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ORIGINAL RESEARCH

Influence of Different Protection States on the Mental Fatigue of Nurses During the COVID-19 Pandemic

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Background: COVID-19 has brought greater workload pressures to the medical field, such as medical staff being required to wear personal protective equipment (PPE). While PPE can protect the safety of staff during the pandemic, it can also accelerate the accumulation of fatigue among operators.

Objective: This study explores the influence of different protection states on the mental fatigue of nurses.

Methods: In this study, 10 participants (5 males and 5 females) were randomly selected among applicants to monitor mental fatigue during the nurses' daily work in four different PPE states (low temperature and low protection; low temperature and high protection; high temperature and low protection; high temperature and high protection). The NASA subjective mental fatigue scale was used for subjective evaluation. Reaction time, attention concentration, attention distribution, memory, and main task completion time were used for objective evaluation.

Results: The results demonstrated a significant difference in the effects of different protection states on mental fatigue. The state of high temperature and high protection had the greatest influence on mental fatigue, the state of low temperature and low protection had the least, and states of high (low) temperature and low (high) protection had intermediate effects on mental fatigue. Furthermore, the correlation between the subjective and objective fatigue indices was analyzed using a multiple regression model.

Conclusion: This study clarified the influence of different protection states on the mental fatigue of nurses, and verified that nurses require more time and energy to complete the same work as before under high protection states. It provides a basis for evaluating the mental fatigue of nurses in the unique period of the COVID-19 pandemic and specific ideas for optimizing the nursing process.

Keywords: COVID-19, personal protective equipment, mental fatigue, experimental research, nurse

Introduction

Globally, at the time of writing, there have been 608,328,548 confirmed cases of COVID-19 reported to the World Health Organization (WHO), including 6,501,469 deaths.[1] Today, the COVID-19 pandemic can be considered the largest global health problem, which brings great burden to the medical field by requiring the medical staff to endure an increased workload, work fatigue, and risk of disease infection.[2,3] Because COVID-19 is highly contagious, the UK's National Health Service requires medical staff to wear personal protective equipment (PPE) during the treatment of patients to reduce the risk of infecting or spreading COVID-19.[4]

PPE plays a critical role in protecting medical staff from infectious diseases.[5] While PPE successfully blocks the virus from entering the body, it also limits the body's heat exchange with the surroundings. In addition, the restriction of movement caused by the obstruction of PPE threatens the health and work efficiency of medical staff.[6–8] While using PPE, medical staff experience a higher sweat rate, increased heat discomfort, and fatigue, which can increase heat stress and reduce human health

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and physiological function.[4,9,10] Thus, negatively affecting work performance. Cvirn et al found that participants exposed to high temperature (33–35°C) for a long time were not only prone to dehydration, but also likely to suffer from complex cognitive impairment.[11] Cyril et al found that those increasingly hot environmental conditions induce adverse cognitive functions and negatively affect behavioral performance results, and additionally found an inverted U-shaped relationship between temperature and cognitive performance.[12]

The medical field has always experienced heavy demands, high-pressure, and complications, meaning the fatigue of medical staff have long been a topic of interest in the academic field. Fatigue is defined as a common and potentially debilitating symptom that affects an individual's health and quality of life.[13] Due to the diversity, urgency, complexity, and variability of medical procedures, there is a large amount of information processing content and associated cognitive processes involved in the daily operations of medical staff, which easily causes mental fatigue.[14,15] Mental fatigue is defined as a psychobiological state caused by long-term and/or intense cognitively demanding activities, and is characterized by subjective feelings of "tiredness" and "lack of energy".[16] In the medical field, mental fatigue is the primary manifestation of fatigue.[17,18] In addition, some studies have suggested that PPE can promote the accumulation of mental fatigue. For example, Kumar et al evaluated the influence of PPE on the physical and mental health of medical staff and the influence on patient safety. They found that 77% of patients experienced execution errors and inattention while wearing it.[19] Benítez et al assessed the influence of PPE worn by surgeons during emergency surgeries during the COVID-19 pandemic, and found that the use of such equipment affected their non-technical skills, decision-making, and increased fatigue.[20]

Personal protective equipment (PPE) can protect against or mitigate the risk of accidents and occupational hazards during an operation.[21] PPE has a wide range of applications in building construction, fire protection, and medical treatment. During the COVID-19 pandemic, PPE relieved the psychological stress of healthcare workers by protecting their safety and reducing the risk of virus transmission.[22–24] However, wearing PPE also has a negative impact on the operator. For example, LeBlanc et al investigated the types and prevalence of PPE-related skin lesions among Canadian health professionals and showed that wearing PPE can easily cause a variety of complications including postauricular soreness, acne, skin redness, skin breakage, and increased perspiration.[25] Yunus et al found that wearing PPE with N95 masks may cause discomfort, headaches, inattention, irritability, etc., and that wearing PPE may also cause eye pain and exhaustion due to mask reflection and refraction of light.[26] Jin et al also proposed that PPE not only increases operator fatigue, but also affects the work performance of operators.[27] Therefore, PPE can protect the operator from danger but can also cause physiological or operational performance effects.

