Original Article

Comparison of Changes in Physiological and Perceptual Indices of Cold Stress under Normal Clothing and Thermal Insulation Clothing among Automotive Service Workers in Isfahan

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Abstract

Aim: Exposure to cold can have negative physiological and psychological effects on human health. The purpose of this study is to compare the changes in physiological and perceptual indicators of cold stress under normal clothing and thermal insulation clothing (TIC) among automotive service workers (auto mechanics) in Isfahan, Iran. **Materials and Methods:** Using the simple random sampling method, this cross-sectional descriptive analytical study focused on 35 automechanics in Isfahan during the winter of 2021. Physiological indicators including cold stress index, cold sensitivity, core temperature (eardrum), skin temperature, systolic and diastolic blood pressure, heart rate, and environmental variables were measured before and after TIC. Data were analyzed using the SPSS version 21. **Results:** The index for cold sensitivity showed that none of the subjects wearing insulation clothes complained about the cold environment. Furthermore, the index for equivalent chill temperature was statistically significant before and after TIC ($P < 0.05$). No significant relationship was established for cold strain index before and after TIC ($P > 0.05$). After 1 h of exposure to cold, a significant relationship occurred between the average forehead temperature and hand temperature before and after wearing clothes ($P < 0.05$). **Conclusion:** Automechanics in Isfahan is affected by cold strain. The protective effect of insulation clothing on cold strain shows that required clothing insulation index is a strong indicator for evaluating cold stress according to the environmental parameters.

Keywords: Auto mechanics, cold stress, required clothing insulation index, physiological index

Introduction

Exposure to cold has always been a constant risk for human health, and its negative effects on people's health appear in both physiological and psychological form.[1,2] Psychological responses to cold include behavioral reactions, stimulation of cognitive performance, reduction of memory capacity and perception, and changes in mood and personality, which negatively affect social dynamics and could lead to apathy and reduced interaction with the environment.[1] The general complication of cold is hypothermia. It has various symptoms such as decrease in body temperature, consciousness, and heart rate (tachycardia and subsequently bradycardia); severe shivering; low contraction and stiffness of muscles; respiratory arrest; and even death in severe cases. Other symptoms of cold include freezing, frostbite, and immersion foot.[1] According to the experts, working at a temperature below 15°C is considered a cold environment,[2] and the combination of air velocity and air temperature determine the intensity of the effects of cold on the body. In this regard, higher air velocity and lower air temperature facilitate the harmful effects of cold on human health. Considering the dry temperature in most parts of the country and the workers' workload, Iran's Environment and Labor Health Center has set a 4-h time period as the maximum time allowed for working in the cold conditions.[3] To determine the combined effect of air velocity

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and air temperature, Ji W *et al*. proposed the Wind Chill Index (WCI). This index evaluates a person's exposure to cold based on the changes in two factors of temperature and air velocity and also assesses their impact on both the heat exchange between the skin and environment and the reduction of body temperature.[4]

The American Conference of Governmental Industrial Hygienists provides threshold limit values for exposure to cold and the risk of freezing on the basis of the wind chill temperature (WCT) index, which is obtained by calculating both temperature and air velocity. The following instructions are suggested according to the latest standards provided by this organization to support workers who are required to use their hands and fingers during their work:

- If delicate manual work is performed with bare hands for more than 10–20 min in a temperature below 16°C, warm air flow and radiant heaters or heating contact plates are required
- At temperatures below −1°C, the metal handles and control levers must be covered with thermal insulating materials
- If delicate, precise, and skillful manual work is not required, workers should use gloves if the air temperature drops below 16°C for work in sitting positions, 4°C for light work, and −7°C for medium work.[5]

Another important index in cold stress is the equivalent chill temperature (ECT). It refers to the air temperature with a slow current and a velocity lower than 1.8 m/s. ECT is calculated using a mathematical regression equation based on air temperature and air velocity in the form of numerical tables, which include the estimation of the risk of frostbite in different conditions.[6]

