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THE EFFECT OF AMBIENT TEMPERATURE ON THE CANADIAN HOME FITNESS TEST

by

© ALLAN JOSEPH MAC DOUGALL

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

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Date Aug 15/83 ....

Dedication

To my mother and father

Abstract

One hundred and three (51 males and 52 females) subjects ranging in age from 7-69 years performed the Canadian Home Fitness Test (CHFT) in temperatures of 21°C, 24°C, 27°C and 30°C, with the relative humidity at 70%. The subjects were categorized by sex and age into ten groups. The data of each group was subjected to separate statistical analysis.

Heart rate showed a progressive rise during exercise in all age groups. Differences in heart rate between temperatures tended to increase with time, however, statistical analysis showed this to reach statistical significance ($p<0.05$) in only three groups.

Ambient temperature was found to have little effect on arterial blood pressure. Systolic blood pressure increased with exercise, but was not affected by the ambient temperature. Diastolic blood pressure showed little change during exercise and significant ($p<0.05$) differences between temperatures were observed in only one group. Although statistical tests carried out on this group showed that diastolic blood pressure decreased slightly as temperature increased, this trend was not observed in any other group.

Core temperature showed a progressive increase with work rate and significant ($p<0.05$) differences were observed between temperatures in three groups. Statistical analysis of these groups failed to reveal any trend which could be attributed to the ambient temperature.

The ambient temperature, within the range examined, does not appear to have any effect on scores obtained on the CHFT. Inconsistency of statistical significance suggests that little difference actually exists between the scores obtained at the various temperatures.

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I. INTRODUCTION

A method of estimating maximal oxygen consumption (VO_2 max.) based on heart rate and work rate during an exercise test that does not require a subject to exercise to exhaustion (submaximal test) was first proposed by Astrand and Rhyming (1954). These authors concluded that submaximal tests could provide reliable information about a person's capacity to perform work, as is reflected by the rate of his oxygen uptake, but without the inconvenience or stress of undertaking a maximal exercise test. A variety of submaximal tests have been widely used to estimate VO_2max. However, Astrand and Ryhming and others, including Davies (1968); Lindemann et al. (1973); Rowell et al. (1964) and Taylor et al. (1963) pointed out that these tests have limitations. For example, Taylor et al. (1963) indicated that these tests are affected by environmental conditions, food intake and heavy physical activity prior to testing.

The Canadian Home Fitness Test (CHFT) is one such submaximal test, developed in 1975, as a safe and simple test to provide a reliable means to evaluate cardioresperatory fitness (Canadian Home Fitness Test Leader Manual, 1975). As with other submaximal, indirect (predictive) fitness tests, the CHFT utilizes heart rate at a given exercise rate to estimate VO_2max.

Heart rate is influenced by many factors, and as submaximal tests are based on the response of heart rate to work rate, their predictibility could be affected. Among the number of factors examined by Taylor et al. (1963) was the ambient temperature at which the test was carried out. Upon the examination of studies in which the effects of temperature on the prediction of VO_2max. were investigated, they concluded that ambient temperature could alter the relationship of submaximal heart rate to the VO_2max. High environmental temperatures tended to produce values lower than those obtained when measured at lower environmental temperatures.

Extremely warm conditions have been recognized to alter many physiological functions both at rest and during exercise. Pandolf et al. (1974), in review of previous studies, suggested that in an effort to maintain a normal internal body temperature in hot environments, heat is transported from the central core to the skin by the circulatory system and this results in an increased burden on the circulatory system. Nadel et al. (1979) postulated that, during exercise, cardiac output must be partitioned between the contracting muscles to meet their oxygen requirements, and the skin to meet the heat transfer requirements of the temperature regulatory system. During exercise in the heat both the skin and muscle requirement for the blood flow are high, and as the heart must provide sufficient circulation to both vascular beds cardiac output is increased. Increased heart rate is the most evident circulatory change caused by a hot environment. This has been well established. For example, Williams et al. (1962)

demonstrated that this was apparent at all levels of exercise up to and near the maximum.

The aim of the present study was to evaluate the extent to which heart rate is affected by ambient temperatures over a range likely to be encountered in various testing locations when the CHFT is administered. It has been postulated that should heart rate response seen in the CHFT be significantly higher in the hotter environments, then this influence would have to be taken into account in evaluating cardio-respiratory fitness. In addition to its effect on heart rate, the effect of the elevated ambient temperature on arterial blood pressure (systolic and diastolic) and core temperature was determined, as these could be indicative of mechanisms underlying differences which might become evident as a result of increased temperature. Added stress imposed on the cardiovascular system by higher temperatures may be hazardous to some participants, and should therefore be avoided.

A. Statement of the Problem

The CHFT is used extensively, and in various environmental conditions. As there is a lack of information and a possibility of error in the scoring of the CHFT due to these environmental variations, the data obtained were subjected to statistical analysis in order to determine whether or not significant differences exist between the results obtained at different ambient temperatures.

B. Limitations

Findings of the present study may have been limited by the following factors:

1. The test sample was not truly random as all subjects were volunteers and, as such, probably had a higher fitness level than the general population.

2. There was no control of the subjects' nutritional or physical activity patterns prior to testing.

3. The time of day at which subjects were tested was not uniform.

4. Deep body temperature was not measured by the same means in all subjects; esophageal, rectal and oral techniques were used.

C. Delimitations

Findings of the present study were delimited by the following factors:

1. Only subjects sufficiently fit to complete at least two stages (see Methods) of the CHFT were included in the study.

2. Each subject had to be tested under four environmental conditions within a 14 day period to avoid possible changes in their fitness level.

3. Most subjects were staff or students from the Faculty of Physical Education at the University of Alberta. The people making up the 'sample' were likely more fit than the population as a whole.

4. The subjects were exposed to each of the test temperatures for only a short period of time (less than 10 minutes) prior to testing.

D. Independent and Dependent Variables

The independent variables of this study were:

1. temperature

2. sex

3. age

whereas the dependent (measured) variables were:

1. heart rate

2. arterial pressure (systolic and diastolic)

3. core body temperature.

E. Definition of Terms

Maximal Oxygen Consumption (VO_2max.)

The maximal rate of oxygen uptake which can be attained during exercise.

Predicted Maximal Oxygen Consumption

The indirect assessment of maximal oxygen consumption. It is calculated from the cardiac response to a submaximal work rate.

Core Temperature

The temperature of the core portion of the body. For this study rectal or esophageal temperature were prefered as a measure of core temperature, however in some instances such measurements were not possible and oral temperatures were measured as a substitute.

II. Review of Literature

A. Introduction

Man's responses to work in the heat has long been of interest, not only from the scientific aspect but also from the industrial aspect. Concern for the welfare of workers in adverse environments and their productivity has motivated much of this interest. Under normal conditions exercise produces an increase in heart rate, an increase in mean arterial pressure (with systolic pressure showing an increase and diastolic pressure showing a slight decrease or no change) and an increase in core temperature. Such responses to exercise are well described in many studies, including those of Bruce et al. (1974); Comess and Fenster (1981); Davies (1979 c); Chapman (1954); Snellen (1969) and Wolthuis et al. (1977). Exposure to more extreme environments, such as high or low temperatures, appear to accentuate these physiological responses to exercise. The following review is primarily directed to the effect of exercise at high (27°C or greater) ambient temperature on heart rate, arterial blood pressure (systolic and diastolic), core temperature and other factors which may influence the cardiovascular and thermoregulatory responses to exercise in the heat.

B. Effect of Environmental Temperature on Heart Rate

There appears to be consistent agreement that heart rate is significantly increased by increasing environmental temperature, both at rest and during exercise. Many researchers, including Grollman (1930) and Koroxenides, Shepherd and Marshall (1961) have found significant increases in resting heart rates during exposures to high ambient temperatures. Other studies have shown significant increases in exercise heart rates during exposures to high ambient temperatures. In his review Saltin (1964) commented that during resting conditions exposure to heat causes an increase in cardiac output (30-75%), which is reflected by increased heart rate. The heart rate at a given rate of oxygen uptake (percent $\bar{V}O_2max.$) is higher if the work is performed in a hot environment as compared with a cool one.

The increase in heart rate seen during exercise in a hot environment reflects both the increased need for blood flow by the muscles, to meet increased oxygen requirements, and increased blood flow to the skin for heat dissipation. This was suggested by Kamon and Belding (1971) and later Nadel et al. (1979). This combined need of the active muscles and skin for blood flow, they suggest, superimposes an extra work load on the circulatory system during exercise in the heat.

The added need for circulation to the skin over and above that to muscles, as Appenzeller and Atkinson (1981) explained, is determined not only by deep body temperature, but also appears to be related to average skin temperature, which is in turn related to environmental temperature. During strenuous exercise in high ambient temperatures, the circulatory demands are considerably increased. The heart must then provide sufficient blood flow to both muscles and skin or compromise delivery of blood to one or the other. To prevent compromised blood flow to muscles, skin or any other tissue during exercise, particularly in the heat, cardiac output must increase continuously.

The competition between skin and muscle blood flow during exercise in maintenance of body temperature within the normal range is further complicated by pooling of blood in cutanesus venous 'reservoirs' during elevated body temperature. This increase they thought to be due in part to increased compliance (reduced tone) of the veins of the skin which resulted from an increased thermoregulatory drive. Increased venous blood in the skin is generally considered to facilitate heat transfer because of decreased velocity of flow and increased time for heat exchange between the blood and skin. Appenzeller and Atkinson (1981) interpreted this as an indication of increased peripheral blood volume reducing central volume and it, in turn, reducing the cardiac filling thus potentially compromising cardiac stroke volume. Such a reduction in stroke volume would elicit a compenstatory increase in heart rate so that cardiac output could be maintained. As can be seen in Table 1 several studies have shown that there appears to be little doubt that exercise heart rate is significantly increased by raising the ambient temperature above normal conditions. In this connection, Grimby and Nilsson (1963) induced subjects with fever to increase cutaneous venous dilation. Eight healthy male subjects rested and then worked on a bicycle ergometer at successively greater work rates of 49.0, 98.0 and 147.0 watts for 8 minutes each, without interruption. Their tests were performed first under normal conditions and then repeated the same day after injection of a bacterial pyrogen (Pyrexal). Heart rate was found to be significantly higher during the 'flush' phase (cooling phase when dilation occurs) of the fever than during normal conditions. It was on the average 30 $b \cdot min^{-1}$ higher during fever as compared to the non-fever conditions at the 49.0 and 98.0 watt work rates, while at the 147.0 watt work rate it was 17 $b \cdot min^{-1}$ higher.

TABLE 1
Effect of Temperature on Heart Rate(H.R.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in H.R. ($b \cdot min^{-1}$)
Asmussen, E., 1940.	6M	—	(1)22.0 (2)30.6	treadmill	120-180	5.6(8.6%)**	↑in heat*
Eichna, L.W., et al., 1950.	3M	—	(1)25.6(39) (2)50.6(15)	treadmill	60 (intermittent)	4.0(2.5%)**	↑in heat*
Brouha, L., et al., 1960.	6M & 5F	20-58	(1)25.0(43) (2)37.2(25) (3)37.2(82)	ergometer	34	(1)30 min submax. (2)4 min max.	↑in heat*
Lind, A.R., 1963.	2M	—	(1)22.8 (2)27.5 (3)30.5	treadmill	55	5.6**	↑5-20 at 30.5°

TABLE 1 (continued)
Effect of Temperature on Heart Rate(H.R.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in H.R. ($b \cdot min^{-1}$)
Rowell, L. B., et al., 1965.	9M	21-37	(1)25.6 (2)43.3	treadmill	15	5.6(2-4 unspecified grades)**	Max. H.R. reached at lower intensities at 43.3°
Rowell, L.B., et al., 1966.	6M	21-27	(1)25.6 (2)43.3	treadmill	105-120 (intermittent)	(1)5.6(7.5%)** (2)5.6(10%) (3)5.6(12.5%) (4)5.6(15%)	↑in heat*
Damato, A.N., et al., 1968.	16M	22-41	(1)25.6 (2)37.8 (3)46.1 (4)51.7	ergometer (supine)	—	not specified	↑in heat*
Kitzing, J., et al., 1968.	5M	18-25	-4 — +32	ergometer	120	147.1W	H.R.↑ continuously from 11°

TABLE 1 (continued)
Effect of Temperature on Heart Rate(H.R.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in H.R. ($b \cdot min^{-1}$)
Rowell, L.B.,[2] et al., 1969.	11M	21-28	21 – 50	treadmill	105	26-64% $\dot{V}O_2max$.	(1)41.1%↑ in H.R. during moderate exercise (2)26.4% ↑ in H.R. during severe exercise
Saltin, B., et al., 1970.	3M	22-33	(1)10(40) (2)20(40) (3)30(40)	ergometer	150 (intermittent)	25% $\dot{V}O_2max$. 50% $\dot{V}O_2max$. 75% $\dot{V}O_2max$.	(1)167 at 10° (2)178 at 20° (3)194 at 30°
Schvartz, E.[3] and Beror, D., 1972.	7M	mean:23	(1)25 (2)30 (3)35 (4)40 (5)45	treadmill	120	3.5**	↑in heat*

TABLE 1 (continued)
Effect of Temperature on Heart Rate(H.R.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in H.R. ($b \cdot min^{-1}$)
Pandolf, K.B.* et al., 1974	6M	mean: 22	(1)25 (2)32 (3)40	ergometer	30-40	25% $\dot{V}O_2$max.	For each 1°C rise above 25°C: H.R.↑ 1 in hot-dry H.R.↑ 2 in 32° H.R.↑ 4 in 40°
Adams, W.C. et al., 1975	1M	38	(1)10(28-30) (2)22(28-30) (3)35.4(28-30)	treadmill	60-165	15.34**	↑in heat*
Clarmont, A.D. et al., 1975	8M	—	(1)0 (2)35	ergometer	30-60	52-59% $\dot{V}O_2$max.	↑in heat*
Fink, W.J. et al., 1975	6M	—	(1)9 (2)41	ergometer	65 (intermittent)	75-85% $\dot{V}O_2$max.	H.R.↑ 26 at 41° compared to 9°

TABLE 1 (continued)
Effect of Temperature on Heart Rate(H.R.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in H.R. ($b \cdot min^{-1}$)
Miller, G.J. & de V. Martin, H.,1975	4M	18-29	21 – 35	ergometer	12	70% VO_2max.	1.4% ↑ for each 1° rise above 21°
Pandolf, K.B. et al.,1975	10M	18-26	(1)24 (2)44 (3)54	ergometer	30	40% VO_2max.	H.R.↑ 1 for each 1° rise above 24°
Sen Gupta,J. et al.,1977	10M	mean:26.4	(1)29.0(50) (2)44.3(20) (3)36.5(55) (4)49.3(23) (5)41.0(55)	ergometer	–	(1)98.1W unspecified, graded maximal work	(1)H.R.↑ during submaximal work* (2)No significant increase in H.R. during maximal work
Wells, C.L. & Paolone, A.M., 1977	4M & 3F	mean:28.5	(1)25(55) (2)32(55) (3)40(55)	treadmill	40	58% VO_2max.	H.R. was ↑ 35 in F & 34 in M at 40° compared to 25°

TABLE 1 (continued)
Effect of Temperature on Heart Rate(H.R.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in H.R. ($b \cdot min^{-1}$)
Sakate, T., 1978	10M	20-25	(1)5(50) (2)20(50) (3)35(50) (4)50(50)	treadmill	to exhaustion	5.7 (1° elevation every min)**	↑ in heat*
Myhre, L.G., et al., 1979	5M & 1F	20-41	(1)23.2 (2)33-40	ergometer	10	16-82% $\dot{V}O_2$max.	↑ in heat*
Nadel, E.R., et al., 1979	3M	–	(1)20 (2)26 (3)36	ergometer	20-25	40% $\dot{V}O_2$max. 70% $\dot{V}O_2$max.	H.R. was ↑ 15 at 40% and 20 at 70% $\dot{V}O_2$max. at 36° compared to 20 or 26°
Sengupta, A.K., et al., 1979	15M	mean:25.2	(1)22 (2)30 (3)37	ergometer	40	32.6-97.8W	(1)147.3 at 22° (2)156.2 at 30° (3)167.7 at 37°

TABLE 1 (continued)

Effect of Temperature on Heart Rate(H.R.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in H.R. ($b \cdot min^{-1}$)
Wells, C.L., 1980	5M & 6F	—	(1)23 (2)39	treadmill	40	50% $\dot{V}O_2max$	↑ in heat*

* Heart rate increases at higher temperatures were significant but were not specified.
** Treadmill test work rates are in $km \cdot hr^{-1}$ with treadmill elevations in brackets.
↑ Increase
— Data not given.
[1] Work load was predetermined and not specified.
[2] Skin temperature was changed by perfusion of a special suit with water.
[3] Subjects wore vapor barrier suits.
[4] Tests were conducted first at low vapor pressure and then repeated with vapor pressure increased toward saturation.

