EFFECTIVENESS OF THE "A1-PD" DEVICE FOR STAFF WEARING PROTECTIVE CLOTHING WHILE PERFORMING COVID-19 PREVENTION DUTIES IN HOT WEATHER CONDITIONS

Nguyen Vinh Quoc, Chu Hong Lap, Vu Van Thai
Military Institute of Traditional Medicine

Abstract

The research and development of the A1-PD cooling device to support healthcare workers in combating the Covid-19 pandemic is of great significance, particularly in the harsh working conditions with protective suits during the summer of 2021. The A1-PD device utilizes the cooling principle of dry ice and a fan, helping to create a cool airflow inside the protective suit without affecting the user's activities. This device is easy to use, lightweight, and can operate continuously for at least 8 hours, enough for a full shift. Test results show that the A1-PD device helps lower the temperature inside the protective suit, with a temperature difference of -3.77°C after 60 minutes and -3.44°C after 120 minutes compared to the external environment. User satisfaction is very high, with 90% rating the device as effective throughout the shift. However, some users reported feeling restricted when bending down, indicating a need for improvement in future versions. The A1-PD device not only improves working conditions but also helps protect healthcare workers' health, ensuring they can complete their tasks in hot conditions without encountering serious health issues.

Keywords: *Cooling device, A1-PD, Covid-19 prevention, cooling effectiveness.*

I. INTRODUCTION

The Covid-19 pandemic, which has affected the world and Vietnam, has caused severe consequences, including the loss of human lives and significant disruptions to the economy and society. Countries around the world, including Vietnam, have concentrated on mobilizing all available resources, developing, and implementing decisive actions to prevent and reverse the pandemic [1], [2]… So far, under the firm and coordinated leadership of the government, ministries, and departments from central to local levels, the pandemic has been controlled and curbed [3]. In this success, the important role of the medical force at hot spots shall be mentioned, including the Military Institute of Traditional Medicine's staff.

According to regulations, personnel involved in pandemic control must wear four levels of protective clothing depending on

* Date received: 30/09/2024
* Date accepted: 15/12/2024

their working positions to prevent infection [4]. In the extreme heat of the summer of 2021, wearing level 3 and level 4 protective gear to perform their duties had detrimental effects on the health of healthcare workers, compounded by the inability to take bathroom breaks or drink water, making the situation even more challenging. This has motivated many scientists, students, and researchers to innovate and create solutions to provide cooling inside the protective clothing, ensuring the health of healthcare workers while performing pandemic control duties [5],[6]. Based on proposals to overcome some limitations of previous cooling support devices, the research team proposes the development of the "A1-PD" cooling device with the following objectives:

1. Providing circulated cooled air inside the epidemic protective suit but must ensure safety, with little or no impact on the user's activities.

2. Manufacturing from readily available domestic materials, compact, lightweight, easy to use, acceptably priced, and capable of continuous operation for at least 01 work shift.

3. Preliminary evaluation of the cooling effectiveness of the device on healthy volunteers.

II. DEVICE AND METHODS

2.1. Device

2.1.1. Operating Principles

The device creates a continuous circulation of air cooled by dry ice inside the protective clothing to optimize the internal temperature when worn.

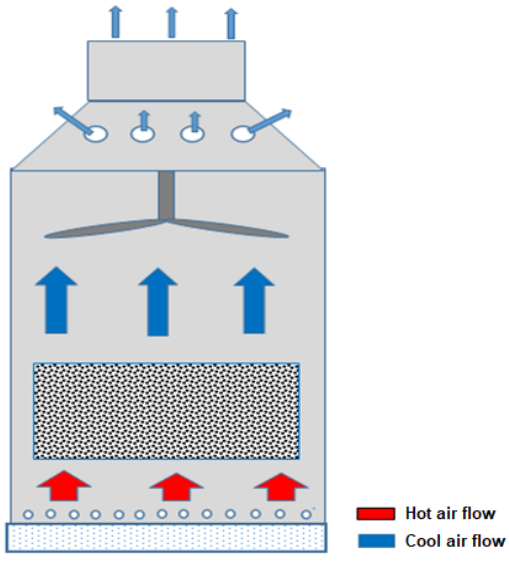

Figure 1. Airflow Diagram of the "A1-PD" Device

2.1.2. Objectives and Requirements for the Device

- Objectives:

+ Manufacturing from readily available domestic materials, compact, lightweight, easy to use, and acceptably priced.

+ No direct interference with the protective clothing and no impact on the user's ability to perform duties.

