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Posted Date: 9 April 2026

doi: 10.20944/preprints202604.0651.v1

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Article

# Psychosocial, Environmental, and Functional Capacity Determinants of Psychological Workload in Retail Workers: A Multidomain Assessment Using a Digital Tool

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## Abstract

Retail service workers face complex occupational demands across psychosocial, environmental, and physical domains; however, integrated multidomain assessments of psychological workload remain limited. A cross-sectional study was conducted among 253 full-time retail workers using the Find My Stress Progressive Web Application (PWA)—a field-deployable digital screening tool. The PWA assessed subjective workload (Subjective Workload Index; SWI), psychosocial factors (workplace bullying, postural difficulty), environmental discomfort (thermal conditions, air quality, noise), musculoskeletal symptoms, and bilateral handgrip strength. Spearman correlations and multiple regression identified significant predictors. Postural difficulty ( $\beta = 0.21$ ,  $p = .003$ ), workplace bullying ( $\beta = 0.17$ ,  $p = .008$ ), thermal discomfort ( $\beta = 0.16$ ,  $p = .021$ ), air quality concerns ( $\beta = 0.14$ ,  $p = .043$ ), task duration ( $\beta = -0.16$ ,  $p = .010$ ), and grip strength (suppressor effect;  $\beta = 0.13$ ,  $p = .030$ ) independently predicted SWI (Adjusted  $R^2 = .22$ ,  $F(6, 214) = 11.45$ ,  $p < .001$ ). The PWA demonstrated excellent reliability (Cronbach's  $\alpha = 0.97$ ) and high usability (87% positive ratings;  $n = 359$ ). A multidomain digital assessment successfully identified interacting psychosocial, environmental, and functional determinants of psychological workload. The Find My Stress PWA offers a scalable, low-burden platform for occupational stress screening applicable in workplace health surveillance.

**Keywords:** occupational stress; psychosocial factors; workplace bullying; environmental stressors; functional capacity; grip strength; digital health; retail workers; public health surveillance

## 1. Introduction

Retail service employees constitute one of the world's largest and most rapidly expanding occupational groups, yet they remain among the most understudied from a public health perspective [1,2]. Recent evidence confirms that psychosocial risk factors — including excessive workload, interpersonal conflict, and job insecurity — continue to disproportionately affect retail employees, with work stress and technological disruption emerging as compounding occupational hazards in this sector [28]. Customer-facing duties, prolonged standing, manual handling, and high-volume, variable workloads collectively contribute to elevated fatigue and psychological strain [3]. These psychosocial demands frequently co-occur with adverse environmental conditions — including thermal discomfort, poor air quality, noise, and crowding — that independently amplify perceived workload and increase the risk of occupational stress-related illness [4].

From a public health standpoint, occupational stress in retail workers is not merely an organizational concern; it represents a significant and preventable contributor to population-level mental health burden, work disability, and associated healthcare costs [5]. Empirical evidence from essential retail and grocery workers further confirms that stress accumulation in service occupations translates directly into measurable declines in mental health and workforce sustainability [29]. Psychological workload — the subjective experience of mental, physical, and temporal demands — serves as an early indicator of stress accumulation and is a precursor to burnout, depression, and musculoskeletal disorders if left unaddressed [6,7].

Occupational health psychology frameworks emphasize that workplace stress emerges from dynamic interactions between job demands and available psychological resources [8,9]. The Job Demands-Resources (JD-R) model posits that stress results when psychological demands outweigh resources including physical capacity, social support, and autonomy [10]. Conservation of Resources (COR) theory extends this, proposing that stress occurs when individuals perceive threatened or actual resource loss [11,12]. Both frameworks converge in supporting a multidomain understanding of occupational stress that integrates psychosocial, environmental, and physical capacity factors simultaneously.

Despite the theoretical rationale for multidomain assessment, prior occupational health research has tended to examine isolated stressor domains — focusing either on psychosocial factors [13], physical demands [3], or environmental conditions [4] — without addressing their combined effects on perceived workload. This fragmented approach limits the capacity for early, targeted public health intervention.

Functional physical capacity, assessed via absolute handgrip strength, offers a practically important and field-deployable indicator of workers' available resources. Grip strength is associated with musculoskeletal health, overall vitality, and vulnerability to both physical and psychological demands [14,15]. Grip strength has increasingly been proposed as a vital sign of health, reflecting overall physical reserve and population-level mortality risk [30]. Crucially, absolute handgrip strength can be obtained rapidly in workplace settings using a standard dynamometer, making it suitable for integration into occupational health screening programs without specialist infrastructure [16]. From a public health screening perspective, grip strength provides an objective, low-cost indicator that can complement self-reported psychosocial data to identify workers at elevated risk before clinical-level problems emerge [17].

