be influenced by reporting bias. Fourth, BMI provides only an indirect indicator of body composition and does not capture muscular fitness, cardiorespiratory fitness, or other physiological characteristics relevant to occupational performance. Finally, the preliminary expert and user evaluations do not substitute for formal psychometric validation or standardized usability testing. Future research should therefore employ larger and more diverse samples, longitudinal or prospective designs, validated usability procedures, and objective measures such as physical activity monitoring and wearable-derived physiological indicators. Such studies could further establish the reliability, validity, and practical utility of the system for occupational fatigue assessment.

CONCLUSION

This study found that perceived workload was significantly associated with subjective fatigue among industrial workers, whereas the association between BMI and subjective fatigue was not statistically significant. Although participants with obesity showed a higher proportion of high fatigue than those with normal BMI, this descriptive pattern should not be interpreted as evidence of a statistically significant association. The study also demonstrated the preliminary feasibility of a mobile-based assessment application integrating BMI, perceived workload, and subjective fatigue within a single digital workflow. These findings demonstrate the potential of applying concepts from exercise physiology, physical activity and health, and human performance to a practical mobile-based assessment approach. However, the cross-sectional design, convenience sampling, reliance on self-reported fatigue measures, and preliminary nature of the expert and user evaluations limit causal inference and generalisability. Future research should use larger and longitudinal samples, conduct comprehensive psychometric and standardised usability evaluations, and integrate objective indicators, including wearable-derived physiological and physical activity measures.

ACKNOWLEDGEMENTS

Employees of PT HM PT HM Sampoerna's manufacturing division were the subjects of this study, and the author is grateful to them for their time and efforts.

CONFLICT OF INTEREST

There are no vested interests in this research.

AI DISCLOSURE STATEMENT

The authors used Grammarly and DeepL Write, AI-assisted writing tools, solely for language editing, grammar checking, and improving the clarity and readability of the manuscript. The authors retained full responsibility for the scientific content, including the study design, data analysis, interpretation of the findings, and conclusions.

REFERENCES

Anjani, R., & Ariesyady, H. D. (2022). Effects Evaluation of Heat Stress Index and Workload to Miner's Fatigue Level in Underground Gold Mining Area PT Dwinad Nusa Sejahtera. *IOP Conference Series: Earth and Environmental Science*, *1109*(1), 012014. https://doi.org/10.1088/1755-1315/1109/1/012014

Anwar, M. S., & Sari, R. (2021). Penegakan Hukum Lingkungan Berbasis Asas Tanggung Jawab Negara di Indonesia. *PROGRESIF: Jurnal Hukum*, *16*(1), 112–129. https://doi.org/10.33019/progresif.v16i1.2336

Behrens, M., Gube, M., Chaabene, H., Prieske, O., Zenon, A., Broscheid, K.-C., Schega, L., Husmann, F., & Weippert, M. (2023). Fatigue and Human Performance: An Updated Framework. *Sports Medicine*, *53*(1), 7–31. https://doi.org/10.1007/s40279-022-01748-2

Bennett, K. J. M. (2019). *An Australian Perspective on Talent Identification and Development in Soccer*. Dissertation. University of Technology Sydney

Bonvanie, A., Broekhuis, M., Janssen, O., Maeckelberghe, E., & Wortmann, J. (Hans) C. (2020). Health Self-Management Applications in the Work Environment: The Effects on Employee Autonomy. *Frontiers in Digital Health*, *2*(9), 1–17. https://doi.org/10.3389/fdgth.2020.00009

Bourke, E., Rawstorn, J., Maddison, R., & Blakely, T. (2024). The Effects of Physical Inactivity on Other Risk Factors for Chronic Disease: A Systematic Review of Reviews. *Preventive Medicine Reports*, *46*, 102866. https://doi.org/10.1016/j.pmedr.2024.102866

Brambilla, C., Lavit Nicora, M., Storm, F., Reni, G., Malosio, M., & Scano, A. (2023). Biomechanical Assessments of the Upper Limb for Determining Fatigue, Strain and Effort from the Laboratory to the Industrial Working Place: A Systematic Review. *Bioengineering*, *10*(4), 445. https://doi.org/10.3390/bioengineering10040445

Brick, T. R., Mundie, J., Weaver, J., Fraleigh, R., & Oravecz, Z. (2020). Low-Burden Mobile Monitoring, Intervention, and Real-Time Analysis Using the Wear-IT Framework: Example and Usability Study. *JMIR Formative Research*, *4*(6), e16072. https://doi.org/10.2196/16072

Chang de Pinho, I., Giorelli, G., & Oliveira Toledo, D. (2024). A Narrative Review Examining the Relationship between Mental Health, Physical Activity, and Nutrition. *Discover Psychology*, *4*(1), 162. https://doi.org/10.1007/s44202-024-00275-7

Cho, H., Sagherian, K., Scott, L. D., & Steege, L. M. (2022). Occupational Fatigue, Workload and Nursing Teamwork in Hospital Nurses. *Journal of Advanced Nursing*, *78*(8), 2313–2326. https://doi.org/10.1111/jan.15246

Ghirardini, B. (2011). *E-Learning Methodologies: A Guide for Designing and Developing E-Learning Courses*. Rome: Food and Agriculture Organization of the United Nations.

