مجلة أبحاث كلية التربية الأساسية ، المجلد ٢٠، العدد (١)، لسنة ٢٠٢٤

College of Basic Education Researchers Journal. ISSN: 7452-1992 *Vol. (20), No.(1), (2024)*

Comparative Study between (24 C°) and (15 C°) Regarding Some Functional Variables and Achievement Time After Cardiorespiratory Effort Test

Omar Aladdin Ahmed Al-Naqeeb

University of Mosul/ College of Basic Education/ Department of Physical Education and Sports Sciences

(Recieved in 16/9/2023 Accepted in 24/12/2023)

Abstract

There is a debate among researchers regarding the impact of environmental factors, such as varying temperatures, on bodily functions, particularly the respiratory system of athletes. Hence, investigating the influence of moderate to cold weather on athletes during exercise is essential for comprehending this relationship and determining optimal strategies for public health maintenance, fitness enhancement, and performance improvement under diverse environmental conditions. Consequently, this study aims to ascertain the impact of the surrounding environment on individuals, the extent to which their physiological systems are affected, and the resultant manifestations, especially during physical exertion.

The primary aim of the present study was to assess the differences in respiratory system variables (respiratory rate (RR), tidal volume (TV), pulmonary ventilation ($\dot{V}$E)), as well as other parameters (heart rate (HR), completion time (Ct)), at rest and post-cardiorespiratory exercise test (CPET) between moderate heat (24°C ± 1) and cold conditions (15°C ± 1). The researcher hypothesized that there would be no significant disparities in respiratory system variables (RR, TV, $\dot{V}$E), HR, and Ct between the moderate and cold conditions, both at rest and after CPET.

A descriptive approach was chosen for its suitability to the nature of the study. The research sample comprised eight randomly selected individuals aged between 22 and 24 years who engaged in physical activity. The experimental sessions were conducted in two different thermal conditions: moderate temperature (24°C ± 1) with 30-40% humidity, and cold temperature (15°C ± 1) with 30-40% humidity. Data processing involved the use of statistical and computational methods such as arithmetic mean, standard deviation, coefficient of variation, body mass index, body surface area, and t-tests for two related samples.

The findings of the study revealed the following:

- Cold environmental conditions led to a significant increase in comfort in the variables TV, $\dot{V}$E, and HR at the conclusion of physical exertion, as well as an increase in RR, compared to temperate conditions.
- Cold environmental conditions did not result in a significant increase in comfort in RR, TV, $\dot{V}$E, and HR at the end of physical exertion in comparison to temperate conditions.
- The cold environmental condition during physical exertion did not exhibit a clear negative or positive impact on Ct in terms of the duration of the end of exertion compared to the moderate

Keywords: cold environment, moderate environment, respiratory system, pulmonary ventilation, cardiovascular, breath volume, respiratory rate

مجلة أبحاث كلية التربية الأساسية ، المجلد ٢٠، العدد (١)، لسنة ٢٠٢٤
College of Basic Education Researchers Journal. ISSN: 7452-1992 *Vol. (20), No.(1), (2024)*

دراسة مقارنة بين درجتي حرارة (١٥ C°) (٢٤ C°)بدلالة عدد من المتغيرات الوظيفية وزمن الإنجاز بعد أداء اختبار الجهد القلبي التنفسي

عمر علاء الدين النقيب
جامعة الموصل كلية التربية الأساسية قسم التربية البدنية وعلوم الرياضة

الملخص:

هدفت الدراسة الحالية إلى: التعرف على دلالة الفروق بين ظرفي الحرارة المعتدلة (٢٤ C° ±١) والباردة (١٥ C° ± ١) في عدد من متغيرات الجهاز التنفسي (عدد مرات التنفس (RR)، وحجم النفس (TV)، التهوية الرئوية(V̇E))، وبعض المتغيرات الأخرى (معدل ضربات القلب (HR)، زمن الإنجاز (Ct)) في الراحة وبعد أداء اختبار الجهد القلبي التنفسي (CPET). وافترض الباحث عدم وجود فروق ذات دلالة معنوية بين ظرفي الحرارة (المعتدلة والباردة) في متغيرات الجهاز التنفسي (RR، TV، V̇E)، ومتغير (HR)، و (Ct) في الراحة وبعد أداء اختبار الجهد القلبي التنفسي. استخدم الباحث المنهج الوصفي لملائمته وطبيعة الدراسة، أما عينة البحث فتكونت من (٨) أفراد تم اختيارهم بطريقة عشوائية تتراوح أعمارهم ما بين (٢٢-٢٤ سنة) من الممارسين للنشاط الرياضي، أُجريت التجربة النهائية في ظرفين حراريين مختلفين، مرة في الظرف الحراري المعتدل (٢٤ C° ±١) ورطوبة (٣٠-٤٠٪)، وأُخرى في الظرف الحراري البارد (١٥ C° ± ١) ورطوبة (٣٠-٤٠٪)، على عينة الدراسة في الراحة التامة، وبعد الانتهاء مباشرة من الجهد البدني (CPET). توصل الباحث إلى الاستنتاجات الآتية:

- يؤدي الظرف في البيئة الباردة إلى إحداث زيادة ملحوظة في الراحة في متغيرات (TV، V̇E، HR) وفي نهاية الجهد البدني في متغير (RR) مقارنة مع ظروف البيئة المعتدلة.
- لم يؤدي الظرف في البيئة الباردة إلى إحداث زيادة ملحوظة في الراحة في متغير (RR) وفي نهاية الجهد في متغيرات (TV، V̇E، HR) مقارنة مع ظروف البيئة المعتدلة.
- لم يؤدي الظرف في البيئة الباردة أثناء الجهد البدني دوراً سلبياً أو إيجابيا واضحا في (Ct) بدلالة زمن نهاية الجهد بالمقارنة مع الظرف في البيئة المعتدلة.