Advances in digital health technology offer new opportunities for scalable occupational health surveillance. Progressive Web Applications (PWAs) provide cross-platform compatibility, require no installation, and enable secure, real-time data collection in naturalistic workplace settings [18]. These features are well-suited to ecological momentary assessment principles, capturing workers' psychological experiences in context [19]. Scoping reviews of mobile applications for workplace health promotion confirm the growing potential of app-based tools for occupational screening, while also identifying usability and evidence quality as key gaps requiring further investigation [31]. Emerging evidence for digital workplace health promotion programs further supports the feasibility of technology-enabled occupational health surveillance at scale [32]. Despite this growing interest, evidence for the validity and usability of PWA-based multidomain assessment platforms in retail populations remains limited.

This study addressed the following primary research question: Which psychosocial, environmental, and functional capacity factors are most strongly associated with perceived psychological workload in retail workers, and can a mobile digital tool reliably assess these factors in the field? The study aimed to: (1) identify multidomain determinants of psychological workload; (2) demonstrate the validity and usability of the Find My Stress PWA as an occupational health screening tool; and (3) provide evidence-based targets for public health intervention in retail workplaces.

## 2. Materials and Methods

### 2.1. Study Design and Participants

A cross-sectional study was conducted among full-time retail service employees working in large-scale home improvement stores across multiple branches in Thailand. Participants were eligible if they were aged 18–59 years, employed for at least three months, and engaged in customer-facing or merchandise-handling tasks. Employees with acute illness at the time of assessment were excluded. A total of 253 workers completed the full workload and functional capacity assessment. An additional 359 workers participated in the PWA usability evaluation, giving a combined sample of 634 participants across assessment components.

This study was conducted in accordance with the Declaration of Helsinki and approved by the Human Research Ethics Committee (approval number available on request). All participants provided written informed consent prior to participation.

### 2.2. The Find My Stress Progressive Web Application

The Find My Stress PWA is a field-deployable digital occupational health screening tool developed to enable rapid, multidomain assessment in workplace settings without requiring software installation. The application operates via standard web browsers on smartphones and tablets (iOS 13+; Android 8+; major desktop browsers), and was designed following ergonomic interface principles including high-contrast visual elements, large touch targets (minimum 44 × 44 pixels), and clear navigation pathways.

Key technical features of the PWA include: (a) responsive design optimized for screen sizes from 4.7 to 10 inches; (b) offline functionality enabling data collection in areas with limited connectivity; (c) secure cloud-based database with encrypted data transmission (TLS 1.3 protocol); (d) average assessment completion time of 6–8 minutes; (e) automatic data validation and quality checks; and (f) real-time synchronization when network connectivity is restored.

The PWA assessment interface is organized into task-specific modules. Workers first select their primary task type — Task 1: Item lookup and retrieval for customers; Task 2: Product recommendation and direct customer service; Task 3: Product restocking and shelf arrangement — before completing relevant assessment items. Variable labels in the data (e.g., Posture1, Bully3, Others3) reflect this task-specific structure, where the appended numeral denotes the task context (1, 2, or 3) in which the rating was provided. For example, 'Posture1' refers to perceived postural difficulty during Task 1 (item lookup), while 'Bully3' refers to bullying experiences during Task 3 (product restocking). This task-linked structure allows assessment of how stressor profiles differ across job roles, providing more ecologically valid data than generic global ratings. Workers rate each item on standardized scales (5-point or 11-point, depending on the domain), and the application automatically calculates summary scores and flags potential concerns. Handgrip strength values measured prior to PWA completion are entered directly into the application alongside anthropometric data, enabling integrated functional capacity documentation within the same assessment workflow.

Following validation within Rangsit University, the Find My Stress PWA has been adopted by the university's health services for institution-wide occupational stress monitoring, demonstrating scalability and practical applicability beyond the research context.

### 2.3. Procedure

Data collection was performed on-site during scheduled work shifts. After receiving a standardized brief orientation from trained research assistants, grip strength measurements were first conducted by trained assessors using a calibrated digital dynamometer. Workers then accessed the PWA using personal smartphones or store-provided tablets and completed the assessment in approximately 6–8 minutes. All responses were encrypted and transmitted to a secure cloud database.

## 2.4. Measures

Subjective Workload Index (SWI). Perceived psychological workload was assessed using the SWI, which evaluates physical, psychosocial, and environmental demand dimensions. Workers rated six negatively work-related factors, and two motivative work-related factors on an 11-point scale (0–10), with higher scores indicating greater perceived workload for the negative factors, and vice versa for the positive factors. The SWI has demonstrated strong internal consistency and validity across multiple occupational settings [20,21].

Psychosocial factors. Task-specific psychosocial demands were assessed including: perceived postural difficulty (Posture1–3), workplace bullying (Bully1–3), organizational climate (Organization1–3), interpersonal demands from others (Others1–3), and general health perception (GeneralHealth1–3). All subscales demonstrated acceptable internal consistency (Cronbach's  $\alpha > .80$ ).

