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Mini Review

High Intensity Exercise: Lessons from the Past, Implications for the Future

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Introduction

The popularity of anaerobic exercise in the management of obesity and physical fitness levels Martin et al. [1] is due to the high intensity nature of the activity and the relatively short time period spent exercising. These activities are also popular with athletes and the general public because participation does not require sophisticated equipment [2]. In addition, the training modality lends itself to large participation numbers, often occurring in groups, that makes performance of high intensity activity more sociably acceptable.

Furthermore, the activity can be undertaken by all ages and genders, in local areas and can be performed either indoors, or in open environments such as parks. Anaerobic work bouts require maximal efforts with different rest recovery ratios.

The work bouts employed can be continuous in nature, requiring maximal effort over a pre-determined distance, or can be intermittent. These work bouts can be designed using periods of intense activity and shorter or longer rest recovery ratios.

The exercises performed may be subject specific and individuals may perform incredibly high intensity levels followed by passive or active recovery periods [3]. These efforts can be performed daily, or two to three times per week, depending on physical activity status and requirements of the individual participants.

Metabolic Considerations

Anaerobic training has gained in popularity over the years, and the training methods employed have resulted in metabolic benefits that include improvement in aerobic as well as anaerobic metabolism. Health benefits have also been observed such as reductions in body fat, and increases in cardio respiratory and cardiovascular fitness.

In spite of the increasing popularity of high intensity training, little research has focused on the dose response required that will illicit maximum benefits for both the high performance athlete, and for individuals who use the methodology for the benefits of fitness and weight management.

Although a new training concept, that has gained popularity, there has been considerable early research looking at the effects of high intensity exercise, and associated health and athletic benefits.

Historical Perspectives

Free running and body weight measures.

The following are studies of high intensity performance that employ experimental protocols involving “free” running procedures.

Houston & Thompson [4] examined the effect of a six week programme of intense, intermittent hill running on five endurance trained men. The exercise regime was performed several times a week for up to six weeks, and consisted of high intensity running, on a long paved hill of 3.3% grade, and a grassy hill of 4.4% grade. Following a low intensity warm up, subjects performed several maximum runs on the 3.3% grade for 60-sec, with 2 minutes of recovery jogging. Five sprints of 6-sec duration up the 4.4% grade, with 24-sec recovery, and 2 maximal runs of 90-sec duration on the 3.3% grade, with 3 minutes of recovery jogging. High intensity capacity was determined using a treadmill run to exhaustion.

Power output was recorded measured using the Margaria step test [5]. Results from the study demonstrated that a high intensity anaerobic running protocol, significantly improved performance during intense runs of 60-sec and 90-sec duration over a 6 week period, interestingly, power output did not change significantly.

Prediction of high intensity capacity employing an optimal exercise stress has been investigated by Thompson [6]. Thompson investigated sprinters, aerobic athletes and individuals with no training status. All were required to “sprint maximally” around a track while speeds and times were being recorded.

The results obtained were then compared with their individual high performance capacities (determined by treadmill sprinting in the laboratory) and this made it possible to develop a test for predicting high intensity energy release. The results showed that

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sprinting time to 256 metres, provided the highest prediction of "sprint" capacity ($P<0.05$).

Beckenholdt and Mayhew, (1983) compared specificity among power tests in male athletes. Subjects performed a specific test order comprising of the vertical jump (VJ), standing broad jump (SBJ) and Margaria-Kalamen (MK) test. Because of the potential fatigue factor induced by the 40 metre dash, it was always administered last. Factor analysis on the tests, isolated two power components, one associated with mass, the other related to speed. The VJ, SBJ and 40 metre dash were found to be linked with the speed factor. While the MK and VJ power tests were associated with the mass component. (The VJ was found to be common with both speed and mass). The study concluded that power tests cannot be used interchangeably when evaluating subjects.

Equipment based evaluation

High intensity performance has been evaluated by Patton & Duggan [7]. The main aim of the experiment was to investigate any relationships between a 30sec cycle test, a 60-sec isokinetic knee test (isokinetic endurance), a 50 metre sprint, a 200 metre sprint and the Margaria stair-climb test. Correlations, (ranging from $r = 0.52$, $P<0.05$ to $r = 0.79$, $P<0.05$) were noted between the Wingate test and isokinetic knee extensions, for peak and mean values of power and torque respectively. Indices from both these tests also correlated significantly with the other tests of high intensity performance ($P<0.05$).

The best single index was mean power output from the Wingate test, which had correlations of $r = 0.79$, $P<0.05$; $r = -0.82$, $P<0.05$ and $r = 0.74$, $P<0.05$ with the 50 metre sprint, 200 metre run, and Margaria test, respectively.

The relationships found between mean power output and running performance were in contrast to a study by Manning et al. [8] who investigated various high intensity performance tests. The tests evaluated were, the vertical jump, Margaria-Kalamen test, Wingate power and capacity test, Cybex isokinetic knee extension test, standing long jump and the 40 metre dash. The results showed that there was no single power test that could be used to measure power compared with the maximum oxygen uptake test which measures "aerobic power".

Factor analysis, when applied to both the field and laboratory tests, revealed that unrelated aspects of performance exists among all the tests studied, and that they were measuring different aspects of high intensity energy release.

Treadmill tests

Hermansen & Medbo [9] used a motorised treadmill to determine the significance of aerobic and glycolytic metabolism during short periods of maximal exercise. Prior to testining, preliminary experiments were performed, including measurement of aerobic capacity, and selection the highest possible speeds that subjects could run.

