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Deer hunting is a popular recreational activity with serious implications involving cardiovascular events. Previous studies have demonstrated large heart rate (HR) responses during deer hunting activities. This study compared the HR and metabolic costs of maximal treadmill (TM) exercise to simulated hiking while deer hunting and to dragging a deer. Healthy male volunteers ($n = 16$) performed a maximal TM exercise test, a 0.5 mile hiking test, and a 0.25 mile dragging test over lightly rolling terrain. VO_2 was measured by a portable spirometer and HR by radiotelemetry. Subjects averaged $74.0 \pm 7.0\%$ and $89.1 \pm 4.5\%$ of peak TM HR during the hike and drag, respectively. They also achieved a peak of $83.2 \pm 6.0\%$ and $94.9 \pm 4.2\%$ of peak TM HR, respectively. Subjects averaged $62.2 \pm 15.8\%$ and achieved a peak of $77.2 \pm 19.0\%$ of TM VO_2 while hiking. This corresponded to $86.8 \pm 17.3\%$ and $108.1 \pm 22.3\%$ of ventilatory threshold (VT), respectively. Subjects averaged $72.3 \pm 21.0\%$ and achieved a peak of $91.2 \pm 21.4\%$ of peak TM VO_2 while dragging the deer. This corresponded to $101.5 \pm 27.7\%$ and $128.5 \pm 26.8\%$ of VT, respectively. The VO_2/HR relationship showed significant ($p < 0.05$) difference between the dragging test and the hiking and TM tests. The VO_2/HR relationship between the hiking and TM tests was comparable. In part, the high rate of cardiovascular complications associated with deer hunting is attributable to the elevated metabolic costs of associated activities, specifically, dragging a deer.

THE METABOLIC COSTS OF ACTIVITIES ASSOCIATED WITH DEER HUNTING

A MANUSCRIPT STYLE THESIS PRESENTED

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This thesis is approved by the College of Health, Physical Education, and Recreation.

4-27-99

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INTRODUCTION

It is well established that vigorous exercise, and especially exercise in the cold, is associated with an increased risk of acute cardiovascular events.[1,2] Deer hunting is an outdoor activity that is frequently associated with both cold air and intense physical exertion. A recent study found that various deer hunting activities elicited heart rate (HR) responses well beyond 85% of the subjects maximum HR observed during clinical exercise testing.[3] Another recent study suggests that exertion above 85% of maximal HR is associated with an increased incidence of cardiovascular complications.[4] Strenuous exercise by sedentary individuals seems to be associated with a higher risk for exercise related myocardial infarction.[5] Increased levels of sympathetic stimulation and circulating catecholamines also increase the risk of acute cardiovascular events.[6,7] Severe exercise at intensities above the ventilatory threshold is associated with increased circulating catecholamines.[8]

Various factors associated with exercise in the cold increase the risk of cardiovascular complications.[2] These include reduced myocardial efficiency of arm exercise, upright posture, isometric exertion, use of the valsalva maneuver, and inhalation of cold air. All of these factors may also be associated with deer hunting. There are specific populations at an increased risk for acute exercise related events including individuals with underlying coronary artery disease, a sedentary lifestyle, smokers, those over age 45, or those with an underlying cardiomyopathy[9-13]. Populations at an increased risk are much more likely to have cholesterol or other fragments dislodge from the arterial walls under the stress of elevated blood flow.[9]

The purpose of the present study was to document the heart rate (HR) and metabolic responses associated with deer hunting activities in the absence of the emotional arousal accompanying hunting. These values were then compared to those obtained during maximal treadmill (TM) exercise.

METHODS AND PROCEDURES

Subject selection: The subjects for this study were 16 male volunteers ranging from 20 to 28 (mean ± sd 22.6 ± 2.5) years of age, with a mean height of 179.8 cm ± 5.1 cm, and weight of 85.4 kg ± 16.7 kg. All subjects provided written informed consent (see Appendix A). The study was approved by the University of Wisconsin-La Crosse Institutional Review Board. All subjects were apparently healthy and without major risk factors for cardiovascular disease. They either had previous experience dragging a deer or were allowed an opportunity to familiarize themselves with the procedure before testing.

Testing protocol: The subjects performed 3 separate tests. These included a maximal treadmill (TM) test using an Åstrand type protocol, a 0.5 mile hiking test (0.8 km), and a 0.25 mile (0.4 km) deer drag test. During the tests the subjects wore a radiotelemetry HR monitor (Polar Electro Inc., Port Washington, NY) with a memory mode, and HR was recorded at 15-second intervals. Respiratory metabolism was monitored in 60-second intervals through the use of open circuit spirometry with the Aerosport KB1-C portable gas analyzer and a mask style breathing apparatus (Aerosport

Inc., Ann Arbor, MI). The validity of the KB1-C has been documented against standard laboratory methods.[13]

Treadmill testing: As a baseline, all subjects performed a maximal TM test. The protocol was the same for all subjects. The testing began with 3 walking stages at 1% grade. The stages were 5 minutes each, and the treadmill speed was set at 2.0, 3.0, and 3.5 miles per hour (0.89, 1.34, and 1.57 $m*s^{-1}$) for the first 3 stages respectively. At that point, the TM was brought down to 0% grade and the speed was increased to 6 miles per hour (2.68 $m*s^{-1}$). The remaining stages were performed at 6 miles per hour (2.68 $m*s^{-1}$) for all subjects, and only the grade was changed. Every 2 minutes the grade increased by 2.5% until the subjects could no longer continue. VO_2 peak was defined as the highest 1 minute oxygen uptake value achieved during TM exercise. The ventilatory threshold was computed using the V-slope technique.[14]

Field tests: Prior to the 2 field tests the subjects were contacted with a list of instructions detailing what they should wear and what to expect during the tests (see Appendix B). Upon arrival at the testing site, the subjects were fitted with the heart monitor and the Aerosport KB1-C portable gas analyzer. Once they were comfortable, the subjects were given an encased shotgun to carry, and then walked from the parking area to the start of the course, as shown on the map (see Appendix C). Once at the start of the course, the subjects were instructed to hike at a brisk, yet comfortable, pace, as if they were late arriving at their deer stand in the morning.

Hiking test: The hiking test was 0.5 mile (0.8 km) in length. Throughout the course, the subjects carried a shotgun in front of them with both hands (see Figure 1).

Figure 1. Setup for Hiking Test

The gun was encased in a sleeve style case and fitted with a cable lock. Permission was obtained from the city police department for the subjects to carry a gun in a city park. The subjects began the first 0.25 mile (0.4 km) of the course by hiking 33 yards (30 m) up a gradual hill followed by a right turn and 162 yards (148 m) on level ground. The next 184 yards (168 m) were down a gradual hill, followed by 61 yards (56 m) on level ground where the subjects reached the half-way point of the test. The second half of the hiking course was the same course used in the 0.25 mile (0.4 km) dragging test. The second half of the test continued with another 26 yard (24 m) hike on level ground, followed by a left turn. The subjects then descended 45 yards (41 m) down a steeper hill. At that point, they turned right and proceeded along a sloping trail. Here the trail sloped down from right to left, and the footing was often very unstable. While navigating the sloping trail, the subjects were initially on an even grade for 30 yards (27m) followed by a gradual downhill for 21 yards (19 m) and another section with a level grade for 47 yards (43 m). The sloping trail then went up a gradual hill for the next 100 yards (92 m) before leveling off. At the top of that hill, the subjects again turned left and started a gradual descent for the next 101 yards (92 m). The subjects finished the test by ascending a steep hill for the final 70 yards (64 m) of the course. Upon completion of the hiking test, the information was printed from the Aerosport KB1-C portable gas analyzer, and the subjects were allowed to rest for 20 minutes before beginning the dragging test.

Dragging test: Once the subjects were prepared to start the dragging test, the Aerosport KB1-C portable gas analyzer and the heart rate monitor were both reset. During the dragging test, the subjects dragged a 125-pound (56.8 kg) deer carcass 0.25 miles (0.4 km) on the second half of the hiking course. The carcasses were obtained from the La Crosse County Highway Department, with permission from the Wisconsin Department of Natural Resources. The weight was standardized by either removing muscle tissue from the carcass or by adding salt bags to the body cavity. The deer carcass had a 5/8-inch (1.59 cm) rope tied around its neck with a noose style knot. The subjects all dragged the deer by placing the rope over their shoulder and holding on to a loop tied in the distal end of the rope out in front of them (see Figure 2). During the test, the subjects were allowed to take breaks as frequently as they needed until they reached

Figure 2. Setup for Dragging Test

the end of the course with the intent that they would mimic as much as possible the ordinary patterns of deer hunting.

STATISTICAL ANALYSIS

The mean HR, VO_2, pulmonary ventilation, and kilocalories per minute were all analyzed. Both the maximal and mean values from the hiking and dragging tests were compared to the maximal TM results (VO_2 peak, ventilatory threshold, HR). The analysis of these variables was limited to descriptive statistics. The mean METs, as well as the range of METs for both the hiking test and the dragging test, were also calculated. From the regression of HR and VO_2, HR values were calculated corresponding to a VO_2 of 10, 20, and 30 $ml*kg^{-1}*min^{-1}$ for the maximal TM exercise, the hiking test, and the dragging test. A t-test with a Bonferonni correction for 3 variables was used in the analysis of the HR and VO_2 relationship. HR and VO_2 values for the hiking test and TM exercise were also compared at the same speed.

