A HEART RATE/ECG RECORDING DEVICE FOR SPORTS RESEARCH OR REHABILITATION

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INTRODUCTION

Although heart rate (HR) may seem like a relatively unsophisticated physiological parameter, it is nevertheless an accurate and reliable indicator of some basic biological information regarding an individual's cardiovascular system. The heart rate is also known to be an excellent 'barometer' of a person's cardiovascular fitness (Simpson and Morris, 1978). For example, resting heart rates as low as 28 have been reported in elite world class endurance athletes (Van Ganse, *et al.*, 1970).

The heart rate has also been shown to have a nearly linear relationship to oxygen consumption over most of the submaximal workload range and hence HR may indicate the overall metabolic activity of the individual during periods of exercise stress (Åstrand and Rodahl, 1977). HR of itself also reflects accurately the work done by the heart since the correlation between HR and coronary blood flow is fairly high (Wilmore, 1975). It is one thing to imagine the stress of vigorous activity causing certain skeletal musculature rapidly to contract and relax at 60-90 times per minute (e.g. leg muscles); however, it is a more extraordinary realization to note that the cardiac muscle often is required to contract and relax at approximately 2½ times this rate during intense exercise stress. Since the heart receives its major oxygen and energy supply during diastole, this shortened period of time becomes more crucial as the HR increases rapidly to meet the demands of total body movement.

The interest in HR received increased attention during the 1950s when Karvonen (1959) showed that a person must elevate his heart rate to sixty percent of his heart rate range several times a week for a training effect to take place. Faria (1970) and Sharkey and Holleman (1967) have also corroborated these earlier findings. Still others have suggested that elevating the HR to 75-85% of maximum is necessary for an aerobic training effect (Åstrand and Rodahl, 1977).

One of the difficult practicalities of monitoring heart rate during exercise is that it must be done in a laboratory, that is to say, in an artificial, environment. Alternatively it may be monitored by the person exercising by immediately stopping exercise to check his carotid, radial, temporal or brachial pulse. This procedure

of checking one's heart rate immediately upon exercise completion is difficult at best in competitive situations when one has the light-headed, heavy-legged sensation of fatigue which accompanies vigorous sustained exercise. Although these methods are useful, they are nevertheless suspect as scientific measures to study physiological involvement during unrestrained activities. Also it is known that the heart rate drops immediately in a curvilinear manner after one stops exercising (Jette, *et al.*, 1976 and Bowles and Sigerseth, 1968). Additionally, these procedures do not permit monitoring instantaneous responses across time.

METHOD

We wanted to monitor HR responses of runners during cross-country competition. Although telemetry equipment has been used to study runners, there are several limitations. These include: 1) The quality of printout; 2) the distance from the monitor must be restricted; 3) it does not allow for immediate accurate monitoring. To overcome these problems we have used a new lightweight (<1.2 kg) Electrocardiorecorder* which is very compact (17 cm X 9.5 cm X 6 cm), illustrated in Figure 1. With this device, the Holter Monitor, a cross-country runner may have his ECG and HR recorded for

Figure 1 Illustration of Holter Monitor, waist elastic belt, 5 lead electrode configuration and pencil and ruler to illustrate compact size of entire apparatus.

*Del Mar Avionics, Irvine, California

the entire warmup, race and warmdown period. The Holter Monitor consists of a tape recording of ECG responses recorded in real time. It was originally developed for cardiologists to monitor cardiac patients for ECG abnormalities occurring during normal daily activities. (Up to 24 hours of real time may be recorded for later recovery.) However, the Holter Monitor may be used on other populations. In our work we have used it to study responses of runners during actual competition (Morris, *et al.*, 1977) and to study cardiac responses of fire fighters during different firefighting tasks (Davis, *et al.*, 1977).

A small tape recorder is placed comfortably in the small of the subject's back and standard V₅ ECG lead position electrodes lead off to the recorder. It may also be pointed out that duplicate electrode placements are permitted with one serving as a backup. Other subjects prefer to wear the recorder under the axilla similar to an American police officer's shoulder holster. The unit comes equipped with shoulder straps or waist belts. This small unit is powered by a small battery pack which may be recharged when the monitor is not in use.

