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Relative humidity of 40% inhibiting the increase of pulse rate, body temperature, and blood lactic acid during exercise

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ABSTRACT

Background: Excessive sweating of the body is a reaction to decrease the heat caused by prolonged exercise at high relative humidity (RH). This situation may cause an increase in pulse rate (PR), body temperature (BT), and blood lactic acid (BLA) workout.

Objective: This study aimed to prove that a RH of 40% better than a RH of 50% and 60% RH in inhibiting the increase of PR, BT, and BLA during exercise.

Methods: The study was conducted on 54 samples randomly selected from the IKIP PGRI Bali students. The samples were divided into three groups, and each group was given cycling exercise with a load of 80 Watt for 2 x 30 minutes with rest between sets for five minutes. Group-1 of cycling at 40% of RH, Group-2 at a RH of 50%, and the Group-3 at a RH of 60%. Data PR, BT, and BLA taken before and during exercise. The mean difference between groups before and during exercise were analyzed by One-way Anova and a further test used Least Significant Difference (LSD). Significance used was $\alpha = 0.05$.

Results: The mean of PR during exercise was significantly different between groups with $p = 0.045$, the mean of BT during exercises was significantly different between groups with $p = 0.006$, and the mean of BLA during exercises was significantly different between groups with $p = 0.005$ ($p < 0.05$). Also found that PR, BT, and BLA during exercise at 40% RH was lower than 50% RH and 60% RH ($p < 0.05$).

Conclusion: Thus, the RH of 40% was better than RH of 50% and 60 % in inhibiting the increase of PR, BT, and BLA during exercise. Therefore, when practiced in a closed room is expected at 40% relative humidity.

Keywords: relative humidity, pulse rate, body temperature, blood lactic acid.

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INTRODUCTION

Sporting environment was an important factor that should be considered because it can be affect the physical appearance. Environmental influences consist of environmental temperature, relative humidity, radiation, wind velocity, and others.[1]

High of relative humidity, increase the index of wet-bulb-globe-temperature (WBGT). WBGT index was a number that indicates the role of the environmental temperature, relative humidity, radiation and wind velocity. WBGT index reached 28°C can cause heat stress.[2] WBGT index increase causes dehydration and ending with unconsciousness.[3]

Heat stress lead to various health problems and death. In 1995, as many as 100 people died from the heat wave in Chicago and 400 people in America die each year due to heat stress. From the years 1995-2001 in the United States recorded 21 football players died from heat stroke. In Japan, from 2001-2003 as many as 483 people exposed to heat stroke, as many as 63 people died.[4]

Physiological changes in the body during exercise for a long time due to the decreased volume of body fluids through sweating along with heat emitting body.[5] The results of the study Cheuvront et al.[6] aerobic exercise for a long time will reduce the body fluid. The decline in body fluids causing increased blood viscosity which led to increased cardiac work.[7] If not matched by consuming enough fluids, will complicate expenditure body heat through convection.[8]

Physical exercise for a long time at a high relative humidity will increase spending body fluids and resulted in increased PR.[9] The decline of 2-6% of body fluids resulting in increased work of the heart characterized by increased PR. Losing excess body fluids during exercise will aggravate the heart and can lead to death.[10] Results of the research Muplichatun.[11] of the 41 workers at Donorejo-Batang iron workers, obtained occurred a significant relationship between exposure to heat with PR. Furthermore, Telan[12] conducted a study of 50 iron workers, obtained an increase compared to the prior PR given heat exposure.

BT increased to 40°C in strenuous exercise for 20 minutes.[13] The results of research are aligned Gonzalez-Alonso et al.[14] that increased BT reaches to 40°C when prolonged physical exercise in a

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humid environment. The results of the study Saunders et al.[15] an increase in BT at a relative humidity of 80% compared with 59% relative humidity to nine subjects after cycling for two hours. This statement was in accordance with the results of research Yashasi et al.[16] physical exercise at high relative humidity causes the core body temperature was higher than the low relative humidity.

The results of the study Bloomer and Cole[17] against the men on the bench press exercise, acutely can increase the BLA. Increased the BLA followed by an increase in CO_2 can interfere with muscle contraction.[18] Extracellular fluid serves as a carrier to the liver for metabolism results immediately recycled as an energy source, resulting in decreased BLA.[19] Another opinion is consistent is that the role of transporting the body fluids such as CO_2 and the metabolism of lactic acid.[20,21] Transpiration rate will decrease the body fluids, thereby accelerating the improvement of BLA.[9] According Kusnanik et al.[13] a decrease in body fluids causes a decrease in blood O^2 concentration. The decrease O_2 will reduce glycolysis in the liver, so that an increase in BLA.

