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ORIGINAL ARTICLE

Occupational exposure to cold thermal environments: a field study in Portugal

A. Virgílio M. Oliveira · Adélio R. Gaspar · Divo A. Quintela

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Abstract The present work is essentially dedicated to the study of cold thermal environments. The analysis includes 32 industrial units from 6 activity sectors and the measurements were carried out in 101 workplaces. Different environmental conditions were identified and a clear relationship with the different types of workplaces was established. The work environments were thus allocated to three typical exposure categories corresponding to freezing and refrigerating cold stores and free-running or controlled air temperature manufacturing workplaces. In order to characterize the level of cold exposure, the method proposed by ISO/TR 11079, Technical Report, 1st edn, International Organization for Standardization, Geneva (1993) was adopted. The results for each activity sector demonstrate that a significant percentage of workers are repeatedly exposed to extreme conditions with insufficient clothing insulation. A value between 20 and 40% corresponds to the most critical situation, where the selected clothing ensemble does not provide adequate insulation ($I_{\mathrm{clr}} < IREQ_{\mathrm{min}}$). The ideal scenario, represented by I_{clr} values between $IREQ_{\mathrm{min}}$ and $IREQ_{\mathrm{neutral}}$, shows the lowest percentages with an overall result of only 10%. When all the sectors are considered together, from a total of 3,667 workers, about one-third (1,151) are exposed to the cold. Among the workplaces under analysis, 14 are characterized by a continuous exposure greater than the DLE_{neutral}. Those who work under such conditions, on average, have a time shift 60 min longer than the calculated *DLE* value.

Keywords Cold stress · Required insulation (*IREQ* model) · Thermal insulation of clothing

Introduction

The studies concerning extreme thermal environments traditionally have its origin within the military community. Particularly, the cold stress investigation has also been moved by expedition activities and in working outdoors (Parsons 2003). The attention given to indoor thermal environments achieved an increasing interest in the scientific community only in the recent years and is now becoming a priority area of investigation. The improvement of occupational safety and health is giving rise to updated and new legislation and to the promotion of public awareness, education and investigation in this field. As a consequence, different research studies are being developed in order to characterize the actual indoor working conditions through field measurements. The research activities carried out in Japan (Tochiara 1998, Kim et al. 2005), Denmark (Nielsen 1998) and Brazil (Gallois 2002) can be referred to as examples of this new approach.

The hazards of cold stress include health effects, physiological adjustments, psychological responses and behavioural reactions. ISO 12894 (2001) addresses these

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A. V. M. Oliveira · A. R. Gaspar · D. A. Quintela
ADAI, Department of Mechanical Engineering,
University of Coimbra, Pólo II, 3030-788 Coimbra, Portugal
URL: http://www.dem.uc.pt

A. V. M. Oliveira (✉)
Department of Mechanical Engineering,
Superior Institute of Engineering,
Polytechnic Institute of Coimbra, Rua Pedro Nunes,
Quinta da Nora, 3030-199 Coimbra, Portugal
e-mail: avfmo@mail.isec.pt
URL: http://www.isec.pt

matters and summarizes the main illnesses that can arise from changes in body heat storage. Particular attention is given to the effects of the general hypothermia, to local cold injuries (frostinip, frostbite and non-freezing cold injuries) and to other health effects related to cold conditions, namely to the cardiovascular, respiratory and metabolic physiological responses. Thus, the activities developed in cold have to be evaluated in multiple perspectives. The methods derived to assess cold stress, i.e., the amount of heat that has to be produced to maintain the body in thermal equilibrium, should thereby account for the thermal compensability of the environment which defines the interaction of the human body and the thermal environment (Taylor 2006). For several environmental conditions (air and mean radiant temperature, air velocity and humidity), protection provided by clothing (thermal insulation) and activity (metabolic rate), all of the mentioned hazards are enhanced by the cooling power of the environment.

Holmér (1993) suggests that cold stress should be evaluated in terms of both whole body cooling and local cooling (extremity, respiratory, convective and conductive skin cooling). The methods actually available to assess these different ways of cooling are still few, and the most common cold stress indices can in fact be reduced to the required clothing insulation, the *IREQ* index (Holmér 1984) and to the *Wind Chill* index (Siple and Passel 1945) which has been recently replaced by a new formulation from the Weather Services of the United States of America (NWS 2007) and Canada (EC 2007).