There are many levels of PPE used within COVID-19 situations, with associated differences in the resulting conditions in which operators work. Therefore, a systematic study on the influence of the different protection states of PPE on mental fatigue will help evaluate the mental fatigue of medical staff, and provide ideas and guidance for further optimization of the medical operation process in these unique times to reduce the fatigue accumulation of medical staff. This study explores the influence of different protection states on the mental fatigue of nurses. Considering that a large proportion of nurses are medical operators who are involved in complex operation scenarios and close contact with patients, nursing operations are used as the research object within this study.[28]

Methods

Participants

There were 10 participants (five men and five women) within this experiment. The age, weight, and height of the participants were 22±3 years old, 63±16 kg, and 170±10 cm, respectively, and all the participants were right-handed. The participants were required to be in good health and have no history of disease. In the early stage of the experiment, the participants were required to have adequate sleep, a regular daily life, and not do strenuous physical labor before the experiment. The 10 participants were randomly selected from qualified candidates, ensuring an equal number of men and women.

Experimental Conditions

The experiment was carried out in a laboratory, where the humidity was controlled at 55±5%, and the noise was controlled below 40 dB. Four experimental conditions were developed, namely low temperature and low protection, low temperature and high protection, high temperature and low protection, and high temperature and high protection. Low protection status is the daily protection status of nurses before the COVID-19 pandemic, and high protection status is generated under the influence of the COVID-19 pandemic; therefore, low protection status served as the control group of this experiment. Specifically, high temperature was defined as 30 °C and low temperature as 15 °C. Specific experimental conditions are shown in Table 1, and a diagram demonstrating the classification of low and high protection is shown in Figure 1.

Experimental Tasks and Procedures

Based on observations of nurses' daily mental work, this study designed four representative tasks for the experiment: inputting patient data information, distributing drugs, monitoring patient data information, and confirming medical goods information. The specific contents of each experimental task are shown in Figure 2.

The study conducted a pre-experiment to verify the overall experimental process. The experimental procedure involved each participant completing an experiment under four different experimental conditions, as detailed in Table 1. Three rounds of the experimental tasks presented in Figure 2 were required to be completed in each experiment. In order to eliminate the influence of experimental order, the four experimental conditions in Table 1 were designed in Latin square order, and the four experiments of each participant were arranged on different dates to ensure that the cognitive state of the participants had been restored before each experiment began. Before the experiment commenced, the participants were uniformly trained to understand and master the whole experiment process.

Experimental Indices and Instruments

To collect the mental load state of the participants within the experiment, data were collected regarding two aspects: subjective index and objective index.

In terms of subjective index, this experiment adopted mental demand items from the NASA Scale to conduct subjective evaluation of mental load. The scale requires participants to give subjective scores on mental activities (such as thinking, decision-making, calculation, memory, searching, etc.) in the process of completing a round of experimental tasks. The score is given on a scale of 0–100, with zero being the lowest level of mental demand and 100 being the highest.

The collection of objective indices mainly involves two aspects. One is to use main task completion time to evaluate the work performance of the participants. The other is to use experimental instruments to evaluate the participants' information processing, and hence to reflect the mental fatigue. In the evaluation of information processing, the change of information perception ability was evaluated by obtaining an index of reaction time, the change of attention was evaluated by obtaining indices of attention concentration and attention distribution ability, and the change of memory was evaluated by obtaining an index of memory. Objective indicators were collected at the beginning of the experiment and after the completion of each round of experimental tasks. They were measured for four times in total. The experimental instruments used to evaluate the above indices are shown in Table 2. The following are the experimental instruments used to evaluate the above indices: a visual reaction time tester, a concentration ability tester, an attention distribution experiment, and instantaneous memory apparatus.

Table 1 Design of Experimental Conditions

Experimental Conditions	P_{L*L}	P_{L*H}	P_{H*L}	P_{H*H}
Disposable surgical mask for medical use	√		√	
KN95 protective mask		√		√
Protective clothing for medical use		√		√
Disposable sterile rubber examination gloves		√		√
Medical isolation shoe cover		√		√
Medical face shield		√		√
Disposable medical cap		√		√
Temperature	15°C	15°C	30°C	30°C

Abbreviations: P_{L*L}, low temperature and low protection; P_{L*H}, low temperature and high protection; P_{H*L}, high temperature and low protection; P_{H*H}, high temperature and high protection.

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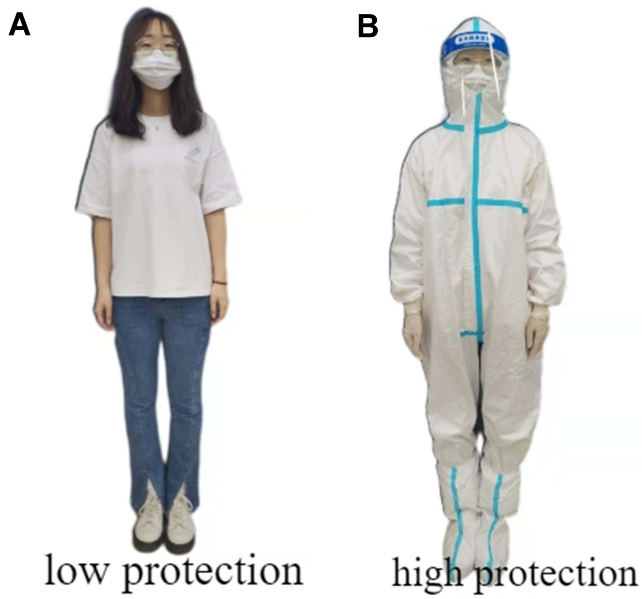


Figure 1 Experimental design ((**A**) low protection; (**B**) high protection).