C. Effect of Environmental Temperature on Blood Pressure

Under normal conditions mean arterial blood pressure during exercise increases (systole increases and there is little or no change in diastole). This response has been observed in many studies: Bruce et al. (1974); Comess and Fenster (1981); Fraser and Chapman (1954); and Wolthius et al. (1977).

The problem of maintaining blood pressure during exercise combined with heat stress was addressed in a review by Rowell (1977). He concluded that blood pressure is normally well maintained or is increased during exercise, despite massive vasodilation in skeletal muscle, by a increase in cardiac output and by regional (renal and splanchnic) vasoconstriction. Rowell (1977) felt that heat stress augments the sympathetic nervous stimulation of certain organs, resulting in increased vasocontriction in these organs during exercise. Such increased vasoconstrictor activity is directed toward the renal, splanchnic and cutaneous vascular beds. Rowell (1977) suggested that this pattern of sympathetic nervous activity not only optimizes the distribution of cardiac output but also controls peripheral displacement of blood volume thereby minimizing reductions in central blood volume, stroke volume and blood pressure.

Experimental evidence, as seen in Table 2, indicates that modifications in blood pressure during exercise in a hot environment reflect the work rate more than the effect of the ambient temperature. Several researchers have reported statistically significant decreases in systolic and diastolic blood pressure during rest at high ambient temperatures (see Table 3). The arterial blood pressure changes which occur during exercise in the heat, however, differ little from the arterial blood pressure changes occuring during exercise at normal conditions. The environmental temperature appears to have little effect on blood pressure during exercise although statistically significant changes have been observed in some studies (see Table 3).

TABLE 2
Effect of Temperature on Blood Pressure(B.P.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in B.P.
Brouha, L., 1960.	6M & 5F	20-58	(1)25.0(43) (2)37.2(25) (3)32.2(82)	ergometer	34	(1)30 min submax. (2)4 min max.	No B.P. differences in heat*
Marx, H.J., et al., 1967.	6M	21-27	(1)25.6 (2)43.3	treadmill	60	(1)5.63(7.5%) (2)5.63(10.0%) (3)5.63(12.5%) (4)5.63(15.0%)	**S.B.P., D.B.P. & mean B.P.↓ at 43.3°
Morimoto, T., et al., 1967.	13M & 13F	17-32	1 2 (1)36 33 (2)41 34 (3)45 36 (4)47 37 (5)49 38	treadmill	30	5.63	(1)S.B.P.↑ in F in the two hottest of both series* (2)D.B.P.↓ in M in all and ↓in F only in hottest*

TABLE 2 (continued)
Effect of Temperature on Blood Pressure(B.P.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in B.P.
Rowell, L.B. et al.,1967.	6M	21-27	48.4	treadmill	to exhaustion	5.63	Aortic B.P. remained stable up to exhaustion
Damato, A. N., et al.,1968.	16M	22-41	(1)25.6 (2)37.8 (3)46.1 (4)51.7	ergometer (supine)	–	not specified	(1)Arterial B.P. ↓ 19% at 46.1° but was not significant (2)Pulmonary B.P.↓ 31% at 46.1°*
Rowell, L.B.,[3] et al.,1969.	11M	21-28	21-50	treadmill	105	26-64% $\dot{V}O_2$max.	11.2% ↓ in aortic B.P. during moderate exercise & 11.1% ↓ in aortic B.P. during severe exercise

TABLE 2 (continued)

Effect of Temperature on Blood Pressure(B.P.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in B.P.
Suzuki, Y., 1980.	4M	—	(1)0 (2)20 (3)40	ergometer	to exhaustion	66% $\dot{V}O_2max$.	Arterial B.P. was 107mm of Hg. at 0° and 99 at 40°*

* All results statistically significant unless otherwise indicated.
** *Treadmill test work rates are in km•hr⁻¹ with treadmill elevations in brackets.*
↑ Increase
↓ Decrease
— *data not given*
S.B.P. Systolic Blood Pressure
D.B.P. Diastolic Blood Pressure
! Work load was predetermined and not specified
[2] Two series of tests were carried out; the first at 29-31% R.H. and the second at 80-82% R.H.
[3] Skin temperature was changed by perfusion of a special suit with water

TABLE 3
Effect of Temperature on Blood Pressure(B.P.) During Rest

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Rest Position	Duration (min)	Changes in B.P.
Grollman, A., 1930.	5 not specified	—	0-45	sitting or recumbant	—	S.B.P. and D.B.P.↓ with pulse pressure remaining constant
Wells, G., 1933.	45M	14-18	18.3-43.3	sitting	—	S.B.P. and D.B.P.↓ 10mm. of Hg. at 43.3°
Sancetta, S.M., et al., 1950.	10M & 6F	—	36.6(40)	recumbant	120	(1)Arterial S.B.P.,D.B.P. and mean B.P.↓ • (2)Pulmonary S.B.P. and mean B.P.↓in all and D.B.P.↓in all but 2 •
Koroxenidis, G.T., et al., 1961.	8 not specified	25-38	44	—	—	(1)S.B.P.↓ 15mm. of Hg. (2)D.B.P.↓ 5mm. of Hg.

TABLE 3 (continued)
Effect of Temperature on Blood Pressure(B.P.)During Rest

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Rest Position	Duration (min)	Changes in B.P.
Marx, H.J., et al., 1967.	6M	21-27	(1)25.6 (2)43.3	standing	—	S.B.P. and D.B.P.↓ *

* All results statistically significant unless indicated otherwise
↓ Decrease
— Data not given
S.B.P. Systolic Blood Pressure
D.B.P. Diastolic Blood Pressure
¹ Subjects sprayed with water for ten minutes at 5' intervals
² Subjects' feet and legs were immersed in water with the body wrapped in blankets

D. Effect of Environmental Temperature on Core Temperature

It is well known that when man exercises his core temperature tends to rise. This was firmly established by Nielsen (1938) and in many subsequent studies including those of Snellen (1969) and Wyndham (1973). Nadel (1980) in his review points out that with the onset of exercise a large amount of energy is converted to heat and this metabolic heat production increases to a rate that is proportional to the exercise intensity. If it exceeds the ongoing rate of heat dissipation the core temperature rises as heat is stored. To balance the rate of heat production the heat loss mechanisms (increased skin blood flow and sweating rate) are activated sufficiently to maintain body temperature.

There is some conflict between the interpretation by various investigators as to whether core temperature is independent of ambient temperature or not. Nielsen (1938) concluded that the level at which body temperature is regulated increases with work rate and is independent of environmental conditions as long as thermal equilibrium with the environment can be maintained. When the environmental stress exceeds the capacity of the heat loss mechanisms the core temperature rises. In reviewing studies Snellen (1969) concluded that there is a very close relationship between core temperature and metabolic rate, which is largely independent of ambient temperatures. Studies by other researhers such as Lind (1963); Wyndham et al. (1953) and

Wyndham et al. (1965). concluded that core temperature is never entirely independent of environmental temperature. The heat loss mechanisms, depending on the work rate, are adequate up to a certain ambient temperature. If this temperature is exceeded the core temperature rises. Thus the core temperature is no longer determined solely by the metabolic rate. This is quite apparent in several studies listed in Table 4.

The degree to which core temperature is increased during exercise in the heat depends primarily on the work rate, and to a lesser extent on the ambient temperature. High ambient temperatures have little effect on core temperature during light work. The core temperature appears to be significantly affected by the ambient temperature only when both the ambient temperature and work rate are high. This is particularly evident in conditions where the humidity is high. In a humid environment the effect of ambient temperature is pronounced as the effectiveness of the evaporative heat loss mechanism is reduced.

TABLE 4
Effect of Temperature on Core Temperature(C.T.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in C.T.
Eichna, L.W., et al., 1950.	3M	–	(1)25.6(39) (2)50.6(15)	treadmill	60 (intermittent)	4.0(2.5%)**	↑C.T(r) 1.2° at 50.6°.
Brouha, L.,[1] et al., 1960.	6M & 5F	20-58	(1)25.0(43) (2)37.2(25) (3)32.2(82)	ergometer	34	(1)30 min. submax. (2)4 min. max.	↑in C.T.(o) at 32.2°(82) condition with 0.94°↑ in M and 0.51°↑ in F*
Consolazio,[2] C.F., et al., 1963	7M	19-25	(1)21.2 (2)29.4 (3)37.7	ergometer	100	(1)50 min heavy (2)50 min moderate	↑in C.T. at 37.7°*
Lind, A.R.,[3] 1963.	3M	–	10-32	treadmill	60	(1)209.3 W (2)348.8 W (3)488.3 W	No differences in C.T.(r)

TABLE 4 (continued)
Effect of Temperature on Core Temperature(C.T) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in C.T.
Lind, A. R., 1963.	2M	–	(1)23.9 (2)29.4 (3)36.7	treadmill	480	(1)5.63** (2)5.63(7.5%)	No differences in C.T.
Rowell, L.B., et al., 1965.	9M	21-37	(1)25.6 (2)43.3	treadmill	15	(1)5.6(2-4 unspecified grades)**	No differences in C.T.(r)
Rowell, L.B., et al., 1966.	6M	21-27	(1)25.6 (2)43.3	treadmill	105-120 (intermittent)	(1)5.6(7.5%)** (2)5.6(10.0%) (3)5.6(12.5%) (4)5.6(15.0%)	No difference in C.T.(r)
Saltin, B., et al., 1970.	3M	22-33	(1)10(40) (2)20(40) (3)30(40)	ergometer	150 (intermittent)	(1)25% VO,max. (2)50% VO,max. (3)75% VO,max.	No difference in C.T.(r) or C.T.(e)

TABLE 4 (continued)
Effect of Temperature on Core Temperature(C.T) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in C.T.
Schvartz, E.,* & Benor, D., 1972.	7M	mean:23	(1)25 (2)30 (3)35 (4)40 (5)45	treadmill	120	3.5**	C.T.(r) differed only between 25° and the other temperatures
Adams, W.C., et al.,1975.	1M	38	(1)10(28-30) (2)22(28-30) (3)35.4(28-30)	treadmill	60-165	15.34**	C.T.(r) was 40.1° at 35.4, 39.5° at 22 and 39.4° at 10
Clarmont, A.D., et al.,1975.	8M	–	(1)0 (2)35	ergometer	30-60	52-59% VO,max.	C.T.(r)↑at 35°*
Fink, W.J. et al.,1975	6M	–	(1)9 (2)41	ergometer	65 (intermittent)	75-85% VO,max.	↑C.T.(r) at 41°*

TABLE 4 (continued)

Effect of Temperature on Core Temperature(C.T) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Changes in C.T.
Wells, C.L. & Paolone, A.M., 1977.	4M & 3F	mean:28.5	(1)25(55) (2)32(55) (3)40(55)	treadmill	40	58% VO,max.	C.T.(r) ↑ 0.92° in F and 1.34° in M at 40° vs. 25°*
Myhre, L.G. et al.,1979.	5M & 1F	20-41	(1)23.2 (2)33.0-40.0	ergometer	10	16-82% VO,max.	C.T. was .5° higher in heat*
Nadel, E.R. et al.,1979.	3M	–	(1)20 (2)26 (3)36	ergometer	20-25	(1)40% VO,max. (2)70% VO,max.	C.T.(e) was 38.18° at 20°, 38.12° at 26° and 38.84° at 36° at 70% VO,max.
Suziki, L.J. 1980	4M	–	(1)0 (2)20 (3)40	ergometer	to exhaustion	66% VO,max.	No difference in C.T.(r)

TABLE 4 (continued)
Effect of Temperature on Core Temperature(C.T.) During Various Forms of Exercise.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	$\dot{V}$ Exercise Test	Exercise Duration (min)	Work Rate	Changes in C.T.

* All results statistically significant unless indicated otherwise
** Treadmill test work rates are in km•hr⁻¹ with treadmill elevations in brackets.
↑ Increase
– Data not given.
C.T.(o) Core Temperature (oral)
C.T.(e) Core Temperature (esophagal)
C.T.(r) Core Temperature (rectal)
[1] Work load was predetermined and not specified.
[2] Subjects pedalled for two fifty min. periods first at an O_2 consumption of 1.2-1.6 $l \cdot min^{-1}$ then at one of 0.6-0.9 $l \cdot min^{-1}$.
[3] Subjects exercised at four different temperatures chosen from a range of 10-32°C
[4] Subjects performed eight hours of continuous work (55 min. work, 5 min. rest) and eight hours of intermittent work (25 min. work, 35 min. rest)
[5] Subjects wore vapor barrier suits

E. Factors Which May Influence the Cardiovascular and Thermoregulatory Responses to Exercise in the Heat

Several factors in addition to the environmental temperature have been found to influence one's response to exercise. These include sex and age which were taken into account in the present study and therefore require further discussion.

Differences Attributable to Sex

There appears to be no difference between males and females in the thermoregulatory responses that occur during exercise at normal conditions (approximately 22°C) when exposed per unit body size. This was demonstrated by Saltin and Hermansen (1966) who found that there was no difference between the increase of deep body temperature of male and female subjects during exercise at ambient temperatures that range from 19.0°C and 22.0°C.

As is evident in Table 5, the results are inconsistent among studies in which the difference in responses of the sexes was measured during exercise at high ambient temperatures. Most of those studies reviewed had shown that females had consistently higher heart rates than men during work at high temperatures. Brouha et al. (1960) found that, in spite of lighter work rates, the cardiac cost for women was greater and their cardiac output smaller than that of men during exercise in the heat.

There has been a great deal of variation among the findings of previous studies in regard to differences in core temperature between males and females during exercise in the heat. This point is evident in Table 5 where some studies have shown core temperature to be higher in females, others higher in males and still others exhibit no difference between the sexes during exercise at high ambient temperatures.

Blood pressure was considered in only two of the studies reviewed and the conclusions of these did not agree. Brouha et al. (1960) concluded that both sexes had similar increases in systolic blood pressure with exercise. However, as the females exercised at a lower work rate their increases were not as great. Morimoto et al. (1967) reported that systolic blood pressure increased slightly more in females than in males, but only at the two hottest conditions. They also found that diastolic blood pressure decreased significantly in males in all test conditions whereas in females the decrease was significant only at the highest temperature.

It appears that under heat stress women generally show relatively more 'peripheral' blood pooling, greater heart rate increase, lower maximal sweat rates, higher skin temperature with greater body heat storage, and poorer maintenance of circulating blood volume with more impact from dehydration . These are the conclusions drawn by Burse (1979) based on a review of previous studies. However, Wyndham et al. (1965) concluded from their study that once acclimatized the temperature and circulatory reactions of both sexes are very similar, except that females tend to sweat less than males.

