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Developing a Revised Rule on Workplace Temperature Requirements

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Abstract

The German Ordinance on Workplaces calls for a room temperature range conducive to health. This requirement is specified in a revised version of the German rule for Workplaces ASR A3.5 'Room Temperature'. The former version of this rule laid down that the indoor air temperature shall not exceed 26°C (79°F). During a hot summer period with outside temperatures above 26°C the indoor air temperature may be higher as an exception. In view of misinterpretation of this former version, the aim was to explain how to deal with a high room temperature during a hot summer period in Germany. In comparison to the former version of this rule the revised version defines the requirements for acceptable higher room temperatures in the case of high outside temperatures using a step model following the principle of the adaptive approach. This paper explains the need for the revision, the development of the revised version and the new rule in detail.

Keywords

workplace, office buildings, risk assessment, indoor temperature, adaptation

1. Introduction

This paper explains the background and the development of a revised version of the German rule on workplace temperature which aims to define the minimum requirement regarding indoor temperature.

On the basis of the German Occupational Safety and Health Act (1996/2003) the Federal Ministry of Economics and Labour ordered an Ordinance on Workplaces (1975/2004/2010). The Ordinance on Workplaces defines general requirements for setting up and operating indoor workplaces. It states that the "...employer must ensure that workplaces are set up and operated in accordance with the provisions of the present ordinance ... in such a way that they are not the source of any hazards to the safety and health of workers." Before setting up and operating indoor workplaces "...the employer shall first establish whether the workers are exposed or may be exposed to risks...If this is the case...the employer shall lay down protective measures in accordance with the regulations of the present ordinance including its annex in

conformity with the state of the art, occupational medicine and hygiene.” (Ordinance on Workplaces, 2010). The Annex of the German Ordinance of Workplaces lists the following requirements regarding working conditions: movement area, arrangement of workstations, equipment, lighting and visual communication, ventilation, noise and room temperature. The section concerning room temperature calls for a temperature range conducive to health taking account of the working process, the physical strain of the workers and the specific use of the room during working hours.

The Rules on Workplaces explain these overall requirements in detail and formulate values for these requirements. The first version of the rule on room temperature ASR 6/1.3 (1976) postulated that the “...air temperature shall not exceed 26°C (79°F)”. This formulation has been interpreted very strictly by Higher Regional Courts (Court decisions, 1991, 1994, 1998, 2000), District Courts (Court decision, 2003) or Superior Courts of Justice (Court decision, 2002) and has been applied to room temperature during the summer season. The working group who developed this phrase in 1975 intended to protect the employees from high room temperature caused by overheating due to the operation of non-controlled radiators in the winter or in a transitional season. It was not the intention of the working group to define a rule for the summer season (e.g. Schramek, 1978).

In 2001 the original version of the rule was revised. The original text: “The air temperature at workplaces shall not exceed 26°C (79°F).” was extended to include the following: “If the outside temperature exceeds the value of 26°C the indoor temperature may be higher by exception.” Even though in 2003 a District Court (Court decision 2003) concluded that “...the room temperature must not exceed 26°C (79°F). If the outside temperature is higher than 32°C (90°F) the indoor temperature must be 6°C (11°F) lower.” Courts have assigned the task of meeting these newly defined requirements to landlords and property developers. Meeting a fixed maximum temperature and a fixed temperature difference between the outside and the inside temperature is very difficult to achieve without air-conditioning, and it increases investment costs and the energy demand of buildings. Sustainable building concepts, e.g. night cooling by natural ventilation or the application of thermo-active buildings systems are measures which cannot guarantee a fixed maximum indoor air temperature. As a consequence active cooling measures cannot be avoided (Hausladen et al. 2004).