Environmental discomfort. Environmental conditions were assessed via 5-point ratings of perceived heat, air quality, dust exposure, noise, lighting, and vibration during each task type. Subjective environmental appraisal was selected consistent with transactional stress theory, which emphasizes the psychological significance of individuals' perceptions of their environment [22].

Musculoskeletal symptoms. Musculoskeletal discomfort experienced during the past month was assessed across body regions including neck, shoulders and upper back, lower back, arms and fingers, wrists and hands, and legs and feet, using a 5-point severity scale consistent with standardized ergonomic assessment protocols [3].

Functional capacity: Handgrip Strength. Bilateral handgrip strength was measured on-site using a calibrated digital dynamometer following a standardized protocol. Participants completed 2–3 maximal-effort trials per hand, and the highest value was recorded. Grip strength was additionally normalized by body mass index (BMI; kg/m<sup>2</sup>) to derive the HG/BMI index for descriptive sex-comparison purposes (Table 1). Measured absolute grip strength values were interpreted using age- and sex-specific normative standards for the Thai population [23].

Usability evaluation. Usability of the Find My Stress PWA was assessed in 359 retail employees using a structured questionnaire evaluating clarity, ease of navigation, response accuracy, and perceived usefulness on a 5-point Likert scale.

## 2.5. Statistical Analysis

Data were analyzed using SPSS version 26. Descriptive statistics summarized demographic characteristics, SWI scores, environmental and psychosocial factors, musculoskeletal symptoms, and grip strength. Mann-Whitney U tests with effect size  $r$  compared sex differences in continuous variables, given the ordinal nature and non-normal distribution of scale data. Spearman rank-order correlations examined associations between SWI, environmental, psychosocial, symptom, and functional capacity variables. Multiple regression analysis examined independent predictors of SWI using a stepwise procedure, with model diagnostics including residual plots and variance inflation factors (VIFs) to assess multicollinearity. Because the stepwise procedure included task-specific variables that were only applicable to workers performing those tasks, listwise deletion reduced the regression sample to  $n = 221$  complete cases. Descriptive and correlation analyses were conducted on the full sample ( $N = 253$ ) unless otherwise noted. Statistical significance was set at  $p < .05$ . Effect sizes were reported using Spearman  $r$  coefficients and standardized regression coefficients ( $\beta$ ).

## 3. Results

### 3.1. Demographic and Physical Characteristics

The sample comprised 253 retail workers. Median age was 33 years (IQR: 27–41) for men and 31 years (IQR: 24–38) for women. Significant sex differences were observed in height, weight, BMI, and grip strength measures, both in absolute and normalized values (all  $p < .001$ ), with men demonstrating higher absolute and BMI-normalized grip values than women (Table 1). HG/BMI

differed significantly between sexes (left:  $p < .001$ ,  $r = -.42$ ; right:  $p < .001$ ,  $r = -.39$ ), confirming the utility of BMI normalization for cross-sex comparisons in this sample.

**Table 1.** Sex differences in demographic and physical characteristics of retail workers (N = 253).

Variable	Men, Median (IQR)	Women, Median (IQR)	U	Z	p	r
Age (years)	33 (27-41)	30 (23-37)	13985	-0.47	0.639	0.03
Height (cm)	170.0 (165-175)	160.0 (156-165)	2344	-8.17	<.001	0.51
Weight (kg)	73.0 (61.8-85.0)	59.0 (51.9-72.0)	4931	-5.08	<0.001	0.32
Grip Strength Left (kg)	35.2 (26.9-39.8)	26.0 (22.4 - 28.6)	2495	-9.37	<.001	0.59
Grip Strength Right (kg)	36.5 (30.6-41.5)	27.7 (25.3- 30.9)	2420	-9.51	<.001	0.60
LHG/BMI	1.46 (1.20-1.68)	1.05 (0.86-1.32)	3747	-5.30	<.001	0.33
RHG/BMI	1.44 (1.26-1.69)	1.12 (0.96-1.36)	3876	-5.04	<.001	0.32

Note. Mann-Whitney U test. LHG/BMI = left handgrip/BMI; RHG/BMI = right handgrip/BMI. Effect size  $r$  reported.

### 3.2. Perceived Work Strain

Both male and female retail workers reported broadly similar levels of perceived work strain across all SWI subscales, with no statistically significant sex differences observed (all  $p > .05$ ; Table 2). Overall SWI scores were comparable between men (Mdn = 3.5, IQR: 2.9–4.5) and women (Mdn = 3.6, IQR: 2.9–4.6), indicating moderate psychological workload in both groups. Among the individual workload dimensions, responsibility attracted the highest median ratings for both sexes (Mdn = 8.0), reflecting the high degree of accountability inherent in customer-facing retail roles. Autonomy received the lowest ratings (Mdn = 5.0), suggesting that workers perceived limited control over their tasks—a pattern consistent with JD-R theory predictions of high-demand, low-control occupational profiles [10]. Fatigue and concentration also received elevated ratings (Mdn = 7.0–8.0), indicating substantial perceived cognitive and physical load across the workforce irrespective of sex.