TABLE 5
Differnces Between Sexes During Various Forms of Exercise in Heat.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Differnces
Brouha, L.,[1] et al.,1960.	6M & 5F	20-58	(1)25.0(43) (2)37.2(25) (3)32.2(82)	ergometer	34	(1)30 min. submax. (2)4 min. max.	(1)H.R. 16% higher in M No differences in S.B.P. and D.B.P. C.T.(o) 0.94°† in M and 0.51°† in F
Wyndham, C.H., et al.,1965.	30M & 26F	–	33.9(89)	step	240	12 step•min⁻¹	H.R. higher in F* C.T.(r) higher in F*
Morimoto, T.,[2] et al.,1967.	13M & 13F	17-32	1 2 (1)36 33 (2)41 34 (3)45 36 (4)47 37 (5)49 38	treadmill	30	5.63**	(1)S.B.P. slightly higher in F (2)D.B.P. higher in M* (3)No difference in C.T.(r)

TABLE 5 (continued)
Differnces Between Sexes During Various Forms of Exercise in Heat.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Differences
Wells, C.L., & Paolone, A.M., 1977.	4M & 3F	mean:28.5	(1)25(55) (2)32(55) (3)40(55)	treadmill	40	58% VO_2max.	(1)No difference in H.R. (2)C.T.(r) 1.34°↑ in M and 0.92°↑ in F at 40°
Wells, C.L., et al., 1978.	4M & 3F	—	(1)25 (2)30 (3)40	treadmill	40	50% VO_2max.	(1)H.R. higher in M (2)No difference in C.T.(r)
Shapiro, Y., et al., 1980.	10M & 9F	—	(1)20(40) (2)32(80) (3)35(90) (4)37(80) (5)49(20) (6)54(10)	treadmill	120	4.82**	(1)H.R. was higher in F* (2)C.T.(r) higher in F in hot-dry but higher in M in hot-wet*

TABLE 5 (continued)
Differnces Between Sexes During Various Forms of Exercise in Heat.

Author	Subjects	Age(yrs)	Environment [°C(%R.H.)]	Exercise Test	Exercise Duration (min)	Work Rate	Differences
Wells, C.L., 1980.	5M & 6F	—	(1)23 (2)39	treadmill	40	50% VO_2max.	(1)H.R. 3% higher in F. (2)No difference in C.T.(r)

* All results statistically significant unless indicated otherwise
** Treadmill test work rates are in km•hr⁻¹ with treadmill elevations in brackets.
† Increase
— Data not given.
C.T.(o) Core Temperature (oral)
C.T.(r) Core Temperature (rectal)
[1] Work load was predetermined and not specified.
[2] Two series of tests were carried out; the first at 29-31% R.H. and the second at 80-82% R.H.
[3] Subjects were exposed to each temperature for two hours (40 min. rest, 40 min. work and 40 min. recovery)
[4] Subjects were exposed to each temperature for two hours (10 min. rest and 50 min. work each hour)

Differences Attributable to Age

It is well recognized that maximal attainable heart rate decreases with age. For example, in a study by Wolthuis et al. (1977) 704 healthy men aged 25 to 54 years walked on a threadmill at a speed of 5.28 $km \cdot hr^{-1}$ with a 1% increase in grade each minute until a maximum effort was reached. They observed that maximal attainable heart rate decreases with age.

The effect of age on the elevation of arterial pressure with exercise was also investigated by Wolthuis et al. (1977). They found that maximal systolic blood pressure showed little change wheras maximal diastolic blood pressure increased slightly with age. The increase in rectal temperature during exercise does not appear to change with increasing age. Davies (1979c) concluded on the basis of his study that there were no differences in rectal temperature during exercise between younger and older subjects provided they worked at the same relative work rate (i.e. at the same percentage of their VO_2max.).

The heart rate increase during exercise at high ambient temperatures tends to be higher in older individuals. This was the conclusion of Hellon et al. (1956) and Pandolf et al. (1975). Hellon et al. compared two groups of 18 men, one with a mean age of 26 years and a second with a mean age of 43 years. Both groups performed a four hour work routine which consisted of alternating periods of work and rest (10R 30W 30R 30W 30R 30W 60R 20W) in an environment of 37.8°C, 56% relative humidity with an air speed of 30.5 $m \cdot sec^{-1}$. The work consisted of stepping on and off a 30.5 cm. high stool at a rate of 12 steps per minute. They observed the older group to have greater heart rates and slightly higher rectal temperatures than the younger group. Pandolf et al. (1975) had 10 male subjects aged 18 to 26 years pedal a bicycle ergometer at 40% their VO_2max. for 30 minutes in temperatures of 24°C, 44°C and 54°C. They also found that at high ambient temperatures, the heart rate increase was greater and the heat tolerance lower in older individuals than in younger ones.

Children and older adults appear to be more susceptible to heat stress than middle aged adults. Drinkwater and Horvath (1979) interpreted previous findings as suggesting that an inadequate sweating rate is primairly responsible for their low tolerance. In their investigation 38 women aged 12 to 68 years were examined. It was concluded that the low tolerance of those at the extremes is the result of the instability of an immature cardiovascular system in children, while in older adults it is associated with a marked decrement in VO_2max.

It appears that, during exercise at high ambient temperatures, older individuals have greater increases in heart rate and slightly higher increases in core temperature than younger individuals.

III. Methods

One hundred and three (51 male, 52 female) subjects ranging in an age from 7 to 69 years were included in the present study. They were arranged in five age groups; 7-13, 14-18, 19-29, 30-45 and 45-69 years with ten males and ten females in each age group, except for both 30-45 age groups and the 19-29 female group which had 11 subjects each. Each subject performed the Canadian Home Fitness Test (CHFT) at four different temperatures, 21°C, 24°C, 27°C and 30°C in an environmental test chamber with relative humidity set to 70%. As the temperature of the chamber could not be changed quickly, tests carried out on any one day were the same temperature. Subjects were assigned in random order to the tempertature conditions. Tests on any one subject were completed within 4-14 days. Subjects were not required to alter their level of physical activity or pattern of food intake over the period of the study. They were asked not to drink tea, coffee or alcoholic beverages, smoke or eat a large amount of food two hours prior to testing. Before undertaking the tests subjects were asked to read and sign an informed consent and a Physical Activity Readiness Questionnaire (Par-Q).

During testing the CHFT protocol was followed with the exception that heart rate, and body core temperature were monitored every minute throughout the nine minute test period and for a recovery period of five minutes. Heart rate and core temperature were determined from the recordings at rest before the exercise and at each minute interval for the duration of the test and recovery period. Arterial blood pressure was also monitored. It was determined at rest and during the pause between exercise intensity levels, at the third, sixth and ninth minute during the exercise, and every minute during recovery.

A. Canadian Home Fitness Test

The CHFT is a step test in which participants step up and down two 20.3 cm. steps at a predetermined cadence for their age group. Stepping rate is governed by the rhythm of music provided by a cassette tape or record played during the test. The test consists of three stages of progressively increasing rates of stepping with each stage being of three minutes followed by a ten second pause. Maximal oxygen consumption rate is predicted from a regression equation based on the average energy expenditures during the last stage of exercise, the postexercise heart rate and the subect's age and weight. The equation developed by Jette et al. (1976) is as follows:

$$VO_2max. = 42.5+16.6(VO_2)-0.12(W)-0.12(H)-0.24(A)$$

where VO_2 is the average oxygen cost of the last completed exercise stage (in $l\cdot min^{-1}$), W is the body weight (in kg.), H is the post-exercise heart rate (in $b\cdot min^{-1}$) and A is the age (in years).

B. Apparatus

Environmental Conditions

The tests were carried out in an environmental chamber located in the Medical Sciences Building at the University of Alberta. The temperature could be controlled to within 1°C and relative humidity to within 5%.

Heart Rate

Heart rates were obtained using a cardiotachometer (Cardionics Ab, Stockholm) and an electrocardiograph (Model 500 Viso-Cardiette, Sandborn Instruments Co.) with the input of the two instruments in parallel. The ECG was picked up using disposable electrodes (Hewlett-Packard, Model 14445c) applied to the chest (at the fifth intercostal space on the anterior axillary line) with a grounding electrode on the back (medial to and slightly below the scapula).

Core Temperature

Core temperature was determined in one of 3 ways; esophageal, rectal or oral, using thermocouples made up into probes of suitable configurations for each mode using plastic (Tygon) tubing. The temperatures were displayed using a digital readout device (Bailey Instruments Co., Model BAT-8).

Each subject was asked to first swallow an esophageal probe (40 cm. long and 0.24 cm. in diameter). If they were unable to swallow the esophageal probe they were requested to insert a rectal probe (10 cm. long and 0.40 cm. in diameter). For subjects unable to carry out each of these procedures core temperature was determined by means of a small thermocouple held sublingually. This latter method was used exclusively for subjects 7-13 years of age.

Blood Pressure

Blood pressure was determined by a modified auscultatory method using an electronic sphygmomanometer device (Gulf-Western, SD-500). Blood pressure during the initial resting phase was recorded with the subject seated and during the exercise phase, at the brief interval between stages of the test, with the subject standing. During the final recovery phase pressures were obtained with the subject in a seated position.

C. Statistical Analysis

Data recorded for each of the physiological functions was subjected to separate statistical analysis. A two-way analysis of variance (ANOVA) with repeated measures on temperature and time was carried out to determine whether or not significant differences existed within each of the variables measured as a consequence of differences in ambient temperature. The analysis was applied on the data of each sex-age (sex x age) group at the third, sixth and ninth minutes of the test. The basic statistical design can be seen in Figure 1. The difference between selected means was tested for statistical significance by a Newman-Keuls' multiple-range test on a posteriori basis (Bruning and Kintz, 1977).

TEMPERATURE

TIME	21°C	24°C	27°C	30°C
min 3	X_{11}	X_{12}	X_{13}	X_{14}
min 6	X_{21}	X_{22}	X_{23}	X_{24}
min 9	X_{31}	X_{32}	X_{33}	X_{34}

FIGURE 1. Experimental Design

IV. Results

A. Heart Rate

Heart rate showed a progressive rise during exercise in all tests. The extent of this rise was similar across all age groups and both sexes. As illustrated in Figures 2 and 3 with the onset of exercise the mean heart rate showed an immediate increase followed by a further progressive increase throughout the exercise period. On cessation of exercise the heart rate dropped rapidly within the first minute followed by a further progressive fall during the succeeding 4 minutes. The mean heart rate had not returned to pre-exercise levels 5 minutes after the cessation of the exercise, when the last measurement was made.

The mean heart rates associated with the four temperatures tended to diverge with time, as is evidenced in Figures 2 and 3. Statistical examination of the heart rates at the third, sixth and ninth minutes of exercise, however, showed this divergence to be significant in only 3 groups (see Tables 6, 7 and 8, Appendix A).

B. Systolic Blood Pressure

Systolic Blood Pressure showed a similar pattern to that of heart rate. As demonstrated in Figures 4 and 5, systolic blood pressure progressively increased with exercise and progressiveily fell in the first minute after the cessation of exercise, and in the ensuing 4 minutes to near pre-exercise levels by the last minute of measurement. Temperature had little or no effect on systolic blood pressure. Statistical analysis at the third, sixth and ninth minute of exercise showed no significant difference in systolic blood pressure with temperature for any sex-age group.

C. Diastolic Blood Pressure

As illustrated in Figures 6 and 7, diastolic blood pressure gradually decreased or showed little change during the exercise period and was not influenced by the ambient temperature. Significant differences in diastolic blood pressure between temperatures were observed in only one sex-age group (see Table 9, Appendix A). No trend which could be attributed to the ambient temperature was found however, when statistical tests were carried out on this group.

D. Core Temperature

Core temperature showed a progressive increase during exercise in all age groups and both sexes. As can be seen in Figures 8 and 9, with the onset of exercise all subjects demonstrated a progressive increase in core temperature throughout the exercise period. The core temperature dropped gradually with the cessation of exercise and had not returned to pre-exercise levels 5 minutes after exercise had ceased. The ambient temperature had no effect on core temperature.

Statistical analysis at the third, sixth and ninth minute of exercise showed no significant difference in core temperature with temperature in all but 3 sex-age groups (see Tables 10, 11 and 12, Appendix A). Further analysis of these groups however, did not reveal any pattern which could be attributed to differences in ambient temperature.

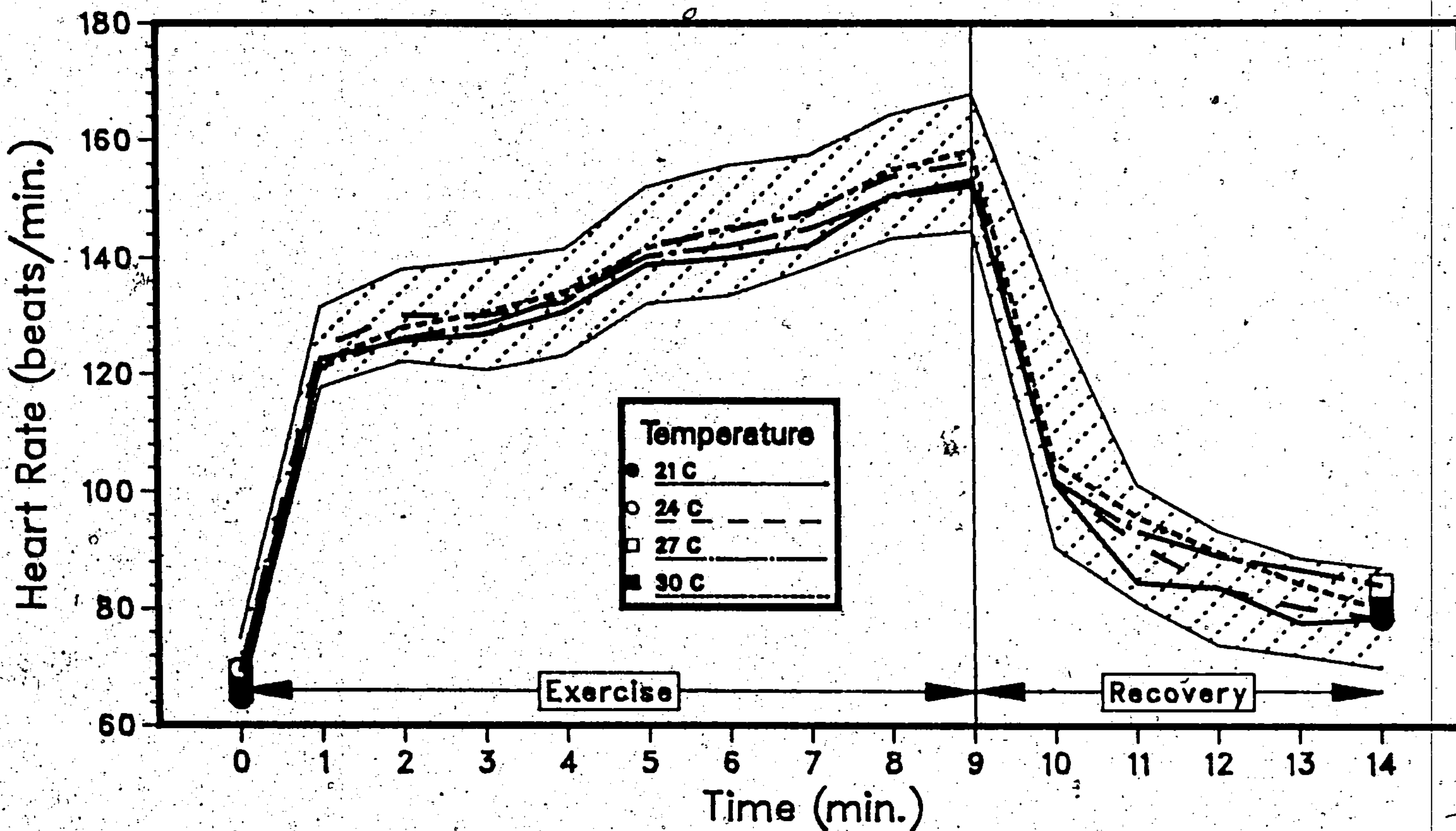

FIGURE 2. The Effect of Ambient Temperature on Heart Rate During the CHFT
(Males, 19-29 years)
(Shaded area represents the standard deviations of 24°C which had the largest standard deviations of the four temperatures)

