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PRE-EXERCISE FOOD AND HEART RATE DURING SUBMAXIMAL EXERCISE

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ABSTRACT

The heart rates of 20 movement studies students were measured during multi-stage cycle ergometer tests. The tests were repeated on five occasions following the ingestion of different pre-exercise meals and the results compared. A glucose solution taken three hours prior to the exercise (G3) resulted in the lowest heart rates at each work rate. The highest heart rates at each work rate were recorded following the ingestion of glucose or protein one hour before the exercise (G1 and P1 respectively). The heart rate values during G3 were on average 10.3 beat.min^{-1} lower than those used during G1 and P1. Intermediate heart rates were obtained with protein taken three hours prior to the exercise or a complete fast for 12 to 14 hours. The results have implications for those attempting to predict maximum oxygen uptake from submaximal heart rates.

Key words: Specific Dynamic Action, Submaximal heart rates, Pre-exercise food.

INTRODUCTION

Experiments conducted on resting individuals have shown that the ingestion of food and even the intravenous injection of nutrients will have a profound effect on the body's metabolic rate and therefore its consumption of oxygen (Brody, 1945; Grisolia and Kennedy, 1966). Proteins, fats, carbohydrates and amino acids all have this effect which is referred to as the Specific Dynamic Action (SDA) of food. Investigations into the SDA of food have shown that the increased oxygen consumption is reflected by an elevated resting heart rate. Whereas the SDA of food has been investigated under resting conditions it has not been studied extensively in exercising individuals. Here it may have significant effects upon the performer who requires maximal oxygen utilisation by the working muscles. The purpose of the study was therefore to investigate the effect of recently ingested food upon submaximal heart rates and suggest the implications, if any, for aerobic fitness testing and aerobic exercise.

MATERIALS AND METHODS

The subjects used in the investigation were 20 Movement Studies students aged between 18 and 26 years. They were selected for their good level of aerobic fitness enabling them to reach the required work rates. This also ensured that the tests undertaken would not produce a significant training effect during the duration of the investigation. Each subject was tested six times over a period of two to five weeks. Subjects were not tested if they had been ill, undertaken exhaustive physical activity or ingested significant amounts of alcohol within 72 hours of the test. They did not participate in any physical activity within 14 hours of the test. Prior to each test the subject was seated for 5 minutes before having their pre-exercise heart rate measured. All tests were carried out on a Monark exercise cycle. Subjects pedalled at 50 rpm and remained at each work rate for 2 minutes with their heart rate being constantly measured using a Tunturi pulse meter. Two minutes was found to be an adequate length of time for the pulse to reach a steady rate. In order to obtain a gradual increase in exercise intensity the female subjects started exercising at approximately 17 watts and went up in increments of approximately 17 watts whilst the male subjects began exercising at 25 watts and went up in increments of 25 watts.

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The pre-exercise dietary regimens were as follows; The first and last tests (F1 and F2) were undertaken following a 12 to 14 hour overnight fast with no food being ingested on the morning of the test. The results of these tests were compared using a paired t-test in order to ascertain whether or not a training effect had occurred during the duration of the investigation. The remaining 4 tests involved a 12 to 14 hour overnight fast followed by the ingestion of food at a set time before the test. The order in which these tests were administered were varied to prevent any significant order effect.

The 4 pre-exercise meals were as follows;

(i) G1: 60g of glucose given in a 20% solution 1 hour before the test,
(ii) G3: 60g of glucose given in a 20% solution 3 hours before the test,
(iii) P1: 20g of protein powder (Sportiv-Perform) given in a 10% solution 1 hour before the test, and
(iv) P3: 20g of protein powder given in a 10% solution 3 hours before the test.

The amounts of glucose and protein used in the investigation were calculated to represent a light pre-exercise meal. The quantity of glucose taken corresponded approximately to the energy value of 4 slices of bread or a 'typical energy drink'. The amount of protein powder ingested corresponded approximately to the number of grams of protein in 100g of meat or fish.

RESULTS

The heart rates recorded prior to the exercise and at three work rates (50, 100 and 150 watts) were analysed to determine whether the pre-exercise meal had any significant effect on submaximal heart rates. For many subjects these workloads represented an easy, moderate and difficult work intensity. This was confirmed by the mean heart rates obtained at each of the work rates (Table I). The mean heart rates obtained during tests F1 and F2 were compared using paired t-tests and showed no significant difference ($p > 0.1$) prior to the exercise or at any of the three work rates. This implied that there had been no significant training effect during the duration of the investigation. Therefore any observed differences in heart rate prior to the exercise or at any of the three work rates could be attributed to the pre-exercise meals rather than altered levels of aerobic fitness. The heart rates obtained from all six tests were then analysed using Analysis of Variance on repeated measures (Cohen and Holliday, 1982). The data collected prior to the exercise and at 50, 100 and 150 watts were analysed separately using four individual analyses. The results showed a highly significant difference ($p < 0.001$) between the heart rate values obtained following different pre-exercise meals. This was significant at all levels of work rate including pre-exercise. The data for each work rate was then analysed further using Least Significant Difference tests. Thus it was possible to determine which of the pre-exercise meals produced significantly different heart rates.

