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REVIEW ARTICLE

A Comprehensive Systematic Review of Heat Stress Assessment Questionnaires in Workplace Environments: The Gaps and Recommendations

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ABSTRACT

Background: Heat stress is considered one of the harmful factors in workplace environments, and prolonged exposure beyond recommended levels can adversely affect workers' health. Various methods have been proposed to assess heat stress. Questionnaires are among the most important subjective tools, gaining popularity among researchers due to their ease of use and non-intrusiveness for workers. Nonetheless, a comprehensive questionnaire that covers all aspects of heat stress and is recognized as a standard tool by international organizations has not yet been fully established. This study aims to review existing questionnaires used to assess heat stress in workplace environments and compare their various dimensions from 2010 to 2022.

Methods: First, relevant keywords were extracted. Then, using the chosen search strategy, searches were conducted in the PubMed and Web of Science databases, considering inclusion and exclusion criteria. After thoroughly reviewing the extracted articles (448 in total), 11 articles were selected for final analysis

Results: The dimensions of "individuals' perceptions of workplace environmental conditions" and "workload" were included in most studies (8 studies). In contrast, the dimension "availability of work guidelines in hot environments" was mentioned in only one study. Some questions were not categorized within the identified dimensions and were therefore grouped under a "miscellaneous" category.

Conclusion: The review of questionnaires revealed that none fully covered all aspects of heat stress in workplace environments, likely due to the multifactorial and complex nature of heat stress. These findings suggest a need for the development of a more comprehensive and standardized questionnaire to provide a complete assessment of heat stress.

KEYWORDS: *Heat stress, Questionnaire, Subjective evaluation, Workplace environments*

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INTRODUCTION

Climate change has significantly intensified and increased the frequency of natural events such as heat waves worldwide [1]. The number of people exposed to heat waves is rising dramatically, with one study indicating that between 2000 and 2015, the number of individuals affected by heat waves increased by approximately 125 million [2]. During this period, the productivity of those working outdoors decreased by about 5.3% [3]. It is estimated that around 30% of the global population is exposed to critical climatic conditions—dangerous to human health—for at least 20 days each year [4]. One of the consequences of increased heat waves is the rising heat stress experienced by the general population, particularly among workers and laborers [2]. Heat stress refers to the net heat load imposed on the body, resulting from internal metabolic heat production and environmental factors such as temperature, humidity, radiant heat, air movement, and the type of clothing worn [5]. Workers are constantly exposed to heat stress in both indoor and outdoor occupational environments, either due to climate change or the heat-generating nature of their workplace, such as in industries like steel, smelting, oil, and gas. Hot work environments are considered a significant occupational health issue, negatively affecting key organs including the heart, kidneys, and brain [6]. The body's physiological response to excessive heat exposure is known as heat strain.

This condition arises when the internal body temperature exceeds normal limits, surpassing the body's capacity to regulate temperature effectively [7]. Prolonged exposure of workers to heat stress can lead to heat exhaustion, muscle cramps, heat syncope, increased accidents, and a reduced level of workplace safety [8]. Even before the onset of clinical symptoms, heat exhaustion and heatstroke can have a significant negative impact on workers' productivity, efficiency, and mental performance [9]. As a result, beyond its effects on human health, heat stress also has detrimental effects on worker productivity, increases accidents, reduces workplace safety, and creates economic losses. In one study, it was noted that in poorer countries, every degree increase in temperature resulted in a 1% reduction in economic growth [10].

Heat-related illnesses and injuries are largely preventable. It is essential that workers are aware of the potential harmful effects of working in high temperatures and that preventive measures and strategies to mitigate heat exposure are implemented in the workplace to protect workers from the detrimental impacts of extreme heat [4]. Given these reasons, assessing heat stress in work environments and subsequently providing control and preventive solutions are necessary.