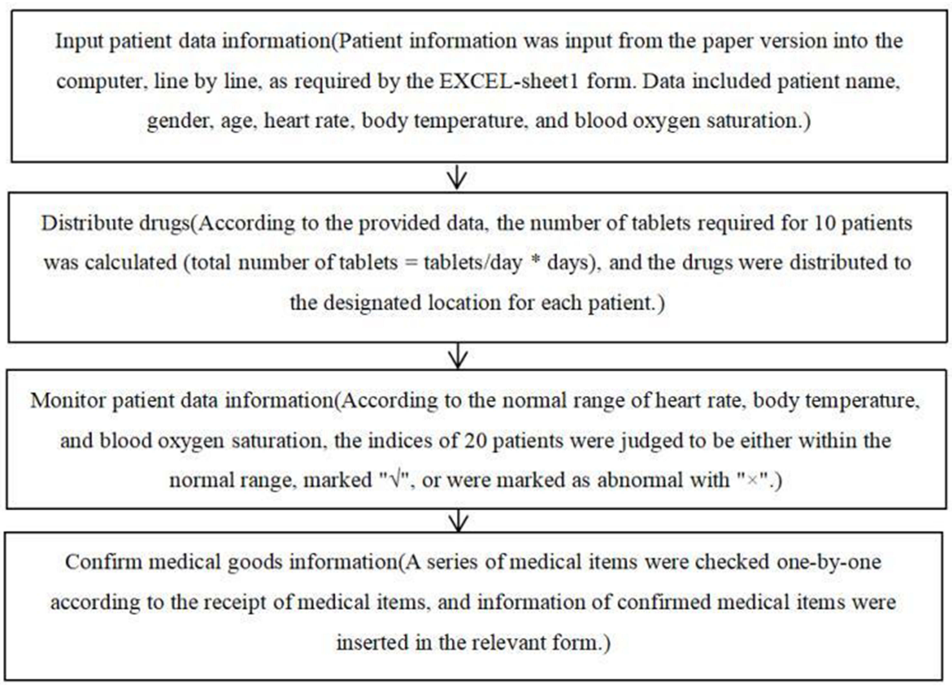


Figure 2 Experimental tasks.

Results

Objective Indices

Reaction Time

Reaction time is a common index to measure information perception, which was used to measure an individual's information perception ability under four different protection states. The reaction time data was sorted according to different protection states and different experimental stages of each participant, as shown in Figure 3.

Table 2 Experimental Instruments

Index	Instrument	Manufacturer	Model	Parameters	Descriptions
Reaction time	Visual reaction time tester	Beida Jade Bird	BD-II -511 Type	Reaction time	When the participants notice the light stimulus, they immediately press the response button, and this process was repeated 10 times for both the left and right hands. The time interval between the appearance of the light signal to the pressing of the button is the reaction time. The shorter the response time, the stronger the information perception ability.
Attention concentration	Concentration ability tester	Beida Jade Bird	BD-II -310 Type	Successful time	Under the interference of noise, the participant track the light spot on the moving disc with the probe of the test rod for 120s. The successful time is the total time of the probe on the spot within 120s.
Attention distribution	Attention distribution experiment	Beida Jade Bird	BD-II -314 Type	Q value	Participants were first asked to judge sound stimuli with different tones (low, medium and high), and then light stimuli with different positions. Finally, they were asked to judge the sound and light stimuli simultaneously by pressing the left and right buttons, respectively. The calculation formula of Q value is as follows: $Q = \sqrt{\frac{S2}{S1}} * \sqrt{\frac{F2}{F1}}$ Where S1 is the response time of the participants to the sound stimulus; S2 is the response time of the participants to the sound stimulus when both sound and light stimuli appear simultaneously. F1 is the response time of the participants to the light stimulus; F2 is the response time of the participants to the light stimulus when sound and light stimuli appear simultaneously.
Memory	Instantaneous memory apparatus	Beida Jade Bird	BD-II -408 Type	Instantaneous memory retention	The instrument randomly generated three lines and four columns of numbers or letters, and asked the participants to type the required line from memory after 9.99 seconds. Instantaneous memory retention = average number of correct answers ×3 (maximum 12)

The horizontal axis of Figure 3A represents each participant, the vertical axis represents the reaction time after averaging the test results from the four rounds, and the four lines respectively represent the reaction time under different protection states. The shorter response time indicated higher information perception ability. According to the results, the

