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EFFECT OF AMBIENT TEMPERATURE ON PHYSIOLOGICAL COST INDEX, HEART RATE RECOVERY, AND RATE OF PERCEIVED EXERTION FOLLOWING A ONE-MILE TREADMILL WALK TEST IN COLLEGE GOING STUDENTS.

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ABSTRACT

Background: Sub-maximal exercise tests assess cardiorespiratory fitness(CRF) using heart rate, blood pressure, and perceived exertion. One-mile treadmill walk test (1MTWT) is a commonly used exercise test. For submaximal exercise testing, the ambient temperature is a crucial factor that has to be well monitored. fitness tests should ideally be conducted in controlled environments for accuracy; this practice is not widely implemented due to practical challenges.

Objective: Aim of the study is to evaluate the physiological cost index(PCI), one-minute heart rate-recovery(HRR_1), and perceived exertion(RPE) after 1MTWT at two different temperatures, comparing their effects on college students.

Methods: An observational crossover study on 11 college going students was conducted after obtaining verbal consent and explaining the procedure. Each Student performed the 1MWT on treadmill in two different ambient temperature environments-(1)Room with air-conditioner plus fan (2)Room without air-conditioner or fan. Post-testing, PCI, RPE, and one-minute heart rate recovery (HRR_1) were measured. PCI and RPE across two ambient temperatures were analyzed using paired t-tests, while HRR_1 was compared using the Wilcoxon Signed Ranks Test.

Results: Significantly higher PCI ($p < 0.048$), RPE($p<0.001$) and lower HRR_1 ($z<0.003$) in room without Air-conditioner or Fan vs with Air-conditioner plus Fan trials.

Conclusion: There is significant effect of ambient temperature on PCI, HRR_1 and RPE following a 1MTWT. Results emphasize the value of maintaining a controlled environment during CRF assessments to obtain precise outcomes.

Keywords: Temperature, One-mile treadmill walk test, College students, Physiological cost index, Heart Rate Recovery, Rate of Perceived Exertion.

INTRODUCTION

The human body is physiologically regulated to keep it homeostatic when environmental conditions change. Humans produce or lose heat through thermoregulation to maintain the homeostasis of body temperature and protect themselves against excessive heat or cold. In the same way, environmental temperature may affect

physiological responses to exercise through thermoregulation. For example, our body minimizes heat dissipation by reducing body surface under cold conditions, promoting heat generation by skeletal muscle contraction (i.e., shivering), and preventing heat loss by contracting skin blood vessels (i.e., vasoconstriction).[1] By contrast, our body promotes heat dissipation by sweat evaporation through increased skin blood vessels (i.e., vasodilation) when exposed to heat.[2]The cardiovascular system plays an essential role in temperature regulation. Heat exchange between skin and environment via sweating and dry heat exchange is governed by biophysical properties dictated by surrounding temperature, humidity and air motion, and clothing.

In exercise testing settings lacking of ideal ambient testing temperature may interfere with accurate exercise assessments and reduce the effectiveness of training programs. The impact of fan cooling and AC cooling during moderate to vigorous submaximal exercises on cardiovascular responses remains largely unexamined. Therefore, the purpose of this study was to verify the effects of environmental temperature on physiological responses and exercise capacity during One mile treadmill walk test in college going students.

Cardiorespiratory fitness (CRF) is a critical indicator of overall health and physical performance. Submaximal exercise tests, such as the one-mile treadmill walk test (1MTWT), are commonly employed to assess CRF due to their practicality and safety. These tests evaluate physiological responses—including heart rate (HR), blood pressure (BP), and rating of perceived exertion (RPE) to standardized physical activity, providing valuable insights into an individual's functional capacity. [3]
The Physiological Cost Index (PCI) is a notable metric derived from submaximal exercise tests. Physiological cost index (PCI) has been developed by MacGregor for measuring energy expenditure of walking. It serves as an indirect measure of the energy expenditure associated with walking. This index offers a simple yet effective means to estimate the metabolic cost of locomotion. [4]
Heart rate recovery in one minute (HRR_1), particularly the rate at which the heart rate declines after one-minute post-exercise, is another vital parameter.[5]
The Rating of Perceived Exertion (RPE) scale is employed to measure an individual's subjective assessment of exercise intensity. This scale ranges from minimal to maximal exertion and is instrumental in monitoring and prescribing exercise intensities. [6,7]