There are various methods for measuring thermal conditions and thermal comfort in the workplace. Over the years, numerous heat stress evaluation indices have been developed, including empirical, analytical, and direct indices. These require measuring environmental factors (such as dry bulb temperature, wet bulb temperature, air velocity, etc.), job-related factors (such as clothing thermal resistance, estimated metabolic rate), and heat strain indicators (such as core body temperature, skin temperature, heart rate, sweating rate, etc.). Additionally, some indices can be time-consuming, complex, or disruptive to work processes, or may require computerized equipment [11].

Given Iran's geographical location and the heat-intensive nature of many occupational activities, continuous assessment of workplace heat conditions is essential. However, regular evaluation of heat stress in these environments seems impractical due to various challenges. This is because direct measurement methods are often costly, challenging to implement, and complex to analyze. One effective method for assessing heat stress risk, especially in small to medium-sized workplaces with fewer than 150 employees, is the use of screening and observational methods. These methods are efficient, simple, inexpensive, non-intrusive to workers, and provide rapid results, making them highly applicable in many work environments [11].

In most workplaces, screening methods can be employed to evaluate heat stress. The effectiveness of these methods has also been proven for assessing cold stress and musculoskeletal disorders [11]. One practical approach is the use of validated questionnaires to quickly assess heat stress and provide control and preventive measures. Several questionnaires have been developed for evaluating heat stress in workplaces, each with its own strengths and limitations. This review study

aims to examine a selection of these validated heat stress assessment questionnaires, highlighting their positive features and limitations.

MATERIALS AND METHODS

This study is a systematic review conducted in 2022. Relevant articles and studies were sourced from the PubMed, Web of Science, and Google Scholar databases. Due to the large volume of available literature, the time frame for article review was limited to the years 2010–2022. The inclusion criteria required that the study population consist of humans, the article be an original research article with full text available, and that the questionnaire used be fully mentioned within the article text. Key search terms included heat stress, thermal stress, thermal condition, thermal perception, heat strain, thermal strain, questionnaire, reliability, validity, validation, and subjective. Boolean operators "AND" and "OR" were utilized for more precise and scientific searches. All downloaded articles were reviewed for relevance to the subject matter. To avoid duplicate articles, they were stored separately in EndNote software. The initial screening phase involved reviewing articles based on their titles and abstracts to eliminate unrelated studies. In the second phase, full-text screening was employed to identify the most relevant studies for inclusion in the review.

Data Collection

Eligible articles were extracted into an Excel file. The extracted data from each study included the article title, year of study, authors' names, publisher, country of study, questionnaire assessment domain, questionnaire characteristics, study objectives, and a summary of the findings.

RESULTS

A total of 500 articles were downloaded based on the entered keywords. Of these, 52 articles were duplicates across different databases, leaving 448 unique articles. After reviewing and matching the articles' content with the keywords, 39 articles remained, and 409 were excluded. Following a more detailed screening and full-text review, 11 articles met the study's criteria, while 28 were excluded. The specifications of these articles are fully outlined in Figure 1.

Table 1 presents the detailed results from the systematic review of the various articles.

Table 2 outlines the most items addressed in each questionnaire.

As indicated in the table above, questionnaires 2 and 10 covered the largest number of items, making them the most comprehensive questionnaires for assessing heat stress.