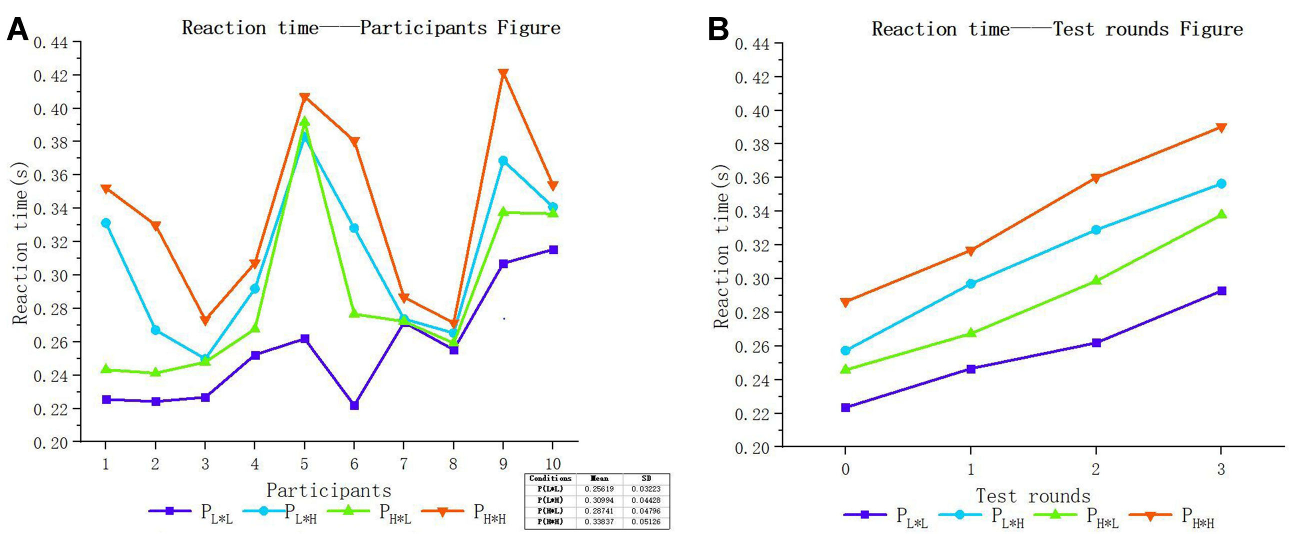


Figure 3 Test results of reaction time ((**A**) Reaction time - Participants; (**B**) Reaction time - Test rounds).

reaction time of each participant was the longest under the high temperature and high protection condition, and the reaction time was the shortest under the low temperature and low protection condition. The reaction time under the low temperature and high protection condition was slightly longer than that under the high temperature and low protection condition. Therefore, it is clear that different protection states have an influence on people's information perception ability, and the information perception ability is the worst under high temperature and high protection conditions, best under low temperature and low protection conditions, and intermediated under conditions of low (high) temperature and high (low) protection.

The horizontal axis of Figure 3B represents the number of test rounds for the objective index before the experiment (0), after the end of the first round (1), after the end of the second round (2), and after the end of the third round (3). The vertical axis represents the reaction time after averaging the test results of 10 participants; the four lines represent the reaction time under different protection states. As seen from the results, an increasing number of test rounds give rise to a trend of increasing reaction times under the four protection states. Within each round of testing, the reaction time was the longest under the high temperature and high protection condition and shortest under the low temperature and low protection condition. Conditions of low (high) temperature and high (low) protection were intermediate. It is clear that under different protection states, information perception decreases with the increased length of working time. It was again found that information perception decreased the most under the high temperature and high protection condition, the least under the low temperature and low protection condition, and the degree of decline in information perception within the state of low (high) temperature and high (low) protection condition were intermediate.

Attention

The distributions of successful time of concentration and Q value of attention are two commonly used indices for measuring attention. In this study, the successful time of concentration and the Q value of attention distribution were collected from 10 participants under four different protection states, and they were sorted according to different protection states and different experimental stages of each participant, as shown in Figures 4 and 5.

The horizontal axes of Figures 4A and 5A represents the participants, and the vertical axes are the successful time and Q value, respectively, after averaging the results of four rounds of testing. The four lines represent the successful time and Q value of attention under different protection states. The longer the successful time, the higher the attention concentration ability, and the larger the Q value, the higher the attention distribution ability. According to the results, each participant has the shortest successful time and the smallest Q value under the high temperature and high protection condition, and the longest successful time and the largest Q value under the low temperature and low protection condition. While operating under the conditions of low (high) temperature and high (low) protection, the participants demonstrated intermediate successful times

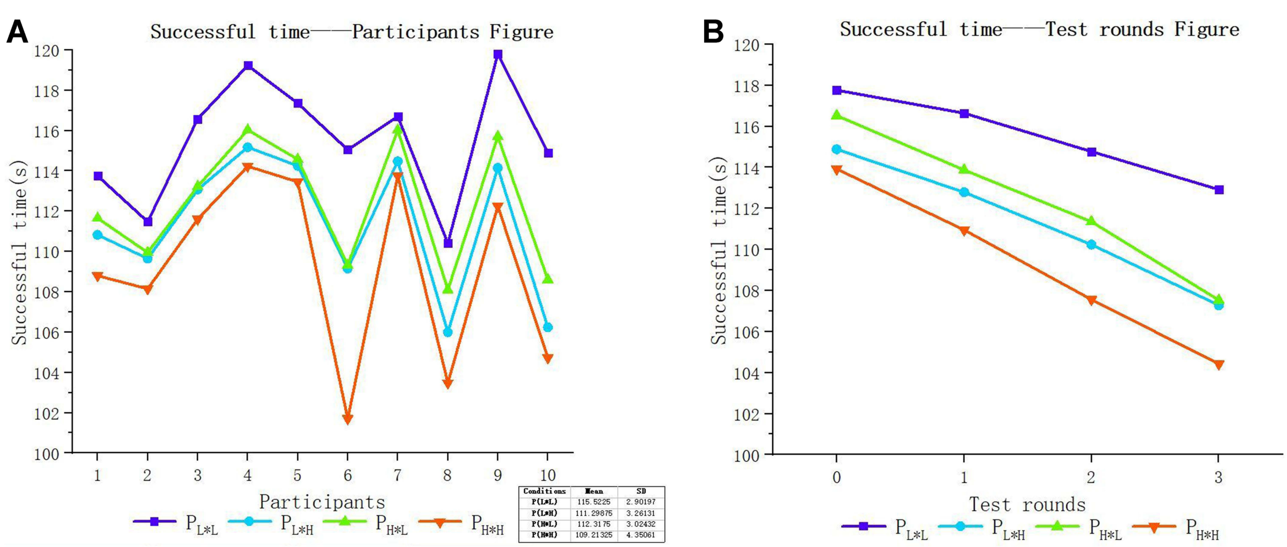


Figure 4 Test results of attention concentrate ((**A**) Successful time - Participants; (**B**) Successful time - Test rounds).