The subjects considered were naturally ventilated offices and one air-conditioned workplace (Court decisions). If one looks at the building construction it can be seen that, given the large percentage of glazed area in the façades and the inadequate or even complete lack of sun shading device, the subjects concerned represent negative examples. The number of hours in which 26°C (79°F) are exceeded totalled to 800 hours per year and the maximum temperature exceeded 40°C (104°F), for example (Hausladen et al. 2004). Hence the courts confirmed apparent defects, but the reasons given for the judgements defined new and very strict requirements for work places in the summer which cannot be fulfilled by means of sustainably constructed buildings. The court’s decisions therefore caused some confusion among landlords and property developers as to whether to generally budget for air-conditioning systems or not.

In 2004 a revision of the Ordinance on Workplaces (2004) was published. Within the framework of this revision process and in order to revise the rule on workplace

temperature a new working group was constituted from representatives of private employers, a representative of public employers, representatives of the state authorities responsible for the ordinance, representatives of the trade unions, representatives of the accident insurance bodies and, in an advisory capacity, three external consultants from the domain of science. They defined the main aims of the revision process as follows:

- Definition of an upper value for a temperature range conducive to health.
- Finding a clear definition of the temperature requirements for outside conditions in summer.

Regardless of these aims the rule should be easy to apply in small and medium-sized enterprises. According to figures published by the German Federal Labour Market Authority in 2009, approximately 11 million employees work in companies with less than 50 employees. This equals 41% of all employees subject to social insurance contributions. In these companies there is often no specialist for occupational safety and health available as is the case in bigger companies. In very small companies the employers have to carry out a risk assessment for the workplaces at least every 5 years. Further consultancy and support is available on demand. Therefore the rule has to provide methods for verifying the temperature with easy to use measuring devices and a method which can be understood by a layperson.

An initial validation of the concept was carried out in the study “Heat strain and performance in offices at elevated outside temperatures” and has been described in Nöske et al. (2011) and Hellwig et al. (2012). This study investigated how subjects behave in and cope with an elevated room temperature during summer outside temperature. The aim was to investigate whether an elevated room temperature in a summer heat wave affects a subject’s mental status, self-assessed performance or impairs a subject’s mental performance.

This paper concentrates on the requirements on room temperature for outside temperature conditions in the summer but outlines the main notion of the rule in the results section. In the conclusion section the main results of the initial validation of the new requirements on room temperature for outside temperature conditions in the summer are mentioned briefly to inform whether the new requirements can be regarded as appropriate or not.

2. Materials and Methods

A review of literature and standards in the area of comfort temperature range and also regarding definitions of working in heat was carried out in order to develop a new approach for a revised rule. Typical outside weather data for Germany was analysed. Test Reference Year data (Christoffer et al., 2004) for a location representative of German cool weather conditions and a location for German warm weather conditions was processed. Using weather data covering a hot summer the distribution of the daily mean outside temperature, the daily running mean outside temperature according to EN 15251 (2007) and the number of days with an outside temperature above 26°C (79°F) were calculated. From the daily running mean temperature the maximum

comfort temperature according to the adaptive model of EN 15251 (2007), Category III was calculated.

In the analysis the sultriness limit developed in 1941 by Scharlau was used. The temperature and relative humidity combinations equalling a vapour pressure of 18.8 hPa were used for several years in the German Rule on Workplace Ventilation ASR A3.6 (2012). The combinations of temperature and relative humidity are shown in Table 1. The water content of these combinations corresponds to 12 g/kg and reference can also be made to EN 15251 (2007).

The water content with outside temperatures above 26°C (79°F) was analysed. The number of hours where water content exceeded 12 g/kg was counted. For these hours the normal effective temperature (NET) developed in 1927 by Yaglou according to the German standard governing working in heat, DIN 33403-3 (2001) was determined. The normal effective temperature is derived from a nomogram which includes the influence of air temperature, humidity and air velocity. The normal effective temperature was calculated for all outside temperatures higher than or equal to 26°C (79°F) and a humidity higher than or equal to 12 g/kg. For acclimatised persons with a metabolic rate of less than 130 W and long-term exposure a normal effective temperature of 31 to 33°C (88 to 91°F) is acceptable for working in heat. German occupational health professionals recommend a maximum normal effective temperature of 25°C (77°F) for light to medium work load in a summer heat wave. Assuming the air velocity is very low, this value corresponds as a function of relative humidity to an air temperature of 29 to 34°C (84 to 93°F) (Bux and Pangert, 2007). The normal effective temperature was calculated considering a low air velocity of 0.1 m/s (20 fpm).