DISCUSSION

Assessing various harmful factors is one of the primary responsibilities of professionals in industrial health within work environments. Heat stress in the workplace can adversely affect workers' health, increase accident rates, and reduce productivity. The evaluation of heat stress in work settings is usually conducted for a variety of reasons, including assessing workers' perceptions of their working conditions, analyzing the thermal environment, determining the need for engineering or management controls, and evaluating the effectiveness of implemented measures. Questionnaires are commonly used as reliable assessment tools across different areas such as noise, ergonomics, and thermal stress due to their ease of use, cost-effectiveness, and minimal disruption to workers.In this study, the tools for assessing thermal stress (including heat stress and humidity) in industrial settings, validated by the authors, were introduced and analyzed. Ultimately, based on specific selection criteria, 11 questionnaires advanced to the final stage of the study. Recognizing the impact of various factors on individuals' perceived heat stress in the workplace, researchers included diverse items in their questionnaires to achieve their assessment goals. Although some items were somewhat similar, the study first identified frequently mentioned domains across the questionnaires and then categorized the questions into subgroups associated with each domain. For instance, under the category "personal protective equipment," questions included the type of work clothing, fabric material, clothing color, and the use of sun protection hats. In the "occurrence of heat-related illness symptoms" category, questions included headache, dizziness, weakness, and the presence of red rashes. It is important to note that, as previously mentioned, certain questions were not categorized under common domains according to the authors' objectives and were thus placed in the

