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Effects of Different Environment Temperatures on Some Motor Characteristics and Muscle Strength

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ABSTRACT

The aim of this study was determine the effects of different environment temperatures on motor characteristics and muscle strength. 15 athletes participated to study. Flexibility, vertical jump, hand grip-leg strength,30m sprint, 20-meter shuttle run and coordination-agility tests were measured in five different environment temperatures. (22°C, 10,5°C, 0°C, -5,5°C ,-11°C). Kolmogorov-Smirnov test was used to determine whether the data showed normal distribution. ANOVA was used to compare the data for normal distribution and Kruskal-Wallis-H test was used for showing not normal distribution. Additionally, Tukey test and Mann-Whitney U test were used for meaningful difference. The significance levels were taken as 0.01 and 0.05. Significant changes were found all measured parameters compared to cold environment and Significant differences were found in all motor scores except anaerobic capacity ($p<0.05$). In all sport activities done in hot environment, higher efficiency is obtained compared to those done in cold environment and therefore, performances of athletes increase depending on the environment temperature.

KEYWORDS
Temperature, performance, motor characteristic, muscle strength

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Introduction

Motor skills are considered as the fundamental movement characteristics of humans that can be developed for specific purposes starting from childhood and teen hood years and they are very important in terms of sportive performance. Basic motor skills are examined in five groups in order of importance. Three of these are main skills that are strength, endurance, and speed while the other two are complementary skills that are mobility and coordination (Sevim, 2002).

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Basic motor skills are known to affect performance. As is known, training is distinguished as technical, tactical, and condition training. Modern training is distinguished as “technical skills (movement skills)” and “basic motor skills.” Motor skills vary based on the adaptation skill and efficiency level of an organization. These skills are present in essence, they are not learned but developed. The result of development of a motor skill becomes evident after organic and functional adaptation period during a regular training period. Development level is determined by tests and strength controls. Development of motor skills is an indispensable piece of training (Sevim, 2002).

The factors that affect performance in sports are internal and external factors. As it is difficult to objectify internal factors, it is almost impossible to calculate its effects on performance and to envision changes that can be done. External factors do not stem from the human body and its structure and it comes from exterior and therefore, these are factors that ımpact sprotive performance through physical and psychical components. The impact on external factors is more than the impact on internal factors. Temperature, warming, and climate can be included in the external factors which are more than the internal factors (Bayraktar & Kurtoglu, 2004).

The tolerance for heat is related to humidity level. The body temperature does not increase to 50-55°C in dry and flow air and the internal temperature can be kept stabilized through evaporation. However, if the environment is humidified 100%, the body temperature will start to increase as soon as the environment temperature goes over 35°C. The body temperature that is around 37°C can increase to 40°C (Zorba, 2009). Mechanisms that kick in to regulate the body temperature due to the increase of metabolic activity during challenging training in hot environment increase perspiration and blood flow from active tissues to passive tissues and therefore, increase performance by adapting to the heat (Gunay et al., 2006; Johnson, 1998; Smolander, 1987).

A 1°C decrease in body temperature in a cold environment impacts the performance negatively and when it drops to 35°C consciousness is lost. When the body temperature drops, three mechanisms come into play with the purpose of regulating temperature. More metabolically energy and heat is formed, skin vessels contract, perspiration decreases and this leads to heat loss (Akgun, 1994). This study aims to determine the effects of different environment temperatures on motor skills and mscle strength, as well as the changes that may happen in athlete performances.

Methods

Research Population

The population of the study consists of 15 athletes with 3 athletes (1 middle distance, 2 long distance), 7 soccer players, 5 skiers (2 alpine skiing, 3 north skiing). Measurements were conducted in five different environment temperatures (22°C 34% humidity, 10,5°C 34% humidity, 0°C 32% humidity, -5.5°C 32% humidity, -11°C 32% humidity). All measurements were done between 12pm and 4pm in order to find the appropriate temperature.

Data Collection

Height and weight measurement: Height measurement of subjects was taken with Holtain anthropometric set with a sensitivity of 0.001m while weight measurements were taken on a scale with a sensitivity of 0,1 kg, with bare foot and light clothes on.

Body-Mass Index (BMI): To determine the body composition, the body mass in kg was divided by the weight in meters (Tamer, 2000).

BMI=Body mass (kg) / Height (m)X Height $(m)^2$

BMI=kg/m^2

Resting heart rate: The resting heart rate was determined by using a stethoscope in lying position after the subjects were rested for 15 min lying on their back.

Hand Grip Strength Test: It was measured with Takei brand digital hand dynamometer. All subjects' first right and then left maximum hand grip strengths were measured. Three measurements were done and the best value was recorded as the test score.