The *Wind Chill* index has been widely used to predict thermal discomfort outdoors since it was derived particularly in the United States and Canada. In contrast, for the *IREQ* index, during the first years insufficient experimental support and practical experience in its use were recognized (ISO 11399 1995). Thus, following the trend of other research teams (Gavhed and Holmér 1998; Griefahn 2000), field studies in this area are encouraged.

In Portugal, probably due to our mild climate, the analysis of moderate thermal environments has deserved further attention (Quintela et al. 1998; Gaspar et al. 2002) as compared to hot or cold exposures. Particularly in the case of cold environments, the authors were unable to find any published work on this subject in spite of being aware of the growing number of industrial activities with different kinds of cold chambers. The absence of such studies and the need to characterize the Portuguese reality have motivated the present survey. By adopting the *IREQ* index to assess the thermal stress due to cold exposure indoors, this work was aimed to provide a wide database and to clarify if workers are wearing proper clothing.

Methods

IREQ model

The evaluation of thermal stress is mainly supported by measurements of physical parameters [air and mean radiant temperatures (t_a and t_r), air velocity (v_a) and humidity (rh)] and the estimation of individual parameters [metabolic rate (M) and thermal insulation of clothing (I_{cl})], which are assessed in terms of the required clothing insulation index, *IREQ*. Developed by Holmér (1984) and adopted by ISO as a Technical Report (ISO/TR 11079 1993), the *IREQ* index provides a method to calculate the thermal stress associated with the exposure to cold environments. It applies to continuous, intermittent and occasional exposure either for indoor or outdoor working conditions. With the support of the human heat balance equation, the clothing insulation required to maintain thermal equilibrium is calculated by satisfying the following equations:

$$IREQ = \frac{\bar{t}_{sk} - \bar{t}_{cl}}{M - W - E_{res} - C_{res} - E} \tag{1}$$

$$M - W - E_{res} - C_{res} - E = R + C \tag{2}$$

where $\bar{t}_{sk}$ and $\bar{t}_{cl}$ are the mean skin temperature and the mean clothing surface temperature (°C), M is the metabolic rate (W m^{-2}), W is the effective mechanical work (W m^{-2}), E_{res}, C_{res}, E, R and C are the heat exchanges by respiratory evaporation and convection, by evaporation, radiation and convection at the human body surface (W m^{-2}), respectively.

The listed human heat exchanges are estimated from the physical parameters (t_a, t_r, v_a and rh) and individual parameters (M and I_{cl}) using the set of expressions presented in ISO/TR 11079 (1993). As Eq. (1) and the expressions for R and C in Eq. (2) contain the independent variables *IREQ* and $\bar{t}_{cl}$ the *IREQ* value is then calculated by iteration.

The physiological strain is proposed at two levels in terms of mean skin temperature, skin wettedness and change in body heat content:

- $IREQ_{neutral}$ defines the thermal insulation required to maintain thermal equilibrium at a normal level of mean skin temperature ($\bar{t}_{sk} = 35.7 - 0.0285 \times M$) and wettedness ($0.001 \times M$). It represents no or minimal cooling of the human body.
- $IREQ_{min}$ is defined as the minimal thermal insulation required to maintain thermal equilibrium at a subnormal level of mean skin temperature (30.0°C) and wettedness (0.06). This level represents the highest admissible body cooling during work.

When the resultant clothing insulation of the selected ensemble, I_{clr}, calculated on the basis of the intrinsic clothing insulation (I_{cl}) to account for the effect of body motion, posture and wind, is less than the calculated required clothing insulation (*IREQ*), exposure has to be time limited to prevent progressive body cooling. Thus, a duration limited exposure (*DLE*) is defined in terms of the recommended maximum time of exposure with available or selected clothing. It can be calculated for both levels of strain from:

$$DLE = \frac{Q_{\mathrm{lim}}}{s} \tag{3}$$

$$S = M - W - E_{\mathrm{res}} - C_{\mathrm{res}} - E - R - C \tag{4}$$

where Q_{lim} and S are the body limit heat loss (-40.0 Wh m^{-2}) and the rate of change in heat content (W m^{-2}).