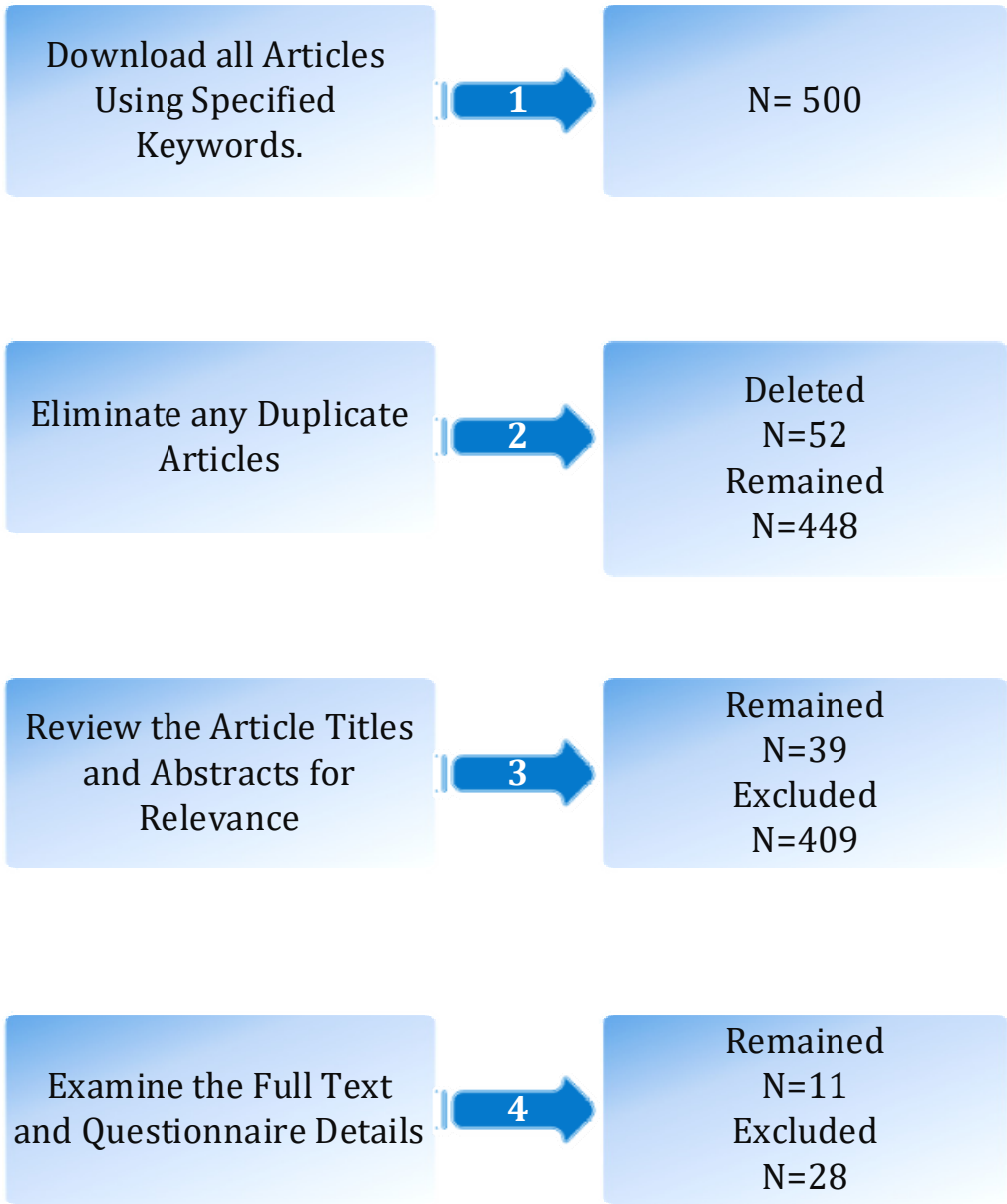

Figure 1. Flowchart illustrating the procedure for selecting eligible articles

"other" category.

An analysis of the questionnaires reveals that none have comprehensively addressed all dimensions of heat stress in workplace environments. This shortcoming is largely due to the complex and multifactorial nature of heat stress. At best, questionnaires 2 and 10 assessed 16 and 12 domains, respectively. Most of the questionnaires (8 out of 11) included questions concerning individuals' assessments of the thermal conditions in their work environment, as well as their workload. Perceptions of temperature—both warmth and coolness and the thermal state of the workplace are critical factors in evaluating heat stress [20, 21]. Additionally, qualitative inquiries into individuals' perceptions of environmental parameters such as temperature, humidity, air flow rate, and radiant temperature are often conducted to identify individuals who may be more vulnerable to heat stress or to estimate the overall thermal conditions of the work environment. This necessity is highlighted by the establishment of specific indices, such as PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied), which serve as indicators of comfort

Table 1. Details of the included articles

N	Title	Authors	Country/ Year	Questionnaire evaluation scope	Questionnaire Details	Study Aim	Ref
1	Workers' perceptions of climate change related extreme heat exposure in South Australia: a cross-sectional survey	Jianjun Xiang et al	Australia, China/2016	Assessing workers' awareness and behavioral reactions to intense heat exposure in warm climates	The questionnaire includes 5 demographic factors and 20 questions addressing various aspects of workplace conditions, previous experiences with heat-related illnesses and injuries, heat prevention strategies, and awareness of severe heat exposure at work. Some of the multiple-choice questions focus on individual work habits, access to preventive information on heat exposure, and preventive measures for managing heat exposure	This study aimed to assess workers' awareness and behavioral reactions to severe heat exposure in warm climates	(12)
2	Development and validation of a questionnaire for preliminary assessment of heat stress at workplace	H Dehghan et al	Iran/2015	The purpose of this questionnaire is to provide a preliminary evaluation of heat stress in workplace environments	This questionnaire comprises four factors: Factor One: Levels of fatigue, thirst, discomfort, clinical symptoms, and body posture. Factor Two: Clothing type, material, personal protective equipment (PPE), surface temperature, clothing color, airflow, air conditioning, workplace location, and physical activity. Factor Three: Amount of sweating, humidity levels, air temperature, and confined spaces.	The objective of this study was to create a questionnaire titled the Heat Strain Scoring Index, aimed at conducting an initial assessment of heat stress in work settings	(5)
3	Heat stress and inadequate sanitary facilities at workplaces - an occupational health concern for women?	V Venugopal et al	India/2016	This questionnaire aims to investigate the health impacts associated with exposure to hot work environments and insufficient sanitary facilities at the workplace.	It comprises 18 sections: the first section collects demographic information, the second focuses on job-related details, the third covers heat exposure experiences in the workplace, the fourth examines health effects stemming from heat exposure at work, the fifth addresses how heat affects individual productivity and performance, the sixth pertains to the influence of clothing on heat stress and productivity, the seventh explores coping strategies and measures against heat exposure at work, the eighth assesses access to drinking water, the ninth investigates kidney-related issues, the tenth focuses on dehydration, the eleventh, twelfth, and thirteenth sections relate to restroom access and urinary frequency, the fourteenth and fifteenth sections discuss menstrual health, while the eighteenth section addresses other unspecified concerns in the questionnaire.	This study aims to assess the health consequences of exposure to hot work environments and inadequate sanitary facilities specifically for female workers.	(13)