RESULTS

During the TM testing the subjects achieved an average maximum HR of 197.1 ± 8.9 beats per minute, a VO_2 of 44.7 ± 9.9 ml*kg^{-1}*min^{-1}, a pulmonary ventilation of 95.9 ± 13.6 liters per minute, and an energy expenditure of 18.8 ± 3.2 kilocalories per minute. The VO_2 data were also used to calculate the intensity of the tests relative to the ventilatory threshold. During the hiking test the subjects reached an average peak VO_2 of 33.2 ± 4.8 ml*kg^{-1}*min^{-1} which corresponded to 108.1% ± 22.3% of ventilatory threshold and 77.2% ± 19.0% of TM peak VO_2. The peak values ranged from 76.6 to 162.9% of ventilatory threshold. The subjects maintained a level of 86.8% ± 17.3% of ventilatory threshold throughout the course of the test. During the dragging test the subjects reached an average peak VO_2 of 39.3 ml*kg^{-1}*min^{-1} which corresponded to 128.5% ± 26.8% of ventilatory threshold and 91.2% ± 21.4% of TM peak VO_2. The peak values for the dragging test ranged from 191.6 to 94.8% of ventilatory threshold. The subjects averaged 101.5% ± 27.7% of ventilatory threshold throughout the duration of the dragging test.

The mean peak HRs during the hiking and dragging tests were 164 ± 15.2 and 187.4 ± 10.9 beats per minute, respectively. This corresponded to 83.2% ± 6.0% and 94.9% ± 4.2% of TM peak HR for the hiking and dragging tests, respectively. The maximal HRs achieved ranged from 70.8% to 94.7% and 88.0% to 102.7% of TM peak HR for the hiking and dragging tests respectively.

Throughout the course of the hiking test the subjects average HR corresponded to 74.0% ± 7.0% of their peak TM exercise. During the dragging test the subjects' heart rates remained at a level of 89.1 % ± 4.5% of their maximal TM exercise. These values include exertion and resting values during the tests. The HR, VO_2, pulmonary ventilation, and kilocalories per minute data are included in Table I. Figures 3 and 4 show a representative HR and VO_2 response to the testing protocol. The HR data during the dragging test typically increased dramatically at the start of the test and remained elevated throughout resting periods. The VO_2 data, on the other hand, increased dramatically at the start of the test, but quickly dropped off when the subjects stopped to rest.

Table I. Peak Values as % of Maximal TM Exercise

	Heart Rate	VO2	Ventilation	Kcal/min
Hike	83.2% ± 6.0%	77.2% ± 19.0%	60.3% ± 10.5%	76.0% ± 18.8%
Drag	94.9% ± 4.2%	91.2% ± 21.4%	88.6% ± 13.3%	90.2% ± 21.3%

VO_2 data obtained from the hiking and treadmill testing were also converted to METs and are included in Table II. During TM testing the subjects achieved a mean peak of 12.8 ± 2.8 METs. During the hiking test the subjects achieved a mean peak of 9.5 ± 1.4 METs, and the values ranged from 12.8 to 7.6 METs. During the dragging test the subjects achieved a mean peak of 11.2 ± 1.7 METs, and the values ranged from 14.0 to 8.5 METs.