1-1 Introduction and importance of research:

Exercises and physical tests are one of the most important external load factors that affect human body to cause changes in internal functional organs that cannot be caused at rest, Thus, these tests help specialists and physiologists to form a clear idea of efficiency of the functions of these organs, As physical exercise requires interaction of the physiological control mechanism to enable the two systems (cardiovascular and respiratory) to combine their work mechanism to support their joint function, that is, to meet the increased gas exchange requirements (oxygen consumption O_2 and production of carbon dioxide CO_2) of working muscles, This effect varies according to the nature of physical effort or other influences, the most important of which is the ambient temperature, as the surrounding environment is one of the most important factors that affect individuals, especially during physical effort, as physical effort in a cold environment is more burdensome on the body than physical effort in a moderate environment. As the effect of cold weather on exercise performance depends largely on severity of cold weather and nature of exercise.

Many researches and scientific studies have dealt with functional variables in general and the respiratory system in particular, during exercise, and have paid special attention to them due to their importance in knowing special information to select athletes and direct them towards the appropriate specialty for them, in addition to know level of physical fitness by observing performance of functional devices, which reflects The athlete's physical condition, In addition to other factors, researchers also tend to study most important factors and influences related to improvement and development of physical performance and thus athletic achievement, The most important of these factors is ambient temperature during exercise, the importance of this topic was addressed through their researches. Among these studies: a (Braunig & Granacher 2013) study Which focused on effect of exposure to cold weather on breathing functions and oxygen consumption of an athlete, the of (Galloway and Maughan, 1997) study, which dealt with effects of ambient temperature on the ability to perform exercise using the exercise bike for long periods, the (No and Kwak, 2016) study, dealt with effect of different temperature on physiological responses during sub-maximum and maximum exercises among young soccer players, a (Périard & et al, 2015) study , which dealt with effect of the cold environment on arterial hypoxia resulting from exercise on the speed of skating athlete, And a (Tipton & Golden, 2017) study, which dealt with effect of training in cold climates on the performance of athlete.

The results of these studies were mixed, and this difference in results is due to their positive or negative impact on performance, Where the researchers differed about the effect of the surrounding environment, represented by different temperatures, on variables of respiratory system at rest and during physical exercise, Some of them found an effect of increasing these variables, some of them did not find any change, and some of them found a decrease in these variables, But it is not known where the difference and change in variables of pulmonary ventilation (R_R, T_V, $\dot{V}_E$) under exposure to different environmental conditions lies Which, therefore, may be reflected on individual's performance during exercise or even at rest, depending on the duration of effort and temperature under which individual is affected. Therefore, studying the effect of moderate to cold weather on athlete during exercise will help to understand this relationship and determine the best ways to maintain public health and improve fitness and achievement under these different environmental conditions.

Hence the importance of research in knowing the effect of different temperatures on the variables of respiratory system. The results of this study provide us with solid and important information that serves scientific research, researchers, trainers and specialists in physiology of physical effort.

1-2 Research problem:

There is a need for a lot of studies to know the effect of different thermal conditions on a person during exercise , the extent to which functional human devices are affected by them and what are the reflections shown by these devices, as indicated by a number of studies that performing exercise in cold weather is one of the obstacles that athletes face during exercise Exposure to cold affects body's ability to perform physically, Performing exercise in these climates can affect the functions of respiratory system. However, there are many athletes who exercise in cold climates, as some believe that this helps improve some physical aspects such as physical fitness and weight loss. Based on what was mentioned above, the study problem is determined by asking the following questions:

- What are the responses of (R_R, T_V, $\dot{V}_E$, H_R), before and after performing (CPET) in moderate temperature condition (24 C°±1).
- What are the responses (R_R, T_V, $\dot{V}_E$, H_R), before and after performing (CPET) in cold temperature condition (15 C°± 1).
- What is the effect of variation in ambient temperatures before and after (CPET) performance on the values of (R_R, T_V, $\dot{V}_E$, H_R) and (C_t) variables between moderate temperature condition (24 C°±1) and cold temperature condition (15 C°± 1).

1-3 research aims:

1-3-1 To identify significance of the differences in a number of variables: the respiratory system (R_R, T_V, $\dot{V}_E$), and (H_R), before and after performing (CPET) in temperate environment (24 C°±1).

1-3-2 To identify significance of differences on a number of respiratory variables (R_R, T_V, $\dot{V}_E$), and (H_R), before and after performing (CPET) in a cold environment (15 C°± 1).

1-3-3 Identifying significance of differences between the two temperature conditions (moderate and cold) on a number of variables: respiratory system (R_R, T_V, $\dot{V}_E$), (H_R), and (C_t), before and after performing (CPET).

1-4 Research hypotheses:

1-4-1 There were no significant differences in a number of variables: respiratory system (R_R, T_V, $\dot{V}_E$), and (H_R), before and after the performance of (CPET) in moderate temperature condition (24 C°±1).