Subjects warmed up for ten minutes at a speed corresponding to 50% of their $\dot{V}$ O2 max. After warm up, subjects rested for 15 minutes and blood samples were taken immediately prior to the 60-sec maximal exercise period. Expired gas was collected during the entire maximal exercise bout. On the basis of results obtained, it was suggested that maximal oxygen deficit could be used as a measurement of high intensity capacity in exercising man.

Medbo & Burgers [10] investigated the effect of a training programme on the high intensity capacity of non trainied, aerobically trained and anaerobically trained males. In addition, seven women and five men trained for six weeks and their high intensity abilities were compared before and after the training period. There was no change observed in performance capacity between the untrained and the endurance trained subjects, whereas the sprinters capacity was 30% larger presumably as a result of high intensity training. The female performance capacity was 17% less than the males. The training regime of six weeks increased the anaerobic capacity by 10%. A relationship was also observed between performance capacity and peak rate of high intensity energy release. The conclusion of the study was that high intensity performance varies significantly between subjects of different gender and specific training status.

Volkov et al. [11] used a motorised treadmill to determine high intensity metabolism. Testing consisted of increasing running speed every 3 minutes from a level of 2.5m.s-1 to maximal running, through increments of 1m.s-1.

Via measurement of expired CO2 at varying loads, they found that it was possible identify running intensities that reflected aerobic metabolism thresholds, characterised by increases in arterial blood lactate. High intensity power and capacity were monitored by Sawka et al. [12]. Forty four subjects ran to exhaustion on a motor driven treadmill for 3 to 5 minutes with measurement of the 2 minutes recovery O2 uptake, to estimate the glycolytic portion of the oxygen debt.

The findings of the study suggested that the glycolytic portion of the measured oxygen debt, was related to skeletal muscle phosphagen concentration, and that high intensity capacity was related to phosphagen splitting rate.

A study by Thompson & Garvie [13] determined high intensity energy expenditure during sprinting. Subjects sprinted on a motor driven treadmill elevated to a 5% grade. Individual running speeds were selected on the basis that the subject could only sprint 60 to 70 seconds before reaching exhaustion.

There after the following protocols were administered:

a. A continuous sprint to exhaustion was performed 3 to 5times.

b. All sprints were performed with two days rest in between.

c. Pre-exercise O_2 uptake and total O_2 consumed during each sprint were measured.

Over the following 2 week period, each subject then performed four separate sprints of 15sec, 30sec, 45sec and 60sec duration.

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The progressive lengthening of the sprint intervals permitted the segregation and subsequently the independent measurement of two high intensity energy sources, ATP and glycolysis. It was found that the methodology used provided a protocol for the assessment of high intensity metabolism during short term intensive work.

Fujitsuka et al. [14] used maximal treadmill sprinting to determine peak blood lactate levels. Maximal exercise was completed on a running machine at a specified inclination (8.6%).

The running speed was based on previous experimentation to ensure that all subjects could perform for 1min before exhaustion. Various seeds were used and ranged from 4.5 -5m.s^{-1}. Blood samples were taken pre and post exercise for the determination of blod lactate. It was found that peak blood lactate levels occurred around 9 minutes after cessation of exercise.

High intensity performance capacity in runners was studied by Schnabel & Kindermann [15]. A total of 55 male runners participated in the study. The runners were assigned to five groups depending on their aerobic ability. All subjects performed three runs on running machine. The initial run was a test to determine aerobic power ($\dot{V}$ O_2 max). The other two were constant load tests to determine glycolytic capacity. The treadmill was set at a constant slope of 5%. The initial speed was 1.67m.s^{-1} and was increased every 3 minutes by 0.55m.s^{-1} until volitional exhaustion. The constant load tests were performed at 6.11m.s^{-1} with a 7.5% inclination.

The treadmill was accelerated from 0 to 6.11m.s^{-1} within 10sec. In the first test the run was interrupted after 40-sec, including the 10-sec acceleration phase. After 45sec rest the test was performed again. It was concluded that running time was a function of high intensity capacity.

Conclusion

Although gaining in popularity, there has been much early research relating to the benefits of high intensity exercise. Training modalities studied range from brisk walking, to maximal sprints with pre determined activity and recovery ratios.

Anaerobic training is a training method which needs maximum effort to gain benefit from the activity. The effort required is related to rest recovery ratios that aid in the development of anaerobic capacity and power. The recovery period must ensure that the muscle is fully recovered prior to the next maximal effort.

Anaerobic activity elevates the heart rate and potentially metabolises greater fat deposits while increasing lean tissue mass. Aaerobic metabolism increases the bodys need for oxygen post exercise and the demand is greater that observed following aerobic metabolism. The post exercise effect is referred to as the Excess Post-Exercise Oxygen Consumption (EPOC).

This elevated level of oxygen consumption, post activity is one of the reasons why the fat burning mechanism of anaerobic activity is more effective that aerobic activity in relation to time spent performing the exercise task Buchan et al. [16].

High intensity anaerobic exercise has gained much popularity in recent years, early experimentation provided us with the initial results and methodologies that enabled further development of the high intensity protocols that are used today. The method has now gained massive poularity in relation to fitness benefits, but is also now being used in the management and understanding of obesity, cardiovascular disease, diabetes and associated co morbidities [17].

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