If the workers wear an ensemble with a clothing insulation higher than $IREQ_{\mathrm{neutral}}$, an increasing feeling of warmth and overheating may occur. The interval between $IREQ_{\mathrm{min}}$ and $IREQ_{\mathrm{neutral}}$ can be regarded as the clothing regulatory zone, where each individual chooses the appropriate protection level.

Industrial units and workplaces

The present survey was realised in 8 out of 18 provinces of Portugal main land. Table 1 shows that the sample gathered consists of 32 industrial units of 6 activity sectors, namely in the, fish, meat, milk food production, conservation and distribution (Oliveira et al. 2005a) industrial units. In addition, a few industrial units from the pharmaceutical distribution were also included. A total of 101 workplaces were considered, embracing freezing (21) and refrigerating (34) chambers and free-floating or controlled air temperature manufacturing workplaces (46). The number of people working in the 32 industrial units considered was 3,667 and from these 1,151 were consistently exposed to cold thermal environments.

Physical parameters

The measurement of the physical parameters was carried out according to ISO 7726 (1998). The field evaluations were performed with a mobile and portable apparatus that incorporates three arrays of sensors, placed at 0.1, 1.1 and 1.7 m above the floor. These levels correspond to the ankles, abdomen and head heights for a standing worker.

Equipment from Testo was used, namely the data-loggers 175–T2 (ref [a] 0563 1755) for t_a and t_g and the 445 (ref [a] 0560 4450) for v_a and *rh* recording. To measure the globe temperature, a globe of 50 mm diameter made of a 0.3 mm cooper plate was used, in the center of which an air temperature sensor from Testo (ref [a] 0613 1711) was placed. The main characteristic of this globe sensor is that it has a faster time response than the standard 150 mm globe. The mean radiant temperature was then estimated using the globe temperature according to ISO 7726 specifications. The v_a and *rh* sensors were Testo (ref [a] 0635 1049), (0–10 m/s; −20°C to +70°C) and Testo (ref [a] 0636 9741), (0–100% *rh*; −20°C to +70°C), respectively. With this system, which records each parameter every minute, the air and globe temperatures were measured at three levels while the air velocity and humidity were measured only at the abdomen level.

The measurement of all the physical parameters was done simultaneously and was preceded by an appropriate stabilization period, after which a 1 h evaluation was performed. The mean values obtained during the recording period were used for the *IREQ* determination, therefore leading to an average estimation of the cold stress.

The values of the measured physical parameters t_a, t_g, v_a and *rh*, are shown in Table 2. The freezing chambers can be characterized in terms of a temperature range between −15 and −25°C, the refrigerating stores from 0 to 10°C and the manufacturing workplaces between 10 and 25°C. The manufacturing workplaces have generally lower *rh* values than the cold chambers, which are characterized by *rh* mean values higher than 50%. In the case of the food

Table 1 Industrial units, workplaces and distribution of workers by activities

Activity Sector	Number of Industrial units	Workplace			Number of workers	
		Freezing chambers	Refrigerating chambers	Manufacturing workplaces	Total	Exposed to cold
Milk food industry	5	3	6	5	673	225
Fish industry	6	5	3	10	129	77
Meat industry	5	5	5	8	340	119
Food conservation	6	2	7	6	678	200
Food distribution	5	6	8	12	1,547	350
Pharmaceutical units	5	0	5	5	300	180
Total	32	21	34	46	3,667	1,151