1-4-2 There were no significant differences in a number of variables: respiratory system (R_R, T_V, $\dot{V}_E$), and (H_R), before and after performing (CPET) in cold condition (15 C°± 1).

1-4-3 There were no significant differences between (moderate) and (cold) heat conditions in a number of variables: (R_R, T_V, $\dot{V}_E$), (H_R), and (C_t), before and after performing (CPET).

1-5 Research limits:

1-5-1 Human field: A sample of fourth-year students in Department of Physical Education and Sports Sciences - College of Basic Education, namely (8) students.

1-5-2 Spatial field: Physiology Laboratory of College of Basic Education - Department of Physical Education and Sports Sciences/University of Mosul.

1-5-3 Time field: from 28/12/2022 to 22/3/2023.

2-1 Research method:

Researcher used descriptive comparative method, as it is the most suitable method for the nature of research problem.

2-2 The research sample:

The research sample included (8) students from College of Basic Education - Department of Physical Education and Sports Sciences / University of Mosul / fourth stage, they were chosen randomly, and the coefficient of variation [1] showed an acceptable homogeneity between members of research sample, Table (1) shows some information about the individuals in research sample.

table (1)

means, deviations, and coefficient of variation for the variables age, weight, height, body surface area, and body mass index

Variables / Statistical Parameters		the age (year)	Height (cm)	the weight (kg)	Surface area of the body (m_2)	BMI
ue sa m	arithmetic mean	٢٢,٢٥٠	١٦٩,٣٧٥	٧٧,٠٠٠	١,٨٧٦	٢٦,٩٣٢

[1] If the value of the coefficient of variation is less than 30%, this indicates the homogeneity of the sample (Al-Tikriti and Al-Obeidi, 1999, p. 161).

	Deviations	١,٠٣٥	٥,٠٩٧	١٠,٣٩٢	٠,١٠٧	٤,٢٢٤
	coefficient of variation	٤,٦٥٢	٣,٠٠٩	١٣,٤٩٦	٥,٧٠٣	١٥,٦٨٣

2-3 Data collection methods:

The researcher used technical measurements and tests to collect data.

2-4 Devices used:

- Treadmill to perform test.
- A device (Sperometer) to measure variables of respiratory system.
- A sensitive scale for measuring height and weight (Detecto).
- Heart rate sensor belt from (Polar) company..
- A device (Plus oximeter) to measure heart rate and blood oxygen of European origin.
- Digital thermometer to measure ambient temperature and humidity, type (Delta trak), number (1), German origin.
- Electric fireplace (1) of Chinese origin.
- Cooling-heating air conditioner (2).
- Laptop number (1).
- Stopwatch.
- Special mask sterilizers.

2-5 Description of measurements and tests

2-5-1 Body measurements

2-5-1-1 Height and weight measurement:

Height and weight of research sample members were measured using a (Detecto) type (height and weight measurement) device. The individual stands on base of the device to measure his weight barefeeted, resting his back on metal pole installed vertically on the base of the device. After a member of the assistant work team presses special key for measurement and records the weight after reading digits on electronic screen , the number represents weight of the individual in kilograms and to the nearest (200 g), then the same person moves the metal plate to touch the individual’s head, and after fixing it reads the indicator that represents a person’s height in centimeters.

2-5-2 Functional measurements

2-5-2-1 Heart rate (H_R) measurement:

Heart rate was measured by means of a sensor belt from the company (Polar), which connects the belt around the individual’s chest below level of nipples, tilted slightly to the left, as this sensor sends waves to the (Bluetooth) device by means of wireless communication, which is linked to treadmill, and analyzes the signal It gives value of the heart rate, which appears directly on the screen of the device, while at rest, the heart rate was measured by a device (Plus oximeter).

2-5-2-2 Respiratory Variables Measurement (R_R, T_V, $\dot{V}_E$):

Respiratory functions are tested by a technique called (spirometry), which is a device that measures amount of air entering or leaving lungs during breathing through a tube linked to a mask placed on the mouth connected to the device. The measurements are recorded on a paper tape through which the required data is read. These devices have evolved so that a small device can measure many variables at the same time. The testee places a cylindrical measuring tube in the mouth, for the (Spirometry) device, and a stopper is also placed on the testee's nose to prevent breathing from nose. Testee begins with normal breathing process, (inhalation and exhalation). Then, it will be recognized by the device (Spirometry) on the pattern of pulmonary ventilation, expressed in normal breath volume and number of respirations, and it will be recorded directly on computer with graphical curve of the variables drawn. When conducting the test in a state of rest, care should be taken to give the testee a period of time to breathe before starting measurement in order to overcome psychological condition accompanying beginning of test and for the individual to reach the natural rhythm of inhalation and exhalation processes.

2-5-3 Cardiorespiratory Stress Test (CPET) (Bruce Test):

The cardiorespiratory or (aerobic exercise test) in current study is an application of the Bruce protocol. The test begins with a simple load level, then the load increases over certain units of time until the test ends when the individual is exhausted.

- Aim of the test: to make individual take maximum value of oxygen consumption ($\dot{V}O_{2max}$).
- Tools: a treadmill, a gas analyzer, a mask, and a rubber tube.
- **Test specifications**:
  - The individual warms up for (5) minutes, by jogging lightly on treadmill at a specific speed and incline. speed (km)
  - Give a rest period of no more than (5) minutes.
  - The test begins after giving the device operator command to set a speed and incline, as shown in Table (4).
  - When the individual starts running, the timer starts running the stopwatch.
  - After every three minutes, we raise degree of incline and speed, according to the proven protocol.