**Table 2.** Sex differences in workload factors of retail workers (N = 253).

Variable	Men, Median (IQR)	Women, Median (IQR)	U	Z	p	r
Fatigue	7.0 (6.0-9.0)	8.0 (6.0-9.0)	7335	-1.03	0.303	0.06
Risks	6.0 (5.0-8.0)	6.0 (5.0-8.0)	7658	-0.46	0.645	0.03
Concentration	7.0 (5.0-8.0)	7.0 (5.0-8.0)	7751	-0.30	0.764	0.02
Complexity	7.0 (5.0-8.0)	7.0 (5.0-8.0)	7550	-0.65	0.513	0.04
Work Rhythm	7.0 (5.0-8.0)	7.0 (5.0-8.0)	7718	-0.36	0.720	0.02
Responsibility	8.0 (7.0-9.0)	8.0 (7.0–9.3)	7691	-0.41	0.683	0.03
Interest	7.0 (5.0-8.0)	6.0 (4.0-8.0)	7207	-1.25	0.213	0.08
Autonomy	5.0 (3.0-8.0)	5.0 (3.0-7.0)	7224	-1.22	0.224	0.08
SWI	3.5 (2.9–4.5)	3.6 (2.9-4.6)	7499	-0.73	0.464	0.05

Note. Mann-Whitney U test. SWI = Subjective Workload Index.

### 3.3. Psychosocial and Environmental Factors by Task Type

Workers reported discomfort across multiple stressor domains—including movement constraints, postural difficulty, thermal conditions, dust exposure, organizational climate, general health, air quality, and noise—with profiles differing meaningfully by task type and sex (Table 3). Postural difficulty was consistently elevated and showed significant sex differences across all three task contexts (Posture1–3; all  $p < .05$ ), with women reporting greater postural strain than men, particularly during product restocking (Posture3:  $p = .002$ ,  $r = 0.19$ ). Workplace bullying was reported at higher levels by women during both item lookup (Bully1:  $p = .049$ ) and restocking (Bully3:  $p = .004$ ,  $r = 0.18$ ), suggesting that female retail workers may face disproportionate interpersonal stressor

exposure across job roles. Thermal discomfort also showed significant sex differences during restocking tasks (Heat3:  $p = .049$ ), consistent with evidence that women exhibit lower thermal tolerance thresholds in moderately warm environments. Organizational climate and general health perceptions were rated significantly more negatively by women during both Task 1 and Tasks 2–3, respectively. Overall, these findings indicate that psychosocial and environmental stressor burdens are not uniformly distributed across the retail workforce, and that sex-specific exposure profiles warrant targeted intervention strategies.

**Table 3.** Sex differences in biomechanical, environmental, health, and psychosocial workload-related factors by task type (N = 253).

Variable†	Task	Men (Mdn)	Women (Mdn)	U	Z	p	r
Movement1	1	3.0 (3.0-4.0)	3.0 (3.0-4.0)	5860	-2.20	.026	0.14
Posture1	1	3.0 (2.0-4.0)	3.0 (3.0-4.0)	5925	-2.10	.036	0.13
Posture2	2	3.0 (2.0-4.0)	3.0 (2.0-4.0)	5454	-2.57	.010	0.16
Posture3	3	3.0 (2.0-4.0)	3.0 (3.0-4.0)	4951	-3.03	.002	0.19
Heat1	1	3.0 (2.0-4.0)	4.0 (2.0-4.0)	6090	-1.78	.075	0.11
Heat3	3	3.0 (2.0-4.0)	3.5 (3.0-4.0)	5459	-1.97	.049	0.12
Dust1	1	3.0 (2.0-4.0)	4.0 (2.0-4.0)	5970	-2.00	.045	0.13
Organization1	1	3.0 (2.0-3.0)	3.0 (2.0-4.0)	5687	-2.56	.011	0.16
General health2	2	2.5 (1.0-3.0)	3.0 (2.0-4.0)	5704	-2.06	.040	0.13
General health3	3	2.0 (1.0-3.0)	3.0 (2.0-4.0)	5284	-2.32	.020	0.15
Nutrition3	3	2.0 (2.0-3.0)	3.0 (2.0-4.0)	5331	-2.22	.026	0.14
Bully1	1	1.0 (1.0-3.0)	2.0 (1.0-3.0)	5981	-1.97	.049	0.12
Bully3	3	1.0 (1.0-2.0)	2.0 (1.0-3.0)	5007	-2.90	.004	0.18

†Task 1 = Item lookup and retrieval; ‡Task 2 = Product recommendation and customer service; §Task 3 = Product restocking. Only variables with significant sex differences ( $p < .05$ ) are presented.