Table 2 Mean values of the measured physical parameters and estimated metabolic rates and intrinsic thermal insulation of clothing

	t_a (°C)			t_g (°C)[a]	*rh*, %[a]	v_a (m s^{-1})[a]	*M* (W m^{-2})[a]	I_{cl} (clo)[a]
	Mean	Max	Min					
Milk food industry								
F	−20.4	−17.1	−22.9	−21.1	86.1	0.47	148.5	1.80
R	4.1	7.9	−2.6	3.3	84.2	0.32	151.3	1.47
M	16.5	18.5	13.7	17.0	62.5	0.03	145.9	1.01
Fish industry								
F	−16.3	−4.0	−19.9	−16.8	86.4	0.59	158.0	1.50
R	4.6	7.4	1.1	3.5	86.1	0.34	158.3	0.99
M	14.2	18.3	10.0	13.9	81.0	0.04	140.3	1.17
Meat industry								
F	−17.2	−9.7	−19.6	−17.7	78.5	1.00	193.4	1.50
R	3.6	8.4	1.2	3.2	84.2	0.26	161.3	1.18
M	12.3	15.3	7.4	12.0	74.0	0.19	171.1	1.14
Food conservation industrial units								
F	−19.9	−18.1	−21.6	−21.0	86.4	0.46	172.5	1.44
R	5.1	8.3	2.1	4.6	77.6	0.37	166.5	1.14
M	12.2	15.8	9.0	11.1	66.5	0.07	164.4	1.08
Food distribution industrial units								
F	−17.4	−10.9	−19.6	−18.1	94.1	0.49	151.0	1.48
R	4.5	8.7	1.7	3.9	86.2	0.31	160.9	1.22
M	12.0	15.4	8.1	12.3	69.9	0.09	152.9	1.09
Pharmaceutical distribution industrial units								
F	–	–	–	–	–	–	–	–
R	5.2	6.7	3.3	3.7	84.8	0.12	132.2	1.18
M	17.6	21.0	14.7	18.2	61.5	0.06	144.1	1.18
All								
F	−17.7	4.0	−22.9	−18.4	86.7	0.63	164.7	1.5
R	4.5	8.7	−2.6	3.8	83.5	0.29	155.1	1.2
M	13.8	21.0	7.4	13.8	70.0	0.08	153.1	1.1

F Freezing chambers, *R* Refrigerating chambers, *M* Manufacturing workplaces

[a] Values are given as mean values

and pharmaceutical distribution industrial units, this limit may increase up to 70%. The mean air velocities are usually lower than 1 m/s but the intermittent operation of the cooling units lead to important fluctuations, especially in the cold chambers.

Individual parameters

The activity level, *M*, was estimated according to ISO 8996 (1990), using the methods of level II of accuracy. The standard procedure consisted of adding the metabolic rates corresponding to the posture, the type of work, the body motion related to the work speed and the basal metabolic rate, for each single activity. Whenever we got permission from the workers, the metabolic rate estimation was based on heart rate measurements, using a chest electrode belt with a telemetric heart rate transmitter (Sigma Sport PC 1600) placed on the subject. Nine measurements were performed and the results of these estimations have shown a good agreement with the standard procedure. The observation period for the description of the activity lasted for 1 h and was done by two observers.

The intrinsic thermal insulation of the ensemble, I_{cl}, was calculated following ISO 9920 (1995) by adding the values corresponding to each garment. For this purpose, a questionnaire with a set of figures representing different types of garments was used and the workers were asked to identify the garments worn. In order to consider the reduction of insulation due to body movements, I_{clr} was calculated by reducing I_{cl} values 20 and 10% for activities where *M* is higher or lower than 100 W m^{-2}, respectively (ISO/TR 11079 1993).

The present analysis is thus based on estimations of *M* and I_{cl}. As several authors have referred, these procedures are susceptible of errors. Holmér (2000) and Kähkönen et al. (1992) suggest that the main problem for the calculation of a correct *IREQ* is the accurate estimation of the metabolic rates. ISO 8996 (1990) indicates an accuracy of ±15% for the methods adopted while Parsons and Hamley (1989) have reported errors higher than 50%.

In the case of the thermal insulation of clothing, Parsons (2003) and Griefahn (2000) point out that the estimation method is affected by inaccuracies. McCullough (2001) refers that the summation formulas provide a quick and practical method for estimating the insulation of a clothing ensemble, but they are not theoretically valid and particularly should not be used on protective clothing ensembles. The main source of inaccuracy is in determining the appropriate values for individual garments. For typical indoor clothing, ASHRAE (2001) outlines overall accuracies on the order of ±25% if tables are used carefully. To assess these kinds of inaccuracies the thermal insulation of cold protective clothing was measured with a thermal manikin in a climate chamber (Oliveira et al. 2005b). The results show that the estimated values for 21 typical indoor garments were usually overestimated, but with no significant differences. For eight cold protective clothes the mean thermal insulation value was 0.35 clo above the estimated.