Grevendonk, L., Connell, N. J., McCrum, C., Fealy, C. E., Bilet, L., Bruls, Y. M. H., Mevenkamp, J., Schrauwen-Hinderling, V. B., Jörgensen, J. A., Moonen-Kornips, E., Schaart, G., Havekes, B., de Vogel-van den Bosch, J., Bragt, M. C. E., Meijer, K., Schrauwen, P., & Hoeks, J. (2021). Impact of Aging and Exercise on Skeletal Muscle Mitochondrial Capacity, Energy Metabolism, and Physical Function. *Nature Communications*, *12*(1), 4773. https://doi.org/10.1038/s41467-021-24956-2

Gultom, S., Endriani, D., & Harahap, A. S. (2022). Developing Android-Based Application for Relieving Fatigue. *Journal of Physics: Conference Series*, *2193*(1), 012096. https://doi.org/10.1088/1742-6596/2193/1/012096

Hakim, H., & A.P., R. A. A. (2024). Analyzing Cognitive Ergonomics and Key Determinants of Mental Workload in PDPT Operators at Universities. *Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri*, *10*(1), 7-15. https://doi.org/10.24014/jti.v10i1.23407

Hanif, S., Pinky, Ahmed, I., Nawaz, R., Shabbir, H., & Asif, K. (2024). Association of Fatigue Level and Physical Activity among University Students: A Cross-Sectional Survey. *Journal of Health and Rehabilitation Research*, *4*(1), 1642–1646. https://doi.org/10.61919/jhrr.v4i1.675

Hassanzadeh-Rangi, N., Jalilian, H., Farshad, A. A., & Khosravi, Y. (2023). Correlation of Work Fatigue and Mental Workload in Train Drivers: A Cross-sectional Study. *Journal of Research in Health Sciences*, *23*(4), e00600. https://doi.org/10.34172/jrhs.2023.135

Iman, N., Firmansyah, N. A., & Himayati, A. I. (2025). Evaluation of Mental Workload Using the NASA Task Load Index (NASA-TLX) Method on Production Department Employees. *SAINTEKS : Jurnal Sain Dan Teknik*, *7*(01), 12–22. https://doi.org/10.37577/sainteks.v7i01.858

Kang, J., Sasangohar, F., & Mehta, R. K. (2021). Current State of Worker Fatigue Assessment and Associated Recommendations in Oil and Gas and Petrochemical Industries. *Proceedings of the Human Factors and Ergonomics Society*, *65*(1), 1593–1597. https://doi.org/10.1177/1071181321651207

Kenny, J., & Fluck, A. E. (2023). Life at the Academic Coalface: Validation of a Holistic Academic Workload Estimation Tool. *Higher Education*, *86*(3), 507–526. https://doi.org/10.1007/s10734-022-00912-x

Kjønø, L. G., Killingmo, R. M., Vigdal, Ø. N., Grotle, M., & Storheim, K. (2022). Assessing physical workload among people with musculoskeletal disorders: Validity and reliability of the physical workload questionnaire. *BMC Musculoskeletal Disorders, 23*(1), 282. https://doi.org/10.1186/s12891-022-05222-y

Mänttäri, S., Oksa, J., Lusa, S., Korkiakangas, E., Punakallio, A., Oksanen, T., & Laitinen, J. (2021). Interventions to Promote Work Ability by Increasing Physical Activity among Workers with Physically Strenuous Jobs: A Scoping Review. *Scandinavian Journal of Public Health*, *49*(2), 206–218. https://doi.org/10.1177/1403494820917532

Michielsen, H. J., De Vries, J., & Van Heck, G. L. (2003). Psychometric Qualities of a Brief Self-Rated Fatigue Measure: The Fatigue Assessment Scale. *Journal of Psychosomatic Research*, *54*(4), 345–352. https://doi.org/10.1016/S0022-3999(02)00392-6

Orejel Bustos, A., Belluscio, V., Camomilla, V., Lucangeli, L., Rizzo, F., Sciarra, T., Martelli, F., & Giacomozzi, C. (2021). Overuse-Related Injuries of the Musculoskeletal System: Systematic Review and Quantitative Synthesis of Injuries, Locations, Risk Factors and Assessment Techniques. *Sensors*, *21*(7), 2438. https://doi.org/10.3390/s21072438

Phoemsapthawee, J., & Phoemsapthawee, S. (2025). Impaired Oxygen Consumption Kinetics and Autonomic Dysfunction Contribute to Increased Fatigue in Obese Young Males during Sustained Exercise. *Journal of Exercise Rehabilitation*, *21*(4), 219–230. https://doi.org/10.12965/jer.2550358.179

Scarry, A., Rice, J., O'Connor, E. M., & Tierney, A. C. (2022). Usage of Mobile Applications or Mobile Health Technology to Improve Diet Quality in Adults. *Nutrients, 14*(12), 2437. https://doi.org/10.3390/nu14122437

Vitoulas, S., Konstantis, V., Drizi, I., Vrouva, S., Koumantakis, G. A., & Sakellari, V. (2022). The Effect of Physiotherapy Interventions in the Workplace through Active Micro-Break Activities for Employees with Standing and Sedentary Work. *Healthcare*, *10*(10), 2073. https://doi.org/10.3390/healthcare10102073

Yin, Y., Fang, Q., Min, Z., & Liu, T. (2025). Health Literacy Level and its Influencing Factors among College Students Majoring in Sports: A Cross-Sectional Study. *BMC Public Health*, *25*(1), 3690. https://doi.org/10.1186/s12889-025-24998-x