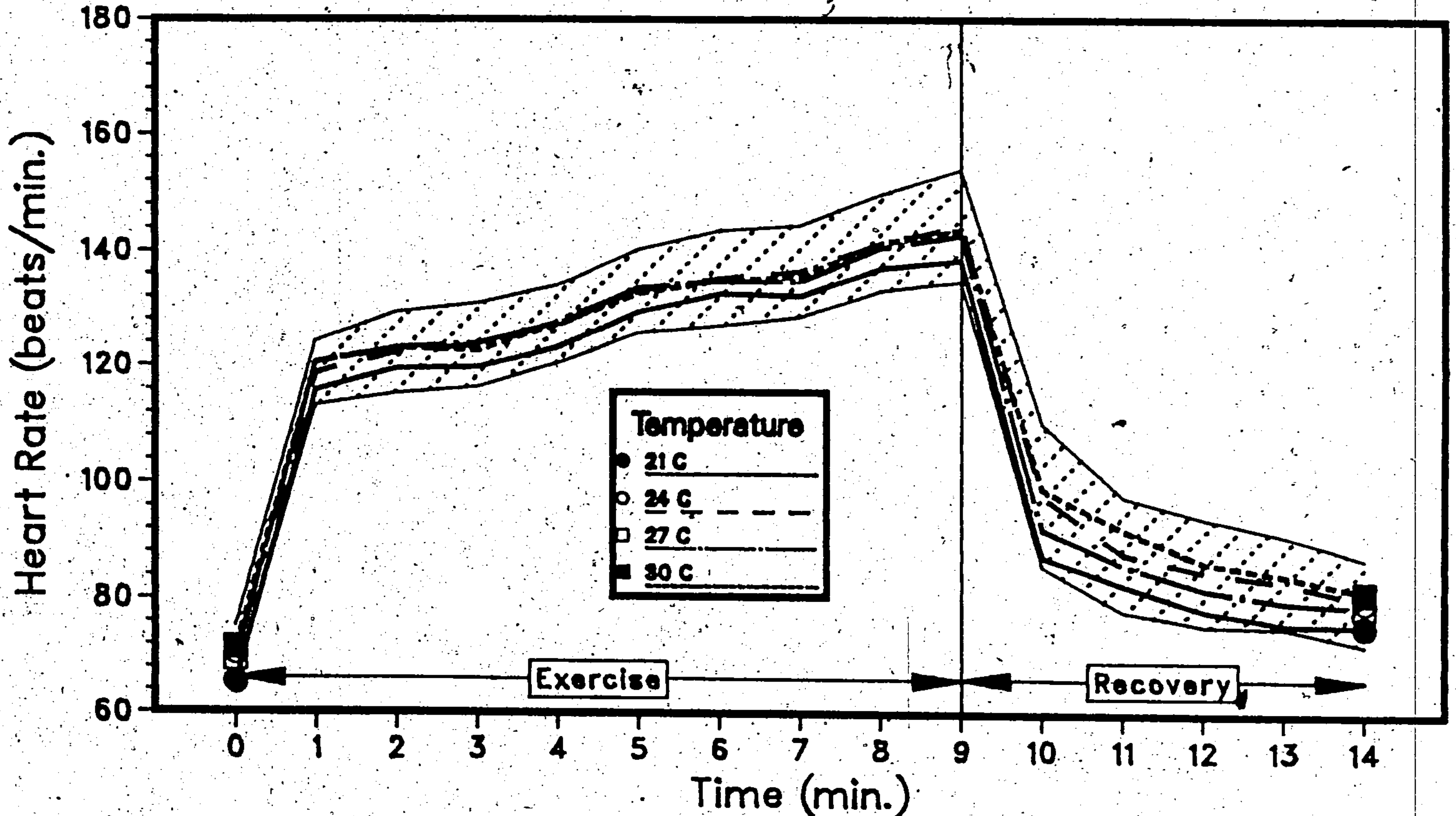

FIGURE 3. The Effect of Ambient Temperature on Heart Rate During the CHFT
(Females, 19-29 years)
(Shaded area represents the standard deviations of 24°C which had the largest standard deviations of the four temperatures)

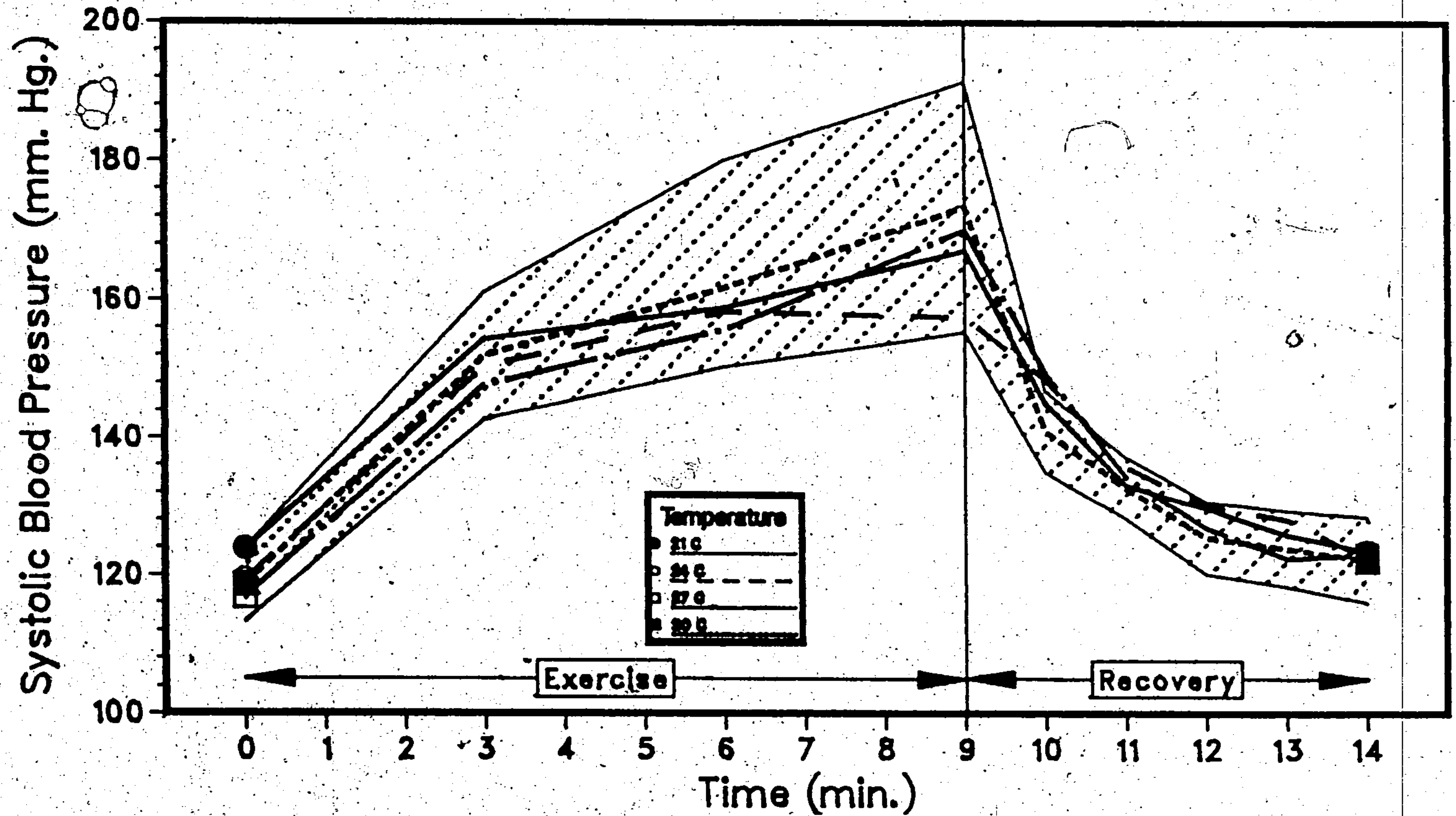

FIGURE 4. The Effect of Ambient Temperature on Systolic Blood Pressure During the CHFT
(Males, 19-29 years)
(Shaded area represents the standard deviations of 30°C which had the largest standard deviations of the four temperatures)

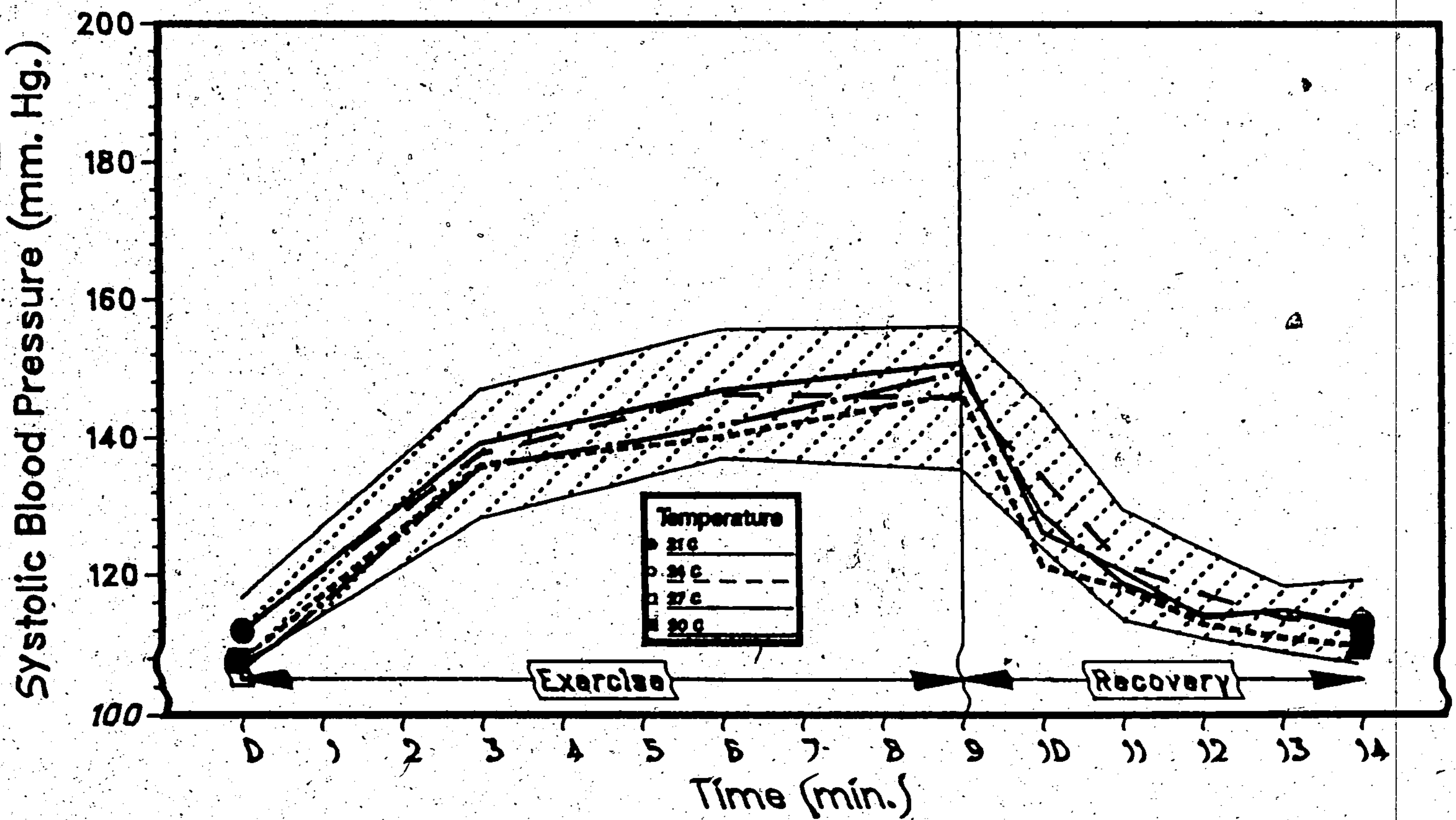

FIGURE 5. The Effect of Ambient Temperature on Systolic Blood Pressure During the CHFT (Females, 19-29 years)
(*Shaded area represents the standard deviations of 24°C which had the largest standard deviations of the four temperatures*)

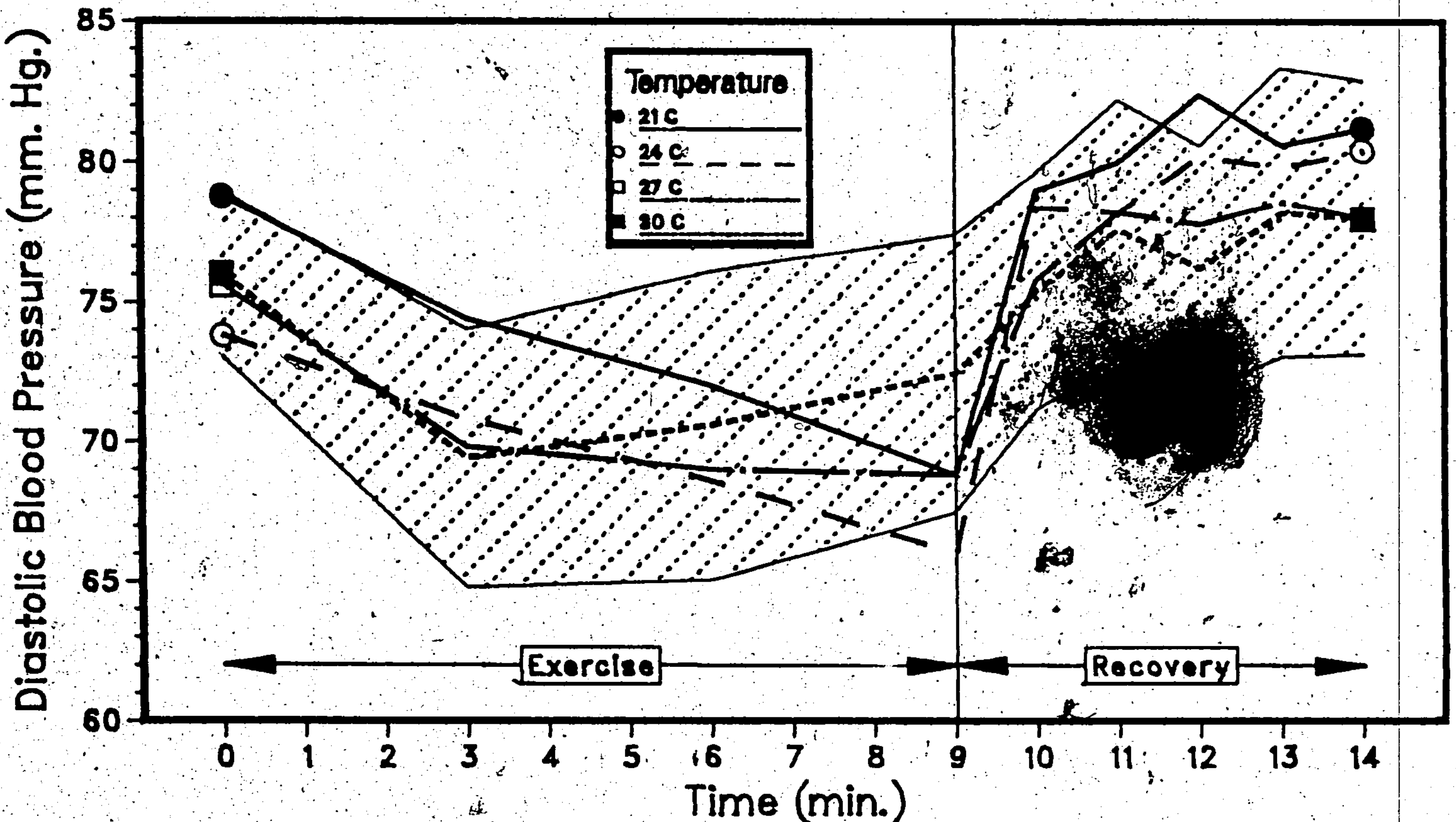

FIGURE 6. The Effect of Ambient Temperature on Diastolic Blood Pressure During the CHFT
(Males, 19-29 years)
(Shaded area represents the standard deviations of 24°C which had the largest standard deviations of the four temperatures)