### 3.4. Musculoskeletal Complaints

Musculoskeletal complaints were prevalent across the workforce, with lower-extremity and axial-region symptoms predominating (Table 4). Legs and feet were the most commonly affected body region (31.0%), followed by upper back and shoulders (23.4%), lower back and waist (18.9%), arms and fingers (15.8%), wrists and hands (10.5%), and neck (6.5%). The predominance of lower-limb and lower-back complaints is consistent with the physical demands of retail work, which involve prolonged standing, repetitive load handling, and sustained awkward postures during shelf-stocking activities [3]. The elevated prevalence of upper back and shoulder symptoms likely reflects sustained overhead reaching and manual handling demands during product restocking tasks. Collectively, over 73% of workers reported musculoskeletal complaints in at least one body region, underscoring the substantial ergonomic burden experienced by this occupational group. The relatively lower prevalence of neck and distal upper-limb complaints may reflect the predominantly gross motor nature of retail tasks compared with sedentary or precision-assembly occupations.

**Table 4.** Musculoskeletal complaints by body region among retail workers (N = 253).

Body Region	% Affected
Legs and feet	31.0
Upper back and shoulders	23.4
Lower back and waist	18.9
Arms and fingers	15.8
Wrists and hands	10.5
Neck	6.5

### 3.5. Correlation Analyses

Spearman correlations revealed significant associations between SWI and variables across all assessed stressor domains (Figure 1). Among task-specific variables, Duration1 showed the strongest positive correlation with SWI ( $\rho = .73$ ,  $p < .001$ ). This strong association reflects the nature of item-lookup tasks: longer search durations indicate greater task difficulty and complexity, which plausibly drives both extended task time and elevated perceived workload simultaneously. Duration1 therefore functions as a proxy for task demand intensity rather than a purely independent predictor. Environmental stressors showed moderate-to-strong positive associations with SWI: air quality and heat during restocking tasks ( $\rho = .33$ ,  $p < .001$  each) and dust during item lookup ( $\rho = .31$ ,  $p < .001$ ) were the strongest environmental correlates. Psychosocial variables were consistently correlated with SWI across task types, with interpersonal demands ( $\rho = .30$ ,  $p < .001$ ) and general health perceptions ( $\rho = .26$ ,  $p < .001$ ) showing the most robust associations. In contrast, grip strength (left hand, absolute value) showed no significant bivariate correlation with SWI ( $\rho = -.004$ ,  $p = .971$ ), indicating that at the bivariate level, functional capacity was not independently associated with perceived workload. Notably, however, grip strength emerged as a significant independent predictor in the multiple regression model ( $\beta = .133$ ,  $p = .030$ ), suggesting a suppressor effect whereby its predictive contribution becomes apparent only when controlling for the shared variance of other stressor domains. Note that Spearman  $\rho$  values reflect bivariate SWI associations and are distinct from the Mann-Whitney effect size  $r$  values reported in Section 3.1 for sex-group comparisons.

### 3.6. Multiple Regression: Predictors of Psychological Workload

Multiple regression analysis identified six significant independent predictors of SWI (Table 5). The model explained 22% of variance in perceived psychological workload (Adjusted  $R^2 = .22$ ,  $F(6, 214) = 11.45$ ,  $p < .001$ ). Variance inflation factors ranged from 1.0 to 1.4, indicating no problematic multicollinearity, and residual analysis confirmed model assumptions were satisfied.

Postural difficulty during item lookup (Posture1;  $\beta = 0.21$ ,  $p = .003$ ) emerged as the strongest independent predictor of SWI, indicating that workers who experienced greater biomechanical strain during item lookup tasks reported substantially higher psychological workload. Workplace bullying during product recommendation tasks (Bully2;  $\beta = 0.17$ ,  $p = .008$ ) was the second strongest predictor, underscoring the psychosocial cost of interpersonal hostility in direct customer-facing roles. Among environmental predictors, thermal discomfort during restocking (Heat3;  $\beta = 0.16$ ,  $p = .021$ ) and poor air quality during restocking (Air Quality3;  $\beta = 0.14$ ,  $p = .043$ ) both independently contributed to elevated workload perceptions, consistent with evidence linking adverse environmental conditions to cognitive load and stress appraisal [4,25].