Table 1: Maximum relative humidity at a certain air temperature according to the rule on workplace ventilation ASR A3.6 (2012) corresponding to 12 g/kg water content (sultriness limit).

air temperature	relative humidity
20°C (68°F)	80%
22°C (72°F)	70%
24°C (75°F)	62%
26°C (79°F)	55%

3. Results

Within this section the results of the weather data analysis are shown and the resulting definition of the revised rule on workplace temperature is explained.

Minimum temperature requirements

To keep the rule simple it has been defined that at workplaces with normal relative humidity, heat radiation or air velocity, e.g. offices, the air temperature can be regarded as a sufficient indicator to assess whether the room temperature is conducive to health or not. Only workplaces with a high relative humidity, high radiation or high air velocity must be regarded differently. Section 4.2 of the revised rule on workplace temperature (ASR A3.5, 2010) provides minimum values for the air temperature which must be guaranteed during all working hours depending on the physical work

load and the posture of the body. Table 2 shows these values. The values have already been proved in practice for many years. Section 4.2 also gives examples for light, medium and heavy physical workload.

Table 2. Minimum temperature requirements on workplaces (ASR A3.5, 2010).

Prevailing posture while working	Physical work load		
	Light	Medium	High
Sitting	20°C (68°F)	19°C (66°F)	-
Standing, walking	19°C (66°F)	17°C (63°F)	12°C (54°F)

Defining the upper temperature limit

Besides the definition of the minimum temperature requirements section 4.2 of the revised rule on workplace temperature (ASR A3.5, 2010) states that the air temperature shall not exceed 26°C (79°F). Another section of this rule is dedicated to outside temperatures above 26°C (79°F). How has this section been developed?

Pangert et al. (2003) suggested that above an air temperature of 37°C (99°F) (in dry climate) a worker carrying out a medium physical workload has to take frequent breaks to cool down his body. Gebhardt and Kampmann (2006) confirmed this concept. Bux and Pangert (2007) suggested an air temperature of 35°C (95°F) be regarded as the maximum temperature for workplaces with low internal heat load, light to medium physical workload and adapted clothing. Taking into account the maximum allowable temperature of 26°C (79°F) mentioned above, an air temperature range from 26°C (79°F) to 35°C (95°F) is obtained. Since 26°C (79°F) is the maximum value of category II according to EN 15251 (2007) (heat balance model) it is still in the comfort range. 35°C (95°F) is definitely outside the comfort range in this climate zone. There was therefore a discussion on splitting up the range into two bands. But which temperature should be chosen?

Weather data analysis

It was assumed that in case of a summer heat wave and in an office with a sufficient sun shading device the room temperature equals the outside temperature. The climate in Germany is moderate. The mean hourly outside air temperature ranges between -14 and 36°C (7 and 97°F) in warm German climate and between -20 and 33°C (-4 and 91°F) in a cool German climate. In a warm climate there are 432 h with outside air temperatures higher than or equal to 26°C (79°F), whereas in a cool climate there are only 98 h of excess temperature. When the outside temperature is higher than 26°C (79°F) the mean hourly relative humidity ranges between 20 and 72%. But 95% of all values are below 55% relative humidity. In a cool climate relative humidity ranges between 24 and 57% with 95% of all values below 50% relative humidity.

At a warm location the maximum water content of 12 g/kg (sultriness limit) is exceeded in 69 h and in a cool climate in 8 h only. The normal effective temperature in a warm climate exceeds 25°C (77°F) in 25 h and in a cool climate in 2 h. For the warm location Figure 1 shows the number of hours with the combination of temperature and relative humidity where an air temperature of 26°C (79°F) and a water content of 12 g/kg are exceeded.