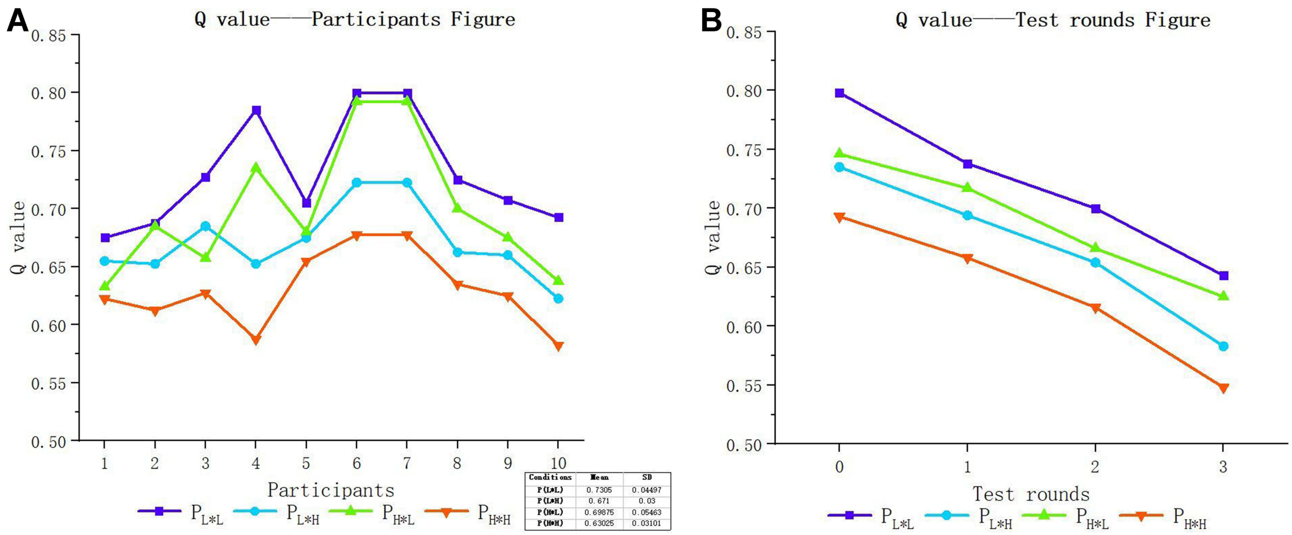


Figure 5 Test results of attention distribution ((**A**) Q value-Participants; (**B**) Q value-Test rounds).

and Q values. It can therefore be seen that different protection states have an influence on people's attention ability. Specifically, attention ability is the worst under high temperature and high protection conditions, strongest under low temperature and low protection conditions, and intermediate in the states of low (high) temperature and high (low) protection.

The horizontal axes of Figures 4B and 5B represents the number of objective index test rounds, the vertical axes represent the successful time and Q value of attention, respectively, after averaging the test results of 10 participants, and the four lines represent the successful time of attention concentration ability and Q value of attention distribution ability under different protection states. The results show that with an increase in the number of test rounds, the successful time of attention concentration and Q value of attention distribution present a trend of decline under the four protection states. In each round of testing, the successful time is the shortest and Q value is the smallest under high temperature and high protection conditions, the successful time is the longest and Q value is the largest under low temperature and low protection conditions; under the states of low (high) temperature and high (low) protection the values are intermediate. It is clear that while operating under different protection states, attention ability decreases with the increase in working time. Specifically, attention ability decreases the most under the high temperature and high protection condition, the least under the low temperature and low protection condition, and the degree of decline in attention ability under the state of low (high) temperature and high (low) is intermediate.

Memory

Instantaneous memory retention is a common index of memory. The data was sorted according to the different protection states and experimental stages for each participant, as shown in Figure 6 below.

The horizontal axis of Figure 6A represents each participant, the vertical axis represents the instantaneous memory retention after averaging the results of four rounds of testing; the four lines represent the instantaneous memory retention under different protection states. A larger amount of instantaneous memory implies a higher memory ability. According to the results, the instantaneous memory retention of each participant was the smallest under the high temperature and high protection condition, largest under the low temperature and low protection condition, and the instantaneous memory retention under low (high) temperature and high (low) protection conditions were intermediate. The instantaneous memory retention under the low temperature and high protection condition was slightly smaller than the memory retention for high temperature and low protection condition. Therefore, it is clear that different protection states have an influence on people's memory ability, with the memory ability being the worst under the high temperature and high protection condition.

The horizontal axis of Figure 6B represents the number of objective test rounds, the vertical axis represents the instantaneous memory retention after averaging the test results of 10 participants, and the four lines represent the instantaneous memory retention under the different protection states. From the results, it can be seen that with an increase in the number of test rounds, the instantaneous memory retention follows a decreasing trend under the four protection