METHODOLOGY

Study Design: Observational crossover study

Study Setting: SVP Hospital, Ahmedabad

Participants: College going students

Inclusion Criteria:

- Both male and female
- Age:18-25 years
- College going students
- Normal BMI
- Students willing to participate

Exclusion Criteria:

- Any recent musculoskeletal injury
- Any cardiorespiratory disease

Procedure:

11 students (18-25 years) voluntarily participated in this study. Subjects' descriptive data is presented in Table 1. Verbal informed consent was obtained from each participant prior to the study. Participants were explained

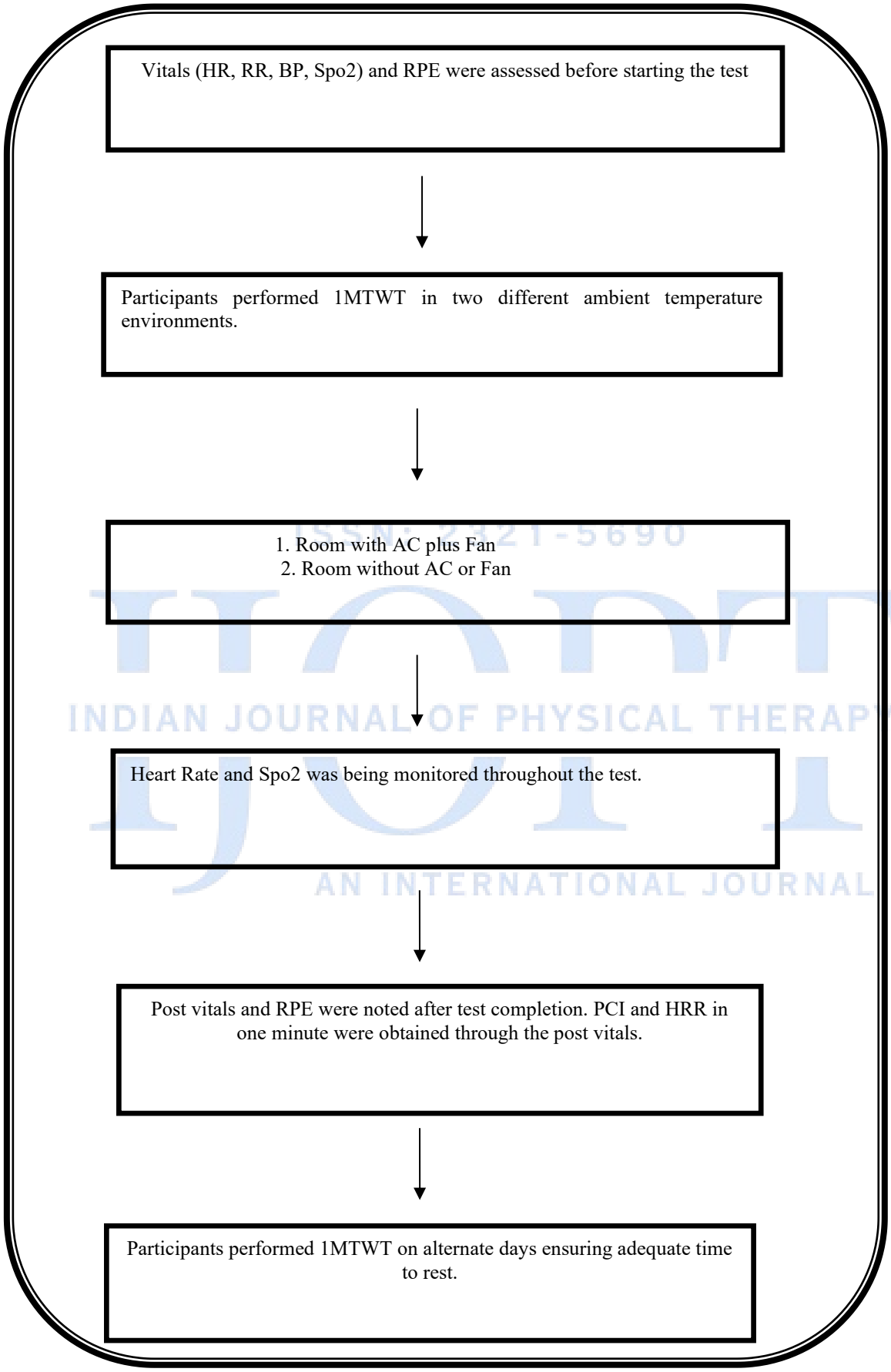
about the procedure priorly. They were informed to wear comfortable clothing and shoes for performing 1MTWT and to refrain from vigorous exercise, heavy meal and caffeine consumption the day before the experiment. Participants were given warm up exercises for 5 mins in the form of stretching exercise of upper limb and lower limb and active exercise of spot marching before starting the test. In the Rockport One-Mile Treadmill Walking test for estimating CRF, an individual walks 1 mile (1.6 km) as fast as possible and HR is obtained in the final minute.[7] The PCI was calculated by formula PCI= (walking heart rate- resting heart rate)/walking speed). [4] Rate of Perceived exertion was measured through Borg's Scale rating from 6-20 as shown in Fig. 1. [6,7] Between testing protocols, there were at least 24 hours of separation and all subjects were tested as close to the same time of day as possible for each session.