Figure 3. Sample HR values

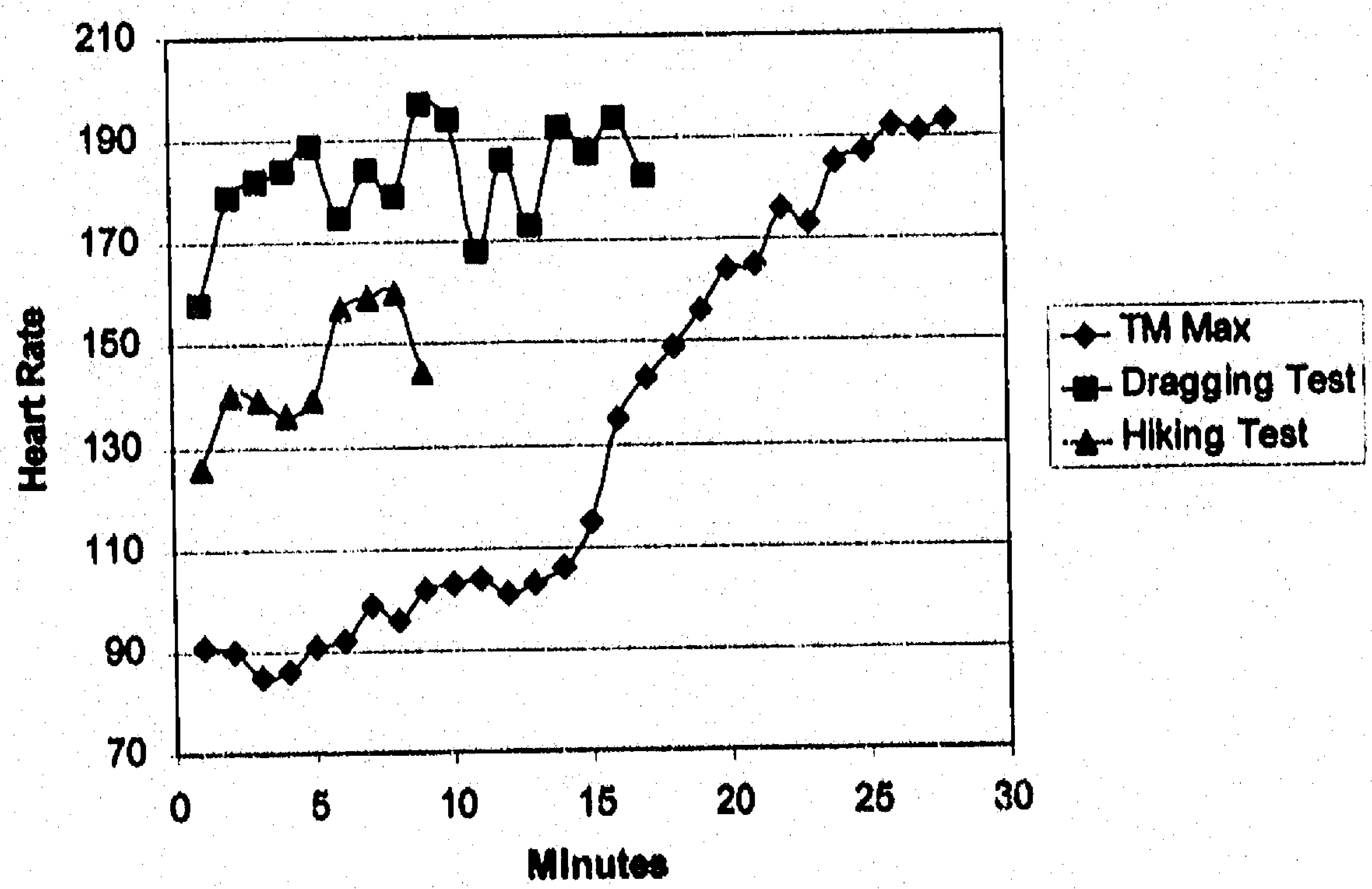


Figure 4. Sample VO_2 Values

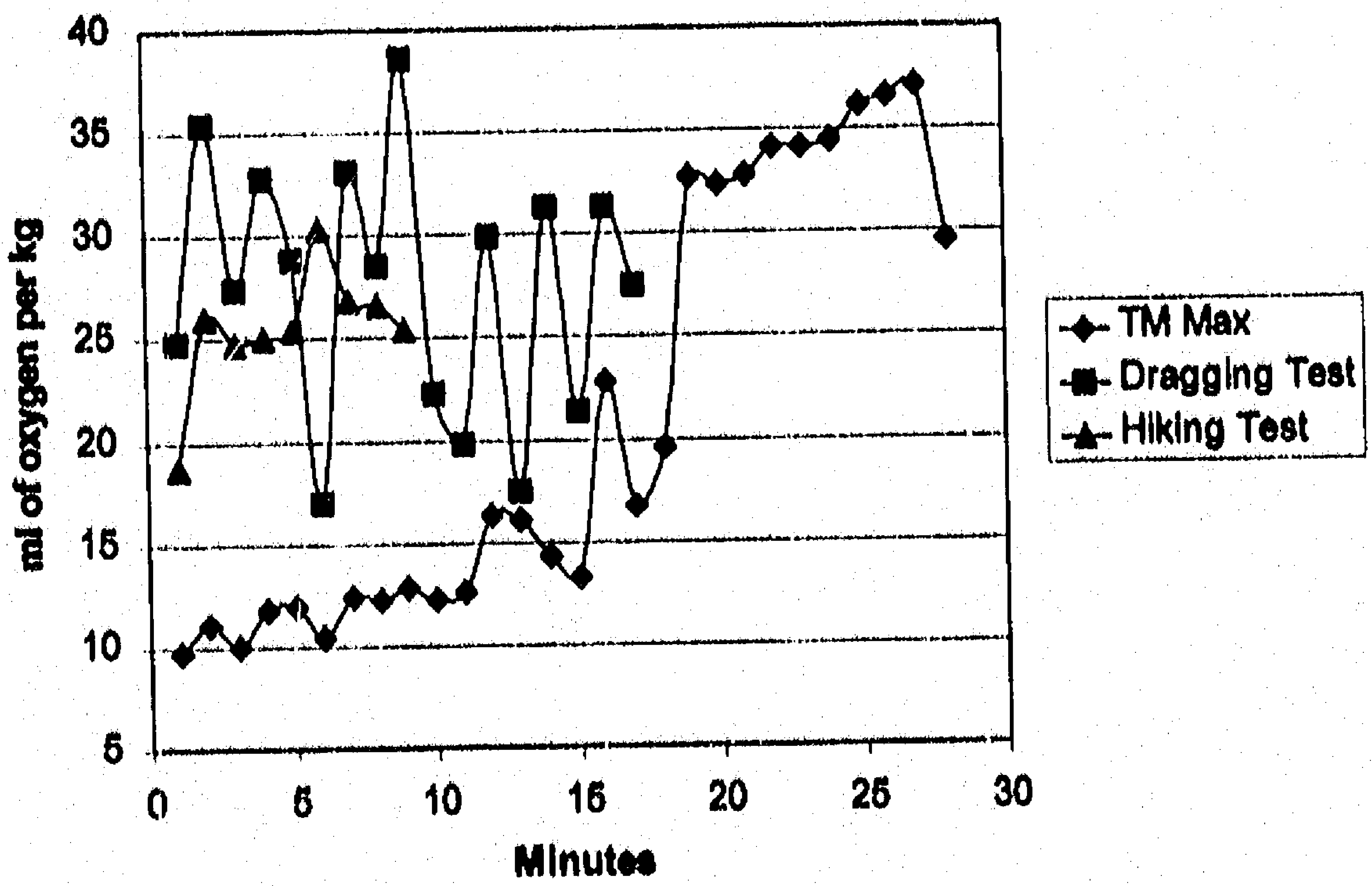
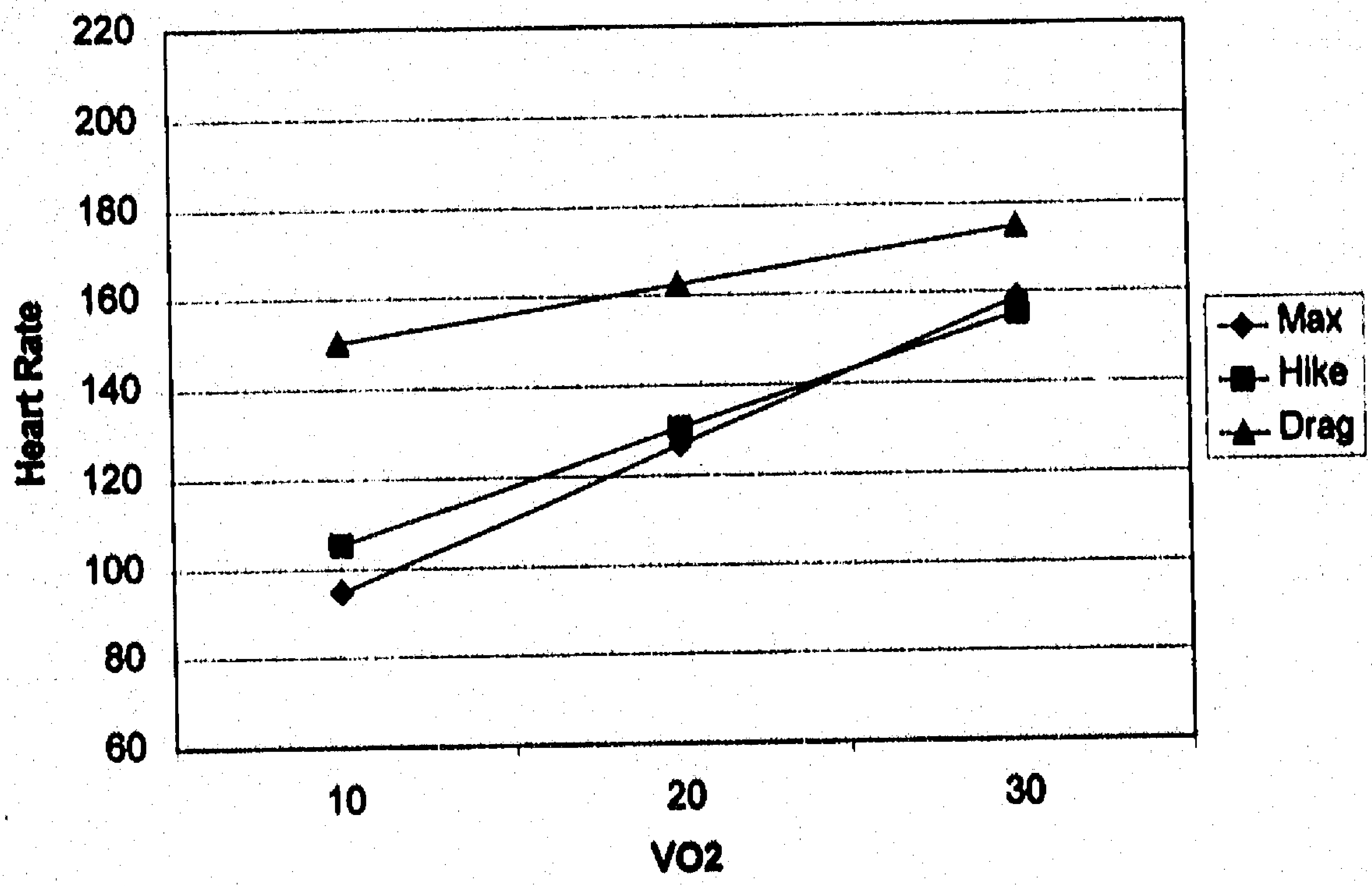


Table II. MET Values of Hiking and Dragging

	Max	% Max	Average	% Max	Max	Min
Treadmill	12.8 ± 2.8	100%	-	-	-	-
Hike	9.5 ± 1.4	74.20%	7.6 ± 1.2	59.70%	12.8	7.6
Drag	11.2 ± 1.7	87.80%	8.9 ± 2.0	69.80%	14	8.5

The relationship of VO_2 and HR can be seen in Figure 5. The HR response to the dragging test showed a significant difference when compared to the TM max exercise ($p = 1.65*10^{-10}$, $p = 1.83*10^{-7}$, $p = 1.73*10^{-2}$) and to the hiking test ($p = 4.34*10^{-10}$, $p = 8.51*10^{-7}$, $p = 1.13*10^{-3}$) at VO_2 values of 10, 20, and 30 ml $O_2*kg^{-1}*min^{-1}$ respectively when using a t-test with a Bonferonni correction for 3 variables. The mean HR values corresponding to a VO_2 of 10, 20, and 30 ml $O_2*kg^{-1}*min^{-1}$ for the dragging test were 150.2 ± 18.1, 162.4 ± 15.1, and 174.6 ± 12.6, respectively. The HR values for the hiking test were 105.3 ± 14.5, 130.3 ± 12.1, and 155.4 ± 15.7 while the TM HR values were 94.9 ± 13.7, 126.6 ± 13.2, and 158.6 ± 17.2 for the same VO_2 levels. There was no significant difference between the hiking test and the maximal TM exercise ($p = .137$, $p = 1.23$, $p = 1.74$) at VO_2 values of 10, 20, and 30 ml $O_2*kg^{-1}*min^{-1}$ respectively when using a t-test with a Bonferonni correction for 3 variables. During the hiking test the subjects averaged 3.8 ± 0.2 mph (1.7 $m*s^{-1}$) which corresponded to a HR of 146.0 ± 16.4 and a VO_2 of 26.7 ± 4.1. These values were significantly higher than TM exercise values of 113.8 ± 11.8 ($p=7.78*10^{-7}$) and 16.2 + 2.0 ($p=5.36*10^{-9}$), respectively.

Figure 5. HR and VO_2 Relationship



DISCUSSION

During the testing protocol the subjects consistently demonstrated elevated metabolic and hemodynamic responses. The results show that deer hunting activities are quite intense and may elicit metabolic and hemodynamic responses greater than peak TM exercise. During the dragging test the subjects displayed a peak HR of 94.9% ± 4.2% and a range of 88.0 to 102.7% when compared to maximal TM exercise. The dragging test also demonstrated an oxygen cost of 91.2% ± 21.4% of maximal TM exercise with a range of 57.7 to 132.8%. While dragging the deer the subjects were consistently above ventilatory threshold with a mean peak of 128.5% ± 26.8% and an average of 101.5% ± 27.7% of ventilatory threshold. During the hiking test a mean peak of 83.2% ± 6.0% of

TM exercise HR was reached with a range of 70.8 to 94.7%. The oxygen cost of the hiking test was 77.2% ± 19.0% of maximal TM exercise with a range of 51.0 to 118.8%. While hiking the subjects were also above ventilatory threshold with a mean peak value of 108.1% ± 22.3% and an average of 86.8% ± 17.3% of ventilatory threshold.

The relationship of HR to VO_2 demonstrated a disproportionately high HR response to the dragging test when compared to the hiking test and maximal TM exercise. At a level of 10 ml $O_2 * kg^{-1} * min^{-1}$ during the dragging test the mean HR was 150.2 ± 18.1 which was significantly higher than the hiking test at 105.3 ± 14.5 ($p = 1.45 * 10^{-8}$) and the maximal TM exercise at 94.9 ± 13.7 ($p = 1.65 * 10^{-10}$). The mean HRs of 162.4 ± 15.1 and 174.6 ± 12.6 during the dragging test corresponding to 20 and 30 ml $O_2 * kg^{-1} * min^{-1}$ respectively were significantly higher than the hiking test HRs of 130.3 ± 12.1 and 155.4 ± 15.7 ($p = 2.84 * 10^{-7}$, $p = 6.78 * 10^{-4}$) and TM exercise HRs of 126.6 ± 13.2 and 158.6 ± 17.2 ($p = 6.10 * 10^{-8}$, $p = 5.77 * 10^{-5}$) at the same VO_2 levels. There was no significant difference between the TM exercise and the hiking test at any values. When the hiking and TM exercise were matched for speed, however, the hiking test elicited significantly higher HR ($p = 7.78 * 10^{-7}$) and VO_2 ($p = 5.36 * 10^{-9}$) responses.