The American Industrial Hygiene Association has defined the risks of working under cold conditions based on the ECT and has presented different ranges of risk based on the amount of exposure to cold and air flow. Furthermore, this association proposes a work-rest program in the cold environment. According to this standard, the permissible limit under normal conditions is 10 min of rest for every 1 h of work.[7,8] According to the permissible occupational exposure limits (OELs) proposed by the Environmental and Labor Health Center of Iran, a decrease in body temperature below 35°C and 33°C causes hypothermia and disability, respectively. Furthermore, a decline in tissue temperature below 0°C leads to frostbite and 17.5°C is considered the lowest temperature that an adult can tolerate and recover. This center also adopts the WCT to assess the exposure to cold. Based on Iran's OEL, workers are allowed to engage in light and medium work in the temperature between 1 and −10°C for a period of 75 min.[5] The cold strain index (CSI) could determine the quantity of physiological cold stress. Based on the CSI, the mean body temperature (T_{core}), the mean skin temperature (T_{skin}), and the difference from the basic values are graded from 1 to 10.[9]

According to the statistics provided by various sources, about 16 million people are employed in Iran, 45% of whom are service workers, 30% work in agriculture, and 25% work in industrial areas. Furthermore, more than 9 million people work outdoors and are affected by climate change. Automechanics work outdoors for various reasons and are affected by changes in air temperature throughout the year.[10] In a study aimed to measure the cognitive performance of students, Pepler observed that the speed of doing tasks as well as errors increased in both cold and hot spectrums at 6 temperature levels from 16.7°C to 33°C.[11] The authors argued, the effect of temperature on cognitive performance also depends on the task: While analyzing the performance based on the type of work, in cold conditions, students' performance dropped by 28.05% in reasoning-required tasks, learning, or memory, and by 7.81% in tasks that required attention and understanding.[12] Investigating the effect of cold-insulating clothing on metabolism, Kuklane *et al*. showed that thick insulation clothing based on the required clothing insulation (IREQ) increases metabolism.[13] Saedpanah *et al*. studied automechanics in Hamadan (Iran) and confirmed that they were exposed to cold stress.[3] Because the majority of automechanics spend their time doing their tasks in an open environment and so far few studies have been conducted on cold stress among this population in Iran, it is imperative to investigate the exposure of this group of workers to the cold and evaluate the type of clothing they use. In this regard, the present study is aimed at comparing the changes of physiological and perceptual indicators of cold stress in these individuals in Isfahan. Furthermore, our study addresses the exposure of automechanics to cold and explores the efficiency of their clothing to promote their health and work efficiency.

Materials and Methods

This cross-sectional study was carried out in two stages. The first stage was devoted to measuring physiological and environmental factors while the subjects wore normal clothes; meanwhile, new clothes were designed and sewed based on IREQ index. In the second stage, physiological indicators and cold stress indicators of the subjects were appraised under thermal insulation clothing (TIC).

This study was conducted on 35 automechanics working in Isfahan during the winter (January 2021). The subjects were selected using random simple sampling, and the number of samples was calculated based on Equations 1 and 2.

$$n = \left(\frac{Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}}{\text{ES}} \right) \quad (1)$$

$$\text{ES} = \frac{|\mu_1 - \mu_0|}{\sigma} \quad (2)$$

In this formula, the reliability coefficient of 0.95 $(Z_{1-\frac{\alpha}{2}})$ is equal to 1.96, the power coefficient is $(Z_{1-\beta})$ equal to 0.84, and according to the statistical variables in previous studies, ES is considered equal to 0.4. Accordingly, the number of samples was estimated at 40 people. However, 5 subjects were excluded from the study due to errors in measuring the physiological indicators; thus the analysis was performed based on the results of 35 subjects.

The inclusion criteria were no history of smoking; taking heart medications, blood sugar lowering drugs, antidepressants and sedatives, antihistamines, and anti-Parkinson drugs; no thyroid disorders; not taking any medication before the test; as well as no history of cardiovascular diseases, breathing problems, and sleep disorders. These criteria were ascertained through questions from the participants. The exclusion criteria were the subject's noncooperation and incomplete questionnaire. In addition, the written consent form was obtained from all participants. Once the eligible subjects were selected, all the tests were fully taught to them and their demographic form was completed.