Table 1: Descriptive data of the subjects.

N	Age	Gender	Height	Weight	BMI
2	23.5±0.71	Male	169.00±1.41	70.25±1.34	24.59±0.56
9	23.11±0.92	Female	153.88±10.09	55.03±8.64	22.80±1.92

Figure 1: RPE Scale

➢ **Flowchart of Procedure**



Statistical Analysis:

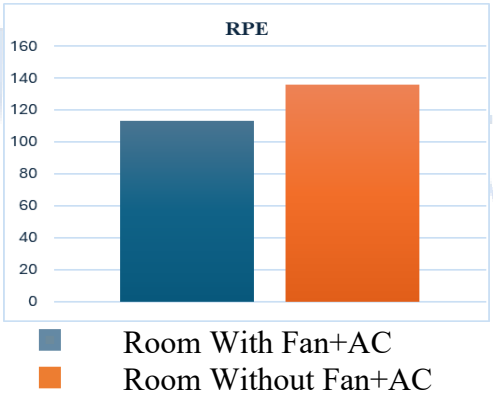
Statistical analysis was done using SPSS version 20.0 by keeping the level of significance 5%. Data was tested for normality. Variables of PCI and RPE of two different ambient temperatures were compared using paired t-tests. Variables of HRR_1 was compared using Wilcoxon Signed Ranks Test.

RESULTS

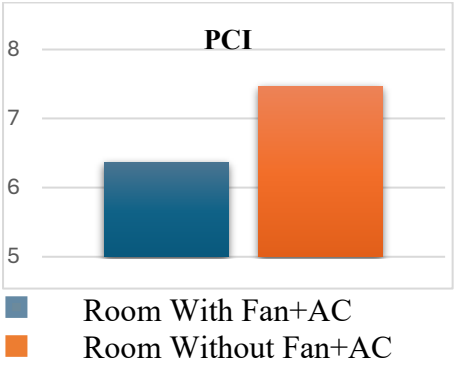
Study results showed significantly higher PCI ($p < 0.048$), RPE($p<0.001$) and lower HRR_1 ($z<0.003$) was observed in room without Air-conditioner or Fan vs with Air-conditioner plus Fan trials. Results showed in Table 2. The effect of ambient temperature is more significant on HRR_1 and RPE than PCI following a 1MTWT.

Table 2: Comparison of PCI, RPE and HRR_1 for two different temperatures

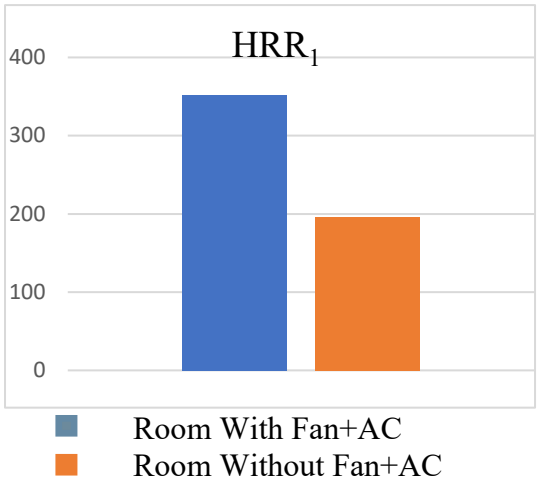
Parameters	With Fan+AC Mean±SD	Without Fan+AC Mean±SD	p and z Values
PCI	0.58±0.16	0.67±0.15	p<0.048
RPE	10.27±1.67	12.36±1.75	p<0.001
HRR_1	32±9.83	17.82±11.28	z<0.003