Leg Strength Test: Leg strength test was measured by Takei brand digital leg dynamometer.

Vertical Jump Test: Measurements were taken with the use of a straight wall. The height that subjects could reach with their fingers by standing sideways was recorded. Then they jumped and the jumping height was recorded by subtracting the height that's reached by standing from the height that can be reached by jumping. After two repeats, the best score was recorded. Vertical jump test results were calculated by anaerobic strength Lewis nomogram.

P= (√4,9 x body weight) x √d,

D = vertical jump value in m.

30 m Speed Test: After goal-specific warming, subjects were waited on stand-by and when they felt ready, they ran with maximum speed. Time in the 30m speed test was determined by New Test 2000 Powertimer device.

Illinois Agility Test: It was applied to determine the subject's coordination and agility. A test course with a width of 5m, length of 10 m that consists of three cones in the middle section lined up on a straight line 3.3 m apart from each other. The test consists of slalom run that includes 40m straight and 20 m slalom running between the cones. 180 ^{o} turns every 10 m. After the preparation of the test course, double door photocell electronic chronometer system with 0.01 sensitivity was placed at the beginning and the end of the course. The finish time was recorded in seconds. The test was repeated 2 times with full rest and the best score was recorded.

Flexibility Test: Flexibility of subjects was measured with Lafayette stability platform with a length of 35 cm, width of 45 cm, and height of 32 cm. Subjects were asked to reach forward without breaking the legs and to try to reach out to the maximum level. Two repetitions were conducted and the best scores were recorded in cm.

Aerobic Capacity Measurement: Aerobic capacity of subjects was measured by 20 m shuttle run.

Data Analysis

Data were analysed by "SPSS 17" packet program. Descriptive statistics related to subjects' age, height, weight, and body mass index values. Group distributions of variables were examined. Kolmogorov-Smirnov test was used to determine whether the data showed normal distribution. One way analysis of variance (ANOVA) was used to compare the data obtained from variables showing normal distribution in 5 different environment temperatures while Kruskal-Wallis-H test was used as the variable of resting heart rate did not show normal distribution. Additionally, when multi-variables were examined, Tukey test and Mann-Whitney U test were used to determine which groups showed a meaningful difference. The significance levels in analysis were taken as 0.01 and 0.05.

Findings

The average age, height, weight, and BMI of the subjects participated in the study are 21.2 years, 174.2 cm, 67.04 kg, and 22.06 kg/ cm^2 respectively.

Table 1. Physical parameters of subjects participated in the study N=(15)

	$\bar{x}$	ss	Min	Max.
Age	21.2	1.980	19	26
Height	174.2	4.056	168	183
Weight	67.04	4.524	60	74.3
BMI	22.6	1.174	17.92	25.95

Humidity Rate: 22°C 34% Humidity, 10,5°C 34% Humidity, 0°C 32% Humidity, -5,5°C 32% Humidity, -11°C 32% Humidity.

According to the ANOVA results done to test the sprint, flexibility, leg strength, right hand, left hand, shuttle run (aerobic strength), effort pulse, agility, vertical jump and anaerobic capacity values of the subjects based on different environment temperatures, statistically meaningful difference was found in the scores of sprint, flexibility, leg strength, right hand, left hand, shuttle run (aerobic strength), effort pulse, agility, vertical jump. [(F=35.73; p<0.01), (F=19.4; p<0.01), (F=4.41; p<0.01), (F=5.16; p<0.01), (F=8.30; p<0.01), (F=8.17; p<0.01), (F=8.60; p<0.01), (F=3.15; p<0.05)]. According to the Tukey test results, which was performed to determine the source of this difference in terms of environment temperature, it is seen that the duration of run shortens as subjects move from cold environment to warm environment during the 30 m sprint. Similarly, it is seen that flexibility and leg strength variables show an increase depending on the increase of the environment temperature. As the environment temperature increases, an increase was observed both in right and left hand strength.

Additionally, as the environment temperature increases, aerobic capacity and vertical jump distance increase while effort pulse and time of coordination decreases (Table 2).

Table 2. ANOVA results of subjects participated in the study based on the variables N=(15)