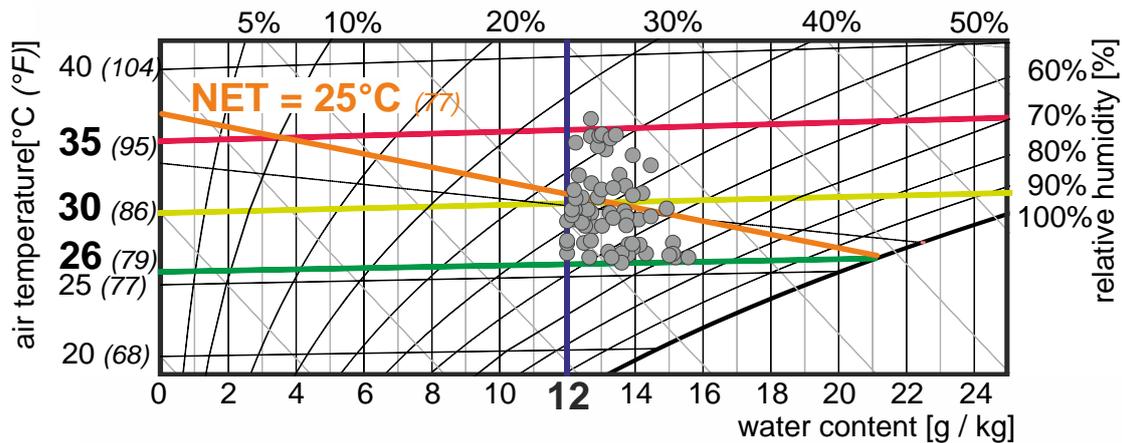


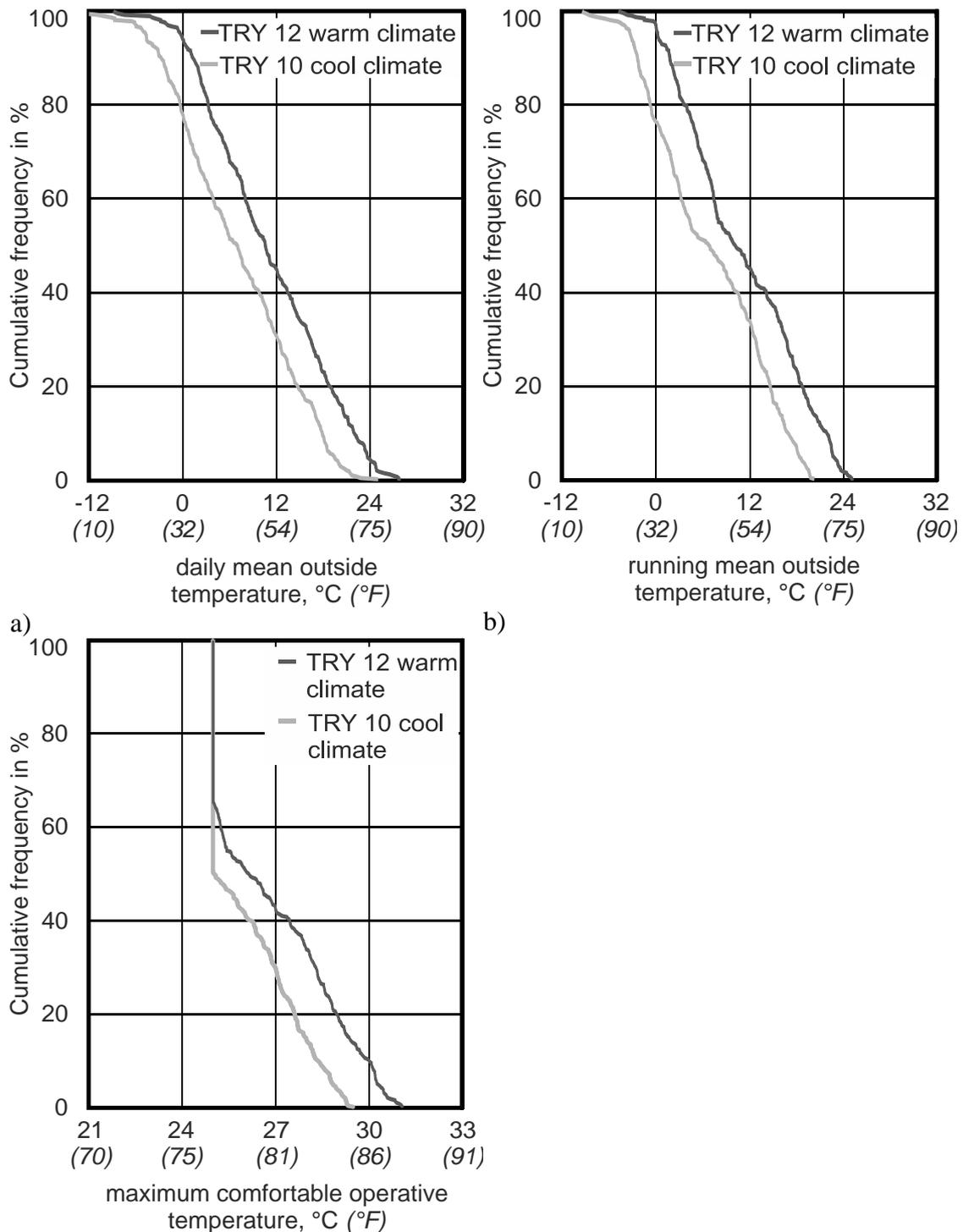
Figure 1. Section of the h-x-diagram showing all combinations of temperature and relative humidity if the outside air temperature exceeds 26°C (79°F) and the water content exceeds 12 g/kg (sultriness limit, according to ASR A3.6 (2012) or EN 15251 (2007)) for warm location TRY 12 (including a hot summer period). The line for a normal effective temperature (NET) of 25°C (77°F) and the lines for an air temperature of 26°C (79°F), 30°C (86°F) and 35°C (95°F) are also shown.