Graph 1: RPE for 1MTWT with and without Fan+AC



Graph 2:PCI for 1MTWT with and without Fan+AC



Graph 3: HRR_1 for 1MTWT with and without Fan+AC

DISCUSSION

The present study aimed to investigate the effect of ambient temperature on sub-maximal exercise responses including Physiological Cost Index (PCI), Rate of Perceived Exertion (RPE), and one-minute Heart Rate Recovery (HRR_1)-in college students following the One-Mile Treadmill Walk Test (1MTWT). The results revealed a significant increase in PCI and RPE, and a significant decrease in HRR_1 when the test was conducted in a room without air-conditioning or fan, compared to a cooler environment with both. These findings highlight the importance of environmental conditions during sub-maximal exercise testing.

During heat stress, vasodilation occurs in skin blood vessels so that the heat is lost from the skin and sweat glands become more active to increase evaporative heat loss. Hence The combination of environmental and exercise-induced heat stress can lead to excessive body heat and elevated brain temperature, ultimately impairing physical performance.

Moore et al. conducted a pilot randomized crossover trial involving 20 patients with moderate Chronic Obstructive Pulmonary Disease (COPD) performing low-intensity treadmill walking. Each participant completed two walking sessions: one using a handheld fan directed at the face and another without any cooling intervention. The primary outcomes included subjective breathlessness (measured using the Borg scale), heart rate, oxygen saturation, and recovery duration. While no significant changes in heart rate or oxygen saturation were observed, the use of the handheld fan significantly reduced perceived breathlessness and resulted in a faster recovery time.[5] Results of this study is similar to our study where rate of perceived excretion (RPE) and heart rate recovery (HRR_1) is reduced in fan+Ac cooling room vs one without Fan or AC. These findings support our study, where HRR_1 was lower in a warm, non-cooled room, emphasizing the impact of ambient temperature and fan cooling on cardiovascular recovery.

Additionally, Mi Hyun No et al. investigated how different environmental temperatures affect physiological responses in soccer players during both submaximal and maximal exercise. Key variables such as heart rate, core temperature, oxygen uptake (VO_2), perceived exertion, and blood lactate levels were measured under varying thermal conditions.[1]

Findings revealed that exercising in hot environments significantly increased heart rate, core temperature, and ratings of perceived exertion at both submaximal and maximal levels. Additionally, performance during maximal exercise declined in heat due to earlier onset of fatigue and greater anaerobic contribution, as shown by elevated lactate levels. Heat also delayed recovery and impaired cardiovascular efficiency, likely due to increased sweat loss and dehydration.

Fernández, Wimer et al. investigated the impact of fan cooling on exercise performance during submaximal, heart rate-based cycle ergometry performed in a thermoneutral indoor environment (~22°C). Sixteen

recreationally active adults participated in two trials: one with fan cooling (air directed at the torso and face) and one without. The study measured oxygen consumption (VO_2), energy expenditure, workload EEI , body mass loss, thermal discomfort, and RPE.[8] The results revealed significantly higher workloads, increased VO_2. Despite the increased physiological output, RPE remained unchanged, and participants reported significantly lower thermal discomfort scores and reduced body mass loss due to sweating. The authors concluded that fan cooling enhances submaximal performance and thermoregulation, even in moderate temperatures, without increasing perceived effort. [9]

These results align closely with our study, where PCI and RPE were lower in a cooled setting, suggesting improved cardiovascular efficiency and reduced subjective strain. Increased PCI and RPE in the warmer environment suggest that participants experienced a higher cardiovascular strain and perceived effort while performing the same workload. [10,11]

In conclusion to our study and prior evidences Thermal stress can impair cardiovascular efficiency and increase the burden of physical tasks, especially during aerobic activities. Dehydration and physiologic strain as indicated by core temperature, heart rate, and perceived exertion responses may rise as a result of exercise-induced heat stress.