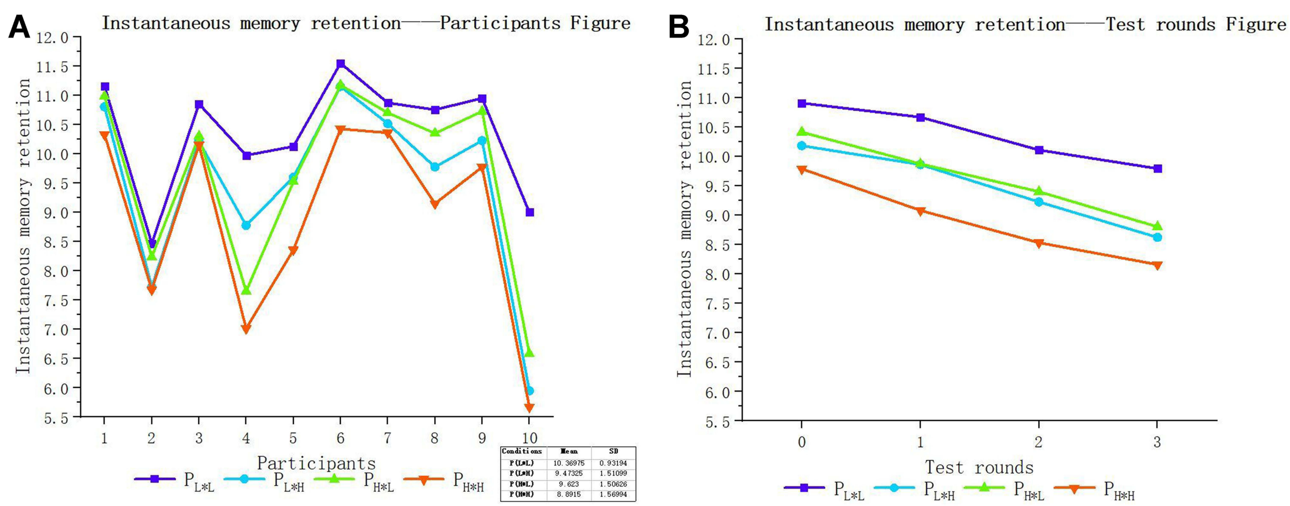


Figure 6 Test results of memory ((**A**) Instantaneous memory retention - Participants; (**B**) Instantaneous memory retention - Test rounds).

states. Specifically, within each round of testing, the instantaneous memory retention was the smallest under the high temperature and high protection condition, while it was the largest under the low temperature and low protection condition. The instantaneous memory retention while under the states of low (high) temperature and high (low) protection were intermediate. It is clear that under different protection states, memory ability decreases with an increase in working time, where the memory ability decreases the most under the high temperature and high protection condition and decreases the least under the low temperature and low protection condition. The degree of decline of memory ability under the states of low (high) temperature and high (low) protection were intermediate.

Main Task Completion Time

Main task completion time is a common index to measure work performance. The data of the main task completion time was sorted according to the different protection states and experimental stages of each participant, as shown in Figure 7.

The horizontal axis of Figure 7A represents each participant and the vertical axis represents the main task completion time after averaging the three main task rounds. The four lines represent the main task completion time under the different protection states. The general trend of a shorter main task completion time corresponding to a higher work performance level was found. According to the results, the main task completion time of each participant was the longest