The analysis of the cool and warm location weather data is shown in Figure 2. In the warm location the mean hourly outside temperature rises above 26°C (79°F) on 57 days per year. In the cool location the temperature rises above 26°C (79°F) on 18 days, only. The resulting daily mean temperature in a cool climate never rises above 26°C (79°F) and in a warm climate in less than 2% of all days. The running mean temperature is above 10°C (50°F) in 40% and 50% of the time of one year in cool and warm location respectively. The maximum running mean temperatures are 20°C and 25°C (68 and 77°C) respectively. According to the adaptive model of EN 15251, category III the resulting corresponding comfortable room temperatures are 29.5°C (85°F) and 31°C (88°F). To define the value for splitting up the range between 26°C (79°F) and 35°C (95°F) into two bands the working group chose 30°C (86°F).

The new rule for outside temperatures above 26°C (79°F)

Contrary to the former rule the new rule contains a step model. This model applies for inside work places with low internal heat load and for light or medium physical work load. Applying the new rule, first it has to be decided whether the outside temperature is above 26°C (79°F) or not. If the outside temperature rises above 26°C depending on the indoor air temperature the following procedure must be applied:

- Air temperature at a workplace between 26°C (79°F) and 30°C (86°F):
If there is an adequate sun shading system already in operation the employer *shall* apply measures according to Table 3.
- Air temperature at a workplace between 30°C (86°F) and 35°C (95°F):
The employer *must* apply measures according to Table 3.
- Air temperature at a workplace above 35°C (95°F):
The workplace is not suitable for work without measures being taken which are appropriate for working in heat during the excess temperatures.



c)
 Figure 2. a) Daily mean outside temperature, b) running mean outside temperature and c) corresponding maximum comfortable operative temperature according to EN 15251, Category III, adaptive model, for cool and warm German locations, 365 days/ 8760 h (TRY data from Christoffer et al., 2004, including a hot summer period).

Figure 3 explains the resulting new rule. The rule on workplace temperature points out that for susceptible persons, for persons carrying out heavy physical work load or persons wearing special protective clothing an air temperature above 26°C (79°F)

may not be conducive to health. In such cases further measures has to be taken according to an adapted risk assessment.