- The test continues with increasing speed or incline until the individual reaches the stage of exhaustion and fatigue.
- Test stops after individual reaches volitional stress through a stop button on the computer on the treadmill.
- Test specifications: The test consists of seven stages, each stage has a speed and slope, and each stage takes three minutes to perform. Table (2) shows stages of testing: (Al-Hazaa, 2009, p. 484).

Table (2)

Shows the phases of the Bruce Protocol test

Testing stages	Time (min)	Speed (Km/h)	Slope (%)
The first stage	1-3	2.7	10 %
The second stage	3-6	4.7	12 %
The third stage	6-9	5.5	14 %
The fourth stage	9-12	6.8	16 %
Fifth stage	12-15	8.0	18 %
Sixth stage	15-18	8.8	20 %
Seventh stage	18-21	9.6	22 %

2-6 Pilot experiments:

All exploratory experiments were conducted on Monday and Tuesday (2-3/1/2023) and included the following:

2-6-1 The first pilot experiment:

A first pilot experiment was conducted on research sample, for the purpose of explaining the method in which sample will be tested, as well as conducting a simplified test on treadmill in order to adapt and familiarize themselves with the device.

2-6-2 The second pilot experiment:

This experiment was conducted to ensure validity of devices and tools used in the experiment, as well as a simplified explanation for the assistant work team [(2)] of the stages in which the experiment will be implemented, training them on the devices and tools, how to use them, the method of measurement, and the distribution of tasks related to the experimental procedures to them, as well as identifying obstacles that may appear when implementing application procedures experiment and to know the approximate time it takes for the test.

---

[2] . The support team included:
- Prof. Dr. Muhammad Tawfiq Othman.
- L.A. Fadi Muhammad Sheet.

2-6-3 The third pilot experience:

In this experiment, the temperature and humidity of test were controlled once under moderate temperature conditions of (24 C°±1) and humidity (30-40%), and once in cold conditions of (15 C°± 1) and humidity (30-40%), making sure through this experiment how to control the required thermal conditions in which the experiment will be carried out.

2-7 The final experiment

2-7-1 First Final Experiment:

The first final experiment, which included performing an aerobic physical effort test of gradual intensity until fatigue was reached, was conducted on Thursday (5/1/2023). This experiment was conducted in a moderate environmental condition (24 C°±1). The average humidity percentage (30-40%), and search variables were measured as follows:

- Measure variables of pulmonary ventilation and heart rate at rest before performing test.
- Giving physical effort of gradual intensity until fatigue is reached.
- Measuring variables of pulmonary ventilation and heart rate immediately after exertion.
- Measuring achievement time taken by athlete on the treadmill.

2-7-2 The second final experiment:

The second experiment was conducted on Wednesday (11/1/2023) and was carried out with the same steps as the first experiment, with a difference in surrounding environment temperature, which was (15 C°± 1).

2-8 The most important procedures that researcher took to implement experiment:

- Ensure health status of research sample members and their safety from all diseases that may lead to a negative impact on the sample during implementation of the experiment.
- Matching all procedures of the two experiments in terms of their execution times and sequence of conducting them on sample, as they were conducted from nine in the morning until one in the afternoon.
- Temperature and humidity were controlled in all moderate and cold conditions of experiments, by controlling air conditioners to adjust room temperature.
- Providing the largest degree of protection for sample members during their implementation of the two experiments, by having a person from the assistant work team stand behind sample members on the treadmill to prevent them from falling off the device.
- The two experiments were conducted in the two environments (temperate and cold) under the same conditions in terms of time and place, the devices and tools used, as well as the sequence of procedures for measuring functional variables.

- "Ensure that the research sample adapts to the thermal conditions by placing them in the test room for a period of not less than half an hour and using an overlapping method" (Ferguson et al, 2002, p.982).

2-9 Statistical and mathematical means:

- Arithmetic mean.
- Standard deviation.
- Coefficient of Variance.
- T-Test of related samples
- Body Mass Index, BMI .
- Body surface area, BSA.

data were processed using the statistical package SPSS version (11).

3-1 Presenting results of differences in a number of respiratory system variables and heart rate due to impact of physical effort in a moderate and cold environment

3-1-1 Presentation of results of differences in a number of respiratory system variables and heart rate due to impact of physical exertion in a moderate environment.

table (2)

Shows arithmetic means and standard deviations for some respiratory system variables and heart rate at rest and after the end of physical effort in a moderate environment (24 C°±1)

functional variables		Arithmetic mean	standard deviation (±)	T- Test	significance level
R_R (f.min^{-1})	before the effort	١٤,٧٢٤	١,٦٩٠	٢٤,٩٠٣	*٠,٠٠١
	after effort	٤٠,٤٥١	١,٨٥٣		
T_V (L)	before the effort	٠,٥١٢	٠,٠٤٦	١٠,٢٤٨	*٠,٠٠١
	after effort	١,٥٣٦	٠,٢٩٤		
$\dot{V}_E$ (L.min^{-1})	before the effort	٧,٥٦٠	٠,٦٧٤	١٥,٨٨٩	*٠,٠٠١
	after effort	٦١,٧٣٩	٩,٩١٥		
H_R (b.min^{-1})	before the effort	٧٠,٥٠٠	٧,٧٠٨	٤٨,٣٢٩	*٠,٠٠١
	after effort	١٨٣,٧٥٠	٦,٢٠٤		