Table 1. Details of the included articles

N	Title	Authors	Country/ Year	Questionnaire evaluation scope	Questionnaire Details	Study Aim	Ref
4	Validation of a questionnaire for heat strain evaluation in women workers	H Dehghan et al	Iran/2013	This questionnaire aims to evaluate heat strain experienced by female workers in their work environment.	It comprises three sections with a total of 16 questions. The first section includes eleven perceptual questions, the second features three environmental questions, and the third contains two personal questions.	The objective of this study is to validate the questionnaire for assessing heat strain among women in the workplace."	(14)
5	Heat stress perception among native and migrant workers in Italian industries—case studies from the construction and agricultural sectors	A Messeri et al	Italy/2017	This questionnaire aims to gather information on workers' risk perception regarding heat stress in the workplace and the possible decrease in productivity resulting from extreme heat	It includes four sections comprising a total of 29 questions. The first section covers demographic and physiological data of the individuals, the second focuses on job and workplace details, the third explores heat perception among individuals, and the fourth discusses coping strategies.	The primary objective of this study is to investigate how cultural factors affect the perception and management of heat stress among both native and migrant workers. This aims to enhance healthcare decision-making to address social and cultural disparities and their effects on vulnerability to heat stress."	(15)
6	Construct validity and invariance assessment of the social impacts of occupational heat stress scale (SIOHSS) among Ghanaian mining workers	Victor FannamNunfam et al	Australia, Ghana; China/ 2021	This questionnaire aims to investigate the impacts of heat stress on health and safety, behavior, productivity, and overall well-being.	It includes two sections based on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The first section comprises four parts: the first addresses safety and health impacts, the second focuses on behavioral impacts, the third relates to productivity impacts, and the fourth concerns social well-being impacts. The second section collects demographic data and information about the individual's job.	The primary objective of this study is to establish the structural validity of the questionnaire used to assess the social effects of occupational heat stress among mining workers	(16)
7	Development of an observational-perceptual heat strain risk assessment (OPHSRA) index and its validation	S Yazdanirad et al	Iran/2021	This questionnaire aims to evaluate heat stress in individuals.	It comprises 16 questions organized into three sections: the first section focuses on observational questions, the second contains descriptive questions, and the third addresses perceptual questions.	The primary goal of this study was to develop and validate the Observational-Perceptual Heat Strain Risk Assessment (OPHSRA) method.	(17)
8	Determinants of heat stress and strain in electrical utilities workers across North America as assessed by means of an exploratory questionnaire	AD Flouris et al	Canada/2022	This questionnaire aims to evaluate heat stress in individuals.	This questionnaire is divided into two sections: the first section includes 13 general and job-related questions, as well as two self-reported heat stress questions. The second section contains the HSSI questionnaire items.	The objective of this questionnaire was to evaluate heat stress and strain among workers.	(18)
9	Heat Waves Occurrence and Outdoor Workers' Self-assessment of Heat Stress in Slovenia and Greece	Tjaša Pogačar et al	Greece, Canada/2019	This questionnaire consists of questions related to demographic information,	The first section of the questionnaire gathers demographic information, while the second focuses on assessing the negative impacts of	The objective of the study is to analyze the climatic background of heat waves	(2)