The last two columns in Table 2 show the mean results for the individual parameters that have been used in the present analysis. As it might be expected, the results for *M* show that higher physical activities are generally found in the freezing chambers and the highest values occur in the meat industry. On the other hand, the clothing insulation seems to be much more related to the air temperature, with the highest values obtained in the freezing chambers, where the mean I_{cl} vary from 1.18 to 1.80 clo.

Results and discussion

The relationships between the resultant clothing insulation, I_{clr}, and the required clothing insulation, *IREQ*, for both neutral and minimal criteria are shown in Figs. 1 and 2 for all the workplaces under analysis. If the selected clothing ensemble provides adequate insulation, the I_{clr} and the *IREQ* have identical values and the points that characterize this condition are located close to the identity line. This situation occurs whenever $IREQ_{\mathrm{min}} \leq I_{\mathrm{clr}} \leq IREQ_{\mathrm{neutral}}$. If the available clothing insulation is higher or lower than required, the points appear to the left or to the right of the identity line, respectively. In the area below, the growing distance to the identity line represents an increasing risk of hypothermia with progressive exposure, while in the area above, the higher the distance the larger the risk of overheating and excessive sweating. Both the figures show a slight tendency for the increase of the actual clothing insulation with the required insulation, and the correlation based on all data demonstrate this fact. However, this trend is far from the ideal situation, i.e., the identity line, which indicates that further attention must be given to these matters in order to adapt the clothing to the work environment.

An alternative graphical representation is shown in Fig. 3. The resultant clothing insulation (I_{clr}) and the required clothing insulation in terms of the neutral ($IREQ_{\mathrm{neutral}}$) and minimal ($IREQ_{\mathrm{min}}$) levels are now simultaneously presented. Ordering the values of $IREQ_{\mathrm{min}}$ increasingly, it is possible to group the different types of workplaces for all the activity sectors and therefore clearly identify the three characteristic zones mentioned before. Accordingly, the encircled zone on the left refers to the free-floating or controlled air temperature manufacturing workplaces, the refrigerating chambers are typically located in the centre and the freezing chambers are placed to the right. It must be underlined that the encircled zones are only representative since different types of workplaces can indeed be placed within each particular zone. The freezing chambers represent the most severe case since all of these workplaces reveal situations with insufficient clothing insulation ($I_{\mathrm{clr}} < IREQ_{\mathrm{min}}$). The manufacturing workplaces show an opposite situation since that the selected clothing ensemble widely provides too much insulation ($I_{\mathrm{clr}} > IREQ_{\mathrm{neutral}}$). The refrigerating chambers show results in the three possible situations ($I_{\mathrm{clr}} < IREQ_{\mathrm{min}}$, $IREQ_{\mathrm{min}} < I_{\mathrm{clr}} < IREQ_{\mathrm{neutral}}$ and $I_{\mathrm{clr}} > IREQ_{\mathrm{neutral}}$). From a global point of view, it is clear that the clothing ensembles worn by the workers are inadequate. In fact, only about 10% of the workplaces have an estimated I_{clr} value in the area between the $IREQ_{\mathrm{min}}$ and the $IREQ_{\mathrm{neutral}}$, where the selected clothing ensemble provides sufficient insulation. This condition seems to be better represented by the refrigerating chambers. The analysis of the relationships between I_{clr} and *IREQ*, for both criteria, shows that the actual I_{clr} increase is still far away from the required conditions depicted by both *IREQ* growing rates. The workplace with the highest difference between *IREQ* and I_{clr} clearly illustrates this evidence. It has been found in a freezing chamber from the milk food industry, with a difference between $IREQ_{\mathrm{neutral}}$ and I_{clr} that reaches 1.4 and 1.16 clo in the case of $IREQ_{\mathrm{min}}$ and I_{clr}.