CONCLUSION

This observational crossover study showed that ambient temperature significantly affects the physiological responses to submaximal exercise testing and benefits of conducting exercise testing in temperature-controlled environments, where participants demonstrated lower Physiological Cost Index (PCI) and Rate of Perceived Exertion (RPE), along with improved Heart Rate Recovery at 1 minute (HRR_1) in a room containing AC+Fan. The findings support the need for controlled testing environments during cardiorespiratory fitness (CRF) assessments to ensure the accuracy of results.

LIMITATIONS

The study was limited by a small sample size of 11 participants. Another limitation was the lack of recorded temperature or humidity. Additionally, the study design did not include randomization or blinding. Long term follow up was not taken such as recovery after 5 or 10 minutes. Separate effect of fan or AC cooling was not assessed.

CLINICAL IMPLICATIONS

The findings show the importance of maintaining a controlled testing environment during cardiorespiratory fitness assessments. For clinical settings, these findings emphasize that the ambient temperature significantly influence cardiovascular and physiological response to exercise and should be regulated accordingly to avoid any error in results of an individual's functional capacity.

FUTURE RECOMMENDATIONS

Future studies should include a larger number of participants and involve people of different ages, BMI and health conditions such as diabetes, hypertension and other cardiopulmonary disorders to make the results more widely applicable.

Conflict of Interest: The authors declare no conflict of interest.
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REFERENCES

1. No M, Kwak HB. Effects of environmental temperature on physiological responses during submaximal and maximal exercises in soccer players. Integrative medicine research. 2016 Sep

1;5(3):216-22.Responses to hyperthermia. Optimizing heat dissipation by convection and evaporation: neural control of skin blood flow and sweating in humans

2. Smith CJ, Johnson JM. Responses to hyperthermia. Optimizing heat dissipation by convection and evaporation: Neural control of skin blood flow and sweating in humans. Autonomic Neuroscience. 2016 Apr 1;196:25-36.
3. Raghuveer G, Hartz J, Lubans DR, Takken T, Wiltz JL, Mietus-Snyder M, Perak AM, Baker-Smith C, Pietris N, Edwards NM, American Heart Association Young Hearts Athero, Hypertension and Obesity in the Young Committee of the Council on Lifelong Congenital Heart Disease and Heart Health in the Young. Cardiorespiratory fitness in youth: an important marker of health: a scientific statement from the American Heart Association. Circulation. 2020 Aug 18;142(7):e101-18.
4. Rana BS, Pun M. Estimation of Physiological Cost Index as an Energy Expenditure Index using MacGregor's Equation. Journal of the Nepal Medical Association. 2015 Jul 1;53(199).
5. Chao KY, Liu WL, Nassef Y, Lai PZ, Wang JS. A pilot crossover trial assessing the exercise performance patients chronic obstructive pulmonary disease. Sci Rep. 2022 Mar 9;12(1):4158. doi: 10.1038/s41598-022-07698-z. PMID: 35264615; PMCID: PMC8907196.
6. Grummt M, Hafermann L, Claussen L, Herrmann C, Wolfarth B. Rating of perceived exertion: A large cross-sectional study defining intensity levels for individual physical activity recommendations. Sports Medicine-Open. 2024 Jun 10;10(1):71.
7. American College of Sports Medicine. *ACSM's guidelines for exercise testing and prescription*. 10th ed. Philadelphia: Wolters Kluwer; 2018. p. [83,86,87].
8. Fernandez A, Wimer GS, Culver MN, Flatt AA, Grosicki GJ. Fan cooling improves submaximal exercise capacity in an indoor thermoneutral environment. Research Quarterly for Exercise and Sport. 2023 Jan 2;94(1):124-30.
9. Brew A, O'Beirne S, Johnson MJ, Ramsenthaler C, Watson PJ, Rubini PA, Fagan MJ, Swan F, Simpson A. Airflow rates and breathlessness recovery from submaximal exercise in healthy adults: prospective, randomised, cross-over study. BMJ Supportive & Palliative Care. 2024 Nov 20;14(4):442-8.
10. Long A, Cartwright M, Reilly CC. Impact of fan therapy during exercise on breathlessness and recovery time in patients with COPD: a pilot randomised controlled crossover trial. ERJ open research. 2021 Nov 8;7(4).
11. Qian Y, Wu Y, de Moraes AR, Yi X, Geng Y, Dibaj S, Liu D, Naberhuis J, Bruera E. Fan therapy for the treatment of dyspnea in adults: a systematic review. Journal of pain and symptom management. 2019 Sep 1;58(3):481-6.