Table 3. Effective measures while indoor air temperature exceeds 26°C (79°F) (ASR A3.5, 2010).

	Effective measures
i)	effective control of shading devices (e.g. keeping blinds closed outside working time)
ii)	effective control of ventilation (e.g. night cooling by ventilation)
iii)	reducing the internal heat load (e.g. running electrical equipment only when necessary)
iv)	early morning ventilation
v)	applying flexible working hours
vi)	casual dress code
vii)	providing soft drinks (e.g. mineral water)

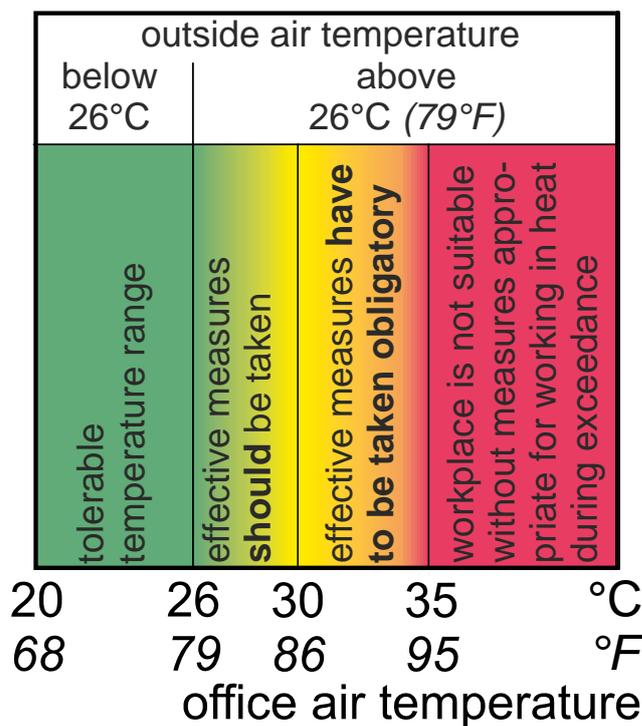


Figure 3. Step model of the new German rule on workplace temperature ASR A3.5 (2010).

4. Discussion

In Germany, standards such as ISO, EN or DIN are generally recognized rules of technology and are used for the planning of buildings. Laws, ordinances and the rules for their implementation define the minimum requirements which must be complied with. It is therefore important to formulate distinct rules on workplaces which cannot be misinterpreted and can be applied in small and medium-sized enterprises. But of

course, the rule on workplace temperature ASR A3.5 does not replace the detailed planning of buildings. The step model provides guidance on how to proceed where there are temperatures between the comfort temperature range and the temperature defining work in heat. An analysis of the weather data shows that in the case of low heat radiation the air temperature is sufficient, without taking into account relative humidity, for assessing whether the indoor climate is tolerable or not.

5. Conclusion and Outlook

To date there has been little practical experience with the new German rule on workplace temperature regarding the regulations for summer outside temperature conditions. An initial validation of the concept was carried out in the study “Heat strain and performance in offices at elevated outside temperatures” (Nöske et al. 2011; Hellwig et al. 2012). This study investigated how an elevated room temperature (30°C (86°F) and 33°C (91°F) affects a subject’s mental status, self-assessed performance or impairs a subject’s mental performance compared to 26°C (79°F)) during summer outside temperature. In the course of 4.25 h selective attention and verbal and numerical thinking did not change significantly either with temperature or over time. Slight effects on performance were found with respect to text correction. The willingness to exert effort and the feeling of being relaxed decreased significantly both with temperature and over time. Drowsiness tended to increase with temperature and rose significantly with time. The feeling of being well-adjusted and self-assessed performance tended to decrease with increasing temperature. The mental and physical work load were perceived to be higher when the temperatures were higher. The results imply the subject’s ability to adjust their mental performance in relation to heat strain. In general, the measures provided for in the study according to the new German rule on workplace temperature, such as allowing for clothing adaptation, breaks and the making soft drinks available, can be regarded as supportive. The study implies that the step model according to the rule on workplace temperature is appropriate.

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