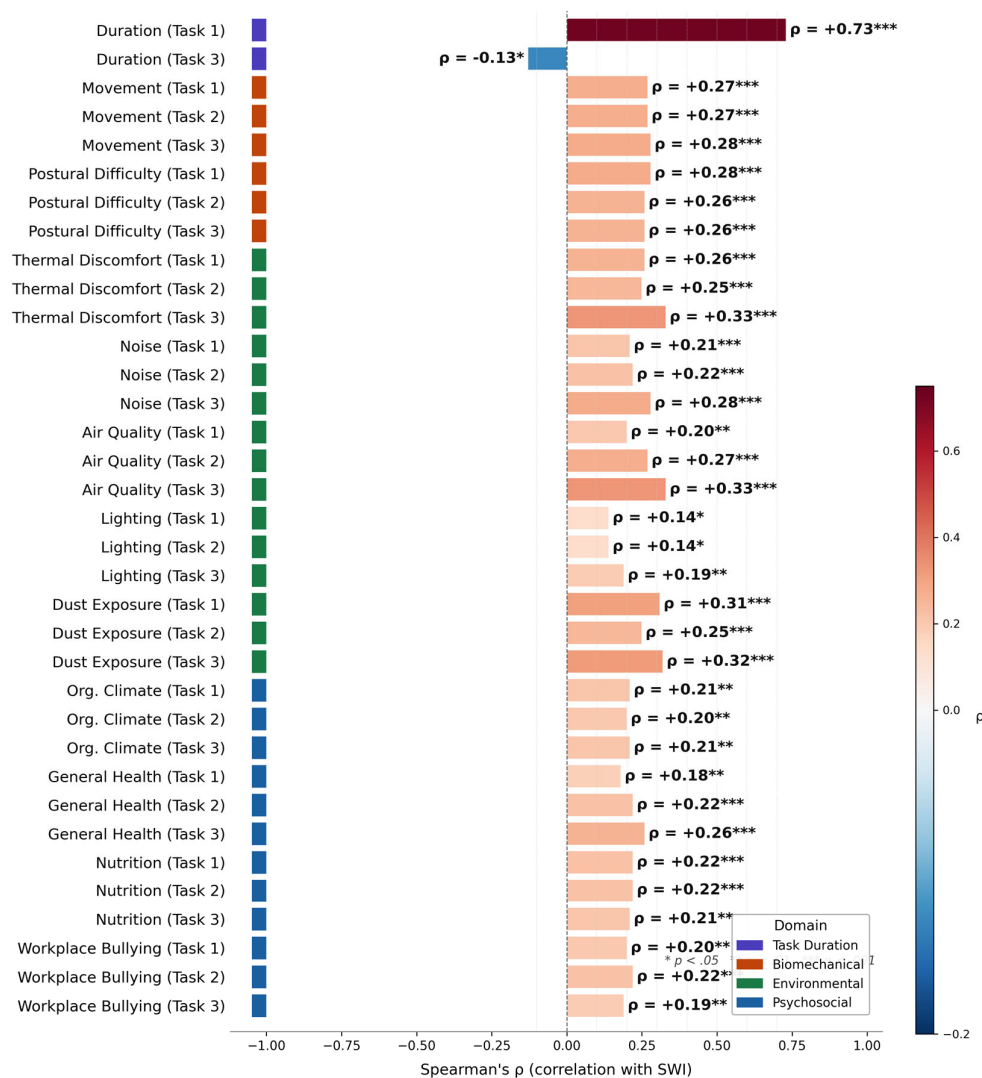


Figure 1. Spearman rank-order correlations between the Subjective Workload Index (SWI) and multidomain occupational stressor variables among retail workers (N = 253). Variables are grouped by domain: Task Duration (purple), Biomechanical (orange), Environmental (green), and Psychosocial (blue). Colour intensity reflects correlation magnitude. Task 1 = item lookup and retrieval; Task 2 = product recommendation and customer service; Task 3 = product restocking. \* p < .05; \*\* p < .01; \*\*\* p < .001.

**Figure 1.** Spearman correlation heatmap between the Subjective Workload Index (SWI) and psychosocial, environmental, and functional capacity variables across task types. Colour intensity reflects correlation magnitude; positive correlations are shown in warm tones and negative correlations in cool tones. \* p < .05; \*\* p < .01; \*\*\* p < .001.

Grip strength (left hand;  $\beta = 0.13$ ,  $p = .030$ ) was a significant positive predictor of SWI in the regression model, despite showing no significant bivariate correlation with SWI ( $r = -.004$ ,  $p = .971$ ). This pattern indicates a suppressor effect: grip strength’s unique predictive contribution to psychological workload becomes evident only after controlling for the shared variance of other stressor domains in the model. Task duration during restocking (Duration3;  $\beta = -0.16$ ,  $p = .010$ ) was a significant negative predictor: shorter task durations were associated with higher SWI, potentially reflecting more intensive, time-pressured work cycles within compressed restocking periods rather than lower overall demand.

**Table 5.** Multiple regression model predicting Subjective Workload Index (SWI) scores.

Predictor	Task Context	B	SE B	$\beta$	p
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Postural Difficulty	Task 1†	0.224	0.075	0.21	.003
Workplace Bullying	Task 2‡	0.137	0.051	0.17	.008
Thermal Discomfort	Task 3§	0.154	0.066	0.16	.021
Task Duration	Task 3§	-0.002	0.001	-0.16	.010
Air Quality	Task 3§	0.120	0.059	0.14	.043
Left Grip Strength	All tasks	0.017	0.008	0.13	.030
Constant		1.691	0.393		<.001

Note. Adjusted  $R^2 = .22$ ,  $F(6, 214) = 11.45$ ,  $p < .001$ . VIF range: 1.0–1.4. †Task 1 = Item lookup and retrieval; ‡Task 2 = Product recommendation and customer service; §Task 3 = Product restocking.