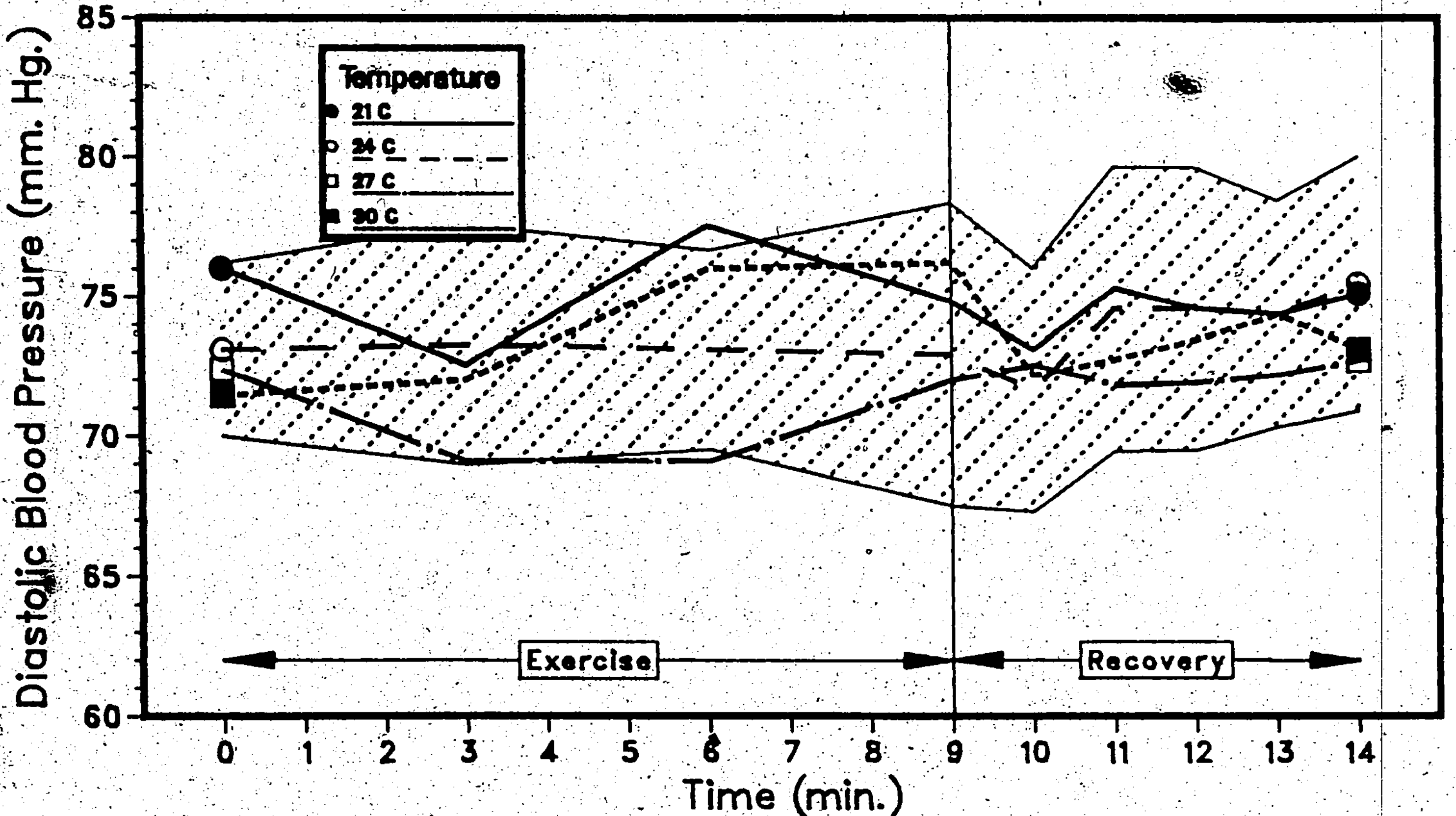

FIGURE 7. The Effect of Ambient Temperature on Diastolic Blood Pressure During the CHFT
(Females, 19-29 years)
(Shaded area represents the standard deviations of 24°C which had the largest standard deviations of the four temperatures)

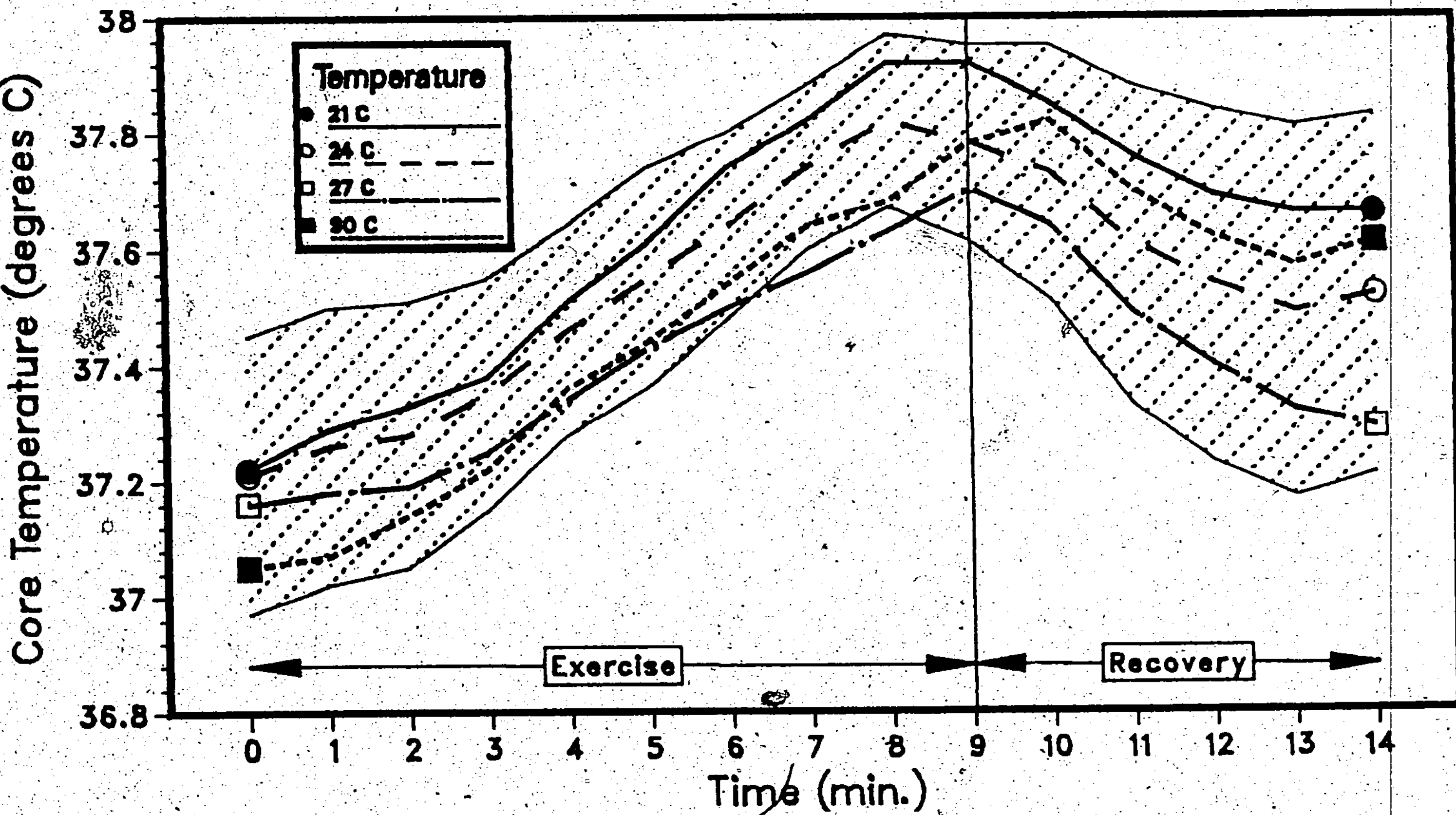

FIGURE 8. The Effect of Ambient Temperature on Core Temperature During the CHFT (Males, 19-29 years)
(Shaded area represents the standard deviations of 24°C which had the largest standard deviations of the four temperatures)

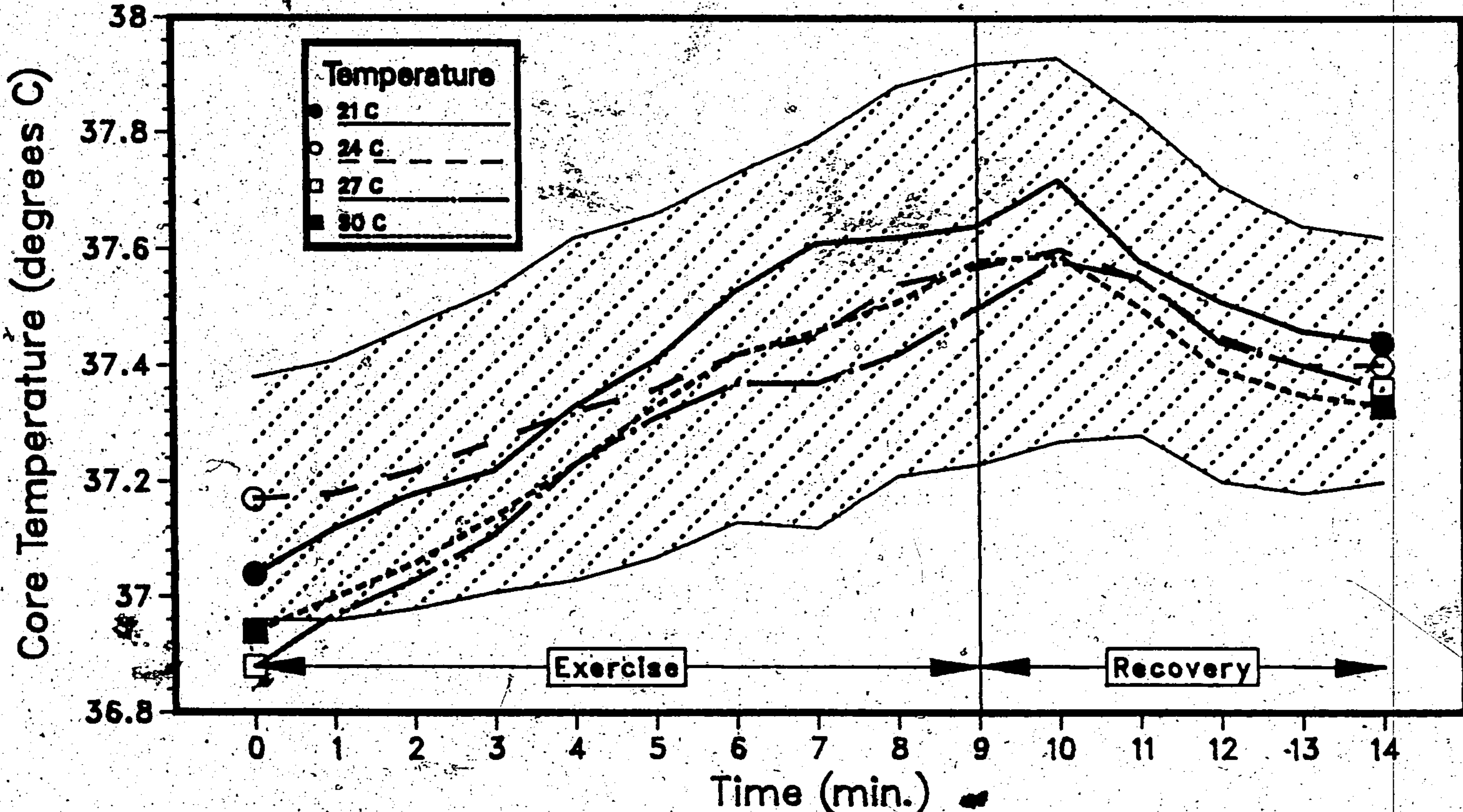

FIGURE 9. The Effect of Ambient Temperature on Core Temperature During the CHFT (Females, 19-29 years)
(Shaded area represents the standard deviations of 24°C which had the largest standard deviations of the four temperatures)

V. Discussion

The predominant findings of the present study, concerning heart rate, appear in contrast to those of other studies where the physiological response to heat stress was investigated (see Table 1). A factor contributing to the difference in the findings of this study and those in which the effect of temperature was investigated is that subjects in such studies were required to exercise for much longer periods than was required for subjects to complete the CHFT in the present study. Subjects in many of the studies reviewed were exposed to each temperature for 30 minutes or longer. In the present study subjects were tested shortly after entering the environmental chamber and the time that elapsed from when they entered to when they completed the last minute of the test was seldom more than 12-15 minutes.

In actual test conditions, subjects undergoing the CHFT at high ambient temperatures would have been exposed to such temperatures for many hours before the test and in effect would already be heat stressed and thus respond differently to the test. Several studies with exercise durations similar to the CHFT have shown significant increases in heart rate with an increase in ambient temperature. For example, subjects in a study by Miller and de V. Martin (1975)(see Table 1) exercised at 70% VO_2max. in temperatures between 21°C and 35°C on an ergometer for 12 minutes and showed signficant increases in heart rate with temperature. Their subjects had rested however, in the climatic chamber for an hour before moving to the ergometer where they sat and rested for a further 10 minutes before commencing to exercise. Similarly, in a study by Myhre et al. (1979) (see Table 1) a significant increase in heart rate with temperature was also observed in subjects who had exercised at 16-82% VO_2max. in temperatures of 23°C and 33-43°C for only 10 minutes. The subjects performed a 10 minute ergometer test, but only after a 15 minute walk in the same environment at an exercise intensity approximating that of the subsequent exercise on the ergometer. It is important to note that some of the temperatures encountered in these studies are greater than those of the present study, or those likely to be encountered in various testing locations where the CHFT may be administered.

Extrapolation from the data in Figures 2 and 3 suggest that if the period of exercise was extended significant differences in heart rate between temperatures would develop. It appears that increases in heart rate which occur with increasing temperature are not as great if the time one is subjected to those temperatures is less than 30 minutes. For example, in a study by Pandolf et al. (1975) (see Table1) subjects exercised at 40% VO_2max. in temperatures of 24°C, 44°C and 54°C. on a bicycle ergometer for 30 minutes after a three minute pre-exercise period. They observed a 1 beat·min^{-1} increase in heart rate for each 1°C increase in ambient temperature above 24°C. They concluded that the heart rate increase for exercise durations less than 30 minutes are slightly lower.

From the above evidence it appears that if the subjects in this study had continued to work or were exposed to the various temperatures for longer periods of time, significant differences in heart rate would have developed. The significant difference between heart rates observed in 3 groups in this study are possible a reflection of this trend. The fact that 2 out of these 3 groups are children and adolescents, however, may have some bearing on these observations.

The major factor which influences systolic blood pressure during work in the heat appears to be the work rate. Increases in systolic pressure during exercise at high ambient temperatures observed in this and other studies (see Table 2) are the result of the work rate, or intensity of exercise. The ambient temperature was found to have no effect on systolic blood pressure.