* Significant when error percentage < (0.05)

3-2-1 Presenting results of differences in some variables of respiratory system and heart rate due to impact of physical effort in a cold environment

table (3)

Shows arithmetic means and standard deviations for some respiratory system variables and heart rate at rest and after end of physical effort in a cold environment (15 C°± 1)

functional variables		Arithmetic mean	standard deviation (±)	T- Test	significance level
R_R (f.min^{-1})	before the effort	١٦,٠٦١	١,٨٧٣	٢٠,١٤٢	*٠,٠٠١
	after effort	٤١,٧٩٦	٢,٨٩٧		
T_V (L)	before the effort	٠,٤٣٢	٠,٠٥٤	٩,٧٥٨	*٠,٠٠١
	after effort	١,٤٩٧	٠,٣١١		
$\dot{V}_E$ (L.min^{-1})	before the effort	٦,٨٧٥	٠,٥٧٤	١٤,٧٠٨	*٠,٠٠١
	after effort	٦٢,٠٥٧	١٠,٩٠٧		
H_R (b.min^{-1})	before the effort	٧٧,٣٧٥	١١,٦٤٨	٣١,٧٥٠	*٠,٠٠١
	after effort	١٨٤,٣٧٥	٤,٩٨٣		

* Significant when error percentage < (0.05)

3-2 Displaying results of differences in a number of variables of the respiratory system, heart rate, and time of exhaustion of effort between influence of the moderate and cold conditions.

3-2-1 Displaying results of differences in a number of variables of respiratory system and heart rate between influence of moderate and cold conditions

Table (4)

Shows arithmetic mean and standard deviations in a number of variables of the respiratory system and heart rate between effect of moderate heat conditions (24 C°±1) and cold conditions (15 C°± 1).

Functional variables		Arithmetic mean	standard deviation (±)	T- Test	significance level
R_R (f.min^{-1})	Rest - Moderate environment	١٤,٧٢٤	١,٦٩٠	١,٩٦١	٠,٠٩١
	Rest - Cool environment	١٦,٠٦١	١,٨٧٣		
	Physical effort - moderate environment	٤٠,٤٥١	١,٨٥٣	٢,٤٨١	*٠,٠٤٢
	Physical effort - Cool environment	٤١,٧٩٦	٢,٨٩٧		
T_V (L)	Rest - Moderate environment	٠,٥١٢	٠,٠٤٦	٥,٠٠	*٠,٠٠٢
	Rest - Cool environment	٠,٤٣٢	٠,٠٥٤		
	Physical effort - moderate environment	١,٥٣٦	٠,٢٩٤	١,٧٤٤	٠,١٢٥
	Physical effort - Cool environment	١,٤٩٧	٠,٣١١		
$\dot{V}_E$ (L.min^{-1})	Rest - Moderate environment	٧,٥٦٠	٠,٦٧٤	٢,٥٠١	*٠,٠٤١
	Rest - Cool environment	٦,٨٧٥	٠,٥٧٤		
	Physical effort - moderate environment	٦١,٧٣٩	٩,٩١٥	٠,٣٨٠	٠,٧١٥
	Physical effort - Cool environment	٦٢,٠٥٧	١٠,٩٠٧		
H_R (b.min^{-1})	Rest - Moderate environment	٧٠,٥٠٠	٧,٧٠٨	٢,٤٦١	*٠,٠٤٣
	Rest - Cool environment	٧٧,٣٧٥	١١,٦٤٨		
	Physical effort - moderate environment	١٨٣,٧٥٠	٦,٢٠٤	٣,٤٩٣	٠,٧٣٠
	Physical effort - Cool environment	١٨٤,٣٧٥	٤,٩٨٣		

* Significant when error percentage < (0.05)

4-2-2 Presenting results of differences in completion time variable due to the influence of moderate and cold thermal conditions

Table (5)

shows arithmetic mean and standard deviations in completion time variable between influence of the moderate environmental condition (24 C°±1) and the cold (15 C°± 1)

functional variables		Arithmetic mean	standard deviation (±)	T- Test	significance level
The time to complete the physical effort	Moderate environment	١١,٤٨٧	١,١٧١	١,٥٦٥	٠,١٦١
	Cool environment	١١,٠٢٨	٠,٦٧٦		

4-3 Discussing results of effect of physical effort on the variables (R_R, T_V, $\dot{V}_E$), (H_R), and (C_t) at rest and after performing the cardiorespiratory stress test in a moderate (24 C°±1) and cold (15 C°± 1) ambient environment.

It is evident from Tables (3, 4) that pertain to respiratory variables that nclude (respiratory rate (R_R), breath volume (T_V), and pulmonary ventilation per minute ($\dot{V}_E$)), in the temperate (24 C°±1) and cold environment (15 C°± 1) there is a rise in value of these variables when moving from resting phase, All the way to the end of physical effort, as these results are consistent with many studies, including: (Al-Rubaie, 2017, pp. 54-59) and (Dilber et al, 2015, pp. 195-202).