The current study agrees with previous research, and found that activities associated with deer hunting can place an increased stress on the cardiorespiratory system and elicit elevated hemodynamic responses.[3] These activities may also place certain individuals at an increased risk for acute cardiovascular events. These individuals include those who are sedentary, over age 45, with known or undiagnosed coronary artery disease, smokers, or those with an underlying cardiomyopathy.[3,9-12] The present data also coincide with research on snow shoveling.[2] Snow shoveling has been associated with increased physiologic demands and rates of acute cardiovascular events. During studies of snow shoveling, 5 factors were found to cause increased cardiac strain. These included reduced myocardial efficiency of arm exercise, upright posture, isometric exertion, use of valsalva maneuver, and inhalation of cold air. All of these factors may be encountered while deer hunting, especially while dragging a carcass. This increased strain might lead to plaque rupture and dislodging of blood clots that may result in acute cardiovascular events.[9] These factors lead to the conclusion that common recreational and domestic outdoor activities can provide an unexpected magnitude of exertion.

The available data clearly demonstrate that strenuous exercise, especially in sedentary populations, increases the risk of acute cardiovascular events.[3] During the current testing the subjects consistently worked at elevated levels of HR and VO_2. It has also been noted that exercise above 85% of maximum HR can initiate acute cardiovascular events.[4] During the dragging test all subjects achieved a HR greater than 85% of their maximal TM exercise. The peak HRs during the dragging test ranged from 88.0 to 102.7% of the subjects' maximal TM exercise. Most of the subjects exercised above 90% of their maximal TM exercise HR, and above 85% of their maximal TM exercise VO_2, the upper levels of recommended exercise intensity for aerobic training by the American College of Sports Medicine, during the test.[15] This demonstrates that dragging a deer is strenuous and increases the risk of acute cardiovascular events.

Although the values were lower for the hiking test, the activity was quite intense. The peak HRs achieved during the hiking test ranged from 70.8 to 94.7% of maximal TM exercise HRs. Activity at this intensity may lead to an increased risk of acute cardiovascular events in some people. The HR and VO_2 comparisons for the hiking test also showed that the activity elicited higher HR and VO_2 responses than TM exercise at the same speed. The incorporation of arm exercise while TM walking has been shown to elicit elevated hemodynamic responses.[16] During the hiking test the HR and VO_2 values were likely increased from isometric arm exertion while carrying the shotgun or from wearing heavier clothing.

The level of ventilatory threshold achieved during both tests was also high. The average peak values were 108.1% $\pm$ 22.3% and 128.5% $\pm$ 26.8% of ventilatory threshold during the hiking and dragging tests, respectively. Exercise at or above 105% of ventilatory threshold has been shown to cause a dramatic increase in catecholamines.[7] The rise in catecholamines causes an increased risk of ventricular arrythmias.[6] Research has shown that exertion at or above 6 METs increases the risk of acute cardiovascular events.[5] In the current study all individuals exercised at an intensity > 6 METs during the hiking and dragging tests. During the dragging test a level as high as 14 METs was achieved, and the average peak METs achieved during the dragging test were 11.2 $\pm$ 1.7 METs. In the joint position statement by the American College of Sports Medicine and the American Heart Association exercise at 12 METs is listed as maximal for young men age 20 to 39, and 10 METs is listed as maximal for men age 40 to 64.[17]

Study limitations: As intense as the activities were, the research also represents some technical limitations. The subjects for this study were all young, apparently healthy, men, who were at low risk for exercise related cardiovascular events, and this may have overestimated the actual cost in older populations. The population at increased risk generally includes older men and women with multiple risk factors or known coronary artery disease. Another possible limitation to the study was the absence of the heightened emotional response associated with hunting situations. This may have underestimated the actual cost of the activities. Previous research documented HRs as high as 114.0% of TM max exercise when the subjects saw a deer while hunting.[3] The current study only recorded the costs associated with dragging a deer and hiking, and did not factor in the emotional components of deer hunting. The potential excitement and subsequent increase in catecholamines may, however, be offset by the intensity of the activity. Exercise decreases parasympathetic stimulation and increases sympathetic stimulation, and the level of circulating catecholamines increases relative to an individual's peak TM exercise.[6,7] Due to the relative intensity of the dragging test, > 105% of ventilatory threshold, it is likely that the subjects experienced a dramatic increase in circulating catecholamines due to exercise alone.[7]

A further limitation to the study was the intensity the subjects employed while performing the dragging test. The subjects may have rushed to finish the test, which would overestimate the cost while deer hunting, or they may have worked at a lower intensity because of the absence of emotional stimulation, which would underestimate the cost while hunting. The intensity required to drag a deer while hunting would also vary a great deal by the weight of the carcass, the local terrain, and the weather conditions. In northern states, such as Wisconsin, a large deer can easily weigh more than 200 pounds (91 kg), while a small deer can weigh less than 100 pounds (45 kg). The trail used for the study was also an ideal location to drag a deer. In many hunting situations a deer must be dragged through wooded areas, heavy vegetation, or on hills much steeper than those on the course. These factors can make the task much more challenging. Factoring in muddy or snow covered ground, or temperature extremes, would also likely have an impact on the intensity employed while dragging a deer carcass. The calculated values may also have been affected by the tendency of individuals to downregulate the intensity of an activity by taking prolonged breaks.[11] This factor may have overestimated the actual cost.

Furthermore, only two activities associated with deer hunting were measured, and they were performed in relative separation from each other. These two activities were assumed to be the most intense, but the results may have been influenced by the separation of the activities or by other activities associated with deer hunting. Other factors such as climbing into elevated deer stands, performing deer drives, smoking, consuming alcoholic beverages, or the influence of the time of day of the activities should be investigated. Finally, the recording interval utilized with the Aerosport KB1-C portable gas analyzer was 60 seconds. If a shorter average interval was used, the peak values may have been higher, and would have likely shown more variability.

Conclusions: When all of these factors are considered, deer hunting should be viewed as an intense physical activity. Individuals who plan to deer hunt should seriously consider their fitness levels before venturing into the woods. Hunters need to be aware of the potential hazards associated with deer hunting, and they should be cautious when participating. Perhaps the most important thing deer hunters can do is to participate in regular physical activity. By increasing their overall fitness they may reduce the likelihood of experiencing an acute cardiovascular event while hunting. Intense exercise training has been shown to reduce significantly the levels of catecholamines associated with exercise. This leads to a decreased myocardial oxygen demand and a reduced likelihood of encountering ventricular arrythmias.[6,7] Individuals who are not fit and still deer hunt should definitely be patient and cautious while participating in these activities. They should take their time while walking, and they should consider other methods of retrieving their deer. This could include dragging with a partner, employing the help of a younger or more fit individual, or using mechanical aides such as all-terrain-vehicles when appropriate. The likelihood of experiencing acute cardiovascular events while deer hunting can be greatly reduced by using common sense. Hunters need to take their time, ask for assistance when necessary, and perhaps most importantly, listen to their bodies when they experience any symptoms indicative of acute cardiovascular events. When they experience these symptoms, they need to stop the activity in which they are involved and seek medical assistance when necessary.

REFERENCES

1. Franklin BA. The smart way to shovel snow. Physician & Sportsmed 1993; 21:1:171-178.

2. Franklin BA, Parker S, Mitchell M, Rubenfire M. Hazards of snow shoveling. Physician & Sportsmed 1980;8:12:40-46.

3. Haapaniemi S, Wegner J, Franklin B, Hamar S, Gordon S, Timmis GC. Deer hunting: A trigger for acute events? Circulation 1996;94:I374.

4. Potera C. When the buck stops the heart. Physician & Sportsmed 1997;25:4:26,29.

5. Willich SN, Lewis M, Lowel H, Arntz HR, Schubert F, Schroder R. Physical exertion as a trigger of myocardial infarction. N Engl J Med 1993;329:1684-1690.

6. Yeh SJ, Lin FC, Wu D. The mechanisms of exercise provocation of supraventricular tachycardia. Am Heart J 1989;117:1041-1049.

7. Ehsani AA, Heath GW, Martin WH, Hagberg JM, Holloszy JO. Effects of intense exercise training on plasma catecholamines in coronary patients. J Appl Physiol 1984; 57:1:154-159.

8. Urhausen A, Weiler B, Coen B, Kindermann W. Plasma catecholamines during endurance exercise of different intensities as related to the individual anaerobic threshold. Eur J Appl Physiol 1994;69:16-20.

9. Franklin BA. Snow shoveling. Fitness Management 1996;12:2:31.

10. Franklin BA, Blair SN, Haskell WL, Thompson PD, Van Camp SP. Exercise and cardiac complications: Do the benefits outweigh the risks? Physician & Sportsmed 1994;22:2:56-68.

11. Mittleman MA, Maclure M, Tolfer GH, Sherwood JB, Goldberg RJ, Muller JE. Triggering of acute myocardial infarction by heavy physical exertion. N Engl J Med 1993;329:1677-1683.

12. Burke AP, Farb A, Virmani R, Goodin J, Smialek JE. Sports-related and non-sports-related sudden cardiac death in young adults. Am Heart J 1991;121:1568-575.

13. O'Neil DS, DeVoe DE, Gotshall RW. Validity of the Aerosport KB1-C gas analysis system. Med Sci Sports Exer 1998;30:S125.

14. Beaver WL, Wasserman K,Whipp BJ. A new method for detecting anaerobic threshold by gas exchange. J Appl Physiol 1986;60:6:2020-2027.