Diastolic blood pressure has been observed in most (if not all) studies of exercise to show little change during exercise. This lack of dramatic change in diastolic blood pressure during exercise is caused by a fall in peripheral resistance due to the flow of blood from the arterial system. The present study was in keeping with these findings.

It appears that any differences that developed in diastolic blood pressure during exercise in the heat are, as with systolic blood pressure, a product of the work rate and not the ambient temperature. These findings are in agreement with those of previous studies (see Table 3).

The increases in core temperature observed in this study are in agreement with the findings of previous studies where the influence of ambient temperature on core temperature was investigated (see Table 4). During exercise at high ambient temperatures increases in core temperature are primarily dependent on the work rate. The ambient temperature influences core temperature only when the ambient temperature is high and the work rate severe.

The variation in temperature, in this study, did not impose sufficient stress upon the subjects to cause alterations in their core temperatures. They might have developed some degree of heat stress if they had exercised longer, the exercise had been more severe or they had been previously exposed to some degree of heat stress. Also, as previously indicated, it is possible that the subjects in this study were quite fit and could therefore better tolerate the higher temperatures.

The inconsistency of statistical significance suggests that the ambient temperature, within the range examined, does not appear to have any effect on the CHFT.

VI. SUMMARY AND CONCLUSIONS

A. Purpose

The purpose of study was to determine whether or not different ambient temperatures significantly affect the results obtained on the Canadian Home Fitness Test (CHFT).

B. Procedures

All subjects (N=103) performed the CHFT at ambient temperatures of 21°C, 24°C, 27°C and 30°C. The relative humidity was held constant at 70% in all temperatures. Subjects were arranged by sex and age into 10 groups.

Heart rate, arterial blood pressure (systolic and diastolic) and core temperature were recorded at various times throughout the course of the test. Each of the dependent variables was subjected to separate statistical analysis.

A two-way analysis of variance with repeated measures on temperature and time was used to analyze the data of each sex-age group. Newman-Keuls' multiple range tests were used to compare selected means.

C. Results

The following results were observed:

Heart Rate

The heart rate increased progressively with exercise and the difference in heart rate between temperatures tended to increase with time however, statistical analysis showed this to be significant ($p<0.05$) in only 3 groups.

Systolic Blood Pressure

Systolic blood pressure increased with work rate, but was not affected by ambient temperature.

Diastolic Blood Pressure

Diastolic blood pressure showed little change during exercise. Statistical analysis revealed significant ($p<0.05$) differences in diastolic blood pressure between temperatures in only one group. However, no trend was observed which could be attributed to the differences in ambient temperature.

Core Temperature

Core temperature increased with increasing work rate and signigicant ($p<0.05$) differences were found between temperatures in 3 groups. No pattern was evident from these differences which could be attributed to the ambient temperature.

D. Conclusions

Within the limits of this study, the following conclusions have been made:

1. There appeared to be a trend in heart rate which suggests that if the period of exercise or exposure were extended, significant differences in heart rate between temperatures would develop.

2. Ambient temperature had little or no effect on arterial blood pressure (systolic and diastolic).

3. Ambient temperature had predominately little effect on core temperature. Significant differences observded in core temperature between temperatures failed to reveal any trend which could be attributed to differences in ambient temperature.

4. The ambient temperature appeared to have little effect on scores obtained on the CHFT.

E. Recommendations

Further research is required to determine what effect increasing the length of time one is exposed to the various temperatures would have on the results. Subjects should be allowed to equilibrate at the test temperature for 30 minutes or more prior to testing. The CHFT should also be carried out at various relative humidities in order to observe possible differences that may occur with increasing humidity. Further investigation on the effect of ambient temperature on the Canadian Home Fitness Test is recommended.

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VII. APPENDICES

A. APPENDIX A: Summaries of Significant Differences

TABLE 6
Summary of Significant ($p<0.05$) Mean Heart Rate Differences for Temperature–Time Interaction
(Males, 14–18 years)
(Δ heart rate changes ($b \bullet min^{-1}$) are indicated in brackets)

	Temperature–Time		Time–Temperature
minute 3	27°C > 24°C (5)	21°C	min 9 > min 3 (22)
	30°C > 24°C (7)		min 9 > min 6 (11)
			min 6 > min 3 (11)
minute 6	30°C > 21°C (7)	24°C	min 9 > min 3 (30)
	30°C > 24°C (6)		min 9 > min 6 (16)
			min 6 > min 3 (14)
minute 9	27°C > 21°C (5)	27°C	min 9 > min 3 (26)
	30°C > 21°C (10)		min 9 > min 6 (13)
	30°C > 24°C (6)		min 6 > min 3 (13)
	30°C > 27°C (5)		
		30°C	min 9 > min 3 (29)
			min 9 > min 6 (15)
			min 6 > min 3 (14)

TABLE 7

Summary of Significant ($p<0.05$) Mean Heart Rate Differences for Temperature–Time Interaction (Females, 7–13 years)

(Δ heart rate change ($b \cdot min^{-1}$) are indicated in brackets)

	Temperature–Time		Time–Temperature
minute 3	no significant difference	21°C	min 9 > min 3 (22) min 9 > min 6 (6) min 6 > min 3 (16)
minute 6	27°C > 24°C (5)	24°C	min 9 > min 3 (26) min 9 > min 6 (12) min 6 > min 3 (14)
minute 9	27°C > 21°C (7) 30°C > 21°C (7)	27°C	min 9 > min 3 (28) min 9 > min 6 (10) min 6 > min 3 (18)
		30°C	min 9 > min 3 (28) min 9 > min 6 (12) min 6 > min 3 (16)

TABLE 8
Summary of Significant ($p<0.05$) Mean Heart Rate Differences for Temperature–Time Interaction
(Females, 30–45 years)
(Δ heart rate change ($b \cdot min^{-1}$) are indicated in brackets)

Temperature–Time		Time–Temperature	
minute 3	24°C > 21°C (7)	21°C	min 9 > min 3 (21)
	27°C > 21°C (4)		min 9 > min 6 (8)
	30°C > 21°C (5)		min 6 > min 3 (13)
minute 6	24°C > 21°C (5)	24°C	min 9 > min 3 (21)
	24°C > 30°C (4)		min 9 > min 6 (10)
			min 6 > min 3 (11)
minute 9	24°C > 21°C (7)	27°C	min 9 > min 3 (26)
	27°C > 21°C (9)		min 9 > min 6 (14)
	30°C > 21°C (5)		min 6 > min 3 (12)
	27°C > 30°C (4)		
		30°C	min 9 > min 3 (21)
			min 9 > min 6 (12)
			min 6 > min 3 (9)

TABLE 9
Summary of Significant (p<0.05) Mean Diastolic Blood Pressure Differences for Temperature–Time Interaction
(Females, 14–18 years)
(Δ diastolic blood pressure changes (mm. Hg.) are indicated in brackets)

Temperature–Time		Time–Temperature	
minute 3	no signinficant difference	21°C	min 6 > min 3 (5) min 6 > min 9 (6)
minute 6	21°C > 27°C (5) 21°C > 30°C (6)	24°C	no significant difference
minute 9	21°C > 27°C ([illegible]) 24°C > 27°C (8)	27°C	min 3 > min 9 (8) min 6 > min 9 (6)
		30°C	min 3 > min 6 (6) min 3 > min 9 (7)

TABLE 10
Summary of Significant ($p<0.05$) Mean Core Temperature Differences for Temperature–Time Interaction (Males, 7–13 years)
(Δ core temperature changes (°C) are indicated in brackets)

Temperature–Time		Time–Temperature	
minute 3	21°C > 27°C (0.30) 21°C > 30°C (0.17) 24°C > 27°C (0.30) 24°C > 30°C (0.17)	21°C	min 9 > min 3 (0.30) min 6 > min 3 (0.20)
minute 6	21°C > 27°C (0.18)	24°C	min 9 > min 3 (0.31) min 9 > min 6 (0.21)
minute 9	no significant difference	27°C	min 9 > min 3 (0.51) min 9 > min 6 (0.19) min 6 > min 3 (0.32)
		30°C	min 9 > min 3 (0.47) min 9 > min 6 (0.20) min 6 > min 3 (0.27)

TABLE 11
Summary of Significant ($p<0.05$) Mean Core Temperature Differences for Temperature–Time Interaction
(Males, 14–18 years)
(Δ core temperature changes (°C) are indicated in brackets)

Temperature–Time		Time–Temperature	
minute 3	no significant difference	21°C	min 9 > min 3 (0.40)
minute 6	no significant difference	24°C	min 9 > min 3 (0.60) min 6 > min 3 (0.40)
minute 9	30°C > 27°C (0.30)	27°C	min 9 > min 3 (0.50) min 6 > min 3 (0.30)
		30°C	min 9 > min 3 (0.90) min 9 > min 6 (0.60) min 6 > min 3 (0.30)

TABLE 12
Summary of Significant ($p<0.05$) Mean Core Temperature Differences for Temperature–Time Interaction
(Females, 19–29 years)
(Δ core temperature changes (°C) are indicated in brackets)

Temperature–Time		Time–Temperature	
minute 3	no significant difference	21°C	min 9 > min 3 (0.42)
			min 9 > min 6 (0.16)
			min 6 > min 3 (0.26)
minute 6	21°C > 24°C (0.13)		
	21°C > 27°C (0.18)	24°C	min 9 > min 3 (0.24)
			min 9 > min 6 (0.13)
minute 9	21°C > 24°C (0.18)		
	21°C > 27°C (0.17)		
	30°C > 24°C (0.15)		
	30°C > 27°C (0.14)	27°C	min 9 > min 3 (0.37)
			min 9 > min 6 (0.17)
			min 6 > min 3 (0.20)
		30°C	min 9 > min 3 (0.46)
			min 9 > min 6 (0.20)
			min 6 > min 3 (0.26)

B. APPENDIX B: Heart Rate Data Analyses

Mean Heart Rate Data For Males
(Numbers in brackets represent ±1 standard deviation from the mean)

	TEMPERATURE											
	21°C			24°C			27°C			30°C		
AGE	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**
7-13 yr.	145.0 (7.180)	156.0 (16.25)	171.4 (17.92)	145.6 (11.65)	156.2 (14.19)	171.5 (16.10)	147.2 (13.38)	160.4 (10.78)	172.3 (11.53)	148.1 (9.814)	160.3 (7.498)	177.7 (13.95)
14-18 yr.	136.8 (17.79)	147.9 (17.72)	154.7 (12.87)	131.5 (14.05)	146.3 (14.3[illegible])	162.1 (17.01)	136.9 (15.43)	150.2 (16.10)	[illegible] (14.42)	138.6 (16.02)	152.7 (17.64)	164.6 (17.93)
19-29 yr.	127.0 (11.50)	140.0 (15.04)	153.4 (19.98)	130.2 (18.77)	144.7 (22.24)	156.3 (23.28)	128.6 (16.78)	142.2 (19.86)	152.4 (21.94)	130.7 (12.26)	145.2 (15.40)	154.3 (17.67)
30-45 yr.	115.1 (11.73)	129.5 (14.73)	143.1 (13.26)	120.1 (11.96)	133.4 (16.46)	146.5 (16.77)	119.5 (13.53)	133.3 (14.90)	143.9 (15.00)	119.4 (13.89)	134.4 (16.25)	143.4 (11.30)
46-69 yr.	111.4 (15.70)	120.2 (18.76)	133.3 (23.78)	111.9 (15.63)	122.0 (17.[illegible]48)	136.8 (21.69)	113.9 (18.[illegible])	125.5 (18.47)	143.4 (16.61)	113.1 (13.24)	124.2 (14.21)	138.2 (19.22)

Mean Heart Rate Data For Females
(Numbers in brackets represent ±1 standard deviation from the mean)

	TEMPERATURE											
	21°C			24°C			27°C			30°C		
AGE	min 3	min 6	min 9	min 3	min 6	min 9	min 3	min 6	min 9	min 3	min 6	min 9
7-13 yr.	152.0 (10.25)	167.6 (16.04)	173.6 (16.42)	152.1 (12.66)	165.5 (14.81)	177.9 (14.73)	152.7 (10.07)	170.6 (14.66)	180.9 (16.12)	152.9 (9.904)	168.8 (12.06)	180.5 (13.64)
14-18 yr.	153.1 (18.56)	166.1 (21.99)	175.7 (21.24)	148.9 (18.37)	163.7 (20.98)	177.4 (21.26)	146.6 (17.82)	161.9 (20.56)	172.4 (20.18)	153.5 (18.99)	169.1 (21.52)	179.5 (19.47)
19-29 yr.	119.7 (11.46)	132.6 (16.71)	138.5 (15.16)	123.6 (14.50)	135.3 (16.46)	144.4 (19.30)	123.8 (12.35)	134.8 (13.89)	142.8 (14.07)	122.6 (10.01)	134.9 (12.96)	143.8 (12.23)
30-45 yr.	124.8 (14.03)	138.7 (14.08)	143.0 (12.97)	127.9 (9.554)	142.4 (12.22)	148.6 (11.78)	126.0 (10.14)	139.8 (11.57)	149.7 (10.64)	128.0 (11.06)	140.7 (12.76)	141.8 (5.947)
46-69 yr.	116.5 (8.501)	135.2 (14.02)	144.6 (8.382)	114.9 (10.45)	132.4 (15.18)	145.1 (13.92)	121.6 (12.61)	137.9 (12.56)	148.7 (12.29)	121.9 (12.40)	140.1 (15.78)	147.8 (7.772)

Analysis of Variance Summary Table
(Males, 7-13 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	8309.000	9.	923.222		
A	408.750	3.	136.250	0.641	0.595
AS-WITHIN	5741.000	27.	212.630		
B	14381.879	2.	7190.938	58.489	0.001
BS-WITHIN	2213.000	18.	122.944		
AB	105.000	6.	17.500	0.519	0.792
ABS-WITHIN	1822.000	54.	33.741		

Analysis of Variance Summary Table
(Males, 14-18 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	15682.000	8.	1960.250		
A	797.063	3.	265.688	4.571	0.011
AS-WITHIN	1395.000	24.	58.125		
B	13095.000	2.	6547.500	102.105	0.001
BS-WITHIN	1026.000	16.	64.125		
AB	201.375	6.	33.563	2.586	0.030
ABS-WITHIN	623.000	48.	12.979		

Analysis of Variance Summary Table
(Males, 19-29 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP	:	1 C21	2 C24	3 C27	4 C30
B - TIME	:	1 MIN3	2 MIN6	3 MIN9	

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	28245.000	8.	3530.625		
A	306.563	3.	102.188	1.049	0.389
AS-WITHIN	2338.000	24.	97.417		
B	12170.250	2.	6085.125	77.579	0.001
BS-WITHIN	1255.000	16.	78.438		
AB	95.063	6.	15.844	1.398	0.235
ABS-WITHIN	544.000	48.	11.333		

Analysis of Variance Summary Table
(Males, 30-45 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP :	1 C21	2 C24	3 C27	4 C30
B - TIME :	1 MIN3	2 MIN6	3 MIN9	

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	9456.000	8.	1182.000		
A	186.188	3.	62.063	0.809	0.502
AS-WITHIN	1842.000	24.	76.750		
B	13136.063	2.	6568.031	144.950	0.001
BS-WITHIN	725.000	16.	45.313		
AB	74.813	6.	12.469	1.715	0.138
ABS-WITHIN	349.000	48.	7.271		

Analysis of Variance Summary Table
(Males, 46-69 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	30239.000	9.	3359.889		
A	216.875	3.	72.292	1.222	0.321
AS-WITHIN	1597.000	27.	59.148		
B	10706.875	2.	5353.438	48.205	0.001
BS-WITHIN	1999.000	18.	111.056		
AB	136.250	6.	22.708	1.060	0.398
ABS-WITHIN	1157.000	54.	21.426		