Table 1. Details of the included articles

N	Title	Authors	Country/ Year	Questionnaire evaluation scope	Questionnaire Details	Study Aim	Ref
				workers' awareness of company initiatives aimed at reducing heat exposure, perceived symptoms of heat stress or heat-related illnesses, and potential protective actions.	heat stress, illnesses resulting from heat exposure, hospitalization history, symptoms related to heat stress, and strategies for mitigating and managing heat stress in the workplace.	and outdoor working conditions in two climatically diverse European countries, Slovenia and Greece. Additionally, it utilizes a heat stress symptom questionnaire to examine heat-related illnesses and the necessary capacities for reducing heat stress exposure. The aim is to compare the two countries to identify the key differences and similarities regarding the incidence of heat waves, their effects, and workers' understanding of heat stress.	
10	Designing and Investigating Content Validity and Reliability of A Questionnaire for Preliminary Assessment of Heat Stress at Workplace	Sh Dehghan et al	Iran/2011	This questionnaire aims to conduct a preliminary evaluation of heat stress in the workplace.	It includes four sections comprising a total of 40 questions related to four categories: environmental factors, occupational factors, individual factors, and physiological factors.	The primary goal of this study was to develop and assess the content validity and reliability of a questionnaire method for the preliminary assessment of heat stress.	(11)
11	heat strain hydration status and symptoms of heat illness in surface mine workers	AP Hunt	Australia/2011	Assessment of workplace conditions regarding the incidence of heat-related illnesses.	This questionnaire is divided into six sections. The first section collects demographic information, the second relates to the work environment, the third focuses on fluid intake and urinary output, the fourth addresses symptoms and illnesses associated with heat and their occurrence frequency, the fifth pertains to physical activity, and the sixth explores the medical history and the types of medications taken.	The primary goal of this study is to evaluate heat stress, hydration status, and the illnesses and symptoms associated with heat exposure experienced by miners.	(19)

Table 2. Items raised in each questionnaire

Proposed Items	Questionnaire number										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Assessments by individuals regarding the climatic conditions of the workplace		*		*	*		*	*	*	*	*
Nature of the job and working posture		*		*			*			*	
Workload intensity	*	*		*	*	*	*			*	*
Levels of fatigue		*	*	*						*	*
Source of heat	*	*		*						*	
Length of work shifts				*	*	*		*		*	*
Use of personal protective equipment (PPE)	*	*	*		*		*			*	*
Implementation of engineering measures	*	*		*			*			*	
Managerial strategies (including work schedules, hydration, and job rotation)	*	*	*						*	*	*
Individual's adaptability to high temperatures				*			*				
Status of heat-related training	*				*		*			*	
History of previous heat-related illnesses	*			*						*	
Incidence of heat-related health issues	*	*	*		*	*			*		*
Work absenteeism due to heat stress			*			*					
Biological factors such as sweat rate and body temperature		*		*	*	*	*			*	*
Manifestation of symptoms associated with heat-related illnesses		*	*		*	*			*	*	*
Availability of first aid and emergency response protocols	*		*		*				*	*	
Work-related incidents	*					*					
Presence of guidelines for operating in hot environments	*										
Physical conditions of the workplace		*		*						*	
Influence of heat on interpersonal relationships with colleagues or social dynamics			*			*					
Effects of heat on comfort, mood, concentration, productivity, and emotional state			*		*	*			*	*	*

[22]. Furthermore, the workload and demands associated with specific jobs significantly affect how individuals perceive heat stress [23].

The review revealed that the most frequently addressed areas in the evaluated questionnaires were personal protective equipment (PPE), heat-related illnesses, biological strains, and heat-related symptoms. These frequent mentions highlight the importance of these factors in the eyes of researchers. Although each of these categories contains subcategories that may impact workers' perceived heat stress, the analysis found that some questionnaires posed only a few questions related to them. For instance, questionnaire 9 included just a single question on the use of PPE. Given that some occupations require specific PPE to mitigate heat exposure—such as face shields, specialized clothing, or heat-resistant gloves in industries like smelting and foundry work—or that some jobs may demand PPE that increases the experience of heat stress (such as full-body suits), accurately identifying the type of PPE becomes critical in heat stress assessments [24–26].