15. American College of Sports Medicine. Guidelines for Exercise Testing and Prescription. 5th ed. Baltimore: Williams and Wilkins, 1995:158-163.

16. Butts NK, Knox KM, Foley TS. Energy costs of walking on a dual-action treadmill in men and women. Med Sci Sports Exer 1995;27:121-125.

17. Balady GJ, Chaitman B, Driscoll D, Foster C, Froelicher E, Gordon N, Pate R, Rippe J, Bazzarre T. Recommendations for cardiovascular screening, staffing, and emergency policies at health/fitness facilities. Med Sci Sports Exer 1998;30:1009-1018.

18. Foster C, Thompson NN. Functional translation of exercise test responses to recreational activities. J Cardiopolm Rehab 1991;11:6:373-377.

APPENDIX A

INFORMED CONSENT

The Metabolic Costs of Activities Associated with Deer Hunting

Informed Consent

I, ________________, give my informed consent to participate in this study of the metabolic costs of activities associated with deer hunting. The study will involve a maximal treadmill test. This test will involve running on a treadmill at increasing workloads until I can no longer continue. The load will start at 6.0 mph and 0% grade. The grade will increase 2.5% every two minutes until I can no longer continue and the test is stopped. The study will also involve hiking on a set course through the woods and performing a deer drag. I have been informed of and agree to the presentation and publication or other dissemination of the results with the understanding that all information is anonymous and that no identification can be made. I have also been informed that a record will be kept of my participation in the study, but the results will be identified by number only.

I have been informed the following will be associated with the study:

- Physical activity resulting in an increased work-load on the cardiovascular system
- Potential muscle discomfort and fatigue, which may persist following the conclusion of the study
- Potential of musculoskeletal and soft tissue acute injuries
- Potential contact with pathogens from deer such as deer ticks
- A potential gain of knowledge of my cardiovascular response to increased physical demand
- The information obtained from this study may educate hunters about the increased demand on the cardiovascular system while deer hunting
- All data collected will be kept confidential
- The use of a Polar Heart Monitor and the Aerosport KB1-C Portable Gas Analyzer will be required during all tests
- The researcher will answer any questions regarding the procedures of the study before the experimental session begins

I have been informed that participation is strictly voluntary and I am free to withdraw from the study, without penalty, at any time, and I state that to the best of my knowledge I am healthy and no conditions exist that should preclude my participation in the study.

Questions or concerns regarding any aspect of the study may be referred to Andrew Peterson at (608)784-7659 and/or Jeff Steffen at (608)785-6536. Any questions regarding protection of human subjects please call Garth Tymeson at (608)785-8155.

Signature of researcher	Date	Signature of participant	Date

APPENDIX B

SUBJECT INSTRUCTIONS

Field Tests – Hiking and Dragging

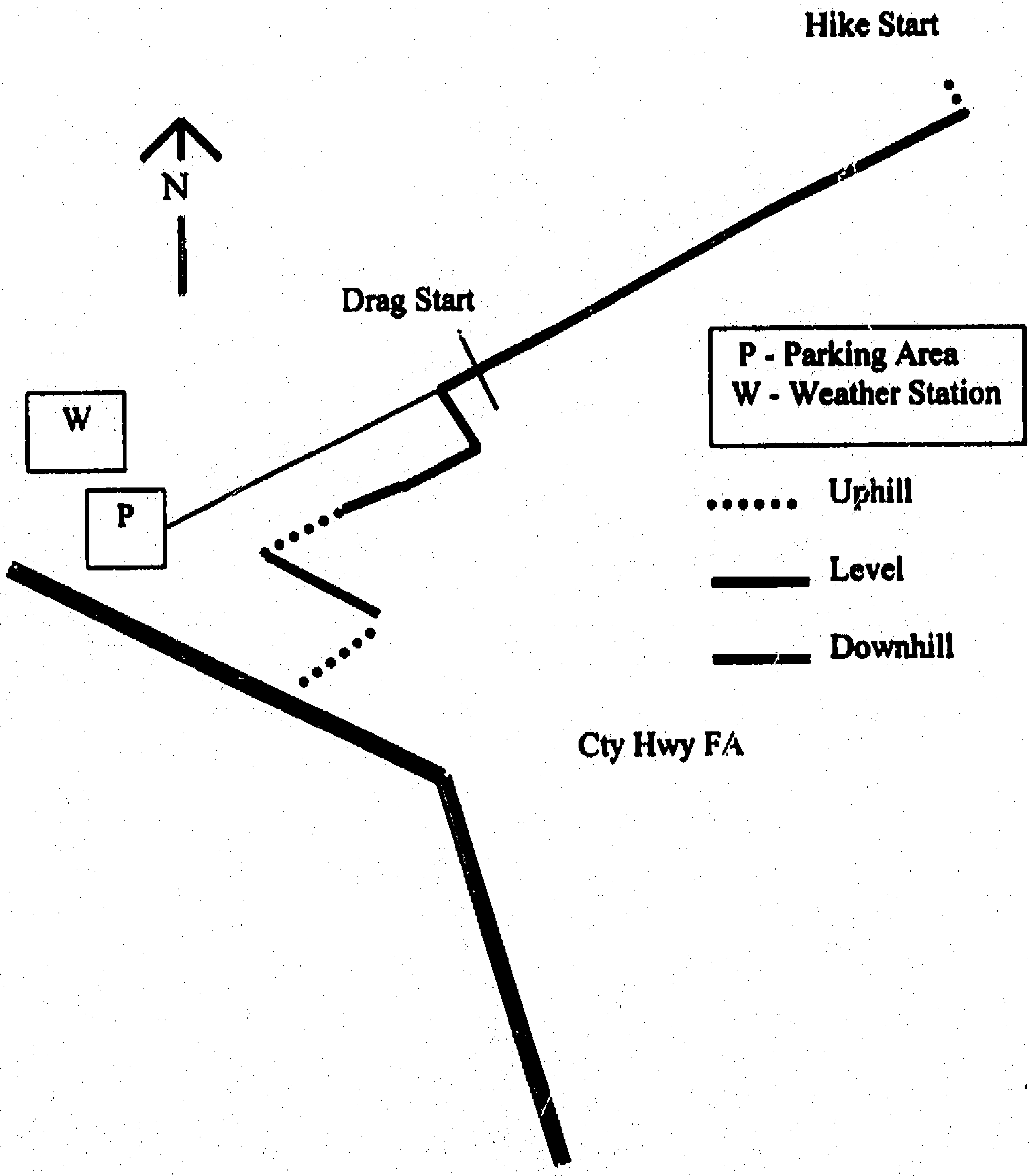
In preparation for your field tests there are a few protocols you are requested to follow and think about before you arrive at the test site.

1. Dress in a manner, based on the weather on the day of testing, that would allow you to sit comfortably in one place for four hours without having to get up and move. Think about being dressed for sitting on a deer stand. The tests will be performed on top of a bluff. Take into consideration the fact that it is generally colder and windier up there.
2. If you have a blaze orange sweatshirt, please wear it as your top layer. If you don't have a blaze orange sweatshirt, one will be provided for you on the day of testing.
3. Bring something to wear on your head. Either a stocking cap or an ear band should be worn if it is cold.
4. Remember that when you arrive for testing you will be fitted with a Polar heart monitor that will be wrapped directly around your chest. For this reason, you may want to bring warm top layers along and put them on after the monitor is fastened.
5. You will be required to wear latex gloves during the dragging portion of the test, but you will also be able to wear gloves over them. The gloves will be provided for you. At no time will you be required to handle the carcass directly. A rope will be tied to its neck to facilitate the dragging.
6. If you have hunting or hiking boots, you should wear them. If not, shoes will work.
7. Although the actual testing should not take more than an hour, plan on a time period of about two hours from start to stop.