Analysis of Variance Summary Table
(Females, 7-13 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	14821.000	9.	1646.778		
A	276.250	3.	92.083	0.742	0.537
AS-WITHIN	3353.000	27.	124.185		
B	13521.250	2.	6760.625	104.366	0.001
BS-WITHIN	1166.000	18.	64.778		
AB	205.625	6.	34.271	2.370	0.042
ABS-WITHIN	781.000	54.	14.463		

Analysis of Variance Summary Table
(Females, 14-18 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	35564.000	8.	4445.500		
A	827.438	3.	275.813	3.161	0.043
AS-WITHIN	2094.000	24.	87.250		
B	13242.375	2.	6621.188	133.930	0.001
BS-WITHIN	791.000	16.	49.438		
AB	63.563	6.	10.594	0.869	0.524
ABS-WITHIN	585.000	48.	12.188		

Analysis of Variance Summary Table
(Females, 19-29 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	7395.000	8.	924.375		
A	362.813	3.	120.938	1.133	0.356
AS-WITHIN	2562.000	24.	106.750		
B	7263.563	2.	3631.781	221.788	0.001
BS-WITHIN	262.000	16.	16.375		
AB	39.375	6.	6.563	1.318	0.267
ABS-WITHIN	239.000	48.	4.979		

Analysis of Variance Summary Table
(Females, 30-45 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	2171.000	5.	434.200		
A	429.750	3.	143.250	1.769	0.196
AS-WITHIN	1215.000	15.	81.000		
B	5808.750	2.	2904.375	68.988	0.001
BS-WITHIN	421.000	10.	42.100		
AB	68.625	6.	11.438	2.984	0.021
ABS-WITHIN	115.000	30.	3.833		

Analysis of Variance Summary Table
(Females, 48-69 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP :	1 C21 ,	2 C24 ,	3 C27 ,	4 C30
B - TIME :	1 MIN3 ,	2 MIN6 ,	3 MIN9	

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	4606.000	6.	767.667		
A	639.188	3.	213.063	3.003	0.058
AS-WITHIN	1277.000	18.	70.944		
B	12832.750	2.	6416.375	106.202	0.001
BS-WITHIN	725.000	12.	60.417		
AB	47.688	6.	7.948	0.596	0.731
ABS-WITHIN	480.000	36.	13.333		

C. APPENDIX C: Systolic Blood Pressure Data Analyses

Mean Systolic Blood Pressure Data For Males
(Numbers in brackets represent ±1 standard deviation from the mean)

	TEMPERATURE											
	21°C			24°C			27°C			30°C		
AGE	min 3	min 6	min 9	min 3	min 6	min 9	min 3	min 6	min 9	min 3	min 6	min 9
7-13 yr.	133.4 (24.91)	144.8 (31.68)	154.2 (43.52)	130.0 (21.72)	146.6 (26.60)	152.8 (26.02)	147.0 (23.65)	150.8 (26.19)	158.8 (26.68)	140.0 (31.22)	159.2 (34.82)	171.8 (41.75)
14-18 yr.	143.6 (23.95)	147.2 (33.77)	135.7 (9.457)	142.4 (23.37)	151.0 (37.71)	160.4 (55.14)	137.3 (33.25)	139.4 (34.52)	141.7 (21.10)	136.8 (24.38)	148.8 (33.83)	154.8 (39.61)
19-29 yr.	154.2 (22.63)	158.8 (25.45)	167.1 (32.77)	150.2 (14.43)	158.2 (21.46)	157.4 (12.36)	147.6 (19.20)	155.6 (31.67)	170.0 (35.75)	151.8 (18.31)	161.6 (22.78)	173.3 (36.02)
30-45 yr.	140.3 (14.44)	145.1 (18.62)	149.0 (17.89)	140.7 (17.96)	141.6 (17.70)	146.7 (21.74)	139.4 (15.33)	149.0 (23.85)	152.2 (26.52)	136.1 (15.91)	147.0 (13.86)	146.6 (19.79)
46-69 yr.	136.2 (20.34)	143.6 (24.18)	149.8 (26.27)	136.4 (19.10)	141.0 (21.81)	150.4 (21.47)	137.4 (20.89)	140.8 (24.28)	149.4 (25.10)	132.6 (14.01)	136.2 (17.77)	143.2 (21.81)

Mean Systolic Blood Pressure Data For Females
(Numbers in brackets represent ±1 standard deviation from the mean)

AGE	21°C min 3	21°C min 6	21°C min 9	24°C min 3	24°C min 6	24°C min 9	27°C min 3	27°C min 6	27°C min 9	30°C min 3	30°C min 6	30°C min 9
7-13 yr.	128.0 (22.60)	136.6 (23.51)	136.3 (26.86)	130.0 (16.33)	140.3 (26.59)	153.2 (26.41)	140.6 (20.06)	146.4 (14.50)	155.2 (17.59)	135.9 (21.02)	138.0 (24.76)	153.0 (33.04)
14-18 yr.	137.6 (26.22)	137.0 (23.63)	144.0 (26.87)	138.0 (24.62)	136.4 (23.52)	142.6 (25.82)	132.4 (22.91)	137.0 (22.65)	142.0 (20.17)	136.0 (28.25)	136.2 (25.69)	152.6 (30.18)
19-29 yr.	139.2 (13.27)	146.9 (17.69)	150.8 (18.35)	137.6 (18.67)	146.3 (18.71)	145.6 (20.83)	135.6 (14.52)	141.8 (15.42)	149.4 (20.82)	136.0 (18.04)	140.1 (17.74)	146.4 (21.41)
30-45 yr.	119.6 (13.61)	128.3 (12.22)	137.7 (11.38)	124.0 (10.31)	134.7 (14.67)	141.2 (27.19)	130.5 (12.29)	138.0 (15.20)	151.0 (19.24)	122.3 (11.02)	135.0 (13.45)	144.6 (15.78)
46-69 yr.	124.0 (19.77)	135.4 (21.25)	132.5 (22.52)	117.2 (17.64)	128.0 (19.25)	130.7 (19.91)	115.8 (20.77)	128.0 (18.69)	123.4 (14.40)	119.4 (11.15)	130.4 (17.48)	130.2 (15.28)

Analysis of Variance Summary Table
(Males, 7-13 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	49264.000	9.	5473.777		
A	5389.375	3.	1796.458	1.531	0.229
AS-WITHIN	31687.000	27.	1173.593		
B	7860.000	2.	3930.000	10.705	0.001
BS-WITHIN	6608.000	18.	367.111		
AB	650.625	6.	108.438	0.423	0.860
ABS-WITHIN	13828.000	54.	256.074		

Analysis of Variance Summary Table
(Males, 14-18 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	20641.000	8.	2580.125		
A	1906.875	3.	635.625	0.720	0.550
AS-WITHIN	21198.000	24.	883.250		
B	2727.563	2.	1363.781	3.945	0.040
BS-WITHIN	5531.000	16.	345.688		
AB	1659.375	6.	276.563	1.528	0.189
ABS-WITHIN	8687.000	48.	180.979		

Analysis of Variance Summary Table
(Males, 19-29 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP	:	1 C21	2 C24	3 C27	4 C30
B - TIME	:	1 MIN3	2 MIN6	3 MIN9	

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	34661.000	8.	4332.625		
A	1227.938	3.	409.313	0.445	0.723
AS-WITHIN	22064.000	24.	919.333		
B	4626.563	2.	2313.281	10.301	0.001
BS-WITHIN	3593.000	16.	224.563		
AB	848.250	6.	141.375	1.166	0.340
ABS-WITHIN	5821.000	48.	121.271		

Analysis of Variance Summary Table
(Males, 30-45 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP	:	1 C21 ,	2 C24 ,	3 C27 ,	4 C30
B - TIME	:	1 MIN3 ,	2 MIN6 ,	3 MIN9	

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN, SQUARES	F RATIO	PROBABILITY
S-WITHIN	25125.000	8.	3140.625		
A	129.938	3.	43.313	0.204	0.893
AS-WITHIN	5108.000	24.	212.833		
B	2227.500	2.	1113.750	12.189	0.001
BS-WITHIN	1462.000	16.	91.375		
AB	357.750	6.	59.625	0.509	0.798
ABS-WITHIN	5620.000	48.	117.083		

Analysis of Variance Summary Table
(Males, 48-69 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP	:	1 C21	2 C24	3 C27	4 C30
B - TIME	:	1 MIN3	2 MIN6	3 MIN9	

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	39599.000	9.	4399.887		
A	675.000	3.	225.000	0.850	0.479
AS-WITHIN	7143.000	27.	264.555		
B	3211.876	2.	1605.938	18.483	0.001
BS-WITHIN	1564.000	18.	86.889		
AB	80.000	6.	13.333	0.299	0.935
ABS-WITHIN	2412.000	54.	44.667		

Analysis of Variance Summary Table
(Females, 7-13 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	30448.000	9.	3383.111		
A	2906.876	3.	968.958	1.416	0.260
AS-WITHIN	18474.000	27.	684.222		
B	5031.250	2.	2515.625	15.344	0.001
BS-WITHIN	2951.000	18.	163.944		
AB	967.500	6.	161.250	1.267	0.288
ABS-WITHIN	6874.000	54.	127.296		

Analysis of Variance Summary Table
(Females, 14-18 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	52613.000	8.	6576.625		
A	588.938	3.	196.313	0.886	0.463
AS-WITHIN	5320.000	24.	221.667		
B	2130.188	2.	1065.094	8.065	0.004
BS-WITHIN	2113.000	16.	132.063		
AB	416.813	6.	69.469	0.931	0.482
ABS-WITHIN	3582.000	48.	74.625		

Analysis of Variance Summary Table
(Females, 19-29 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	23897.000	8.	2987.125		
A	128.250	3.	42.750	0.206	0.891
AS-WITHIN	4972.000	24.	207.167		
B	2255.625	2.	1127.813	9.765	0.002
BS-WITHIN	1848.000	16.	115.500		
AB	258.188	6.	43.031	0.763	0.603
ABS-WITHIN	2707.000	48.	56.396		

Analysis of Variance Summary Table
(Females, 30-45 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP	:	1 C21	2 C24	3 C27	4 C30
B - TIME	:	1 MIN3	2 MIN6	3 MIN9	

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	12339.000	5.	2467.800		
A	1162.875	3.	387.625	2.106	0.142
AS-WITHIN	2761.000	15.	184.067		
B	5215.500	2.	2607.750	43.032	0.001
BS-WITHIN	606.000	10.	60.600		
AB	296.625	6.	49.438	0.860	0.535
ABS-WITHIN	1725.000	30.	57.500		

Analysis of Variance Summary Table
(Females, 46-69 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	8969.000	6.	1494.833		
A	810.688	3.	270.229	1.304	0.304
AS-WITHIN	3731.000	18.	207.278		
B	1472.625	2.	736.313	5.824	0.017
BS-WITHIN	1517.000	12.	126.417		
AB	358.750	6.	59.792	1.013	0.432
ABS-WITHIN	2125.000	36.	59.028		

D. APPENDIX D: Diastolic Blood Pressure Data Analyses

Mean Diastolic Blood Pressure Data For Males
(Numbers in brackets represent ±1 standard deviation from the mean)

	TEMPERATURE											
	21°C			24°C			27°C			30°C		
AGE	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**
7-13 yr.	63.80 (10.68)	60.60 (8.221)	55.90 (10.35)	61.60 (8.474)	57.40 (6.535)	58.20 (5.202)	62.20 (10.20)	61.00 (10.16)	59.00 (6.342)	57.60 (13.52)	60.20 (8.080)	57.60 (8.316)
14-18 yr.	64.60 (10.06)	62.00 (10.32)	57.11 (13.30)	62.80 (4.638)	60.40 (8.422)	53.40 (12.89)	61.20 (7.671)	60.00 (8.944)	51.77 (11.72)	60.40 (10.10)	58.00 (12.89)	49.55 (11.56)
19-29 yr.	74.40 (6.239)	72.00 (9.521)	68.80 (12.47)	70.80 (11.63)	68.60 (11.03)	66.00 (12.85)	69.80 (9.354)	69.00 (9.533)	68.80 (11.82)	69.40 (9.240)	70.60 (11.03)	72.44 (9.938)
30-45 yr.	71.63 (8.040)	70.18 (8.219)	70.80 (8.854)	76.18 (7.180)	72.18 (5.618)	70.90 (7.395)	71.09 (6.833)	67.09 (7.816)	67.20 (8.651)	72.36 (9.330)	74.54 (7.802)	71.55 (5.981)
46-69 yr.	74.40 (7.167)	72.60 (7.662)	74.40 (8.884)	74.60 (9.430)	71.40 (8.113)	71.60 (7.042)	74.60 (7.426)	73.80 (9.997)	76.00 (11.58)	72.40 (8.733)	72.20 (8.350)	68.20 (8.715)

Mean Diastolic Blood Pressure Data For Females
(Numbers in brackets represent ±1 standard deviation from the mean)

	TEMPERATURE											
	21°C			24°C			27°C			30°C		
AGE	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**
7-13 yr.	57.00 (12.15)	55.00 (13.40)	55.00 (13.67)	59.60 (7.820)	59.60 (12.74)	55.60 (11.18)	60.60 (7.662)	58.30 (8.354)	55.00 (6.055)	55.40 (12.40)	50.40 (14.07)	51.20 (13.10)
14-18 yr.	65.00 (10.29)	65.00 (12.93)	60.00 (13.37)	63.60 (7.530)	63.60 (10.61)	62.20 (9.496)	62.60 (10.71)	62.40 (11.22)	54.88 (10.34)	66.80 (10.33)	60.80 (9.295)	58.88 (10.54)
19-29 yr.	72.54 (7.904)	77.54 (10.21)	74.80 (6.746)	73.27 (8.638)	73.09 (7.119)	72.90 (10.85)	69.09 (6.949)	69.09 (5.889)	72.00 (6.863)	72.00 (5.796)	76.00 (8.717)	76.20 (5.996)
30-45 yr.	70.90 (8.960)	70.90 (9.812)	72.00 (9.007)	72.72 (8.866)	71.81 (8.121)	71.75 (8.172)	70.27 (14.26)	70.18 (11.74)	72.50 (11.14)	69.09 (8.407)	72.18 (8.600)	71.66 (8.524)
46-69 yr.	72.90 (12.13)	74.50 (11.10)	72.50 (11.69)	72.20 (8.916)	71.00 (8.498)	71.25 (9.192)	72.40 (10.10)	73.60 (10.01)	74.85 (13.05)	70.40 (11.65)	71.30 (12.11)	71.25 (6.840)

Analysis of Variance Summary Table
(Males, 7-13 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	4100.875	9.	455.653		
A	102.656	3.	34.219	0.385	0.764
AS-WITHIN	2397.188	27.	88.785		
B	279.375	2.	139.688	2.873	0.083
BS-WITHIN	875.188	18.	48.622		
AB	246.016	6.	41.003	1.395	0.233
ABS-WITHIN	1586.875	54.	29.387		

Analysis of Variance Summary Table
(Males, 14-18 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	6865.625	8.	858.203		
A	271.863	3.	90.621	1.165	0.344
AS-WITHIN	1866.625	24.	77.776		
B	1724.063	2.	862.031	13.078	0.001
BS-WITHIN	1054.625	16.	65.914		
AB	97.242	6.	16.207	0.625	0.709
ABS-WITHIN	1244.250	48.	25.922		

Analysis of Variance Summary Table
(Males, 19-29 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	3534.250	8.	441.781		
A	222.609	3.	74.203	0.739	0.539
AS-WITHIN	2409.563	24.	100.398		
B	68.063	2.	34.031	0.999	0.390
BS-WITHIN	545.313	16.	34.082		
AB	369.281	6.	61.547	1.611	0.165
ABS-WITHIN	1833.563	48.	38.199		