The researcher attributes this increase to the effect of physical effort, which is characterized by its increasing intensity in each phase of the physical effort, and this has led to an increase in need for oxygen for the muscles' need for energy and the disposal of carbon dioxide resulting from the wastes of metabolism (CO_2, H^+), This leads to changes in level of respiratory system. During the gradual exercise, the intensity ($\dot{V}_E$) increases by increasing both (R_R) and (T_V). This increase is due to mechanisms of breathing process. As & Howley Powers (2009) indicate that there are two mechanisms that control breathing process during exercise or any effort to increase ventilation, which is (neural control of breathing), and it is represented by voluntary system that is located in the cerebral cortex, This device works to send nerve impulses through respiratory motor neurons by spinal cortical bundles to increase breathing, and the autonomic system (respiratory center) which is located in two regions of the brain (the pons and medulla oblongata), where this device consists of four nerve centers responsible for processes of inhalation and exhalation, The second mechanism is (chemical control of breathing), as there are three chemical factors that work to regulate pulmonary ventilation, which are (PO_2, PCO_2, and H^+), which occur as a result of an increase in the metabolic rate. The effect of these factors occurs through two types of receptors, which are:(central chemoreceptors, peripheral chemoreceptors), The central nervous respiratory centers are affected as soon as the blood is exposed to any chemical change, thus breathing process is affected, and this happens in two ways, the first is directly and through the respiratory nerve centers, and the second is indirect and is represented by the effect reflected by central and peripheral receptors, as these receptors are affected by changes occurring to (molecular pressure of carbon dioxide gas and concentration of hydrogen ions).

Howley Powers (2009) also confirms in this regard that central chemical receptors located in ventral surface area of the medulla oblongata are affected by changes occurring (PCO_2, H^+) in the cerebrospinal fluid (CSF). Therefore, any increase in (PCO_2) or (H^+) stimulates central chemical receptors by sending incoming signals to the breathing centers to increase ventilation. As for the peripheral chemical receptors, which are located in the aortic arch and at the bifurcation of the common carotid arteries, The receptors in the aorta are called aortic bodies, and those in the carotid artery are called carotid bodies. These peripheral chemoreceptors respond to increases in H^+ and PCO_2 concentrations and to a decrease in arterial PO_2. The carotid bodies are sensitive to increases in blood potassium levels. Therefore, the increase in pulmonary ventilation that results from an increase in arterial (PCO_2) is due to stimulation of (CO_2) from both, carotid bodies and central chemoreceptors. Increases in blood levels of potassium also stimulate the carotid bodies and increase ventilation because blood potassium levels rise during exercise due to a net influx of potassium from contracting muscles. During the gradual exercise, blood concentrations of the (H^+) ion increase. This type of exercise provides the main stimulus to increase ventilation by stimulation from the carotid bodies. Evidence also suggests that the right ventricle of heart contains mechanoreceptors that send different sensory information to the respiratory control center in response to increases in cardiac output (eg, exercise). These mechanoreceptors may play an important role in providing afferent sensory input to respiratory control centers at the beginning of exercise. (Powers & Howley, 2009, P.220) .

As for heart rate (H_R) variable, by observing Tables (2, 3) of arithmetic mean and significant values in temperate (24 C°±1) and cold (15 C°± 1) environments, It turns out that there is a rise in (H_R) values when moving from resting phase to the end of physical effort.

These findings of the researcher agree with the results of several studies (Dilber et al, 2015, pp.195-202) and (Edvardsen et al, 2014, pp.1-8).

The researcher attributes these results to physical effort carried out by research sample, which was characterized by its gradual intensity, and this affected physiological functions associated with this activity, As such an effort requires interdependence of functioning of functional systems such as nervous system , the cardiovascular, respiratory and muscular systems to meet the requirements of that effort, When the intensity of work is high, the muscles require (O_2) for energy production process and disposal of waste products of metabolism that occur. This process takes place through blood, which delivers (O_2) to working muscles, and therefore the cardiac output of blood must increase, And the one that works to regulate this is the nervous system, more precisely (sympathetic and parasympathetic nerve fibers).

This was confirmed by Al-Dabbagh and Al-Saadoun (2014) that increase in (HR) variable is due to direct response to exercise intensity as a result of reflected signal from muscle movement and decrease in vagus nerve activity, followed by the flow of sympathetic nerve signals towards heart, And then with the blood vessels prepared for working muscles, as increase in (H_R) during exercise is proportional to work load placed on body's systems and the amount of (O_2) consumed, In addition, during progressive exercise, the increased venous return of blood dilates the large veins, which stimulates pacemaker, which will spread action potential throughout the entire atrial muscle mass. This will lead to an increase in heart rate and force of contraction of heart, Another factor is an increase in (CO_2) in the blood and an increase in body temperature on cardiac center (Al-Dabbagh and Al-Saadoun, 2014, p. 33).

This was confirmed by Beltz et al. (2016) that heart rate increases linearly during exercise with progressive intensity until the (H_R) reaches (170 $b.min^{-1}$), From this point, HR tends to increase slowly until it reaches the maximum heart rate (HRmax) (Beltz et al, 2016, pp. 2-3).

4-4 Discussing results of differences for the effect of moderate environment (24 C°±1) and cold environment (15 C°± 1) on respiratory system variables (R_R, T_V, $\dot{V}_E$), and (H_R) and (C_t) variables.