TABLE I

Heart rate (beat.min^{-1}) during submaximal exercise performed in the fasted state (F1, F2) and after ingestion of glucose (G1, G3) or protein (P1, P3). Mean ± 2 SE.

		Work Rate (Watts)		
Meal	**Pre-exercise**	**50**	**100**	**150**
G1	70.0 ± 5.6	103.8 ± 6.0	134.2 ± 9.3	158.9 ± 9.2
P1	68.6 ± 4.5	102.2 ± 7.1	129.4 ± 9.2	156.2 ± 9.1
F1	64.9 ± 4.0	96.5 ± 5.5	127.0 ± 9.3	154.1 ± 9.2
F2	64.6 ± 4.0	95.3 ± 6.0	126.0 ± 8.3	152.6 ± 9.1
P3	64.1 ± 3.7	95.2 ± 4.9	124.5 ± 9.2	152.7 ± 9.9
G3	62.6 ± 4.3	94.4 ± 6.2	122.1 ± 8.0	146.6 ± 9.5

The results showed that;

(i) Prior to the exercise and at 50 watts: The ingestion of pre-exercise meals G1 and P1 produced heart rates that were significantly higher ($p < 0.005$) than those produced by any other pre-exercise meal.

(ii) At 100 watts: Pre-exercise meal G1 produced heart rates that were significantly higher than those produced after the ingestion of P1 ($p < 0.01$) or any of the other pre-exercise meals ($p < 0.005$). Whilst pre-exercise meal P1 produced heart rates that were significantly higher than those obtained after the ingestion of pre-exercise meals G3 ad P3 ($p < 0.01$). Indeed pre-exercise meal G3 produced heart rates that were significantly lower than those obtained following pre-exercise meals P1, G1, F1 and F2 ($p < 0.01$).

(iii) At 150 watts: Pre-exercise meal G1 again produced the highest heart rates, these being significantly higher than those produced by P1 ($p < 0.05$) or any of the other pre-exercise meals ($p < 0.001$). The heart rates produced by P1 were significantly higher than those produced by G3, P3 and F2 ($p < 0.01$). Pre-exercise meal G3 produced heart rates that were significantly lower than those produced by any other pre-exercise meal ($p < 0.001$).

DISCUSSION AND CONCLUSIONS

The results showed that the ingestion of protein or glucose one hour prior to the test significantly elevated the heart rate. This occurred prior to the exercise and at all levels of work rate. Pre-exercise meal G1 consistantly produced the highest heart rates. Conversely, pre-exercise meal G3 produced the lowest heart rates prior to the exercise and at all of the work rates. The difference in heart rates obtained with G3 were statistically significant from P1 and G1 at all intensities, from F1 and F2 at 100 and 150 watts, and from P3 at 150 watts.

The reasons for the elevated heart rate following pre-exercise meals P1 and G1 may be simply explained by the SDA of the food that had been ingested. The results therefore indicate that the SDA of food has a significant effect during exercise as well as at rest.

The difference in heart rates obtained between the two protein meals (P1 and P3) can be explained by assuming that 1 hour after ingestion, the protein powder was still being digested and assimilated, however three hours after ingestion the SDA had passed. A similar explanation could be used for the two glucose meals G1 and G3. However it should be noted that the heart rates obtained with pre-exercise meal G3 were lower than those obtained with F1 and F2, this needs a little further explanation. It is of course arguable that the heart rates recorded during F1 and F2 were higher due to an order effect, they being the first and last tests in the series. However this is considered to be unlikely. The hypothesis put forward by the authors is as follows. The light glucose meal G3 effectively topped up the body's glucose stores. Whereas fasting for 14 hours (F1 and F2) had markedly decreased the body's liver glycogen (Hultman, 1967, 1978 and Hultman and Nilsson, 1971). It is therefore possible that the ingestion of glucose resulted in a slightly more freely available source of glucose for energy production. Since glucose requires less oxygen than fat to produce the same amount of energy this could result in a reduced heart rate. The difference being more pronounced at more intense work rates since the reliance upon glucose as an energy source increases with work rate.

The results here have implications for both the physiologist and the sports performer. For the physiological tester the results are clear. If estimating maximum oxygen uptake from a submaximal assessment, such as a cycle ergometer test (Åstrand and Ryhming, 1954; Fitchett, 1985) or a PWC170 test (Sinning, 1975), a recently ingested meal could affect the estimate by as much as 0.5 litres min^{-1} or 70 watts respectively (unpublished data). However for the sports performer the implications can only be inferred. If the maximum heart rate is unaltered by recently ingested food (this investigation did not seek to measure this parameter) then pre-exercise food could cause the performer to be working closer or further from their maximum heart rate at any given work rate. The implications being that food ingested within an hour of exercise could be detrimental to aerobic performance of an intense nature. Whilst glucose ingested three hours prior to exercise could be beneficial. In this investigation protein was ingested in powder form which is relatively easy to digest. However high protein foods could take longer to digest and therefore their effects may be longer than those measured in this investigation.

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