APPENDIX C

MAP OF RESEARCH SITE

Map of Research Site



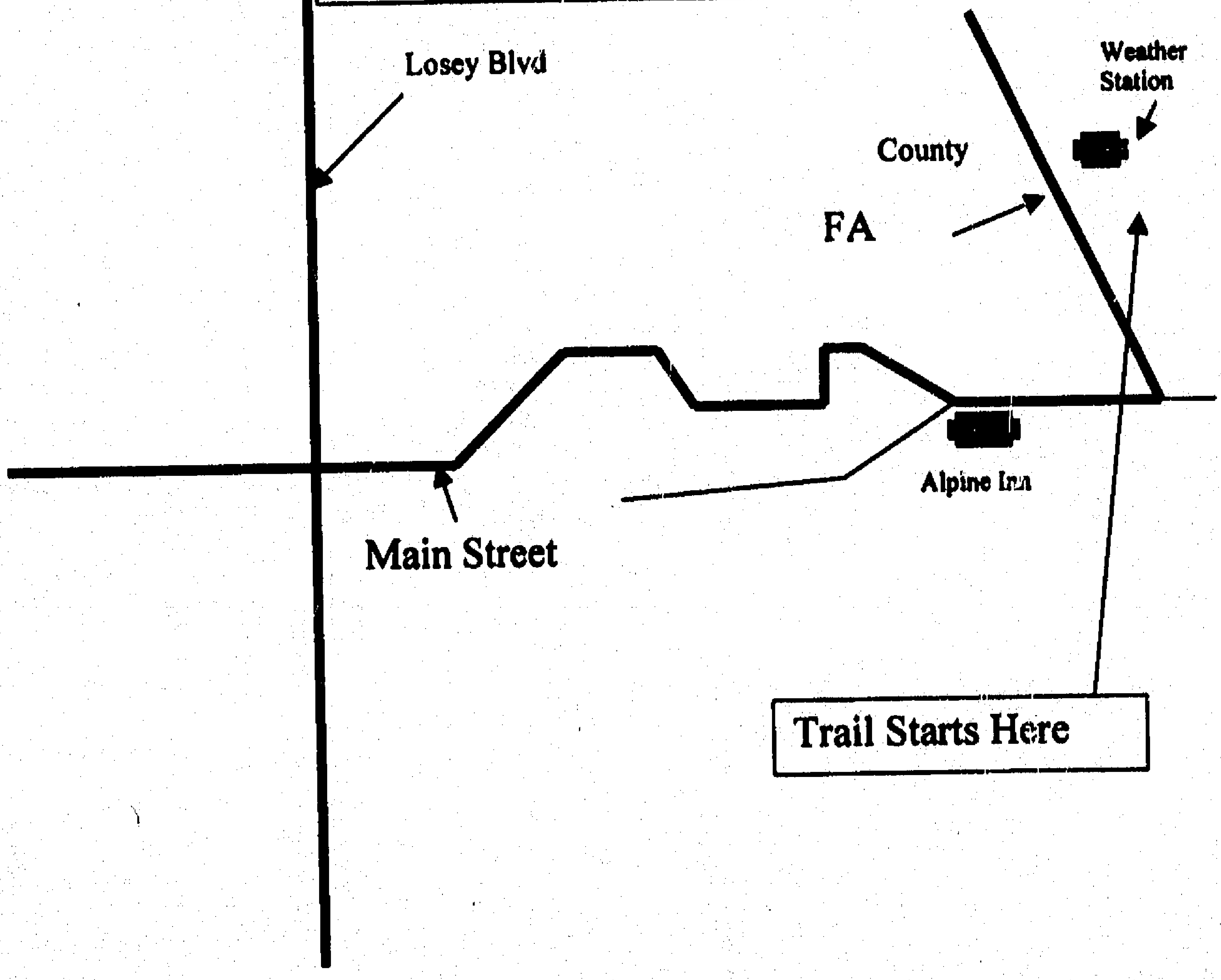
APPENDIX D

MAP AND DIRECTIONS TO RESEARCH SITE

Map to Research Site

Directions

Enter La Crosse on Hwy 16 West.
Turn left on Main Street.
Follow road up the bluff and to County Road FA.
Turn Left on FA.
Turn into parking on the right side of the road just before the weather station.



APPENDIX E

EXPANDED METHODS AND PROCEDURES

EXPANDED METHODS AND PROCEDURES

Introduction

The purpose of this study was to simulate activities associated with deer hunting and monitor the results. Two specific hunting related activities were selected. These included hiking while carrying a gun and dragging a deer carcass. While hiking out to a deer stand, especially in a cold climate, hunters would ideally be dressed in light comfortable clothing layers to prevent them from overheating. Once they arrive at their stands, they ordinarily put on warmer clothes to be comfortable while they are stationary on a deer stand. Unfortunately, many hunters do not follow this practice. Instead, they dress warmly enough for sitting on their stand before they even start walking. This often results in the hunters becoming overheated and perspiring quite heavily before they arrive at their stands.

The same logic dictates that hunters would wear less clothing while dragging a deer. Unfortunately, because of their excitement, or just plain thoughtlessness, hunters frequently do not remove the excess layers of clothing before they initiate a drag. For this reason, the study dictated that the participants wear clothing that would allow them to be comfortable for sitting in the woods for several hours without having to walk around to warm up. The testing protocol was set up to be as realistic as possible by requiring the subjects to carry a gun while hiking and to drag an actual deer carcass for the dragging test. Additionally, during both tests, the subjects wore a blaze orange shirt for their top layer of clothing, as is required by law for deer hunting in many states.

Subject Selection

The subjects for this study consisted of 16 male volunteers from the La Crosse, Wisconsin, area. They ranged from 20 to 28 years of age (mean 22.6 $\pm$ 2.5), averaged 179.8 cm ($\pm$ 5.1 cm) in height, and weighed 85.4 kg ($\pm$ 16.7 kg). The protocol for the test required that the subjects be between 18 and 35 years of age. This range was selected to keep the group as homogenous as possible while also testing a population at a lower risk for acute cardiovascular events. A further benefit of testing this group was the elimination of the necessity of a physician's presence during any of the tests.

For several reasons the subjects were recruited on the basis of previous hunting experience, especially prior experience dragging a deer. First of all, individuals who had previously hunted would likely have a better idea what type of clothing would be appropriate for the weather conditions on the day of their tests. Another benefit to using experienced hunters was their familiarity to the techniques required for dragging a deer as efficiently as possible. Finally, the use of hunters was preferred to lessen the likelihood that a subject would be offended by the testing or become uncomfortable with the testing protocol. Subjects who had not previously hunted were also used once it was established that they would not have any objections to dragging a deer carcass. These subjects were allowed an opportunity to practice their technique for dragging so they would be comfortable once the test started.

Methods and Procedures

Many steps were involved before testing could begin. The first step was to locate a place to perform the tests. Once the location was found, permission needed to be obtained for the use of the land. The selected site was part of Hixon Forest, a city park in La Crosse, Wisconsin. Discussions with the park personnel defined the portions of the park that could be utilized, along with their specific restrictions for land use. The region that was agreed upon was called Prairie Trail Loop. The location of the site is included as the Map to the Research Site (Appendix D). This trail was the most remote of all the park trails, and the park management allowed a vehicle to be driven in for testing purposes. Additionally, they agreed to the use of a deer carcass for the drag and the use of an encased gun for the hiking portion. The use of the encased gun was also cleared through the city police department. The only restriction the park management stipulated was that all testing and driving occur on established trails.

In addition to obtaining permission for the testing location, a power source needed to be located. A National Weather Service station adjacent to the park was contacted about the testing, and their cooperation was also enlisted. They obliged by allowing access to power outlets in the parking lot adjacent to the park.

The next step was to obtain deer carcasses for testing. The first group contacted was the La Crosse, Wisconsin, branch of the Wisconsin Department of Natural Resources. They placed only 1 stipulation on the use of the carcasses. They stated that the carcasses must have a nonsalvage tag attached to them the entire time they were in the possession of the researcher. They then directed the search to an individual who picked up the county road-kill deer. The follow up call was made to Paul Peterson, the individual who was responsible for collecting the road-kill deer. Coincidentally, he was an employee of the University of Wisconsin-La Crosse, which greatly facilitated the process.

An initial meeting was set up with Paul Peterson to discuss the testing protocol and to secure his cooperation in the process. He agreed to provide deer for the study and to place non-salvage tags on them. He also agreed to take the carcasses back and dispose of them when they were no longer of use.

Once the carcasses were obtained, the internal organs were removed. This required a suitable location for disposal of the entrails. A local landowner was contacted, and permission was obtained to use the land. An agreement was made that the organs could be left in one of his fields. The carcasses were then taken out to the land to be field dressed. The organs were removed by making an incision starting at the sternum and proceeding posteriorly to the anus. Once the incision was made, the internal organs were removed up to the diaphragm. The diaphragm was then cut away, and the heart and lungs were also pulled out of the carcass. The body was then rolled onto its stomach, and the front legs were picked up to allow any excess blood to drain out.

Once the carcasses were field dressed, they were ready to be weighed and adjusted to the standardized value. After again contacting the Wisconsin Department of Natural Resources and inquiring what the average weight of a deer carcass is in Wisconsin, a weight of 125 pounds (56.8 kg) was selected to be representative. Not all the deer obtained for the study initially met this weight requirement, and a place to establish their weight was located. Coulee County Recycling was contacted, and they agreed to allow the use of their scale at no cost. The deer carcasses were weighed on their scale, and their weight was adjusted accordingly.

During the course of the study 4 different deer carcasses were utilized in the study. The first carcass weighed 165 pounds (75 kg) field dressed. This variance in weight was corrected by removing 40 pounds (18 kg) of muscle tissue from the carcass. Two subjects dragged this carcass. The second carcass weighed 115 pound (52 kg) field dressed. The variance in weight was corrected by adding a 10-pound (4.5 kg) salt bag to the body cavity of the carcass. Again, only 2 subjects dragged this carcass. The third carcass weighed 130 pounds (59 kg) field dressed, and 5 pounds (2.3 kg) of muscle tissue were removed from the carcass. Five subjects dragged this carcass. The final carcass weighed 100 pounds (45 kg) field dressed, and 25 pounds (11 kg) of salt were added to the body cavity. A rope was tied around the carcass to hold the salt bags in place while it was being dragged. Seven subjects dragged this carcass.

The subjects participated in 3 separate tests. On one day they performed the hiking and deer drag test, and on a different day, they performed a maximal TM test. The order of the days was determined by times the subjects were available to test. The only requirements were that the field and laboratory tests were not performed on the same day and that the subjects signed the informed consent before participating in any of the tests. The only other factor that influenced the testing was inclement weather. Testing was postponed on 2 occasions during rain storms. The temperature was very similar on all days of testing. The temperature ranged between 30 degrees and 40 degrees Fahrenheit (1.1 to 4.4°C) for the testing of all subjects except for 1 individual. The temperature was 50 degrees (10°C) on the day this subject was tested.