### 3.7. PWA Usability

Among the 359 retail employees who completed the PWA usability evaluation, 87% provided positive ratings overall. Positive ratings were distributed across all four usability dimensions: clarity of instructions, ease of navigation, accuracy of response options, and perceived usefulness of the tool for reflecting actual work experiences. The Find My Stress PWA demonstrated excellent internal consistency across all assessment items (Cronbach's  $\alpha = 0.97$ ), indicating that the composite instrument reliably captured a coherent construct of perceived occupational stress across its multidomain modules. The high usability ratings observed across a workforce with heterogeneous levels of digital literacy—including older workers and those with limited prior experience of web-based health tools—suggest that the PWA's interface design successfully achieved accessibility without sacrificing assessment depth. These findings support the suitability of the Find My Stress PWA as a scalable, low-burden platform for occupational health surveillance in retail and comparable service-sector environments.

## 4. Discussion

This study identified psychosocial, environmental, and functional capacity determinants of psychological workload among Thai retail workers using a field-deployable digital assessment tool. The findings have direct implications for occupational public health, workplace health promotion, and digital health surveillance.

The regression model identified postural difficulty as the strongest psychosocial predictor of perceived workload. This finding aligns with ergonomic evidence linking poor biomechanical conditions to heightened strain perceptions [3] and extends the JD-R framework [10] by demonstrating that physical demands function as primary stressors even when psychosocial factors are simultaneously controlled. From a public health intervention standpoint, ergonomic redesign—including workstation adjustment, task rotation, and posture training—represents a high-priority and modifiable target for reducing workload burden in retail settings.

Workplace bullying emerged as the second strongest predictor of psychological workload. This finding is consistent with meta-analytic evidence linking bullying to psychological distress and musculoskeletal complaints in service occupations [13,24]. Bullying effects were particularly pronounced during product recommendation tasks (Task 2), suggesting that the interpersonal intensity of direct customer-facing advisory roles may amplify the impact of hostile social dynamics on perceived workload. Organizational interventions targeting bullying prevention, psychosocial safety climate, and management practices are warranted as public health priorities in high-contact service work.

Environmental stressors—particularly thermal discomfort and poor air quality— independently predicted psychological workload in the regression model. Retail environments, which feature large semi-open layouts, variable ventilation, and direct weather exposure, may be especially vulnerable to environmental stressor accumulation. These findings are consistent with

environmental psychology evidence linking thermal and air quality discomfort to cognitive load, irritability, and stress appraisal [4,25]. Practically, engineering controls such as improved ventilation, heat management, and air filtration represent cost-effective environmental public health interventions.

Grip strength (left hand) emerged as a significant independent predictor of psychological workload in the regression model ( $\beta = .133$ ,  $p = .030$ ) despite showing no significant bivariate correlation with SWI ( $\rho = -.004$ ,  $p = .971$ ). This pattern is consistent with a suppressor variable effect, whereby a predictor's unique contribution to the outcome becomes statistically apparent only after controlling for shared variance with other predictors in the model [33]. In the present context, grip strength likely shares variance with postural difficulty, task duration, and environmental stressors—variables that are themselves associated with both physical demand and SWI. When these shared pathways are statistically controlled, grip strength accounts for residual variance in SWI that would otherwise remain unexplained. This finding underscores the importance of including objective functional capacity measures in multidomain regression models, even when bivariate screening suggests no direct association. From a public health screening perspective, absolute grip strength is a practical, rapidly obtainable field measure requiring only a calibrated dynamometer, making it suitable for integration into routine occupational health assessments without specialist infrastructure [16,17]. Future research should examine whether grip strength moderates the relationship between specific stressor domains and psychological workload, and whether longitudinal changes in grip strength predict incident stress-related outcomes in retail workers.

The multidomain regression model explained 22% of variance in perceived psychological workload (Adjusted  $R^2 = .22$ ). This level of predictive power is consistent with, and in many cases exceeds, published cross-sectional models of perceived occupational stress, which typically account for 15–30% of variance given the inherently multi-determined nature of psychological workload [8,26]. The remaining unexplained variance confirms that additional contributors—including individual coping styles, personality traits, organizational support quality, and cumulative stressor history—are not captured in a single cross-sectional assessment and represent important targets for future longitudinal research. The finding that six predictors spanning three distinct stressor domains independently contributed to the model underscores the importance of integrated, multidomain approaches to occupational health assessment over siloed single-domain evaluations [26].

The Find My Stress PWA demonstrated excellent internal consistency ( $\alpha = 0.97$ ) and high usability (87% positive ratings), supporting its validity as an occupational health screening instrument and its acceptability for use in real-world retail environments. The task-specific assessment structure — linking stressor ratings to defined job tasks (item lookup, product recommendation, restocking) — provides a level of ecological validity not achievable with generic global rating instruments, enabling more targeted identification of high-risk work contexts. The PWA's adoption by Rangsit University's health services for ongoing occupational stress monitoring further demonstrates translational utility and scalability beyond the research setting.