Evaluation of physiological responses, stress indicator, and cold strain indicator while wearing normal clothes

To calculate cold stress index and cold sensation index, we considered the following parameters: Ear temperature (tympanic membrane), skin temperature, systolic and diastolic blood pressure, heart rate, and environmental variables (air temperature, relative humidity, and air velocity). These parameters were measured in the workplace after passing at least 2 h of daily work in the morning shift.[14] Ear temperature was measured using a noncontact thermometer (LAICA TH2002, Italy); also, forehead temperature and finger temperature (index finger) were measured using a noncontact thermometer (Thermofocus 0700A2, Italy) in accordance with the ISO9886 recommendations. The accuracy of the thermometers used in this study was 0.1°C.[15]

A pulse oximeter (Pulse, China) was used to measure heart rate and blood pressure was measured with a digital sphygmomanometer (Omron comfort M6, China). Participants' metabolism was also calculated using Appendix C of ISO8996 2003 series. This standard provides the possibility of calculating a person's metabolism by considering individual factors such as gender, age, height, weight, and the number of heartbeat per minute.[16]

To calculate the WCI, we measured environmental parameters of air temperature and air velocity using a thermometer and a thermal anemometer according to the ISO7726 standard.[17] Furthermore, Equation 3 was used to calculate the WCI in terms of W/m^2:

$$WCI = (t_a)\,(10V^{0.5} - V + 10\ 45) \quad (3)$$

T_a = Dry air temperature in degree Celsius.

V = Air flow speed in m/s,

The ECT index (watts/m^2) was also calculated according to Equation 4 to determine the amount of heat loss in real time.

$$ECT = 33 - \frac{WCI}{25.5} \quad (4)$$

In this research, two methods were used to determine the amount of cold strain: Calculating the CSI (quantitative method) and then determining perceptual responses of the subject (qualitative method). Finally, the results of these two methods were compared. A thermal comfort questionnaire was used to measure the perceptual factors. Accordingly, the subjects were asked to express their cold sensitivity at the same time as their physiological responses were measured by the researcher. These expressions were recorded by the researcher.[18] To determine the CSI, we measured the temperature of the tympanic membrane and the skin temperature at two different times: (1) Before the subjects started their work and (2) At specific intervals while they were doing outdoor activities (Equation 5).

$$CSI = 6.67\,(T_{core\ t} - T_{core\ 0})\,(35 - T_{core\ 0})^{-1} + 3.33\,(T_{-skt} - T_{-sk0})\,(20 - T_{-sk\ 0})^{-1} \quad (5)$$

Calculating the required clothing insulation index

The IREQ was calculated for each person and their average was considered as the required amount of clothing insulation, which was equal to 2.6 (Clo). Equation 6 was used to calculate the IREQ.

$$IREQ = \frac{t_{sk} - t_{cl}}{M - W - E - H_{res}} \quad (6)$$

Evaluation of physiological responses, stress index, and cold strain index after wearing insulation clothing

After the participants wore the insulating clothes, their physiological indicators including the skin temperature (hands and forehead) and the temperature of the eardrum (as a representative of the core body temperature) were measured 4 times (with 20-min intervals) after the subject started working in the morning. Furthermore, at this stage, environmental indicators such as WCI, ECT, and other indicators mentioned in the first stage were calculated and compared with the values obtained in the second stage. The results were recorded to be compared with those of standard occupational exposure to cold under TIC. Using the measured values of the physiological responses of the subjects, we calculated the strain index and CSI and recorded the results to be compared with the results of working under normal clothing condition. The subjects' perception of cold was also recorded in the cold environment.[19,20]

Data analysis

The data were analyzed using SPSS version 21 (IBM Corp, Armonk, NY, USA). The data before and after using TIC were compared through paired *t*-test. The selection of the test method was based on the normality of data as well as the goal set in this research, which was to compare the data in two stages before and after the intervention. $P < 0.05$

was considered statistically significant in the statistical tests performed in this study.

Results

According to the results of this research, the average age of subjects was 33.82 years and the standard deviation was 9 years. Furthermore, 11 subjects had <5 years of work experience, 16 subjects had 5–10 years of work experience, and 8 subjects had more than 10 years of work experience. On average, the subjects had 8 years of work experience. The average weight and height of the subjects were 78.28 kg and 176.31 cm, respectively. The average rate of metabolism in the subjects before and after wearing insulating clothes was 103.64 ± 31.11 and 114.48 ± 24.02 W, respectively. The average body mass index of the subjects was 25.31. The results of measuring environmental parameters (air velocity, relative humidity, and air temperature) are presented in Table 1.