All of the subjects performed a maximal TM test as a standard against which to evaluate the results of the other 2 tests. Prior to testing, the subjects were told to wear comfortable clothing and shoes for running. On the day of testing, the researcher arrived in the lab before the subjects and obtained the barometric pressure for the day and plugged in the Aerosport KB1-C portable gas analyzer to warm it up. The Aerosport KB1-C portable gas analyzer was used to monitor the subjects' breathing through open circuit spirometry. The unit was given at least 30 minutes to warm up before testing began. The unit was also calibrated before the arrival of the subjects. In order to calibrate the Aerosport KB1-C portable gas analyzer, it was connected to the same power source it would utilize during testing. This connection was maintained until the conclusion of the test, and if it was broken, the calibration process started over. The first step in the calibration process was to let the unit run through its warm up and auto zero stages. After this occurred, the manual steps were ready to begin. First, the pneumotach was calibrated by selecting flow head on the main menu and the medium flow setting for the pneumotach. The hoses were then hooked up to the pneumotach, the Aerosport KB1-C portable gas analyzer, and to a 3-liter syringe. After following the prompts, a volume of 21 liters of air was entered, and the 3-liter syringe was pumped 7 times. During the pumping of the syringe, the air was pumped at a rate between 4 and 7 as illustrated on the screen of the Aerosport KB1-C portable gas analyzer. Once a satisfactory value was obtained, the Aerosport KB1-C portable gas analyzer had to be calibrated for percent oxygen and carbon dioxide. A Mylar balloon was attached to a valve so it could be attached to the Aerosport KB1-C portable gas analyzer and to standardized air tanks. The balloon was filled and flushed 3 times with air from a tank before it was filled with the sample to be analyzed. Two separate tanks were used in this process. When available, a large tank was used that contained 16.02 % oxygen and 3.97 % carbon dioxide. When this tank was not accessible, a smaller tank was used that contained 16.0 % oxygen and 4.0 % carbon dioxide. The appropriate selections were made on the Aerosport KB1-C portable gas analyzer to go through the gas calibration, and the balloon was attached at the appropriate time. The next step was to enter the subject data and the current barometric pressure. Once the subjects arrived, they were weighed on a physician scale, and their weight was converted to kilograms. Their height was also measured in centimeters. This data, along with the age of the subjects and the barometric pressure, was entered before each test. Prior to testing, the subjects were given the informed consent form (see Appendix A) if they had not already signed it. They were allowed to ask any questions pertaining to the form or to the tests. Once they signed the form, they were fitted with the testing equipment, and the test was ready to begin. For all of the tests, the subjects were fitted with a radiotelemetry Polar HR monitor and the Aerosport KB1-C portable gas analyzer. The transmitter from the Polar heart monitor was put around the subjects' chest, covering the zyphoid process. The watch was put on the railing of the to allow easy monitoring by the researcher and to reduce the likelihood of the subjects accidentally pushing any of the buttons. The watch was set to record in 15-second intervals and was started when the test began. As a result, the HRs were recorded as 15-second average values. The Aerosport KB1-C portable gas analyzer was fitted on the subjects with a harness provided by Aerosport Inc. It was oriented with the unit in front of their chest, and the battery pack on their back. Small 12-volt batteries, encased in a metal clip on carrier, were used during the maximal TM testing, and each time the battery was changed, the calibration process started over. The subjects breathed through a mask style apparatus, and the pneumotach was set on the medium flow setting. The unit was set to record in 60-second intervals. As a result, the reported values were 1-minute averages. At this point the test was ready to begin. All subjects followed the same warm up and testing protocol. Both the Polar watch and Aerosport KB1-C portable gas analyzer were started at the beginning of the warm up and ran until the minute following the completion of the test.

The warm up consisted of 3 stages lasting 5 minutes each. In the first stage the subjects walked 2 miles per hour (0.89 $m*s^{-1}$) at a 1% grade. The second stage followed with the subjects walking 3 miles per hour (1.34 $m*s^{-1}$) at a 1% grade. For the final warm up stage the subjects walked 3.5 miles per hour (1.57 $m*s^{-1}$) at a 1% grade. At this point, the speed was increased to 6 miles per hour (2.68 $m*s^{-1}$), and the grade became the only factor modified to bring the subjects to their maximal TM values. The measured values included HR, pulmonary ventilation, VO2, and kilocalories per minute. The first stage at 6 miles per hour was at 0% grade. The grade was then increased 2.5% every 2 minutes until the subjects reached their maximal values. The HR monitor and Aerosport KB1-C portable gas analyzer were left on to record the first minute of cool down. After a few minutes of cool down, the subjects stepped off the treadmill. At this point, the subjects were disconnected from the testing apparatus, and they were monitored for any adverse symptoms while the information was printed out from the Aerosport KB1-C portable gas analyzer. The heart rate information was also immediately downloaded from the Polar watches and printed out. Once the subjects had recovered, they were free to go.

On the other day of testing, the subjects performed both the hiking test and the dragging test. Both of these tests were conducted in Hixon Forest (see Appendix C and D), and the courses overlapped. The second half of the ½ mile hike test was the same course that was used for the ¼ mile drag. In all cases, the hiking test was performed first.

Before the subjects arrived for testing, the researcher followed the same calibration steps listed in the maximal TM test section. There were, however, 2 differences in the equipment used. The first difference was in the power source. For the hike and drag tests, a larger 12-volt gel pack battery was utilized. This 5-pound (2.3 kg) battery held its charge longer, but was heavier. As a result, the subjects wore a back-pack, and the battery was placed in the pack. The second difference in equipment was in the gas tank utilized. For both the hiking and dragging tests, the smaller tank with 16.0% oxygen and 4.0% carbon dioxide was used for calibration. Before arriving at the testing site, the subjects were contacted and given instructions on what to wear and what to expect during the testing (Appendix B).

Upon arrival at the test site, the subjects were given the informed consent form to read and sign, if they had not previously signed it, and they were fitted with the Polar HR monitor and the Aerosport KB1-C portable gas analyzer. The HR monitor and Aerosport KB1-C portable gas analyzer were fitted as previously stated in the maximal TM test section. Once the subjects were fitted with the Polar HR monitor, they also put on a blaze orange zip-up shirt as their top layer of clothing. The only differences in the fitting process were in the battery pack and placement of the Polar watch. The watch was strapped to the harness of the Aerosport KB1-C portable gas analyzer to reduce the risk that the subjects would accidentally stop the recording during the test, and the larger battery was in the backpack. At this point the subjects were also handed the gun they would carry for the hike test. The gun was a Winchester Model 1300, pump-action shotgun with a rifled slug barrel. A cable lock was placed through the chamber to disable the gun during testing. Additionally, the gun was encased in a sleeve style case. The case was made of thin cloth and allowed the subjects to carry the gun in a standard manner (Figure 1). All subjects carried the gun with 1 hand on the slide and the other hand on the stock. The subjects were accompanied by the researcher to the starting point of the course. At this point, the test was ready to begin. The subjects were instructed to hike in a rapid, yet comfortable, manner, as if they were a bit hurried in getting to their deer stand in the morning.

The entire length of the 0.5 mile (0.8 km) course was a 10-foot (3.64 m) wide mowed trail. The terrain was quite varied, but did not offer any obstacles other than changes in terrain and footing. The researcher accompanied the subjects on all tests. The test began with a 33-yard (30 m) hike up a gradual hill followed by a right turn and 162-yards (148 m) on level ground. The next 184 yards (168 m) were down a gradual hill, followed by 61 yards (56 m) on level ground where the subjects reached the half-way point of the test. This point on the hiking course was also the starting point of the dragging test. The time at this point was recorded for all subjects. The second half of the test continued with another 26-yard (24 m) hike on level ground, followed by a left turn. The subjects then descended 45 yards (41 m) down a steeper hill. At that point, they turned right and proceeded along a sloping trail. Here the trail sloped down from right to left, and the footing was often very unstable. While navigating the sloping trail, the subjects were initially on an even grade for 30 yards (27m) followed by a gradual downhill for 21 yards (19 m) and another section with a level grade for 47 yards (43 m). The sloping trail then went up a gradual hill for the next 100 yards (92 m) before leveling off. At the top of that hill, the subjects again turned left and started a gradual descent for the next 101 yards (92 m). The subjects finished the test by ascending a steep hill for the final 70 yards (64 m) of the course. At this point, the Aerosport KB1-C portable gas analyzer and Polar watch continued to record for the next minute. The subjects were then led to the parking lot of the weather station where the power source for the printer was located. At this point, the information from the hike was printed from the Aerosport KB1-C portable gas analyzer. The subjects were then allowed to take a 20 minute break, and the gun was put away.

Once the subjects had an opportunity to recover, they were ready to begin the .025 mile (0.4 km) dragging test. The Aerosport KB1-C portable gas analyzer and the Polar watch were reset in order to be prepared to record the next test. Before testing began, however, the subjects were all given a pair of latex gloves. They were required to wear these as dictated by the University of Wisconsin-La Crosse Institutional Review Board. The subjects were also provided with a pair of cotton work gloves to wear over the latex gloves. At this point, the subjects were led to the starting point of the drag test, and they prepared themselves for the test. The subjects all performed the drag by placing the 5/8-inch (1.59 cm) rope over one of their shoulders and holding onto a loop in the distal end of the rope out in front of them (see Figure 2). The rope was attached to the 125-pound (56.8 kg) carcass with a noose-style knot around the deer's neck. They were instructed to drag the deer at a comfortable pace and to take breaks whenever they needed, and they were accompanied by the researcher. While they were dragging the deer, the researcher monitored the Aerosport KB1-C portable gas analyzer and the Polar watch to be sure they were functioning properly throughout the test. The drag course began, as previously stated, at the mid-way point of the hiking test. The specifics of the course are detailed in the previous section, the hiking test. At the completion of the drag, the Aerosport KB1-C portable gas analyzer and the Polar watch again recorded for 1 minute during the cool down. At this time, the subjects were again led to the parking lot of the weather station to obtain access to power for the printer. The information was printed from the Aerosport KB1-C portable gas analyzer, and the subjects were provided with water if they were thirsty. At this point, the subjects were disconnected from the Aerosport KB1-C portable gas analyzer and the Polar HR monitor, and they were free to go.