	Temperature	$\bar{x}$	ss	F	p	Difference***
SPRİNT	-11°C	4.63	0.157	35.734	0.000**	-11°C >-5.5°C, 0°C, 10.5°C, 22°C
(30m Speed)	-5.5°C	4.43	0.133			-5.5°C> 10.5°C ,22°
(min.)	0°C	4.31	0.117			0°C, 10.5°C >22°C
	10.5°C	4.22	0.102			
	22°C	4.14	0.092			
	-11°C	18.66	1.988	19.417	0.000**	-11°C < 0°C,10.5°C, 22°C
FLEXIBILITY	-5.5°C	20.4	2.772			-5.5°C< 10.5°C, 22°
(cm)	0°C	22.06	2.789			0°C< 22°C
	10.5°C	23.86	2.642			
	22°C	26	2.329			
	-11°C	98.48	8.531	4.411	0.003**	-11°C < 10.5°C, 22°C
LEG STRENGTH	-5.5°C	103.66	8.383			
(kg)	0°C	104.34	8.823			
	10.5°C	107.50	7.571			
	22°C	110.26	7.443			
RIGHT HAND	-11°C	45.82	4.604	5.164	0.001**	-11°C, -5.5°C < 22°C
(hand grip	-5.5°C	45.38	3.586			
strength)	0°C	45.59	4.458			
(kg)	10.5°C	46.31	4.71			
	22°C	46.96	4.923			
LEFT HAND	-11°C	43.76	4.525	8.307	0.000**	-11°C < 10.5°C
(hand grip	-5.5°C	44.08	4.130			22°C > -11°C, -5.5°C
strength)	0°C	43.98	3.932			
(kg)	10.5°C	44.19	4.727			
	22°C	45.80	4.597			
SHUTTLE	-11°C	49.42	8.673	8.388	0.000**	-11°C < 10.5°C, 22°C
(AEROBİC	-5.5°C	52.09	7.279			22°C > -11°C, -5.5°C, 0°C
CAPACITY)	0°C	51.58	6.780			
(ml/kg/min)	10.5°C	57.54	6.397			
	22°C	62.22	5.334			
	-11°C	206.13	6.209	8.176	0.000**	-11°C >-5.5°C, 0°C, 10.5°C, 22°C
EFFORT PULSE	-5.5°C	194.93	10.19			
(at/min)	0°C	192	8			
	10.5°C	193.06	12.232			
	22°C	184	14.966			
AGILITY	-11°C	16.28	0.466	8.607	0.000**	-11°C > 0°C, 10.5°C
COORDINATION	-5.5°C	15.99	0.595			22°C< -11°C, -5.5°C
(sec.)	0°C	15.74	0.506			
	10.5°C	15.49	0.473			
	22°C	15.32	0.46			
	-11°C	50.4	5.925	3.150	0.019*	-11°C < 0°C, 22°C
VERTICAL JUMP	-5.5°C	54.6	6.587			
(cm)	0°C	56.66	6.218			
	10.5°C	55.53	6.27			
	22°C	57.33	4.546			
ANAEROBİC	-11°C	105.22	7.185	1.858	0.127	_
CAPACTIY	-5.5°C	108.83	6.777			
(cm)	0°C	110.81	7.06			
	10.5°C	109.45	7.553			
	22°C	111.72	6.923			

*p<0.05 **p<0.01 *** Tukey Test

Table 3. Kruskal-Wallis-H Test results related to resting heart rate variable N=(15)

	Temperature	$\bar{x}$	ss	sd	x^2	p	Diff**
RHR (beat/min)	-11°C	73,33	2,468	4	12.70	0.013*	-11°C >10.5°C, 22°C 22°C < -5.5°C, 0°C
	-5.5°C	72,13	3,067				
	0°C	72	1,851				
	10.5°C	71,2	2,242				
	22°C	70,8	1,656				

*p<0.05 ** Mann Whitney U test

Rate of Humidity: 22°C 34% Humidity, 10,5°C 34% Humidity, 0°C 32% Humidity, -5,5°C 32% Humidity, -11°C 32% Humidity.

According to the Mann-Whitney U test results, that was performed to determine which environment temperatures this difference stems from, as the environment temperatures increase, resting heart rate decreases (Table 3).

Kruskal-Wallis-H Test results, which was performed to test the resting heart rate of subjects in different environment temperatures, showed that there is statistically significant difference [$\chi^2(4)= 12.70$; $p<0.05$].

Discussion and Conclusion

The Changes in motor characteristics in different environment temperatures were examined in our study. According to the results of the tests performed, significant difference was found in resting heart rate, sprint (30 m speed), flexibility, leg strength, left and right hand grip strength, shuttle run (aerobic endurance), pulse, agility-coordination, and vertical jump scores in five different environment temperatures ($p<0.05$). No significant difference was found in the other variable, the anaerobic strength ($p>0.05$).

It can be stated that there was a decrease in resting heart rate with the increase of temperature. However, Chen et al. (2013) state in their study conducted in 2013 that in case of an adaptation to heat, cardiovascular adaptation will occur, the blood flow will increase, and heart rate will decrease in a certain ratio (Chen et al., 2013). In another study, it is determined that the reaction of an organism as a warning to cold weather is to increase the blood pressure and heart rate (Cold Environment Exercise, 2013). Akgun (1994) states that low resting heart rate in athletes is an indicator of good performance levels.