- Requirements:

+ Ensuring user's safety.

+ Simple operation, with the device being able to function continuously for at least 01 work shift of a healthcare worker

2.1.3. Device structure

The "A1-PD" cooling device is constructed from the following materials: a 110 mm diameter PVC shell with a bottom, a 5V x 0.3mA blower fan, a 10,000mA Lithium Kaku rechargeable battery, fabric straps for carrying the device, 500g Coll Magic gel ice packs, and accompanying accessories (power switch, battery charger, and charging port). All materials are readily available domestically and meet the manufacturer's standards

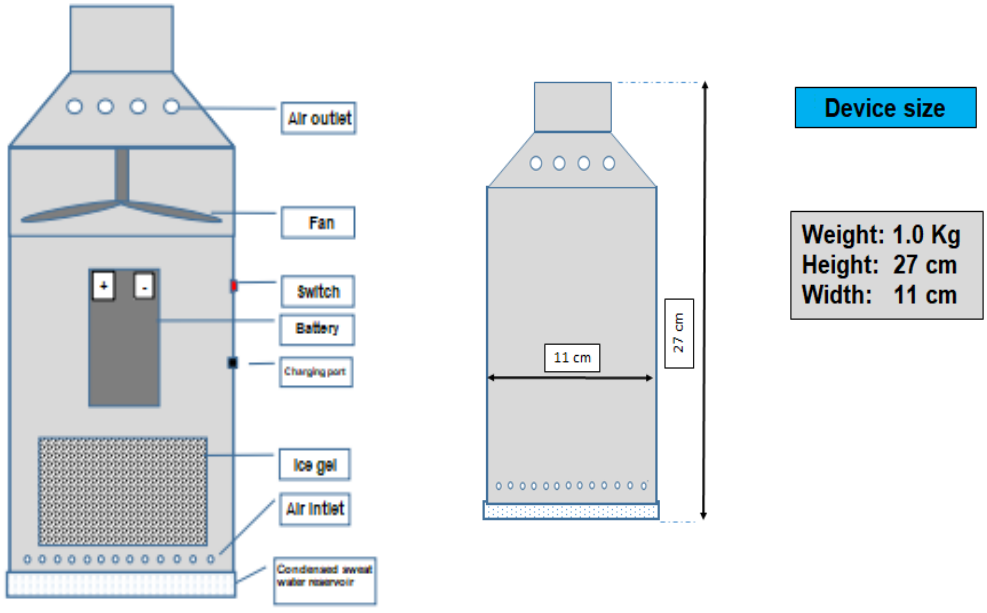

Figure 2. Device Diagram *(Total device weight: 1kg)*

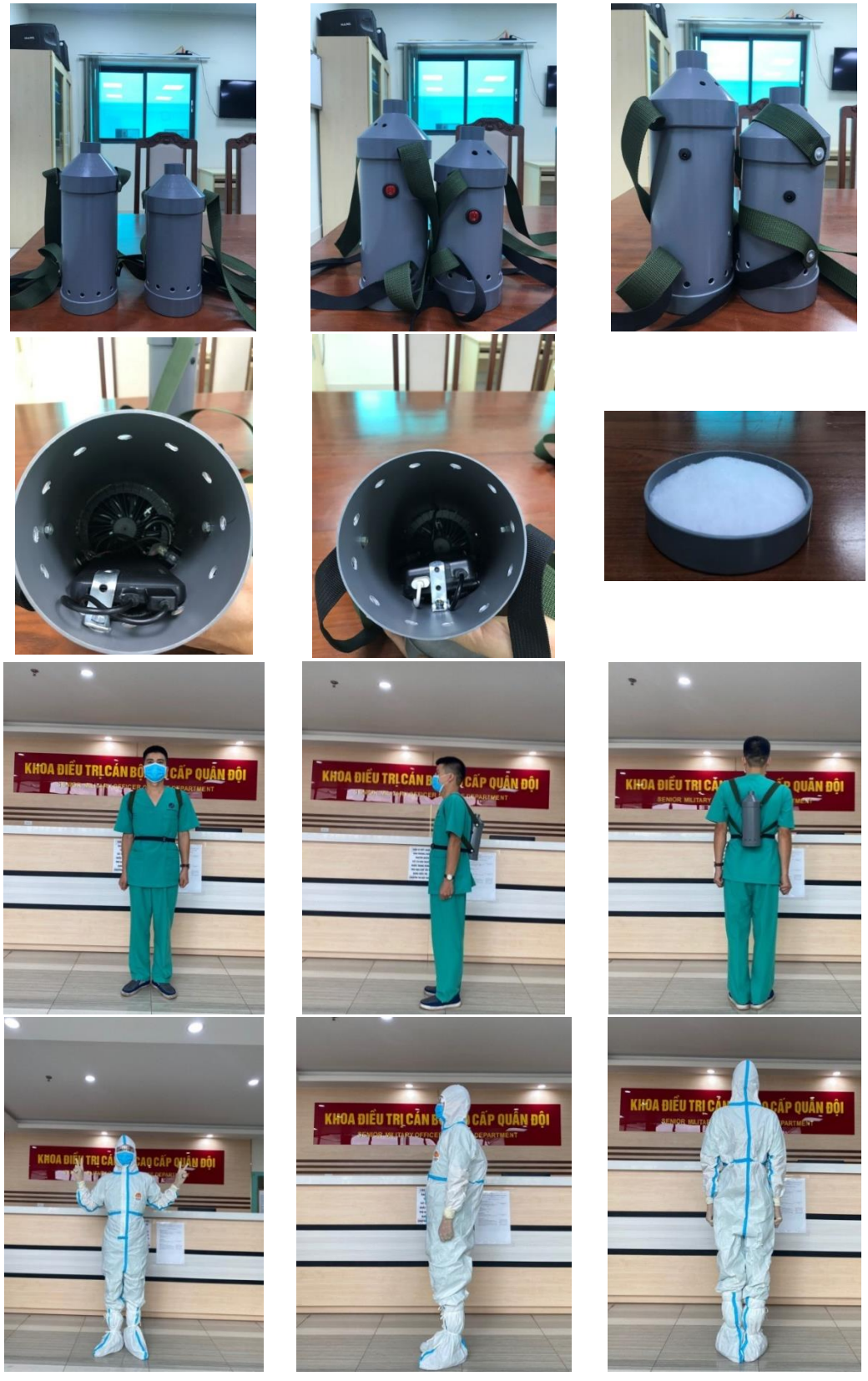

Figure 3. Some images of the "A1-PD" device after production and application

2.2. *Study Subjects and Methods*

2.2.1. Study Subjects:

60 healthy volunteers participated in the experiment.

2.2.2. Research Methods

- Monitoring the continuous operation of the device: The "A1-PD" device was fully assembled and set to operational mode. Continuous operation was monitored for 8 hours or until the device stopped functioning due to battery depletion or other issues.

- Evaluation of device effectiveness: Volunteers were divided into two groups:

+ Control Group: 30 individuals wore level 3 protective clothing without using the "A1-PD" device or any other cooling methods. The suits were worn for 120 minutes.

+ Research Group: 30 individuals wore level 3 protective clothing with the "A1-PD" device, under the same conditions as the Control group.

The trial was conducted during the hot summer (June 2021) when the Covid-19 pandemic was severe and uncontrolled. Pandemic control efforts at the Military Institute of Traditional Medicine were being rigorously implemented according to guidelines from the government, the Ministry of Health, and the Ministry of National Defense.

- Monitoring and Evaluation Criteria:

+ Subjective feedback on the cooling effectiveness of the "A1-PD" device in the Research group, evaluating satisfaction through pre-designed questionnaires.

+ Evaluating changes in pulse rate, systolic blood pressure, external temperature, and internal temperature inside the protective clothing were measured at 60 minutes and 120 minutes in both groups.

- Data Processing: Data were processed using SPSS 16.0 for Windows. Percentage calculations, mean values, standard deviations, and t-student tests were used to compare two mean values. Differences were considered significant when $p < 0.05$.

III. RESULTS

Monitoring the continuous operation of the device showed that it operated stably for at least 8 hours, with no stoppages due to technical issues. Condensation was retained in the device's bottom compartment (lined with medical cotton), and no leakage occurred. It can be concluded that the "A1-PD" cooling device effectively met the time requirements for a work shift.