Therefore, in exercise it takes the RH was causing climate comfortable against the body. Comfortable relative humidity was between 40-60% according to the Ministry of Health of the Republic of Indonesia No: 1077/Menkes/Per/V/2011.[22]

The relative humidity was to be considered as causing excessive sweating, causing acute effects to the improvement of PR, BT, and BLA during exercise. Based on these ideas, physical exercise at a relative humidity of 40%, 50%, and 60% in an enclosed area needs further investigation.

MATERIALS AND METHODS

This study was an experimental with randomized Pre and Post Test Control Group Design.[23] Subjects amounted to 54 people, divided into three groups so that each group numbered 18 people. Each group was given cycling exercise with load 80 Watt for 2 * 30 minutes. Group-1 was given cycling at 40% RH, Group-2 at a RH of 50%, and the Group-3 at a RH of 60%. PR, BT, and BLA were observed before and during exercise in all groups. Observations before exercise carried out after the break lying for 10 minutes and observation during exercise performed at the 30th minute set to two.

The study was conducted in the morning at the Laboratory of the Faculty of Physical Education and Health of IKIP PGRI Bali with temperatures at room between 25.0°C to 30.0°C.

Data were collected starting from 17 November to 30 December 2015. PR was measured with a digital pulse meter brand Omron, BT was measured with a digital thermometer brand *Kawe*, and BLA was measured by *Accutrend plus Cobas*.

The data obtained were analyzed by Shapiro Wilk normality test and the test continued with Levene test to determine homogeneity. Different test between groups used One-way ANOVA followed by LSD test.

RESULT

Characteristics Research

Physical characteristics include age, body mass index (BMI), resting pulse rate (RPR), and physical fitness (PF), as measured by the time you've run 2.4 km. The physical characteristics of the study subjects are presented in Table-1.

Table 1 Physical Characteristics Research Subjects

Characteristics	Group-1 (n=18)	Group-2 (n=18)	Group-3 (n=18)
Age (year)	20,18 ± 0,16	20,53 ± 0,32	20,47 ± 0,18
BMI (kg/m²)	21,78 ± 0,87	22,01 ± 0,54	21,13 ± 0,53
RPR (b/m)	84,33 ± 2,07	80,00 ± 2,80	77,61 ± 3,00
PF (minute)	12,83 ± 0,20	12,59 ± 0,22	12,76 ± 0,24

Description: n = number of samples, SE = standard error, cm = centimeter, kg = kilogram, kg/m² = kilograms per square meter, b/m = beats/minute

Table 2 Normality and Homogeneity Test Result

Exercise	p-value of Normality (Group) 1	2	-3	p-value of Homogeneity
Before				
PR	0,348	0,712	0,139	0,168
BT	0,065	0,315	0,530	0,380
BLA	0,291	0,359	0,364	0,866
During				
PR	0,057	0,571	0,374	0,079
BT	0,330	0,173	0,310	0,267
BLA	0,063	0,615	0,066	0,105

Description: SE = standard error, p = probability value

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Table 3 Different Test Results of PR, BT, and BLA Before and After Exercise

Variable	Mean ± SE			p
	Group-1	Group-2	Group-3	
Before Exercise				
PR	71,55±1,92	72,28±1,31	71,39±1,27	0,909
BT	36,68±0,05	36,72±0,07	36,71±0,06	0,251
BLA	2,12±0,12	2,28±0,10	2,22±0,11	0,590
During Ecercise				
PR	139,00±2,53	148,89±2,77	159,22±3,70	0,000
BT	36,63±0,06	36,89±0,08	37,26±0,09	0,000
BLA	3,38±0,20	4,17±0,16	5,12 ±0,31	0,000

Description: SE = standard error, p = probability value, Unit: PR = beats/minute, BT = °C, BLA = mM/L

Table 4 Different Test Results of PR, BT, and BLA During Exercise Between of Each Group

Couple difference	Mean ± SE	p
PR Group-1 - Group -2	-9,89 ± 4,30	0,026
PR Group -1 - Group -3	-20,22 ± 4,30	0,000
PR Group -2 - Group -3	-10,33 ± 4,30	0,020
BT Group -1 - Group -2	-0,26 ± 0,11	0,019
BT Group -1 - Group -3	-0,63 ± 0,11	0,000
BT Group -2 - Group -3	-0,37 ± 0,11	0,001
BLA Group -1 - Group -2	-0,79 ± 0,32	0,018
BLA Group -1 - Group -3	-1,73 ± 0,32	0,000
BLA Group -2 - Group -3	-0,94 ± 0,32	0,005

Description: SE = standard error, p = probability value, Unit: PR = beats/minute, BT = °C, BLA = mM/L

Normality and Homogeneity Test

As a prerequisite determination of statistical tests, then tested the normality and homogeneity of data on the dependent variables concerning PR, BT, and BLA both before and during training. The results of the analysis are presented in Table-2.