According to Wilcoxon nonparametric test, there was a significant relationship between average WCI before and after wearing thermal insulation clothes ($P = 0.002$). According to Table 2, the average WCI before and after TIC was 551.4 and 667.2 kcal/h/m^2, respectively. Since this index is between 500 and 600 kcal/h/m^2, the air temperature is in the cool zone, according to the nomogram for specifying wind cooling index. According to the ECT values, which were 28.68 before TIC and 27.73 after wearing them, there is no possibility of frostbite even with normal and minimal clothing.[21] According to the results of the index for cold sensation, which was measured qualitatively by asking the subjects' perceptions while wearing thermal insulation clothes and normal clothes, none of the subjects complained about the cold environment after wearing thermal insulation clothes. The values of ECT index before and after TIC are statistically significant ($P = 0.003$), showing that the average of this variable decreased after TIC. Furthermore, the relationship between the WCI before and after TIC was significant ($P = 0.002$), such that the value of this variable increased by insulation clothing. However, no significant relationship was associated with CSI before and after TIC ($P = 0.726$).

Based on Wilcoxon nonparametric test, Figure 1 shows that after 1 h of exposure to cold, there is a significant relationship between the average forehead temperature before and after TIC ($P = 0.009$). The highest forehead temperature before TIC was 33°C at 8:20 and the lowest was 32.7°C at 8:40. Furthermore, according to Figure 1, the highest forehead temperature after TIC was at 9:00 am and the lowest was at 8:00 am.

Figure 2 depicts that based on the results of paired *t*-test, there is a significant relationship between the average hand temperature before and after TIC ($P = 0.001$). The highest hand temperature recorded before TIC was 26.3 at 8:00 am and the lowest was 25.6 at 8:40 am Furthermore, according to Figure 2, the highest skin temperature after TIC was at 9:00 am and the lowest was at 8:00 am.

According to Wilcoxon nonparametric test, there is a significant relationship between the average heart rate before and after TIC ($P = 0.03$). As Figure 3 illustrates, before and after TIC, the highest heart rate was at 9:00 am and the lowest was at 8:00 am. According to the data presented in Figure 4, a significant difference was observed in the alterations of cold

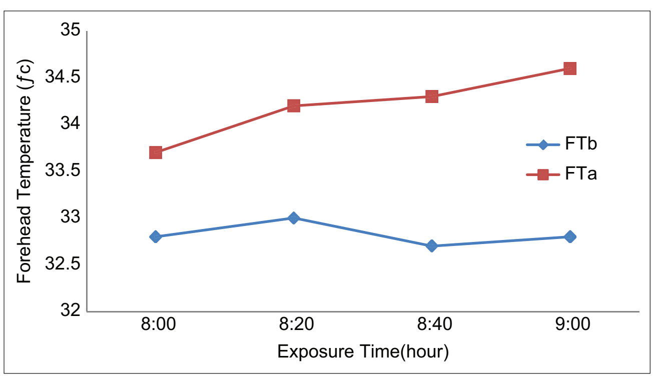

Figure 1: Comparison of FTb and FTa wearing clothing insulation. FTb: Forehead temperature before, FTa: Forehead temperature after

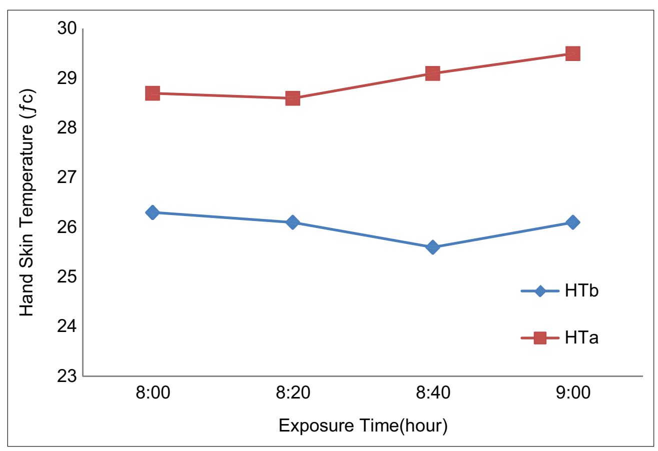

Figure 2: Comparison of HTb and HTa wearing thermal insulation clothes. HTb: Hand skin temperature before, HTa: hand skin temperature after

Table 1: Comparison of environmental parameters measured before and after the intervention