Table 1. Satisfaction levels of research group with the device (n=30)

Criteria	Level 1 (n; %)	Level 2 (n; %)	Level 3 (n; %)	Level 4 (n; %)	Level 5 (n; %)
Device Appearance	-	-	-	08 (26.7)	22 (73.3)
Device Weight	-	-	-	06 (20.0)	24 (80.0)
Convenience of Wearing the Device	-	-	-	07 (23.3)	23 (76.7)
Operating Time During Work Shift	-	-	-	03 (10.0)	27 (90.0)
Impact on Personal Task Performance	-	-	-	10 (33.3)	20 (66.7)
Personal Experience During Device Usage	-	-	-	05 (16.7)	25 (83.3)
Device Safety in Compliance with Regulations	-	-	-	-	30 (100)

Note: Satisfaction levels: *① Very dissatisfied or Very poor; ② Dissatisfied or Poor; ③ Normal or Average; ④ Satisfied or Good; ⑤ Very satisfied or Very good.*

All participants expressed satisfaction or high satisfaction with the "A1-PD" device. Basic feedback and contributions included: the device's suitability and effectiveness in cooling during hot weather; stable operation, ease of use; and a desire to see the device deployed in actual operations to help healthcare workers feel less uncomfortable while wearing protective clothing during the pandemic control duties; a slight inconvenience when bending, and suggested further research to address this issue.

Table 2. Temperature changes in Test Groups

Groups	Temperature (°C; $\overline{X}$ ± SD)	Time point	
		60 minutes	120 minutes
Research Group (n=30)	Outside Environment Temperature (1)	31,61 ± 2,05	32,17 ± 1,77
	Inside Suit Temperature (2)	27,84 ± 2,18	28,73 ± 1,93
	Internal-external temperature difference (A)	-3,77 ± 0,97	-3,44 ± 0,97
	p_{1-2}	<0,05	<0,05
Control Group (n=30)	Outside Environment Temperature (1)	31,19 ± 1,70	31,77 ± 1,54
	Inside Suit Temperature (2)	33,16 ± 1,43	33,86 ± 1,13
	Internal-external temperature difference (B)	1,97 ± 0,93	2,09 ± 0,86
	p_{1-2}	<0,05	<0,05
p_{A-B}		***<0,05***	***<0,05***

The temperature inside the protective clothing in the Research Group was always lower than the external temperature, with a temperature difference of -3.77 ± 0.97°C and -3.44 ± 0.97°C after 60 and 120 minutes, respectively, when using the "A1-PD" device. Meanwhile, in the Control Group, wearing only simple protective clothing, the opposite effect was observed with the corresponding temperature difference of 1.97 ± 0.93 and 2.09 ± 0.86 (degrees). The differences between the Research Group and the Control Group were statistically significant ($p < 0.05$).

Table 3. Changes in pulse rate and blood pressure in Test groups

Indicator		Time Point	
		60 minutes	**120 minutes**
Pulse Rate (beats/min; $\overline{X} \pm SD$)	Research Group (n=30)(1)	72.43 ± 4.94	72.70 ± 4.17
	Control Group (n=30)(2)	72.60 ± 4.12	75.33 ± 3.22
	p_{1-2}	>0.05	<0.05
Systolic BP (mmHg; $\overline{X} \pm SD$)	Research Group (n=30)(1)	115.43 ± 4.56	114.97 ± 3.78
	Control Group (n=30)(2)	114.67 ± 4.13	113.97 ± 19.93
	p_{1-2}	>0.05	>0.05
Diastolic BP (mmHg; $\overline{X} \pm SD$)	Research Group (n=30)(1)	68.63 ± 3.69	68.07 ± 4.41
	Control Group (n=30)(2)	68.70 ± 2.69	70.13 ± 3.32
	p_{1-2}	>0.05	>0.05

The pulse rate of the Control Group was significantly higher than that of the Research Group after 120 minutes, which corresponds to the higher internal temperature in the Control Group's protective clothing at the same time point (as shown in Table 2). No significant differences were observed in blood pressure between the two groups, as the volunteers were all healthy and capable of adjusting to adverse weather changes.

IV. DISCUSSION

4.1. Innovation

The development of the "A1-PD" cooling device is a small initiative aimed at supporting and encouraging comrades working tirelessly in the fight against the Covid-19 pandemic at the Department of Senior Cadre Treatment/Military Institute of Traditional Medicine.

The novelty and creativity of the "A1-PD" device lie in its ability to circulate cooled air inside the

protective clothing, helping healthcare workers maintain their health while performing pandemic control duties in hot weather conditions. This approach differs from previous research [5], [6].

Effectiveness of the A1-PD Cooling Device in the Study

The research results show that the A1-PD cooling device has a positive effect in improving the working environment, especially for healthcare workers who work in hot conditions and need to wear protective suits for disease prevention. Monitoring the device's operation time reveals that it can run continuously for at least 8 hours without encountering technical issues, proving the device's stability and reliability in long-term working environments. The fact that the condensed water is safely retained at the bottom of the device without leaking or spilling indicates the device's design and quality control capabilities.