It can be said that the speed of 30m sprint is run at a better level depending on the increase in the environment temperature. Ball et al stated that the sprint strength produced in 30°C is more than the one that is produced in 19°C in different environment temperature after applying 30 second sprint to eight healthy male (Ball et al. 1999). In a study done by Radamaker, Radamaker reached to the conclusion of tendonds that contract faster produce less power in low temperature compared to tendons contracting slow (Radamaker, 1997).

According to the results we obtained in our study, we can say that the temperature increase affect muscle flexibility positively. Zorba (2009) stated that both body temperature and specific muscle temperature affect the pain of a movement. Wear (1963) stated that warming the muscle locally to 46°C results in a 20% increase in flexibility, locally cooling the muscle to 18,5°C results in a 10-20% decrease in flexibility. In another study, it is stated that the environment temperature increases the flexibility of connecting tissues and therefore, providing movement span to joints and significantly increasing muscle performance (Polloc et al., 1998). Arinik (1995) states that warming, as a factor affecting flexibility, has a positive effect on anaerobic strength, and that warming in intense physical activities performance is affected positively.

According to the results, there is a strength increase in leg strength and hand grip strength with the increase in environment temperature. Müller et al. (2013) determined that people who were exposed to 5°C temperature with bare hands feel a decrease in hand skills. Oksa et al. (2000) showed that cold environment decreases the muscle strength significantly. In another study, it was shown that there was an increase in muscle strength in parallel to the increase in environment and body temperatures of eleven men in four different temperatures at different times of day (Racinais et al. 2005). Brooks et al. (1996) stated that the temperature drop affects the power production of muscles and depending on this, affecting physical performance negatively.

In a study done in different environment temperatures, similar to the environment temperature (aerobic strength) the capacity to be able to use oxygen increases. Physiological adaptation of the respiratory system occurs in physical exercise to provide oxygen. The increase seen depending on the exercise type in respiratory parameters to meet this need depends on factors such as the development of respiratory muscles, the ability of expansion of lungs and rib cage, and flexibility of bronchus and bronchioles (Gozu et al. 1988). Gunay et al. (2006) states that the oxygen consumption is higher with the exercise done in a hot environment compared to cold environment and the accumulation of lactic acid. In another study, Lindberg et al. (2012) determined that max VO_2 is significantly higher in 20°C compared to -12°C in their study where ten males were applied maximal exercise period on bicycle in different temperatures (20°C and -12°C). Nimmo (2004) argues that the environment temperature of 11°C can be an advantage when the exercise is done for a long period with an average intensity and that when the temperature is lower than 11°C, performance can be affected negatively.

In a study performed on cyclists, after aerobic strength programs were conducted, it was determined that the endurance levels of athletes that are trained in hot environment, increase after their adaptation to hot environment (Lorenzo et al. 2010).

When the effort pulse variable is evaluated, it is found that when the temperature decreases (-11°C), although the running distance is shorter, the heart rate is higher. Starting from this point, it can be said that the fatigue threshold decreases in cold weather. In a study conducted by Zhao et al., a decrease in effort pulse was observed during the transition from hot environment to cold environment (Zhao et al. 2013).

It can be said that there is an increase in agility-coordination with an increase in the environment temperature. It was observed that muscles produce less strength, that they are stimulated slower and therefore the muscle coordination decreases in low temperatures (Cold Environment and Exercise, 2014). Unal (2002) states that in exercises done in cold environment, the muscular tonus increases, muscle viscosity increases, the time of muscle contraction increases, relaxation time of antagonist muscles increases, the nerve conduction slows down, the time of reflex reaction increases, skills and coordination deteriorates, and the conditions of athletes decrease. Roberts (2001) stated that in exercises done in cold environment, if athletes cannot maintain their body temperature stabilized, there will be a decrease in their performance and a 1°C decrease in the core heat will result in 5-6% decrease in aerobic capacity. In another study done by Roberts (2005), a decrease in performance and muscle coordination was observed in exercises done in cold environment.

In different environment temperatures, it was observed that during the transition from cold environment to hot environment the vertical jump variable is affected positively. According to Bergh and Ekblom, an increase is observed in jump and speed performance depending on the increase in muscle heat (Bergh &Ekblom, 1979). When literature related to different environment temperatures was examined, we see the positive effects of increase in environment temperatures on performance. Our findings in this study support the findings of previous studies.

As a result, significant differences were found in all parameters measured as the temperature increases compared to the measurements in cold environment. High efficiency is obtained in all sport activities done in hot environment and therefore the performance of athletes increase depending on the environment temperature (between -11°C and 22°C).

Disclosure statement

No potential conflict of interest was reported by the authors.

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