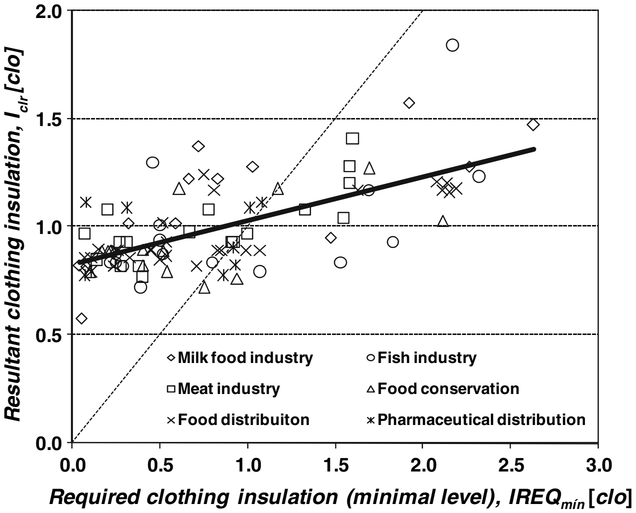

Fig. 1 Resultant clothing insulation (I_{clr}) versus required clothing insulation ($IREQ_{min}$)

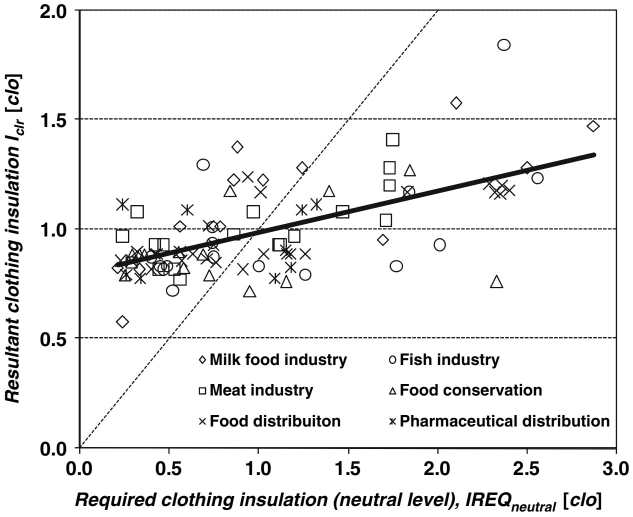

Fig. 2 Resultant clothing insulation (I_{clr}) versus required clothing insulation ($IREQ_{neutral}$)

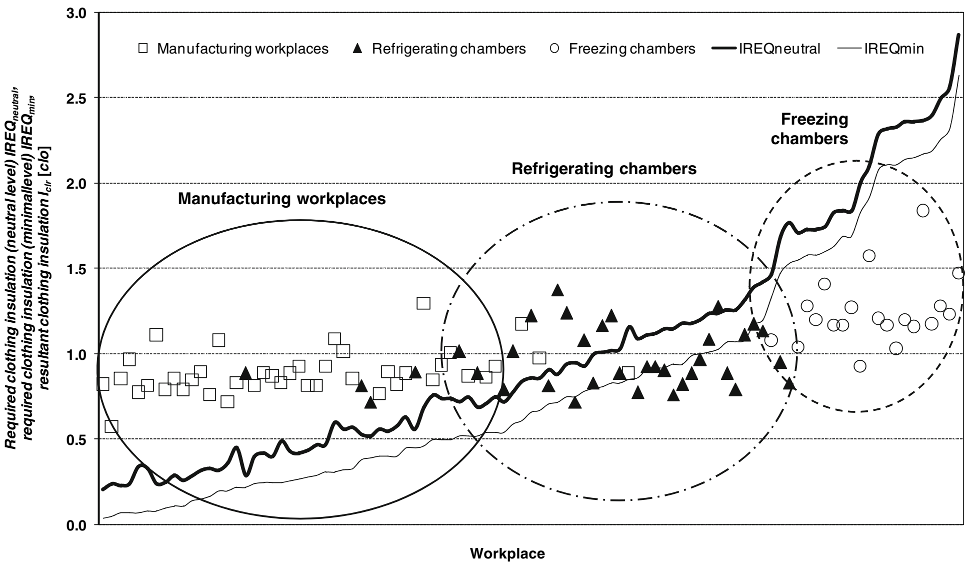

Fig. 3 Values of the required clothing insulation (*$IREQ_{neutral}$*, *$IREQ_{min}$*) and resultant clothing insulation (*I_{clr}*) in each workplace