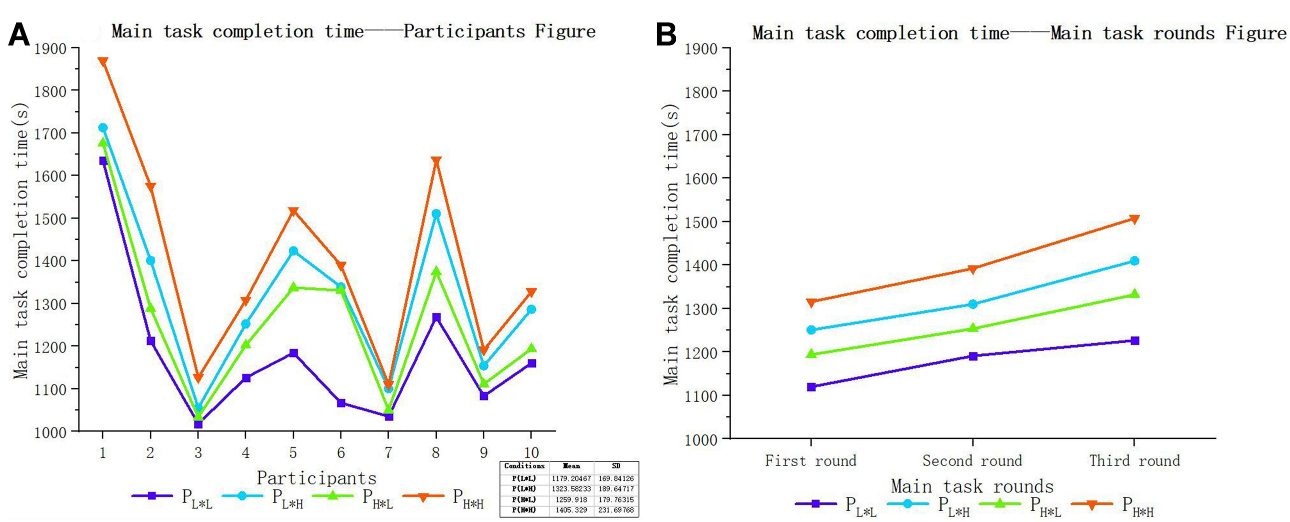


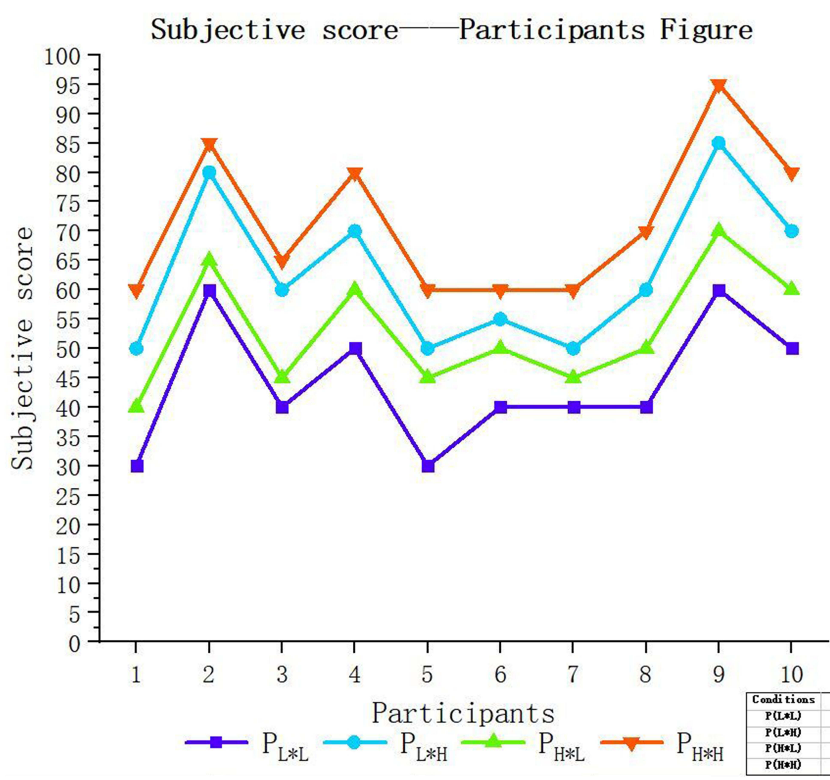
Figure 7 Main task completion time ((**A**) Main task completion time - Participants; (**B**) Main task completion time - Main task rounds).

under the high temperature and high protection condition, and was the shortest under the low temperature and low protection condition. The main task completion time under the low temperature and high protection condition was slightly longer than under the high temperature and low protection condition. Therefore, It is clear that different protection states have an influence on people's work performance, whereby work performance is the worst under the high temperature and high protection condition and the best under the low temperature and low protection condition. The work performance under the states of low (high) temperature and high (low) protection were intermediate.

The horizontal axis of Figure 7B represents the number of main task rounds, the vertical axis represents the main task completion time after averaging the 10 participants, and the four lines represent the main task completion time under the different protection states. The results show that with an increase in the number of main task rounds, the main task completion time followed an increasing trend under the four protection states. Specifically, in each round of main task, the main task completion time was the longest under the high temperature and high protection condition, and was the shortest under the low temperature and low protection condition. The main task completion time under the states of low (high) temperature and high (low) protection were intermediate. In addition, the difference between the time required to complete the first and third rounds of experiments was 106 s under the low temperature and low protection condition, 158 s under the low temperature and high protection condition, 138 s under the high temperature and low protection condition, and 192 s under the high temperature and high protection condition. It is therefore clear that under different protection states, the work performance declines with the increase in working time. The work performance declined the most under the high temperature and high protection condition, the least under the low temperature and low protection condition, while the degree of decline when operating under the low (high) temperature and high (low) protection states were intermediate.

Subjective Index

Mental demand within the NASA Scale is a common index used to measure mental fatigue, the tool measured mental fatigue under four different protection states. The subjective data was collected from 10 participants under different protective states, and the subjective data was then sorted according to the different protection states of each participant, as shown in Figure 8.



Conditions	Mean	SD
P(L*L)	44	10.19804
P(L*H)	63	12.08305
P(H*L)	53	9.53939
P(H*H)	71.5	12.05197

Figure 8 Subjective score of mental fatigue (Subjective score - Participants).

The horizontal axis of Figure 8 represents each participant, the vertical axis represents the subjective score of mental fatigue, and the four lines represent the subjective scores under the four different protection states. A lower score demonstrates a lower level of mental fatigue. From the results, it is clear that the subjective scores of each participant were the highest under the high temperature and high protection condition and lowest under the low temperature and low protection condition. The subjective scores were slightly higher under the low temperature and high protection condition than under the high temperature and low protection condition. In addition, the average score of the 10 participants under the different protection states was obtained, as follows: 44 points under the low temperature and low protection condition, 53 points under the high temperature and low protection condition, 63 points under the low temperature and high protection condition, and 72 points under the high temperature and high protection condition. It can be seen that different protection states have an influence on mental fatigue, and the degree of influence varies from highest to lowest when operating under the high temperature/high protection, low temperature/high protection, high temperature/low protection, and low temperature/low protection conditions.

Regression Analysis

To explore the correlation between subjective fatigue and multiple objective fatigue indices, we performed multiple regression analysis using the IBM SPSS Statistics 19 software. Among them, the reaction time of simple reaction, the successful time of attention concentration, the Q value of attention distribution, and the instantaneous memory retention were the four objective fatigue indices used as independent variables, and the subjective fatigue score was used as the dependent variable. The obtained multiple linear regression model is as follows:

$Y=75.344*X_1-0.167*X_2-79.085*X_3-3.199*X_4+138.786$

Y: Subjective score of mental fatigue

X_1: Reaction time of simple reaction

X_2: Successful time of attention concentration

X_3: Q value of attention distribution

X_4: Instantaneous memory retention of memory

The equation was significant ($P=0.000<0.05$), and the adjusted R^2 value of the equation was 0.445. In addition, this equation passes the Durbin-Watson test, the multicollinearity test, and the normality test for the residuals.