With regard to variables of respiratory system, it appears from Table (5) that there are significant differences for variable (R_R) after performing physical effort, and variables (T_V, $\dot{V}_E$) at rest, Although there were no significant differences for the variables of breath volume (T_V) and pulmonary ventilation (V_E) after performing physical effort, and (R_R) at rest, the effect of cold environment was clear in these two variables by observing arithmetic mean and (t) values in Table (5). These results are consistent with those of No & Kwak (2016), where the $\dot{V}_E$ at (22±1 C°) at rest was significantly lower compared to both (1±10 C°) and (35±1 C°), Also, ventilation was significantly lower at (22±1 C°) compared to both (10±1 C°) and (35±1 C°) in (5, 10) minutes during submaximal exercise. While there were no significant differences in maximum pulmonary ventilation per minute between (10 ± 1 C°), (22 ± 1 C°) and (35 ± 1 C°) (No & Kwak, 2016, 219).

The researcher attributes these differences to the fact that ($\dot{V}_E$) variable depends on change in (R_R, T_V), and when any of these two variables are affected, ($\dot{V}_E$) is affected by rise or fall, In addition to physical effort, which had a clear effect on ($\dot{V}_E$), cold environmental condition had an additional effect, raising the processes of excitation of respiratory system to increase ventilation ($\dot{V}_E$), Also, the performance of exercise in a cold environment increases oxidation processes, which increases production of (CO_2), and the increased reliance on carbohydrates as a substitute compared to a temperate environment raises the concentration of lactate in blood, e, All these factors stimulated control centers of respiratory system to increase ventilation in order to maintain balance of internal environment of the sample during exercise.

This is confirmed by Castellani et al (2006) that while exercising in a cold environment, body produces enough heat to compensate for the decrease in its temperature, then body begins to use adaptation mechanisms to compensate for this decrease in internal temperature, This adaptation varies according to age, gender, and percentage of body fat. Among these mechanisms are (narrowing of peripheral blood vessels, increased muscle activity and sweating, increased secretion of thyroid and adrenal hormones, and increased metabolic rates), One of the advantages of exposure to cold during exercise is that body begins to adapt to decrease in its temperature, as it begins with muscle contraction and involuntary tremors from torso and extends to extremities as a means of generating heat. Oxygen consumption also increases at rates (600-1000) ml per minute, This increase, therefore, comes through an increase in the process of pulmonary ventilation, which depends on an increase in both respiratory rate and number of breathing times, In addition, medium and very cold weather can adversely affect performance in activities that depend on high levels of strength and muscular ability (such as sprinting and jumping), These effects are more severe when conditions are harsh enough to lower muscle temperature (Castellani and et al, 2006, p. 20-28), As body begins to increase the metabolic rate and increase the secretion of adrenal hormones, which allows superficial blood vessels to contract, Decrease in temperature also causes an increase in activity of sympathetic nervous system, an increase in arterial pressure, an increase in heart muscle’s need for oxygen, and an increase in pulmonary ventilation.

(Castellani and et al, 2006, pp.2012-2029) (Erdogan, 2015, pp. 63-73)

This is what Gregson (2010) indicated that when body is exposed to cold, the central nervous system sends signals to muscles to contract and vibrate, and this leads to an increase in energy consumption and metabolic rate. Thus, breathing rate, breath volume, and blood flow may increase during exercise in cold climates. However, it should be noted that this increase in metabolic rate, respiratory rate, breath volume, and blood flow may be limited at relatively cold temperatures, such as (15) degrees Celsius, and increase may be less than increase that occurs at colder temperatures (Gregson & et al, 2010 , p.p. 2328-2334).

As for the variable (H_R), By reviewing arithmetic means in previous tables for the two thermal conditions, and significance value in Table (5) for the effect of thermal condition in cold environment conditions, it had an effect on increasing (H_R) clearly in the rest phase by noting significance value, which reached (0.043), At the end of physical effort, this effect was less clear, as the significance value for this effect reached (0.730), as there was an increase for this variable, but it did not rise to level of significance, but it appears more clearly in the results of arithmetic means for this variable, The researcher attributes this to the fact that exercising in cold environmental conditions increases cardiac output due to decrease in body's center temperature and through the mechanisms that body follows to maintain a thermal environment within body's natural limits, This is confirmed by Castellani et al (2006) that during exercise in a cold environment, the body produces sufficient heat to compensate for the decrease in its temperature, then body begins to use coping mechanisms to compensate for this decrease in internal temperature, This adaptation varies according to age, gender, and body fat percentage. Among these mechanisms are (constriction of peripheral blood vessels, increased muscle activity and sweating, increased secretion of thyroid and adrenal hormones, and increased metabolic rates), so these changes lead to an increase in heart rate (Castellani and et al. al, 2006, p20-28), This is confirmed by No & Kwak (2016) in this regard, that environmental temperature conditions may be an important factor in regulating ability to exercise, through interaction between body's mechanisms for thermal adaptation and environmental conditions (No & Kwak, 2016, p. 220).

As for completion time (C_t), by looking at arithmetic means and significance value of this variable in Table (6), We note that practice of gradual physical effort in conditions of cold environment had a slight negative effect on performance through time of stopping exercise and reaching stage of early fatigue compared to conditions of a moderate thermal environment, but this effect did not rise to level of significance, These findings of researcher agree with the study of No & Kwak (2016), as the results of the study indicated that voltage depletion time at (22 C°) was significantly higher compared to cold and hot environments (10 C°) or (35 C°). (No & Kwak, 2016, p. 220).