The relationships between *DLE* and *IREQ* for the cases with insufficient clothing insulation ($I_{\mathrm{clr}} < IREQ_{\text{min or neutral}}$) are represented in Figs. 4 and 5. The higher values of *IREQ* are seen to correspond to the lower values of *DLE*. The *IREQ* ranged between 0.86 and 2.63 clo for the minimal level and from 0.91 to 2.87 clo for the neutral condition, while the *DLE* variation was between 0.42 and 6.41 h and from 0.35 to 4.46 h, respectively, for the minimal and neutral criteria. In addition, a clear distinction can be pointed out between freezing and refrigerating cold chambers. The results show that the refrigerating chambers led to higher *DLE* values and lower *IREQ* values, while the freezing stores are characterized by a greater level of strain, hence lower duration limited exposures and more requirements in terms of clothing insulation.

It is important to emphasize that the overall results show that the time shifts in the cold chambers consistently demand exposure periods higher than those suggested by the *DLE* calculations. When all sectors are considered as a whole, about one-third of the workers are exposed to the cold. Among the 101 workplaces under analysis, 21 have a continuous exposure greater than the DLE_{min}, from which 14 correspond to exposures above the DLE_{neutral}. Workers submitted to these conditions, on average, must remain in the workplace 60 min more than the calculated *DLE* value.

This is particularly relevant in the case of the freezing chambers and enhances the conclusion that these workplaces are in fact the most critical. An example from the fish industry can highlight this statement. It has a storage capacity for 1,500 ton of fish and is characterized by t_{a} and $\bar{t}_{\mathrm{r}}$ mean values of −18.4 and −17.5°C, respectively, by an *rh* mean value of 95.4% and a v_{a} mean value of 0.59 m/s. The period of exposure is approximately 6 h a day but, in terms of continuous exposure, it rarely exceeds 2 h. The

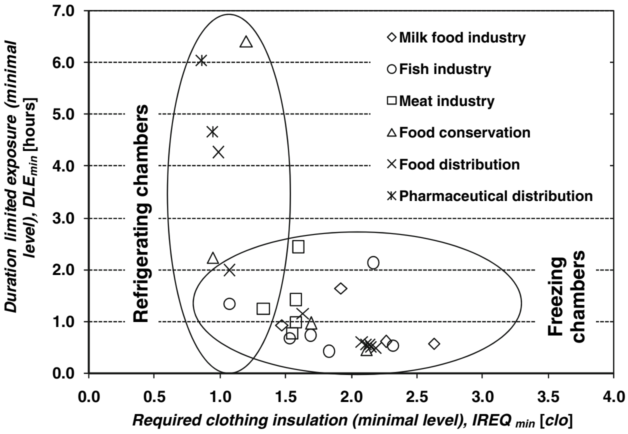

Fig. 4 Minimal level: duration limited exposure (*DLE*) versus required clothing insulation (*IREQ*)

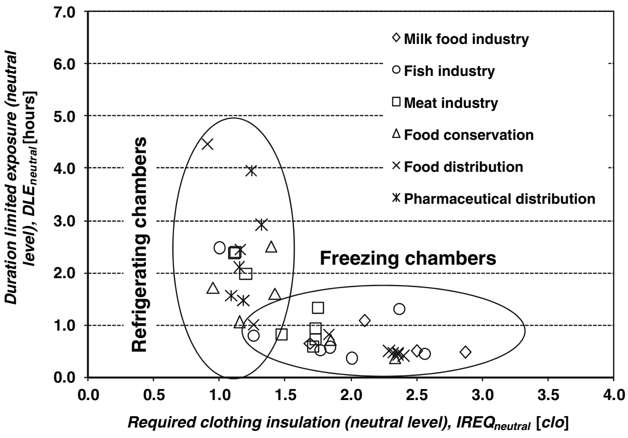

Fig. 5 Neutral level: duration limited exposure (*DLE*) versus required clothing insulation (*IREQ*)