The domains of engineering and managerial controls, work duration, and the effects of heat on comfort, mood, concentration, productivity, and temperament were included in over 50% of the surveyed questionnaires. In terms of engineering controls, the focus was primarily on ventilation; in contrast, managerial measures covered various aspects, including the distance to water coolers, access to cold water, designated break times, halting work when workplace temperatures rise above 40 degrees Celsius, and adjusting working hours across different seasons. To achieve objectives related to evaluation or control, strategies such as spot cooling, job rotation, environmental misting (depending on job type), insulating heat sources, separation, utilizing natural ventilation systems, and providing sugary saline beverages could be incorporated into these categories [27–29].

Heat stress can influence concentration, comfort, productivity, mood, and temperament both directly

and indirectly, highlighting the psychological dimension of heat stress. Although investigating the psychological effects of heat stress in workplace settings can include other factors such as response time, perception, human error, and overall performance [24, 30–35], it seems that assessing the psychological consequences of heat stress may not take precedence in initial evaluations of heat stress conditions in work environments. Instead, such assessments typically appear in studies aiming for more comprehensive evaluations [24, 30, 33].

Training plays a vital role in reducing the effects of harmful factors in workplace environments. Engaging in training and exercises related to various aspects of heat stress—such as recognizing heat-related symptoms and signs, understanding heat illnesses, proper nutrition and hydration, emergency response, adapting to heat, and managing work-rest cycles—can significantly help in preventing and controlling heat-related health issues [21]. As such, the training and exercise aspect can be leveraged for the initial evaluation of the work environment. Nonetheless, only four studies have incorporated this dimension into their questionnaires.

In addition to training, having guidelines for executing work in various conditions particularly in hot environments can greatly enhance individuals' awareness. These guidelines should be provided alongside training to maximize their impact. The existence of guidelines related to heat stress in workplaces is an important consideration in assessing work conditions. Among the studies reviewed, only one included a question about the availability of relevant guidelines, indicating a need for expanding this focus in future research.
Adaptation to heat is crucial in preventing heat-related illnesses, improving productivity, and minimizing accidents. In essence, implementing coping and adaptation strategies for heat serves as an effective means of managing risks, vulnerabilities, and sensitivities to heat stress, while also enhancing workers' productivity and social interactions [36–38]. Reports suggest that 65% of workplace accidents occur within the first three days of employees working in hot environments, which underscores that proper adaptation to heat can reduce both accident rates and the incidence of heat-related illnesses [39]. Given the significance of this adaptation domain, it should be included as a major item in workplace evaluations; however, only two questionnaires have addressed this area.

Following a detailed analysis of the questionnaires mentioned, the authors of this study have proposed additional questions in a separate table attached to the document to address the identified gaps and provide a more comprehensive questionnaire for assessing heat stress in the workplace.

CONCLUSION

This study highlights the limitations of existing heat stress assessment questionnaires in fully capturing the complex nature of heat stress in workplaces. While factors such as personal protective equipment, heat-related illnesses, and biological strains are commonly addressed, critical elements like specific PPE, engineering controls, psychological impacts, heat adaptation, and training remain underrepresented. The authors propose the inclusion of additional questions to create a more comprehensive tool for evaluating heat stress, which could enhance worker safety, productivity, and overall well-being in thermally challenging environments.

Moving forward, further research is needed to validate and refine these proposed questions across diverse industries and work settings. Investigating the effectiveness of specific PPE, engineering controls, and training programs in mitigating heat stress could provide valuable insights. Additionally, future studies should explore the psychological impacts of heat stress and its long-term effects on workers' health. Policymakers may also consider adopting standardized heat stress assessment tools, incorporating these comprehensive factors to ensure better protection and to guide decision-making in occupational safety regulations.

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