Variable	Minimum	Maximum	Average before TIC	Average after TIC	*P*
Air flow speed (m/s)	0.06	1.60	0.35±0.31	0.44±0.41	0.188
Relative humidity (%)	0	31	114.14±64.91	1.28±7.251	0.026*
Air temperature (°C)	0	12	6.11±3.94	7.93±2.3	0.001*

*Significant association ($P<0.05$). TIC: Thermal insulation clothing

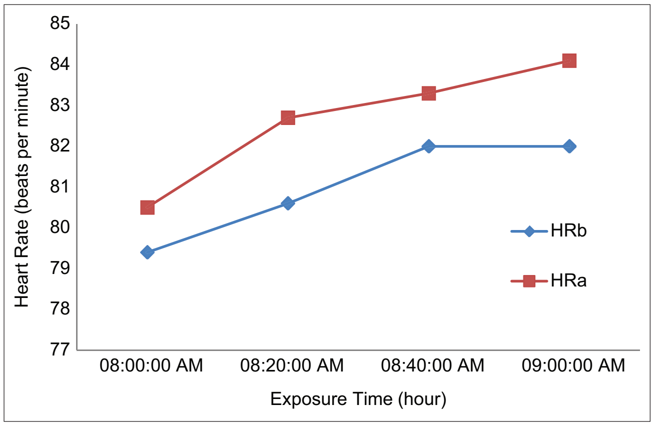

Figure 3: Comparison of changes in HRb and HRa wearing thermal insulation clothes. HRb: Heart rate before, HRa: Heart rate after

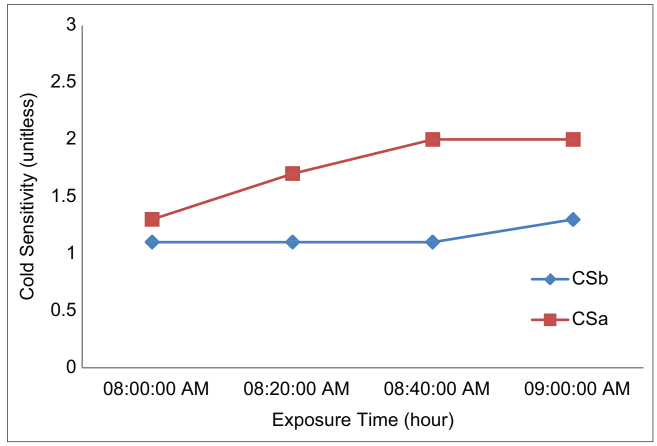

Figure 4: Changes in CSb and CSa wearing thermal insulation clothes. CSb: Cold sensitivity before, CSa: Cold sensitivity after

Table 2: Values of cold exposure indicators in automechanics during activity

Variables	Before TIC	After TIC	*P*
WCI (W/m²)	551.4±3.58	667.2±2.12	0.022*
Equivalent cooling temperature (°C)	28.68±2.39	27.7±2.16	0.003*
CSI	4.94±3.09	4.87±2.96	0.726

*Significant association ($P<0.05$). TIC: Thermal insulation clothing, WCI: Wind chill index, CSI: Cold strain index

sensitivity prior to and following the utilization of thermal insulation garment.

Discussion

The present study aimed to measure and compare the changes in physiological and perceptual indicators of cold stress in automechanics in two different conditions: Normal clothing versus TIC. The IREQ index was used to determine the level of exposure to cold.