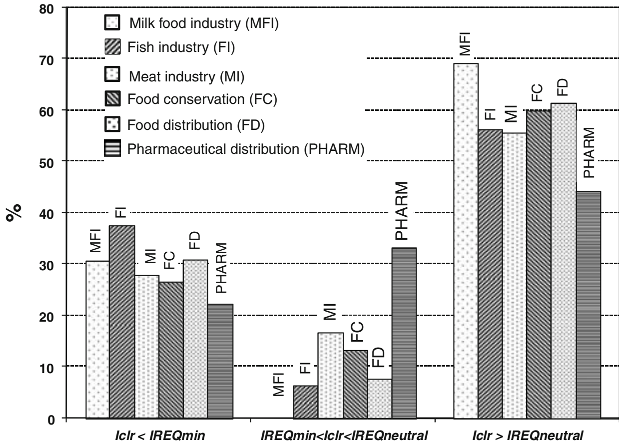

Fig. 6 Statistical results of the required clothing insulation index (*IREQ*) by activities

results are representative of the inadequate protection provided by the selected clothing ensemble. The estimated clothing insulation was equal to 1.54 clo, and the required insulation for both neutral and minimal levels were equal to 2.56 and 2.32 clo, respectively. Thus, this result corresponds to a situation where $I_{\mathrm{clr}} < IREQ_{\mathrm{min}}$. Furthermore, the time needed to complete the required tasks is much higher than the recommended duration limited exposure for both neutral and minimal levels (26 and 32 min, respectively).

Figure 6 summarizes the present survey with a statistical analysis by the type of industry, where it can be seen that in most of the workplaces the available clothing provides more than sufficient protection ($I_{\mathrm{clr}} > IREQ_{\mathrm{neutral}}$). Nevertheless, the percentage of workplaces with situations where $I_{\mathrm{clr}} < IREQ_{\mathrm{min}}$ is also relevant, namely in the fish industry (37.5%) and in the milk food and food conservation industrial units (30.8%). This condition is represented by a range between 20 and 40% of the cases. Such result and the reports made during the visits to the industrial units supports the conclusion that an important number of workplaces have indeed critical working conditions.

Conclusions

The results obtained in the present work show that the environmental conditions correspond to different types of workplaces and demonstrate that a significant percentage of the workers are repeatedly exposed to extreme conditions with insufficient clothing insulation. The low temperatures that characterize the refrigerating and the freezing chambers, associated with prolonged exposures, suggest deep changes in the work/rest regimes, particularly when the time needed to complete the required tasks exceeds the recommended duration limited exposure.

Therefore, further attention must be given to these issues in order to carefully adapt the choice of clothing according to the activity and to the work environment, mainly to their thermal properties. Indeed, not only the clothing insulation is sometimes insufficient, but also the opposite scenario is true, since the selected ensembles frequently provide more than sufficient insulation. The recommended pattern should therefore be represented by results in the clothing regulatory zone ($IREQ_{\mathrm{min}} \leq I_{\mathrm{clr}} \leq IREQ_{\mathrm{neutral}}$), which in fact correspond to the less frequent scenario.

As a final remark, it should be emphasized that the assessment strategies in the studies of human thermal environment should also consider methodologies focused on subjective analysis. Thus, to achieve a more complete characterization of the work environment, data about the worker (gender, age, medical background, subjective judgements about the protective clothing and the thermal environment) and the workplace (individual protection equipment, physical requirements of the activity, existence or not of rest periods, etc.), are relevant issues that should be taken into account. Thereby, as a complement to the foregoing evaluations, a questionnaire consisting of 24 questions was developed. So far, the authors have collected approximately 1,500 questionnaires, and the results of the statistical analysis are now being prepared for publication.

The present survey gives support to the first systematic description of the occupational cold exposure in the Portuguese industry. Furthermore, it provides the knowledge required to promote a sound risk analysis and to adopt preventive procedures and good practices, to improve the working conditions and to reduce the health problems related with cold environments. In fact, the number of people working under such thermal conditions is much more important than it was initially predicted by the authors and institutions responsible for these matters.

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