4.2. User Satisfaction Evaluation

The survey results on user satisfaction among the participants in the trial show that the majority of users highly appreciated the cooling feature of the device, with 83.3% of survey respondents stating that they were very satisfied or satisfied with the device's cooling effectiveness in hot weather conditions. This suggests that the device can meet the need to alleviate the discomfort caused by heat when working for extended periods in a protective suit. Furthermore, 90% of participants rated the device as effective throughout a full shift, confirming that it can support healthcare workers during their entire shift without interruptions. However, some users reported feeling restricted when bending over, indicating the need for further research and improvements in future versions.

4.3. Temperature Change Inside the Protective Suit

The results of temperature measurements inside the protective suit show that the A1-PD device effectively lowers the temperature inside the suit. Specifically, after 60 minutes and 120 minutes of using the device, the temperature difference (inside versus outside the suit) was -3.77 ± 0.97°C and -3.44 ± 0.97°C for the group using the A1-PD device. Meanwhile, the group wearing the protective suit without the cooling device showed a temperature difference of 1.97 ± 0.93°C and 2.09 ± 0.86°C. This difference indicates that the A1-PD device is effective in reducing the temperature inside the protective suit, helping users feel more comfortable in harsh working conditions.

4.4. Changes in Physiological Indicators

The research results on physiological indicators (heart rate, blood pressure) show no significant differences between the group using the A1-PD device and the group wearing only the protective suit regarding systolic and diastolic blood pressure. However, the heart

rate in the group not using the cooling device increased significantly after 120 minutes. This can be explained by the increase in temperature inside the protective suit, which forces the body to adjust to cope with the temperature change, leading to an increase in heart rate. In contrast, the group using the A1-PD device did not show significant changes in heart rate, indicating that the device helps stabilize body temperature and reduces the impact of high temperatures on the user's health.

V. CONCLUSIONS

- The initiative to develop the "A1-PD" cooling device to support healthcare workers in Covid-19 control duties has been carried out systematically with scientific evidence. The preliminary results show that the device meets the set objectives.

- "A1-PD" is a cooling device used to support medical teams in preventing the Covid-19 epidemic. It is made from domestically available materials, compact, lightweight, easy to use, ensuring a minimum of 8 hours of continuous operation. The device received a satisfactory or very satisfied rating from the volunteers when using it. Initial test results on volunteers wearing level 3 epidemic protective suits and using the "A1-PD" device show that the internal temperature is always lower than the outside temperature at times after 60 minutes. and 120 minutes and was lower than the internal temperature in the control group of subjects who only wore simple protective clothing at the same time, a significant difference with $p<0.05$.

- Regularly promoting such initiatives will contribute to improving the scientific research capacity of the nursing and technical staff at the Military Institute of Traditional Medicine.

VI. RECOMMENDATIONS

- Further monitoring is required to assess the safety of the device to make appropriate recommendations and to address certain existing issues to improve the product.

- The device could also be applied in certain areas of military medicine and daily life where prolonged exposure to heat sources is a concern, such as cooling soldiers in chemical protective clothing/firefighters/ workers in foundries…

REFERENCES

1. Ministry of Health (2021). Decision No. 4689/QĐ-BYT dated 06/10/2021 on the issuance of Guidelines for the Diagnosis and Treatment of Covid-19.

2. Ministry of Health (2022). Decision No. 250/QĐ-BYT dated 28/01/2022 on the issuance of Guidelines for the Diagnosis and Treatment of Covid-19.

3. Ministry of Health (2023). Decision No. 3896/QĐ-BYT dated 19/10/2023 on the adjustment of acute respiratory infections caused by the novel Coronavirus (Covid-19) from a Group A infectious disease to a Group B infectious disease under the Law on Prevention and Control of Infectious Diseases 2007.

4. Ministry of Health (2020). Decision No. 1616/QĐ-BYT dated 08/4/2020 on the issuance of the document "Temporary Guidelines on Techniques, Classification, and Selection of Personal Protective Equipment for Covid-19 Prevention and Control".

5. Vuong Tran, Quach Du (2021). Innovation in technology and production of protective clothing against Covid-19. https://laodong.vn/xa-hoi/cai-tien-cong-nghe-che-tao-bo-do-bao-ho-chong-dich-covid-19-916546.ldo.

6. Ministry of Health's Electronic Portal (2021). Cooling fans to prevent medical staff from exhaustion while wearing protective gear. https://covid19.gov.vn/quat-lam-mat-giup-nhan-vien-y-te-khoi-kiet-suc-khi-mac-do-bao-ho-1717354108.htm.