Several methods have been developed and are used to predict the effects of cold exposure. The major physiological concerns about working in cold environments are whole body cooling, which may lead to hypothermia and localized cooling, which may cause cold injury. If exposure to cold is accompanied by pain and discomfort, it becomes a serious problem because it affects people's safe behavior. Two methods to solve these problems are: IREQ for whole body cooling and WCI for localized cooling. The concept of IREQ is that the body is only allowed to cool down to a certain extent for a period of 8 h, which equals a normal working day. IREQ is a method used to prevent the cooling of the body temperature and hypothermia of people exposed to cold. The IREQ index shows that clothing is inadequate in most workplaces. It also specifies how much insulation is needed to maintain thermal balance during a working day at a given physical activity level (metabolic rate) and thermal conditions (air temperature, radiation, air velocity, and air humidity). IREQ can be used for air temperatures below +10°C.[22] According to the findings of the present study, significant changes were observed in the forehead temperature of the automechanics before and after TIC. Indeed, this temperature increased after wearing thermal insulation clothes. Field inspection shows that most of the automechanics engage in outdoor activities, which expose them to temperature changes. Furthermore, these workers are required to do manual work, which makes the effect of cold on their performance all the more substantial. Skin temperature is a common physiological parameter that reflects human thermal responses during environmental changes and it depends on air temperature and time spent in that environment. Weather factors such as air velocity and humidity may also cause changes in the skin temperature.[1] Heus' study showed that a 15–20°C decrease in finger temperature leads to a decline in performance.[3] In the present study, skin temperature increased after wearing thermal insulation clothes. In the present study, skin temperature increased after wearing thermal insulation clothes. These findings were consistent with the study of Kuklane *et al*. and showed that the subjects could continue working at IREQ defined conditions without further cooling. The subjects reported feeling, on average, between neutral and slightly warm.[23] Austad *et al*. considered a temperature of 15°C and below to be an appropriate limit for the fingers because the inability to do work begins at this temperature. This study also showed that the perceptual cold index, obtained from the verbal responses of participants during the test, was not correlated with the results of measuring the temperature of the fingers, suggesting that different people do not have the same cold sensitivity.[24] Cold sensitivity is an important factor in creating a feeling of comfort at workplace, but it varies depending on the level of previous exposure to cold that a person experiences. Meanwhile, in the present study, the participants did not complain about the cold after wearing thermal insulation clothes. The study conducted by Wu *et al*. showed that skin temperature and blood pressure are the most important indicators for measuring the risk of cold stress in the cold environment.[25] Finger temperature is an essential indicator for hand and finger flexibility and exposure to temperatures below −5°C for more than 20 min leads to serious injuries and reduces hand function.[18] In a very cold environment, the temperature of the human skin, especially temperature of the organs, decreases rapidly. This in turn can reduce the dexterity of hands and fingers, muscle function, and grip strength, ultimately affecting physical performance and even causing frostbite. Previous studies support that skin temperature drops if the duration of exposure in an environment with a lower temperature exceeds a certain limit.[4,8,14,26] Most of these studies have been carried out at temperatures above 0°C. Only a few studies have investigated exposure to cold below 0°C, still they have mostly focused on a low-temperature environment. In a very cold environment, body parts that are exposed to cold air are more vulnerable; for example, skin pains caused by cold occur when the skin temperature drops below 18°C.[18] The temperature of the finger changes twice as fast as the temperature of the face. This can be related to blood circulation, since the fingers are located at the bottom of the human body and the blood flow is low, which may result in numbness and pain in the skin. Intense impairment of manual function can be triggered when the finger temperature is <20°C.[3] Blood pressure is an important indicator in evaluating physiological response in a cold environment. A rapid increase in blood pressure is a major risk factor for cardiovascular diseases such as heart attack or stroke. The increase in blood pressure in response to exposure to cold conditions could be due to general environmental resistance. Skin vessels contract due to increased heat loss of the body in a cold environment. On the other hand, upon exposure to cold, the human sympathetic nervous system is stimulated and in order to protect the body against cold, it releases catecholamine that simultaneously constrict peripheral blood vessels and lead to an increase in blood pressure.[27] In addition, the more the surface of skin is exposed to cold, the more blood pressure will change, especially when the face is also exposed to cold.[8] This shows that blood pressure increases immediately after exposure to cold but stabilizes at a high level after 5 min, even though skin temperature continues to decrease.[28] The findings of the present study showed that the effect of frequent exposure to cold on blood pressure was not significant. This is consistent with the study by Li *et al*., who found that systolic blood pressure responds to cold in the first 5 min and continuous exposure to cold is not significantly different in all four clothing groups (normal winter clothing without a hat, with a hat, with an extra pair of pants and with an extra hat and extra pants).[19] Previous studies have shown that exposure to chronic and repeated cold causes significant cooling of the whole body and leads to more obvious physiological responses, including increased vasoconstriction and metabolic rate.