Muscle Glycogen Resynthesis after Short Term, High Intensity Exercise and Resistance Exercise

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Summary

Typical rates of muscle glycogen resynthesis after short term, high intensity exercise (15.1 to 33.6 mmol/kg/h) are much higher than glycogen resynthesis rates following prolonged exercise (=2 mmol/kg/h), even when optimal amounts of oral carbohydrate are supplied (=8 mmol/kg/h). Several factors differ during post-exercise recovery from short term, high intensity exercise compared with prolonged exercise. The extremely fast rate of muscle glycogen resynthesis following short term, high intensity exercise may originate from these differences.

First, peak blood glucose levels range from 6.6 to 8.9 mmol/L during recovery from short term, high intensity exercise. This is markedly higher than the blood glucose values of 2 to 3.4 mmol/L after prolonged exercise. In response to this elevation in plasma glucose levels, insulin levels increase to ~60 μU/ml, a 2-fold increase over resting values. Both glucose and insulin regulate glycogen synthase...
activity, and higher levels of them improve muscle glycogen synthesis. Secondly, high intensity exercise produces high levels of glycolytic intermediates in muscle, as well as high lactate levels ([La]) in muscle and blood. Finally, fast-twitch glycolytic muscle fibres are more heavily used in short term, high intensity exercise. This promotes greater glycogen depletion in the fast-twitch fibres, which have a higher level of glycogen synthase activity than slow-twitch fibres.

While the exact contribution of each of these factors is unknown, they may act in combination to stimulate rapid muscle glycogen resynthesis rates. Muscle glycogen resynthesis rates following resistance exercise (1.3 to 11.1 mmol/kg/h) are slower than the rates observed after short term, high intensity exercise. This may be caused by slightly lower muscle and blood [La] after resistance exercise. In addition, a greater eccentric component in the resistance exercise may cause some interference with glycogen resynthesis.

1. Overview

There have been numerous studies of muscle glycogen repletion following prolonged exercise.1-4 Typically, the exercise intensity in such studies has been described as ‘severe’,1,4 ‘prolonged strenuous’,5,6 and/or ‘exhaustive’1,3 The duration of the exercise in these studies has usually been 20 minutes or more,1 sometimes exceeding 3 hours.1,2,6 The exercise intensity was 70 to 85% of maximum oxygen uptake (VO2max). Exercise of this intensity and duration is quite different from short term, high intensity exercise and resistance exercise.

Short term, high intensity exercise is defined here as exercise in which the muscle contractions are performed at a high frequency (one contraction per second, or faster) with the resistance set so that fatigue occurs in 6 minutes or less. When short term, high intensity exercise is performed using large muscle groups, it requires a whole-body energy expenditure which equals or exceeds 100% of VO2max.

Resistance exercise is defined here as resistive weightlifting tasks in which the contraction frequency is low (e.g. 1 contraction per 3 seconds) and the resistance is high [typically 70% of 1 repetition maximum (RM) or more]. Resistance exercise workloads are commonly reported as a percentage of 1 to 3 RMs and usually do not elicit whole-body metabolic rates which reach or exceed 100% of VO2max.

Short term, high intensity exercise and resistance exercise are also distinguishable on the basis of post-exercise lactate levels ([La]) in muscle and blood, which are considerably higher following short term, high intensity exercise. In addition, weight-resistive exercise has a reduced activation period (sets, repetitions and recovery), is based upon maximal contractile force (percentage of RM) rather than whole-body metabolic rate (percentage of VO2max), contains a sizable eccentric component, and typically uses a smaller mass of muscle. These physiological differences may explain the lower rates of muscle glycogen resynthesis observed after high intensity, weight-resistive exercise, compared with other forms of high intensity exercise. Glycogen repletion following resistance exercise is discussed in section 8 of this review.

While there has been a great deal of study of glycogen repletion following prolonged exercise,1-6 there have been relatively few investigations of glycogen repletion following short term, high intensity exercise. This can be largely attributed to 3 factors. Firstly, the total fuel contribution of muscle glycogen to high intensity exercise of short duration is often considered 'moderate' when compared with the glycogen depletion resulting from prolonged exercise. Secondly, it was once thought that short term, high intensity exercise was