Statistical Treatment

At the conclusion of testing, a large body of information was available to be analyzed. The analysis was largely limited to descriptive statistics. The mean values for HR, VO2, pulmonary ventilation, and kilocalories per minute were calculated from both field tests. The hiking and dragging tests were compared to the maximal TM test as a baseline. Additionally, the maximum values for HR, pulmonary ventilation, VO2, and kilocalories per minute from the hiking and dragging tests were determined and again compared to the maximal TM test. This information also provided the necessary data to calculate the METs associated with the hiking and dragging tests. The V-slope method was used to determine the anaerobic threshold levels from the maximal TM tests for all subjects.[1] The volume of oxygen used during the subjects' field tests was then compared as a percent to their calculated anaerobic threshold. Both peak values and average values of anaerobic threshold were obtained for the hiking and dragging tests. Additionally, HR values were calculated corresponding to 10, 20, and 30 ml of $O_2*kg^{-1}*min^{-1}$ for the maximal TM exercise, the hiking test, and the dragging test. A t-Test with a Bonferonni correction for 3 variables was used in the analysis of the HR and VO_2 relationship.

APPENDIX F

REVIEW OF RELATED LITERATURE

REVIEW OF RELATED LITERATURE

Introduction

A large amount of research has been conducted on cardiac complications associated with strenuous exercise. In particular, much research has been performed on snow shoveling and associated myocardial events. Limited research has been performed on deer hunting activities, but the available data indicate that deer hunting may also be associated with the onset of cardiovascular events.[2]

The purpose of this literature review was first to establish the types of activities that may precipitate myocardial events and the populations at greatest risk for cardiovascular complications, and secondly, to determine the HRs and mechanisms associated with cardiovascular complications. The review also sought to verify the validity of the Aerosport KB1-C Portable Gas Analyzer.

Activities Increasing Risk of Complications

Although snow shoveling can provide a good workout when done correctly, it can also lead to muscle soreness, back aches, or even more serious injuries.[3] A large body of research, primarily conducted by Franklin, has demonstrated that snow shoveling is associated with increased physiological demands and increased rates of cardiac events. The research found a disproportionate degree of myocardial demand from snow shoveling. Five factors were associated with increased cardiac strain. These included reduced myocardial efficiency of arm exercise, upright posture, isometric exertion, use of valsalva maneuver, and inhalation of cold air.[4] All 5 of these factors may also be relevant at one time or another while deer hunting, particularly when dragging a deer carcass. Thus, it can be inferred that deer hunters could also be at risk for increased cardiac strain. The literature has suggested that the exertion can cause an increase in blood flow and lead to cholesterol and other fragments being dislodged from the arterial walls.[5] This can lead to plaque rupture and dislodging of blood clots that may result in an acute cardiac event.

Other Activities

Studies on various recreation activities have also demonstrated an increased risk associated with participation in strenuous exercise. Research has found that individuals who are typically engaged in low levels of activity had 56 times the risk of primary cardiac arrest when they were involved in strenuous activity when compared to other times.[6] This is a particularly significant statistic to deer hunters who are not typically engaged in strenuous exercise. Inactivity for most of the year, followed by intense exertion while hunting, leads to an increased risk of cardiovascular complications.

YMCA facilities across the country were surveyed, and the research documented 1 cardiac event in every 495,971 participant hours.[7] This study did not take into consideration the degree of intensity in the exercise. It merely investigated participant hours versus reported events. The authors also admitted it was likely that a large percentage of nonfatal cardiovascular events were not reported. As a result, the frequency of occurrence of cardiovascular complications is likely higher than that calculated.

A recent study during deer hunting also reported a large increase in myocardial demand. The research concluded that "Deer hunting can provoke sustained increases in heart rate, ST-segment depression, and threatening arrhythmias not evoked by maximal treadmill tests" (p. 1374).[2] The study found that various deer hunting activities were associated with mean HR responses greater than 85% of the maximal HR based on maximal TM exercise. The highest HRs were recorded in walking and dragging a deer, 94 and 97%, respectively. It should be noted that these tests were done under actual hunting conditions. This could have resulted in increases in HR due to the emotional component of the activity.

In many individuals, the level of exertion in intense free range activities may even supercede those achieved during a maximal TM test. Recent research found that free range exercise allows individuals to recover for brief periods of time and, subsequently, achieve levels of power output, HR, and VO2 exceeding those achieved maximal incremental exercise.[8] By resting for a short time, the subjects are able to reduce the level of lactate in their muscles and then resume exercise at an intense level. While dragging deer, hunters could easily enter a pattern similar to this. By dragging, taking a short break when they become fatigued, and then resuming the drag, some individuals may be able to achieve metabolic responses above those reached on a maximal TM test.

Populations at Increased Risk

Although overall risk factors increase for individuals while they participate in strenuous physical exertion, certain individuals are at a much higher risk for complications than others. In general, the risk of exercise-related death decreases in more active populations. In individuals over age 35, about 95% of exercise-related cardiac deaths can be attributed to underlying coronary artery disease.[9] Patients with underlying coronary artery disease appear to be at the highest risk for an exercise-related event. Other research also noted that a sedentary lifestyle has been shown to increase the risk of coronary artery disease and that people with a sedentary lifestyle are at an increased risk for physical exertion-related acute myocardial infarction.[10]

Studies have documented that most individuals over 35 who died during physical exertion had severe coronary atherosclerosis. Research has also found that younger athletes with cardiomyopathy or anomalous coronary arteries were also at an increased risk for sudden cardiac death.[11] According to Franklin, the best way for people to avoid cardiac events is to pay attention to serious warning signs and take heed of them by immediately stopping the activities in which they are engaged.[12]

An even larger group at an increased risk for exercise related cardiac events is sedentary individuals. Research in Germany found that sedentary individuals were at significantly increased risk. They also found that people exercising at a level $\geq$ 6 METs almost doubled their risk of experiencing a cardiac event when compared to rest.[13]

Mechanisms that Trigger Acute Events

Research has concluded that 2 factors are required to precipitate an exercise-related cardiovascular event.[14] These factors include an underlying structural abnormality and forceful exertion placing demand on the myocardium. When these conditions occur simultaneously, the result is some form of cardiac disruption that leads to a decreased blood flow to the myocardium and, subsequently, to a potentially lethal arrhythmia. Studies have also noted that sudden cardiac death can occur as a result of 1 event. This is a myocardial oxygen demand that exceeds the supply and subsequent ischemia that may precipitate a cardiac event.[15]

A review of a recent study on deer hunting stated that exercising above 85% of a person's maximum HR can lead to cardiovascular complications.[16,2] It is hypothesized that this level of increased blood flow can dislodge plaque and lead to an occluded artery. This view agrees with the previously cited studies. When individuals with a structural abnormality, such as coronary artery disease, are exposed to an increased demand on the cardiovascular system, such as a HR ≥ 85% of maximum HR, they may fall victim to an arrhythmia or myocardial infarction. An increase in blood flow and blood pressure may lead to the rupture of a preexisting coronary plaque. Disruption of a plaque frequently precipitates acute coronary syndromes.[17]

Exercising at an intense level may also increase the likelihood of acute cardiovascular events due to an increase in catecholamine levels. Exercise causes an increase in circulating catecholamines. This increase in sympathetic stimulation increases HR and myocardial oxygen demand and has the potential to trigger supraventricular or ventricular tachyarrythmias.[18] The increase in catecholamine response is also related to the relative intensity of the exercise.[19] Another study observed that the degree of catecholamine response could be predicted by the intensity of exercise relative to anaerobic threshold. Endurance exercise at a level ≥ 105% of an individual's anaerobic threshold has been shown to cause a progressive increase in the levels of epinephrine and norepinephrine.[20]

Validity of the KB1-C Portable Gas Analyzer

A recent study tested the validity of the Aerosport KB1-C Portable Gas analyzer against a system with established validity, the Sensor Medics 2900 Metabolic Cart. The testing included a maximal graded treadmill test including 3 steady state stages. The study found no significant differences of any variants analyzed in 3 phases of exertion or at maximal effort.[21]

Summary

The available literature clearly demonstrates that heavy physical exertion may precipitate acute cardiovascular events. These can range from ischaemia and abnormal rhythms to cardiac failure and sudden death. It is also clear that individuals with underlying cardiac abnormalities are at a much higher risk for such complications. Of these abnormalities, coronary artery disease is the most common, especially in individuals over 35 years of age. Other abnormalities are more frequently found in younger individuals suffering from sudden cardiac complications, but these instances are very rare.

The research also indicates that activities involving breathing cold air, arm exercise, isometric exertion, use of the valsalva maneuver, and upright posture, among other factors, place individuals at an increased risk for an acute event. A recent study clearly demonstrate that deer hunting activities may elicit HR responses capable of placing individuals at an increased risk for cardiac complications.[2] However, this study was performed under actual hunting situations that may have involved elevated levels of catecholamines secondary to emotional arousal, which produced elevated heart rate responses. The same activities performed in the absence of catecholamines may not have elicited the same levels of response.

The foundations for research in exertion-related cardiovascular complications have been clearly defined. Also, the groundwork has been started involving studies on deer hunting activities. No work has been done, however, on simulated deer hunting activities in the absence of the assumed heightened catecholamine levels or under more controlled testing criteria.