[11,19] In the study by Joon on the relationship between exposure to cold and high blood pressure, it was shown that systolic and diastolic blood pressure was significantly higher among workers exposed to cold compared to subjects who were not exposed to cold; thus, core body temperature was also lower in the former group.[29] In the present study, no significant relationship was observed between changes in systolic and diastolic blood pressure among the subjects exposed to cold before and after the intervention (TIC). The extent of blood pressure changes is probably related to environment temperature and convection heat transfer, but one's age and physical fitness may also affect it. The present study indicated that the subjects had levels of cold stress when exposed to cold.[30] Gavhed *et al*. reported that cooling the face and respiratory organs constricts arteries and veins and affects not only the circulatory system of the organs but also the coronary veins, hence increasing blood pressure.[18] In the present study, participants' heart rate increased after wearing thermal insulation clothes and being exposed to cold conditions. Exposure to cold leads to a decrease in heart rate. When the subjects were first exposed to cold, heart rate decreased significantly, but as the time went by, and the activity of the subjects increased, heart rate has increased as well. Previous studies confirm the relationship between the increase in cardiovascular diseases and cold weather.[12] The findings of the present study are consistent with the study by Wu *et al*. and showed that normal clothing and exposure to cold for 30 min could lead to significant changes in some physiological responses such as local skin temperature, core temperature, blood pressure, oxygen concentration, heart rate, and respiratory rate. Local skin temperature and blood pressure are the most critical indicators in assessing the risk of cold stress during exposure to cold.[5] In this study, ear canal temperature measurement was used to measure core body temperature, because it has less interference with the worker's activity than other methods. The measurement results showed that the relationship between changes in the core body temperature before and after TIC did not change significantly. This is not compatible with the results reported in Kim's study. It seems the duration of people's exposure to cold contributes to this difference; thus, workers' exposure in Kim's study was 8 h of continuous work under normal clothing in a cold environment,[30] yet in the current study, it ranged from 1 h to 1 h and half. Wu *et al*. confirmed that the ear is the most sensitive organ to environmental temperature changes. Therefore, it is very important to protect workers' ears when they suddenly enter a cold environment. Furthermore, there are functional correlations between local skin temperature and temperature perception, with the ear showing the best correlation in this regard.[5] In the present study, the CSI decreased slightly after TIC, but the changes before and after TIC were not significant. This finding is different from the study by Saedpanah *et al*., who reported a significant relationship between CSI, environmental factors, and other physiological responses including finger skin temperature and finger sensation. These authors confirmed that CSI can be used as an accurate index to evaluate cold strain in cold outdoor spaces.[3] In the present study, WCI increased following TIC. This index is dependent on air temperature, air velocity, and humidity. This is in agreement with the study by Du *et al*., who reported that there is a relationship between WCI and human perception in cold environment. It could be said that following the rise in WCI, caused by changes in environmental factors, the involuntary mechanisms associated with increased body temperature are activated. This, in turn, contributes to increasing skin temperature. This heightened temperature is preserved when thermal insulation clothes are used compared to the time when normal clothes are worn.[31] Both clothing insulation and surface-air-layer insulation are strongly affected by changes in air velocity and body movements. Therefore, wind and body movements also affect the physiological responses of the person.[32] Cold sensitivity may be attributed to both the cooling of the skin and the decrease in the core body temperature. All parts of the body are more sensitive to cold than heat. The highest thermal sensitivity is in the face and the lowest is in the lower limbs. Moreover, pain is felt when the skin temperature is less than about 15°C and more than 45°C.[27,33] The current study had some limitations: (1) The simultaneous collection of physiological data with the spread of the coronavirus, which slowed down the primary design of the study, (2) Not accessing thermal resistance values for fabrics produced by manufacturing industries, and (3) Unavailability of detailed information on these types of fabrics.

Conclusion

The results of the present study substantiate that wearing thermal insulating clothes has a positive effect on some physiological indicators (forehead temperature, skin temperature, and blood pressure) of the individuals exposed to cold. The results of this study highlight that auto mechanics in Isfahan are under cold stress and the mitigating effect of clothing insulation on cold stress supports that the IREQ index is a strong indicator in determining cold stress according to the environmental parameters. The current study implemented the IREQ index, which was derived from the tables available in the existing sources for the amount of Clo in different fabrics. Furthermore, the type of clothing insulation was selected from what is available in the market. In this way, the next step for future studies can be to measure physiological indicators in a laboratory environment to compare the effect of clothing insulation versus normal clothing on these indicators and also to check the approximation of the IREQ value in field and laboratory studies.

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Ethical code

The study was also approved by the Ethics Committee of Isfahan University of Medical Sciences, No. IR.MUI.research.REC.1399.306.

Conflicts of interest

There are no conflicts of interest..

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