Based on the test results of normality and homogeneity of data both before and during exercise, obtained the all group was normal distribution and homogeneous ($p > 0.05$). The data were normally distributed and homogeneous variants were analyzed by One-way Anova and LSD test further.

The Mean difference of Group

Differences of the PR, BT, and BLA between groups before and during exercise was presented in Table-3.

Table-3 shows, the mean of PR, BT, and BLA before exercise was not differ significantly ($p > 0.05$) while the PR, BT, and BLA during exercise showed a significant difference ($p < 0.05$).

The mean difference of PR, BT, and BLA During Exercise Between of Each Group

Differences of the PR, BT, and BLA during exercise between each group were tested with LSD were presented in Table-4.

Table-4 shows no difference FDN, ST, and ALD practice between Group-1 with Group-2, between Group-1 with the Group-3, and between Group-2 with Group-3 ($p < 0.05$).

DISCUSSION

Characteristics of Research Subjects

The mean of age of each group were in the normal range for semester-1 to semester-8 student ranging from 18 to 25 years. BMI in the normal range between 18.5 to 24.9 kg/m^2, RPR that were in the normal range was between 60-100 beats/minute.[24,25] while PF was in the category enough to good.[26]

The Differences of PR, BT, and BLA Before Exercise

The mean of PR before exercise among the three groups was not statistically significant difference ($p > 0.05$). The third group was still in the normal range in the range of 60 - 100 beats/minute.[25]

The mean of BT before exercise between groups showed no significant difference ($p > 0.05$). The mean of BT before exercise was in the normal range in the range below 37°C. The normal range was between 36.3 to 37.1°C.[27]

The mean of BLA prior to the exercise also showed no significant difference ($p > 0.05$). BLA prior to exercise was above normal with the mean being above 2 mM/L. Normal limits ranging between 1-2 mM/L.[28]

Exchange differences Treatment of PR, BT, and BLA

From the results, there was difference between the PR during exercise increase to three groups and no difference between the PR during exercise increase in each group. Where an inhibiting the increase in PR during exercise in a RH of 50% compared with 60% RH of 6.49% and exercise at a RH of 40% inhibiting the increase of 12.70%. Differences increase of the PR during exercise due to differences in transpiration, where transpiration at a RH of 40% lower than the RH of 50% and RH of 60%. This happens because the transpiration was accelerated at high RH and decreased at low RH.[2,19] The results of previous studies of the 51 people obtained a slowdown sweating during exercise at a RH of 50% compared with 60% RH at 114.71 ± 40.94 mL or equal to 15.29% and at 40% RH decreased by 200.00 ± 40.94 mL or 26.67%.[29]

The results showed there were difference between the BT during exercise increase to three groups and

also there was a difference between the increase in BT during exercise each group. An inhibiting the increase in BT of exercise at a RH of 50% compared with 60% at 0.99% and exercise at a relative humidity of 40% inhibiting the increase of 1.69%. Inhibiting the increase of BT during exercise at a lower RH caused by the evaporation goes well. This is because the vapor pressure difference between the skin and the air is increased.[30] Further stated, prolonged exercise at high RH will accelerate the decline in body fluids. The decline would interfere with the body fluids of the body heat dissipation into the environment so that the body's core temperature to rise gradually.[31]

The results also showed there were difference between the exercise BLA during exercise increase to three groups and there was a difference in improvement between each group. Inhibiting the increase at a BLA of exercise at a RH of 50% compared with a RH of 60% amounting at 18.56% and exercise at a RH of 40% inhibiting the of 33.98%. Exercise BLA was lower at 40% relative humidity due to differences in transpiration. At higher humidity, transpiration increases, causing blood viscosity will increase. Increased blood viscosity, causing delays in transportation of metabolism to the liver to be converted into glucose, so that BLA will increase.[32] Results from previous studies of 21 professional soccer players given sub-maximal exercise, it was found that blood viscosity is directly related to BLA.[33]

CONCLUSION

Based on the results, we can conclude that the relative humidity of 40% is better than humidity of 50% and 60% in inhibiting the increase of PR, BT, and BLA during exercise.

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