Analysis of Variance Summary Table
(Males, 30-45 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	2950.188	8.	368.773		
A	508.746	3.	169.582	2.381	0.095
AS-WITHIN	1709.250	24.	71.219		
B	200.988	2.	100.494	3.217	0.067
BS-WITHIN	499.813	16.	31.238		
AB	93.234	6.	15.539	0.810	0.567
ABS-WITHIN	920.750	48.	19.182		

Analysis of Variance Summary Table
(Males, 46-69 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	6078.875	9.	675.430		
A	251.016	3.	83.672	2.228	0.108
AS-WITHIN	1013.875	27.	37.551		
B	58.047	2.	29.023	1.346	0.285
BS-WITHIN	388.063	18.	21.559		
AB	164.883	6.	27.480	2.244	0.053
ABS-WITHIN	661.188	54.	12.244		

Analysis of Variance Summary Table
(Females, 7-13 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP	:	1 C21	2 C24	3 C27	4 C30
B - TIME	:	1 MIN3	2 MIN6	3 MIN9	

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	8477.250	9.	941.917		
A	676.445	3.	225.482	2.018	0.135
AS-WITHIN	3016.875	27.	111.736		
B	315.313	2.	157.656	2.806	0.087
BS-WITHIN	1011.313	18.	56.184		
AB	120.742	6.	20.124	0.743	0.618
ABS-WITHIN	1462.688	54.	27.087		

Analysis of Variance Summary Table
(Females, 14-18 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	8772.563	8.	1096.570		
A	305.297	3.	101.766	2.026	0.137
AS-WITHIN	1205.813	24.	50.242		
B	468.211	2.	234.105	6.202	0.010
BS-WITHIN	603.938	16.	37.746		
AB	251.473	6.	41.912	2.526	0.033
ABS-WITHIN	796.375	48.	16.591		

Analysis of Variance Summary Table
(Females, 19-29 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	3335.313	8.	416.914		
A	351.105	3.	117.035	2.144	0.121
AS-WITHIN	1310.188	24.	54.591		
B	176.520	2.	88.260	4.400	0.030
BS-WITHIN	320.938	16.	20.059		
AB	135.773	6.	22.629	1.790	0.121
ABS-WITHIN	606.938	48.	12.645		

Analysis of Variance Summary Table
(Females, 30-45 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	7347.375	5.	1469.475		
A	50.156	3.	16.719	0.299	0.826
AS-WITHIN	839.063	15.	55.938		
B	94.688	2.	47.344	1.494	0.271
BS-WITHIN	316.875	10.	31.688		
AB	37.641	6.	6.273	0.499	0.804
ABS-WITHIN	376.875	30.	12.563		

Analysis of Variance Summary Table
(Females, 46-69 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	6225.375	6.	1037.563		
A	152.250	3.	50.750	0.990	0.420
AS-WITHIN	923.188	18.	51.288		
B	39.813	2.	19.906	0.529	0.602
BS-WITHIN	451.313	12.	37.609		
AB	42.438	6.	7.073	0.436	0.850
ABS-WITHIN	583.875	36.	16.219		

E. APPENDIX E: Core Temperature Data Analyses

Mean Core Temperature Data For Males
(Numbers in brackets represent ±1 standard deviation from the mean)

	TEMPERATURE											
	21°C			24°C			27°C			30°C		
AGE	min 3	min 6	min 9	min 3	min 6	min 9	min 3	min 6	min 9	min 3	min 6	min 9
7-13 yr.	37.01 (0.331)	37.19 (0.366)	37.30 (0.426)	36.97 (0.400)	37.10 (0.424)	37.31 (0.384)	36.66 (0.422)	37.02 (0.274)	37.21 (0.296)	36.83 (0.391)	37.09 (0.398)	37.30 (0.418)
14-18 yr.	37.09 (0.497)	37.33 (0.575)	37.47 (0.674)	36.98 (0.355)	37.30 (0.432)	37.56 (0.414)	37.00 (0.402)	37.31 (0.422)	37.54 (0.469)	36.88 (0.477)	37.22 (0.576)	37.81 (1.139)
19-29 yr.	37.38 (0.423)	37.74 (0.343)	37.92 (0.361)	37.35 (0.406)	37.64 (0.313)	37.78 (0.348)	37.25 (0.395)	37.50 (0.262)	37.70 (0.240)	37.22 (0.198)	37.54 (0.250)	37.78 (0.261)
30-45 yr.	37.44 (0.380)	37.67 (0.319)	37.88 (0.352)	37.44 (0.254)	37.61 (0.213)	37.85 (0.229)	37.31 (0.282)	37.59 (0.258)	37.77 (0.309)	37.25 (0.395)	37.45 (0.395)	37.56 (0.403)
46-69 yr.	36.96 (0.419)	37.07 (0.473)	37.31 (0.488)	36.93 (0.492)	37.14 (0.435)	37.43 (0.343)	36.96 (0.411)	37.17 (0.340)	37.43 (0.380)	37.02 (0.322)	37.24 (0.259)	37.50 (0.235)

Mean Core Temperature Data For Females

(Numbers in brackets represent ±1 standard deviation from the mean)

	TEMPERATURE											
	21°C			24°C			27°C			30°C		
AGE	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**	**min 3**	**min 6**	**min 9**
7-13 yr.	36.88 (0.407)	37.08 (0.491)	37.23 (0.469)	36.69 (0.552)	36.91 (0.641)	37.18 (0.559)	36.96 (0.450)	37.14 (0.632)	37.34 (0.564)	36.92 (0.502)	37.19 (0.428)	37.47 (0.380)
14-18 yr.	37.28 (0.493)	37.44 (0.505)	37.74 (0.415)	37.12 (0.513)	37.39 (0.636)	37.62 (0.635)	36.81 (0.747)	37.10 (0.733)	37.38 (0.592)	36.82 (0.418)	37.12 (0.515)	37.30 (0.616)
19-29 yr.	37.22 (0.610)	37.53 (0.504)	37.64 (0.542)	37.27 (0.521)	37.42 (0.601)	37.57 (0.684)	37.11 (0.457)	37.37 (0.540)	37.50 (0.583)	37.14 (0.364)	37.42 (0.366)	37.58 (0.364)
30-45 yr.	36.93 (0.659)	37.10 (0.768)	37.33 (0.887)	36.88 (0.601)	37.06 (0.751)	37.10 (0.715)	37.04 (0.582)	37.18 (0.946)	37.16 (1.022)	36.78 (0.389)	37.10 (0.474)	37.16 (0.436)
46-69 yr.	36.44 (0.798)	36.66 (0.665)	36.72 (0.702)	36.82 (0.500)	37.00 (0.476)	37.12 (0.433)	36.66 (0.638)	36.94 (0.605)	37.08 (0.671)	36.68 (0.502)	36.89 (0.570)	36.98 (0.576)

Analysis of Variance Summary Table
(Males, 7-13 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	10.313	9.	1.146		
A	0.703	3.	0.234	1.582	0.217
AS-WITHIN	4.000	27.	0.148		
B	3.398	2.	1.699	61.172	0.001
BS-WITHIN	0.500	18.	0.028		
AB	0.273	6.	0.046	3.281	0.008
ABS-WITHIN	0.750	54.	0.014		

Analysis of Variance Summary Table
(Males, 14-18 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 8 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	21.750	8.	2.719		
A	0.0	3.	0.0	0.0	0.999
AS-WITHIN	6.125	24.	0.255		
B	6.434	2.	3.217	32.940	0.001
BS-WITHIN	1.563	16.	0.098		
AB	0.844	6.	0.141	2.348	0.045
ABS-WITHIN	2.875	48.	0.060		

Analysis of Variance Summary Table
(Males, 19-29 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	4.813	8.	0.602		
A	0.949	3.	0.316	1.761	0.182
AS-WITHIN	4.313	24.	0.180		
B	4.746	2.	2.373	55.227	0.001
BS-WITHIN	0.688	16.	0.043		
AB	0.070	6.	0.012	0.900	0.503
ABS-WITHIN	0.625	48.	0.013		

Analysis of Variance Summary Table
(Males, 30-45 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	4.438	8.	0.555		
A	1.020	3.	0.340	1.764	0.181
AS-WITHIN	4.625	24.	0.193		
B	2.953	2.	1.477	25.200	0.001
BS-WITHIN	0.938	16.	0.059		
AB	0.070	6.	0.012	1.500	0.198
ABS-WITHIN	0.375	48.	0.008		

Analysis of Variance Summary Table
(Males, 46-69 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	7.188	9.	0.799		
A	0.273	3.	0.091	0.325	0.807
AS-WITHIN	7.563	27.	0.280		
B	4.063	2.	2.031	36.563	0.001
BS-WITHIN	1.000	18.	0.056		
AB	0.117	6.	0.020	1.688	0.142
ABS-WITHIN	0.625	54.	0.012		

Analysis of Variance Summary Table
(Females, 7-13 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	18.688	9.	2.076		
A	1.211	3.	0.404	1.384	0.269
AS-WITHIN	7.875	27.	0.292		
B	3.906	2.	1.953	46.875	0.001
BS-WITHIN	0.750	18.	0.042		
AB	0.156	6.	0.026	1.406	0.229
ABS-WITHIN	1.000	54.	0.019		

Analysis of Variance Summary Table
(Females, 14-18 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	9.313	8.	1.164		
A	3.797	3.	1.266	2.455	0.088
AS-WITHIN	12.375	24.	0.516		
B	3.480	2.	1.740	55.688	0.001
BS-WITHIN	0.500	16.	0.031		
AB	0.105	6.	0.018	0.964	0.459
ABS-WITHIN	0.875	48.	0.018		

Analysis of Variance Summary Table
(Females, 19-29 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP	:	1 C21	2 C24	3 C27	4 C30
B - TIME	:	1 MIN3	2 MIN6	3 MIN9	

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	15.625	8.	1.953		
A	0.352	3.	0.117	0.283	0.837
AS-WITHIN	9.938	24.	0.414		
B	2.566	2.	1.283	32.850	0.001
BS-WITHIN	0.625	16.	0.039		
AB	0.141	6.	0.023	2.571	0.031
ABS-WITHIN	0.438	48.	0.009		

Analysis of Variance Summary Table
(Females, 30-45 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	24.938	5.	4.987		
A	0.516	3.	0.172	0.273	0.844
AS-WITHIN	9.438	15.	0.629		
B	1.852	2.	0.926	18.516	0.001
BS-WITHIN	0.500	10.	0.050		
AB	0.164	6.	0.027	1.193	0.337
ABS-WITHIN	0.688	30.	0.023		

Analysis of Variance Summary Table
(Females, 48-69 years)

WITHIN SUBJECT FACTORS ARE:

A - TEMP : 1 C21 , 2 C24 , 3 C27 , 4 C30

B - TIME : 1 MIN3 , 2 MIN6 , 3 MIN9

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
S-WITHIN	18.750	6.	3.125		
A	2.352	3.	0.784	1.929	0.161
AS-WITHIN	7.313	18.	0.406		
B	3.527	2.	1.764	37.625	0.001
BS-WITHIN	0.563	12.	0.047		
AB	0.027	6.	0.005	0.328	0.918
ABS-WITHIN	0.500	36.	0.014		

F. APPENDIX F: Miscellaneous Information

DEPARTMENT OF PHYSICAL EDUCATION
FACULTY OF PHYSICAL EDUCATION AND RECREATION
THE UNIVERSITY OF ALBERTA, EDMONTON, CANADA T6G 2H9

May 18, 1982

Dear Sir/Madam:

The University of Alberta Physical Education Department is conducting research on the effects of various temperatures on fitness evaluations. This study will provide information on the Canadian Home Fitness Test (CHFT), which is critical to the interpretation of Canada Fitness Survey results.

The CHFT is a step test performed on two 20.3 cm. steps. Participants move up and down the steps at a given speed for their age group for a total of 9 minutes with a ten second pause every 3 minutes. Following the test they will be monitored for a 5 minute recovery period. Therefore, the total test time is 14 minutes.

Heart rate, blood pressure and core temperature will be monitored continually throughout the test period. Subjects taking part will be required to perform the test at four different environmental temperatures; 21, 24, 27 and 30°C, with relative humidity held constant at 70%. Testing will be done on four different days.

Although the risk associated with this test is minimal every effort will be made to minimize discomfort and potential risk. All information will be held in strict confidence.

If you have any questions or require further information please contact Allan MacDougall at 432-5503 or 425-8865 (evenings).

Thank you for your cooperation.

Sincerely,

Allan MacDougall

Allan MacDougall

AM/ev

Celebrating our 75th Anniversary
1982-83

Physical Activity Readiness Questionnaire (PAR-Q)*

PARTICIPANT IDENTIFICATION ____________

PAR Q & YOU

PAR-Q is designed to help you help yourself. Many health benefits are associated with regular exercise, and the completion of PAR-Q is a sensible first step to take if you are planning to increase the amount of physical activity in your life.

For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and check (√) the ☐ YES or ☐ NO opposite the question if it applies to you.

YES	NO	
☐	☐	1. Has your doctor ever said you have heart trouble?
☐	☐	2. Do you frequently have pains in your heart and chest?
☐	☐	3. Do you often feel faint or have spells of severe dizziness?
☐	☐	4. Has a doctor ever said your blood pressure was too high?
☐	☐	5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
☐	☐	6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?
☐	☐	7. Are you over age 65 and not accustomed to vigorous exercise?

If You Answered

YES to one or more questions

If you have not recently done so, consult with your personal physician by telephone or in person BEFORE increasing your physical activity and/or taking a fitness test. Tell him what questions you answered YES on PAR-Q, or show him your copy.

programs

After medical evaluation, seek advice from your physician as to your suitability for:

- unrestricted physical activity, probably on a gradually increasing basis.
- restricted or supervised activity to meet your specific needs, at least on an initial basis. Check in your community for special programs or services

NO to all questions

If you answered PAR-Q accurately, you have reasonable assurance of your present suitability for:

- A GRADUATED EXERCISE PROGRAM - A gradual increase in proper exercise promotes good fitness development while minimizing or eliminating discomfort.
- AN EXERCISE TEST - Simple tests of fitness (such as the Canadian Home Fitness Test) or more complex types may be undertaken if you so desire.

postpone

If you have a temporary minor illness, such as a common cold.

* Developed by the British Columbia Ministry of Health. Conceptualized and critiqued by the Multidisciplinary Advisory Board on Exercise (MABE). Translation, reproduction and use in its entirety is encouraged. Modifications by written permission only. Not to be used for commercial advertising in order to solicit business from the public.
Reference: PAR-Q Validation Report, British Columbia Ministry of Health, 1978.
* Produced by the British Columbia Ministry of Health and the Department of National Health & Welfare

CONSENT FORM

I ______________________________ give my consent to take part in the CHFT study being conducted at the University of Alberta.

I understand that I will have heart rate, blood pressure and body temperature measured for the duration of the test period. The test protocol has been thoroughly explained to me and I have had the opportunity to ask questions about the project. I realize that there is some risk in undertaking this series of tests but every effort has been made to minimize potential hazards and at any time I experience unusual discomfort I will ask to discontinue the test. I understand that I am free to withdraw from the study at any time and to discontinue the test at any time.

In agreeing to such an examination, I waive any legal recourse against the University of Alberta from any and all claims resulting from this fitness test.

DATE: ____________________ STUDENT: ______________________________

(Signature)

WITNESS: ______________________________

Must be signed by parent or guardian if participant is less than 18 years of age.

____

(Signature or parent or guardian)

DATA SHEET

PERSONAL DATA:-

NAME__________________________ PH.#________________

AGE________

AMBIENT CONDITIONS:-

TEMPERATURE (C)________ RELATIVE HUMIDITY (%)________

TEST DATA:-

TIME(MIN.)	H.R.(BPM.)	B.P.(SYS.)	B.P.(DIA.)	CORE TEMP.(C)	
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
REC.1					
2					
3					
4					
5					

COMMENTS:-