4-1 Conclusions

- The physical effort of gradual intensity under moderate environmental conditions resulted in a noticeable increase in comfort and after the end of cardiorespiratory stress test in a number of variables (R_R, T_V, $\dot{V}_E$), and (H_R).
- The physical effort of gradual intensity under cold environmental conditions resulted in a noticeable increase when moving from rest stage to stages of physical effort, in a number of variables (R_R, T_V, $\dot{V}_E$), and (H_R).
- The condition in a cold environment leads to a significant increase in comfort in variables (T_V, $\dot{V}_E$, H_R) and in the end of physical effort in the variable (R_R) compared to conditions of moderate environment.

- The condition in cold environment did not lead to a significant increase in comfort in variable (R_R) and in end of effort in variables (T_V, $\dot{V}_E$, H_R) compared to conditions in moderate environment.
- The condition in cold environment during physical effort did not play a clear negative or positive role in completion time as a function of end time of effort compared to condition in moderate environment.

4-2 Recommendations

- Educating coaches and physical education teachers about the effects of training and exercise on body functions depending on environmental conditions.
- Use different effort protocols by increasing time of physical effort to see effect of cold thermal condition more clearly.
- Measuring body's center temperature during physical exertion, to accurately know the effect of different ambient temperatures and thus their effect on variables of various body functions.
- Conducting comparative studies between males and females under different thermal environment conditions.

The References

1. Beltz, N.M., Gibson, A.L., Janot, J.M., Kravitz, L., Mermier, C.M., and Dalleck, L.C., (2016). Graded Exercise Testing Protocols for the Determination of VO_{2max}, *Journal of Sports Medicine*, p.p 1-12., Retrieved from https://doi.org/10.1155/2016/3968393.
2. Bräunig, J., & Granacher, U. (2013). Effects of cold exposure on respiratory function and oxygen consumption in humans. *Journal of Sports Medicine*, 4(2), 136-142.
3. Castellani JW, Young AJ, Ducharme MB, Giesbrecht GG, Glickman E, Sallis RE, (2006); American College of Sports Medicine. American College of Sports Medicine position stand: prevention of cold injuries during exercise. *Med Sci Sports Exerc*. Nov;38 (11):2012-29. doi: 10.1249/01.mss.0000241641.75101.64. PMID: 17095937 .
4. Al-Dabbagh, A. and Al-Saadoun, A. (2014): Responses of pulmonary ventilation and some electrocardiogram variables for the percentage of oxygen consumption in two aerobic efforts depending on speed and resistance, *Al-Rafidain Journal of Mathematical Sciences*, Vol. (22): 1-46.
5. Dilber, D., Malčić, L., Ćaleta, T. and Zovko, *A.*, (2015). Reference values for cardiopulmonary exercise testing in children and adolescents in northwest Croatia, *Journal of Paediatr Croat*; 59:195-202. Retrieved from doi: http://dx.doi.org/10.13112/PC.2015.29.

6. Edvardsen, E., Hem, E., Anderssen, S.A., (2014). End criteria for reaching maximal oxygen uptake must be strict and adjusted to sex and age: a cross-sectional study, *PLoS One*. 2014;9 (1):e85276. Retrieved from doi:10.1371/journal.pone.0085276.
7. Erdoğan, M . (2015). Soğuk Ortamda Egzersiz ve Fiziksel Aktivite . Kara Harp Okulu Bilim Dergisi, 25 (1), 63-73 . Retrieved from https://dergipark.org.tr/tr/pub/khobilim/issue/34215/378211.
8. Ferguson, R.A. Ball, D., Sargeant, A.J., (2002). Effect of muscle temperature on rate of oxygen uptake during exercise in humans at different contraction frequencies, *Journal of Experimental Biology* : 205: 982.
9. Galloway, S. D. and Maughan, R.J., (1997). Effects of ambient temperature on the capacity to perform prolonged cycle exercise in man, *Medicine & Science in Sports & Exercise*: Vol. 29., p 1240-1249. Retrieved from DOI: 10.1097/00005768-199709000-00018.
10. Gregson, W., Black, M. A., Jones, H., Milson, J., Morton, J., Dawson, B., & Atkinson, G. (2010). Influence of cold water immersion on limb and cutaneous blood flow at rest. *American Journal of Sports Medicine*, 38(12), 2328-2334.
11. No, M., Kwak, H.B., (2016). Effects of environmental temperature on physiological responses during submaximal and maximal exercises in soccer players, *Journal of Integrative Medicine Res*earth, 5(3): 216-222. https://doi.org/10.1016/j.imr.2016.06.002.
12. Powers, S.K., and Howley, E.T., (2009). *Exercise Physiology*, Theory and Application to Fitness and Performance , *The McGraw- Hill Companies*, 7 ed., USA:
13. Périard, J. D., Caillaud, C., Thompson, M. W., & Voelcker, T. (2015). The effect of cold environment on exercise-induced arterial hypoxemia in elite speed skaters. *Journal of Exercise Science & Fitness*, 13(1), 20-25.
14. Al-Rubaie, H.H. (2017): A comparative study between obese, overweight and normal children at the age of (10-12) years in the anaerobic threshold and the maximum oxygen consumption for a number of functional variables, unpublished master's thesis, University of Mosul, Iraq.
15. Tipton, M. J., & Golden, F. S. (2017). Cold, exercise and human performance. *Journal of Sports Medicine*, 47(3), 613-617.