### *Strengths and Limitations*

This study presents several strengths. The multidomain assessment approach integrates psychosocial, environmental, and functional capacity data rarely combined in single studies. The inclusion of objective handgrip strength measurement adds a biologically grounded indicator to complement self-report data. The large combined sample ( $N = 634$  across assessment components) and the ecological validity of field-based PWA assessment support the generalizability of findings within the Thai retail sector.

Several limitations warrant consideration. First, the cross-sectional design precludes causal inference; longitudinal studies are needed to establish temporal sequences and determine whether grip strength predicts incident stress-related illness over time. Second, sampling was restricted to large-format home improvement retail stores in Thailand, which may limit generalizability to other retail formats, cultural contexts, or occupational settings [27]. Third, most measures relied on self-

report, which introduces susceptibility to common method bias and social desirability effects; future research should incorporate objective physiological indicators such as cortisol, heart rate variability, or actigraphy to validate subjective workload ratings. Fourth, environmental conditions were assessed via subjective perception rather than objective instrumentation; while perceptual appraisal is theoretically appropriate per transactional stress theory [22], sensor-based environmental monitoring (e.g., WBGT, sound level meters, particulate matter sensors) would strengthen causal inference and enable dose-response analysis. Fifth, the study did not assess individual difference variables --- including personality traits, psychological resilience, coping styles, or work experience --- that likely moderate stressor-strain relationships and may explain residual variance in the regression model. Sixth, the regression sample was reduced to  $n = 221$  due to listwise deletion of task-specific missing data; future studies should employ multiple imputation or mixed-effects models to retain the full sample and improve statistical power. Seventh, the suppressor effect of grip strength [33], while statistically legitimate, warrants replication in independent samples before causal conclusions are drawn.

## 5. Conclusions

Retail service workers experience complex, interacting psychological stressors across psychosocial, environmental, and functional capacity domains. This study demonstrates that postural difficulty, workplace bullying, thermal discomfort, poor air quality, and reduced functional capacity all independently contribute to perceived psychological workload. These findings reinforce the need for integrated, multidomain occupational health approaches grounded in JD-R and COR theoretical frameworks, with direct implications for workplace health promotion policy and practice.

The Find My Stress PWA provides a validated, scalable, and low-burden digital platform for occupational stress screening and early identification of at-risk workers. Absolute handgrip strength represents a practical, field-deployable functional capacity indicator that can be rapidly integrated into routine occupational health screening without specialist infrastructure, and its suppressor effect in the multidomain regression model underscores the value of including objective physical measures alongside self-reported psychosocial data. Together, these approaches support proactive, evidence-based public health interventions targeting psychosocial climate, environmental quality, and worker physical capacity in retail and other high-demand service environments.

Several directions for future research emerge from this study. Longitudinal designs are needed to establish causal pathways between multidomain stressors and psychological workload outcomes, and to determine whether early screening with tools such as the Find My Stress PWA can predict burnout, musculoskeletal disorders, or work disability over time. Intervention studies evaluating the effectiveness of ergonomic redesign, bullying prevention programs, and environmental engineering controls --- guided by the stressor profiles identified here --- would translate these findings into actionable occupational public health practice. Future studies should incorporate objective physiological measures (e.g., salivary cortisol, heart rate variability, actigraphy) alongside sensor-based environmental monitoring to overcome the common method bias inherent in fully self-reported designs. Cross-cultural replication in retail sectors across Southeast Asia and beyond would test the generalizability of the multidomain stressor model and the PWA platform. Finally, examining the suppressor role of grip strength across different occupational groups and task demands will clarify whether this functional capacity indicator has broader utility as a screening variable in integrated occupational health surveillance systems.

**Author Contributions:** Pongjan Yoopat: Conceptualization, Methodology, Investigation, Formal analysis, Data curation, Resources, Funding acquisition, Project administration, Validation, Writing — original draft, Writing — review & editing. Nisakorn Julraksa: Project administration, Data curation. Weerawat Liemmanee: Formal analysis, Data curation. Karn Yongsiriwit: Visualization, Software. Thannob Aribarg: Software. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was supported by the Rangsit University Research Institute. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

**Institutional Review Board Statement:** This study was conducted in accordance with the Declaration of Helsinki and approved by the Human Research Ethics Committee of Rangsit University. Ethics approval number available on request.

**Informed Consent Statement:** Informed consent was obtained from all participants involved in the study.

**Data Availability Statement:** The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request, subject to institutional data sharing policies and ethical approval requirements.

**Acknowledgments:** The authors thank Dr. Kamiel Vanwonderghem for his scientific guidance. We are grateful to the participating retail organizations, employees, and the students who assisted with data collection and system testing.

**Conflicts of Interest:** The authors declare no conflict of interest.

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