After sample data has been recorded (see Figure 2) the recording tape may be played back at various factors of real time (1 to 6 times real time) on a Holter Monitor

Figure 2 Sample recording from a male 21 year old cross-country varsity athlete during warmup (1), race of about 5.2 miles (2) and cooldown period (3). Ordinate indicates heart rate in beats/minutes, while abscissa shows time in minutes.

Scanner**. This permits examination of HR's and ECG complexes on a stripchart printout.

RESULTS AND DISCUSSION

This short section of our report will note some results which we have achieved with this Holter Monitor. It was the purpose of the investigation to monitor ECG and HR responses of two collegiate cross-country runners during an actual race of 5.2 miles.

Results indicated that HR rose to 80% of predicted maximum during the initial 30 seconds of the race which was over a flat portion of the course. Within the first 40 to 120 seconds of the race, HR exceeded 90% of maximum and remained at this level throughout the remainder of the 27 minute effort. This HR intensity was maintained for about 23-24 minutes (see Figure 2). There were three short dips in the HR responses, each lasting about 20-40 seconds where HR fell to about 83% of maximum. These drops in HR corresponded to several downhill respites on the course. It was also noted that HR responses reached 88% of maximum during the warmup period and quickly subsided to about 55% of maximum within 2.5 minutes post-race. These findings are in agreement with other data reported by Danoff, *et al.* (1977) and Uilyot (1973) on long distance runners.

CONCLUSIONS

From these initial case study findings, it seems feasible that HR responses may be studied during maximal running efforts of about one half hour duration of cross-country men over a hilly 5.2 mile course. In addition, in our investigations with firefighters it was concluded that near maximal aerobic effect was required to complete various firefighting tasks when firefighters wore full turnout gear and self-contained breathing apparatus. Again the use of the Holter Monitor enabled us to evaluate objectively HR and ECG complexes in these men during intensive work.

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REFERENCES

- Åstrand, P-O, and Rodahl, K. 1977. *Textbook of Work Physiology*, 2nd ed., McGraw-Hill, Hightstown, New Jersey.
- Bowles, C. J. and Sigerseth, P. O. 1968. Telemetered heart rate responses to pace patterns in the one-mile run. *Research Quarterly* 39: 36-46.

- Danoff, J. V., Davis, P. O. and Anderson, P. A. 1977. Monitoring the heart during a 24-hour relay. *Running Times* 1: 23-25.
- Davis, P. O., Dotson, C. O. and Santa Maria, D. L. 1977. Physiological requirements of fire fighting. *Medicine and Science in Sports* 9: 71.
- Faria, I. E. 1970. Cardiovascular response to exercise as influenced by various intensities. *Research Quarterly* 41: 44-50.
- Jette, M., Thoden, J. S. and Spence, J. 1976. The energy expenditure of a 5 Km cross-country ski run. *Journal of Sports Medicine and Physical Fitness* 16: 134-137.
- Karvonen, M. J. 1959. Effects of vigorous exercise on the heart. In *Work and the Heart*, eds. F. F. Rosenbaum and E. L. Belnap. Paul B. Hoeber Inc., New York.
- Morris, A. F., Dotson, C., Davis, P. and Santa Maria, D. L. 1977. Heart rate responses during a 5.2 mile cross-country race. Abstracts of Research Papers AAHPER Convention.
- Sharkey, B. J. and Holleman, J. P. 1967. Cardiorespiratory adaptations to training at specified intensities. *Research Quarterly* 38: 272-278.
- Simpson, A. G. and Morris, A. F. 1978. Athletic heart syndrome: some recent observations. (submitted).
- Ulyot, J. 1973. Monitoring a marathoner, *Runner's World* 8: 20-22.
- Van Ganse, W., Versee, L., Eylenbosch, W., Vuylsteck, K. 1970. The electrocardiogram of athletes. *British Heart Journal* 32: 160-165.
- Wilmore, J. H. 1975. The significance of maximal cardiovascular performance. In *Adult Fitness and Cardiac Rehabilitation* ed. P. K. Wilson, University Park Press, Baltimore.
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