Discussion

Nurses in medical care represent a large number of staff who have diverse work content and complex multi-job coordination (with doctors, pharmacists, technicians, patients, and family members, etc.), as well as having to partake in 24-hour shift work. Their work fatigue is something that needs to be paid attention to.[29–31] However, the COVID-19 pandemic has not only increased the burden of medical field operations in terms of the number of patients and the complexity of disease but also indirectly increased the fatigue of nurses wearing PPE for the safety of both the workers and the patients. Taking the special medical conditions in consideration, this study illustrates the influence of different protection conditions on the mental fatigue of nurses from subjective and objective perspectives based on experimental methods to provide ideas for optimizing the operation process of nurses.

The mental fatigue of nurses must be paid attention to by medical managers. In previous studies, the measurement of mental fatigue has mainly focused on research methods such as subjective scales and interviews.[32–35] Although mental fatigue can be somewhat characterized through these methods, the results are more subjective and less representative. Therefore, the experimental method used within this study involved acquiring both objective indices (ie, information perception, attention, memory, and work performance) and using a subjective scale to evaluate the mental fatigue of nurses, and therefore obtains consistent subjective and objective experimental results. These results not only verify the reliability of relevant objective indices in evaluating fatigue states but also quantitatively express the changes in people's perception ability, attention, and memory under different fatigue states. In addition, this study pays attention to the different protective states, as well as to the effects of different temperatures on fatigue. Ultimately, the experiment verifies previous results demonstrating that operators under high temperature and high protection states are prone to fatigue.

Through fatigue measurement experiments in different protective states, it has been deduced that the influence of different protective states on mental fatigue is the highest under the high temperature and high protection state, the lowest under the low temperature and low protection state, and intermediate under the high temperature/low protection and low temperature/high protection states. Explanations for the results of this study are highlighted within previous studies. Chaudhary et al found that wearing PPE for long periods may lead to fatigue, discomfort, and low morale, reducing clinical manifestations in healthcare workers.[36] Kolb et al found that surgery with COVID-19 PPE was more uncomfortable than surgery with standard PPE, with a significant decrease in concentration.[37] Murray et al found that PPE is thermally resistant and that wearing PPE for long periods makes the job more difficult, reducing the time and accuracy of mission completion.[38] Jin et al investigated the effect of different types of PPE on the physical fatigue of nurses through experiments and analyzed the indicators of HR, oral temperature, task completion time, and subjective fatigue. They found that the higher the PPE protection level worn by the subjects, the higher the degree of physical fatigue.[27] The main findings of this study are similar to those of the aforementioned studies. This study mainly focused on the relationship between different protective states and mental fatigue, used experimental means to verify the influence of different protective states on the mental fatigue of operators, and established a correlation model between subjective indicators of mental fatigue and objective fatigue indicators. In addition, this study further focused on the influence of different temperatures in different protective states and used experimental methods to verify the effects of high temperatures in the PPE environment, providing guidance for medical practice. Combined with the results of this study, we offer the following recommendations to healthcare administrators:

First, in the context of the COVID-19 pandemic, we should pay attention to the influence of PPE on nurses' mental fatigue, and optimize their work content and resting system to reduce fatigue. Excessive fatigue will not only affect the health of nurses, but also affect the performance of daily operations that may lead to medical errors, which in turn will bring additional work burdens to the medical field.

Second, we should pay attention to the fatigue of nurses in high temperature and high protection states. In the case that the protective state cannot be changed, the working temperature should be reduced as much as possible, allowing for the nurse's high temperature and high protection state to be changed to the low temperature and high protection state, which achieves the effect of alleviating the accumulation of mental fatigue to a certain extent.

Third, it is necessary to understand that different protection states have an influence on the completion time of work. This implies that for the same work content, nurses working under different protection states require a varying number of hours for work completion, or correspondingly, a reduced amount of work content.

Fourth, if conditions permit, the fatigue of nurses in different protective states should be monitored regularly, and nurses' rest should be reasonably organized by setting fatigue thresholds along with other measures to prevent the unexpected impact of fatigue on nurses and patients. The objective indices such as reaction time, attention, and memory used within this experimental study show a close correlation with subjective fatigue, and the relevant measuring instruments are simple to operate and inexpensive. Medical managers can therefore selectively introduce them to the medical field, according to the situation in which nurse fatigue is being monitored.

However, there are certain limitations associated with this study. Firstly, nurse fatigue has two components: brain fatigue and physical fatigue, and this study only focused on mental fatigue without paying any attention to physical fatigue. Secondly, although this study provided a measurement method of fatigue, it did not provide an effective method of fatigue elimination. Thirdly, this experiment was conducted with a small sample size (10 participants); thus, further increases in the sample size are needed to determine the reliability of the results. In addition to the type and temperature of PPE, there are other factors that affect brain fatigue that need to be considered in future studies. Finally, this study focused only on nurses and did not focus on the fatigue of other medical workers in different protective states. In view of the above shortcomings, we will continue to conduct relevant research as a future topic and actively report to readers when we obtain certain results.

Conclusion

Based on the subjective and objective indices collected during the experiment, this study discussed the influence of different protective states on mental fatigue in nursing operations. The findings reveal that the highest influence on mental fatigue was when under the high temperature/high protection state, the lowest influence was when under low temperature/low protection state, and the influence on mental fatigue when under the high temperature/low protection and low temperature/high protection states were intermediate. The research conclusions can provide specific ideas and a basis for the optimization and improvement of nursing operations during the unique period of the pandemic. It can provide methods and ideas for medical managers to evaluate and manage the mental load states in nursing operations.

Ethical Approval

This study was reviewed and approved by the Biological and Medical Ethics Committee, Northeastern University, China (ID: NEU-EC-2021B003S). Informed consent was obtained from all individual participants included in the study.

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Disclosure

The authors declare that they have no conflicts of interest in this work.

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