Chapter I Introduction

Many athletes, as well as the general population, seek to reduce their body weight. Wrestlers must "make weight" prior to a competition. Runners want to reduce the energy cost of running. Since the sport of body building focuses on appearance, great emphasize is placed on reducing body fat prior to competition. When preparing for competition they may eat 50-60% less calories than bodybuilders who aren't preparing for competition (Rankin 1995).

Rapid weight loss may be detrimental to these athletes. Bodybuilders who lost an average of 7.3 kg during the 12 weeks before competition experienced a significant decrease in maximal isokinetic force in the dead-lift (Bamman et al. 1993). Short term energy restriction can also result in decreased performance. After three days of energy restriction (18 kcal kg^{-1} day^{-1}) that resulted in an average weight loss of 2.4 kg $\pm$ 1.0, wrestlers had significantly lower anaerobic performance than before dieting (Walberg-Rankin et al. 1996).

Some researchers have linked a decrease in performance after energy restriction with a decrease in muscle glycogen. Housten et al. (1981) reported that a decrease in muscle strength following short-term weight loss was concurrent with a significant reduction in muscle glycogen. Since muscle glycogen is a fuel used during resistance exercise (Tesch et al. 1986, MacDougal et al. 1988), reduced muscle glycogen due to energy restriction may cause premature fatigue.

An additional problem that athletes may experience after energy restriction is an increase in cortisol levels. Cortisol levels in healthy men have been shown to significantly increase during fasting (Beer et al. 1989, Comeron et al. 1991, Veldhuis et al. 1993, Bergendahl et al. 1996). This increase in cortisol may be a concern for resistance trainers because cortisol causes the mobilization of amino acids from muscle to the liver to be used in gluconeogenesis (the formation of glucose from amino acids). Cortisol causes a reduction in body proteins in all cells throughout the body except the liver. This is due to a decrease in protein synthesis and increase in protein catabolism. This is in direct opposition of the goals of resistance training to increase muscle mass and strength.

Additionally, resistance exercise has been reported to increase cortisol levels (Kraemer et al. 1987, Kraemer et al. 1993, McMillian et al. 1993) and muscle damage as indicated by an increase in creatine kinase (Paul et al. 1989, Hurley et al. 1995, Tiidus and Ianuzzo 1983). Kraemer et al. (1993) reported that the rise in cortisol 5 minutes after exercise was significantly correlated to the increase in creatine kinase (CK) 24 hours after exercise. An increase in muscle damage is also in direct opposition to the goals of resistance training.

Body builders are also prone to use supplements. Fifty-nine percent of 309 body builders surveyed reported spending $25-100 a month on supplements (Brill et al. 1994). Seventy percent said they took supplements "to meet the extra demands of heavy training." Almost 54% reported using supplements to improve training performance. For products taken at least once a week, protein powder was most frequently used, with 57.5% reporting using it. Thirty-one percent reported using carbohydrate loading drinks at least once a week.

It is well known that carbohydrate supplements improve aerobic performance. Numerous studies have shown that carbohydrate ingestion delays fatigue during endurance exercise. Mechanisms suggested to explain the ergogenic effect of carbohydrate include maintenance of blood glucose permitting high rates of carbohydrate oxidation (Coggan and Coyle 1991) and muscle glycogen sparing (Hargreaves et al. 1984). Carbohydrate supplementation prior to aerobic exercise reduces markers associated with protein catabolism (Anderson et al. 1991, Deuster et al. 1992, Mitchell et al. 1990) and muscle membrane breakdown (Cade et al. 1991) and reduces Rates of Perceived Exertion during exercise (Burgess et al. 1991). If the same positive results occur during resistance training this would especially benefit those undergoing energy restriction.

<u>Statement of the Problem</u>

The value of carbohydrate consumption before resistance training is equivocal (Conley and Stone 1996). Lambert et al. (1991) studied the effects of consuming a glucose polymer solution versus a placebo before and during knee extension exercises for subjects who were in energy balance. Performance, as measured as number of sets and total work done to exhaustion tended to improve in the carbohydrate condition ($p=0.067$ for sets and $p=0.056$ for repetitions). On the other hand, Conley et al. (1995) did not observe an increase in performance when carbohydrate was ingested during multiple sets of parallel squats at 65% of 1 RM.

Carbohydrate supplementation may be of more benefit for performance when the athlete is in a negative energy balance. There is evidence that athletes who reduce their caloric intake have reduced muscle glycogen (Housten et al. 1981) and performance (Walberg et al. 1988, Housten et al. 1981). Ingesting a carbohydrate beverage prior to resistance exercise may increase blood glucose availability and improve performance if muscle glycogen becomes limiting. The purpose of this study is to investigate if carbohydrate supplementation prior to resistance exercise allows more total work to be done, reduces cortisol and creatine kinase levels, and lowers rates of perceived exertion for male subjects undergoing energy restriction. This will have implications for athletes who want to decrease body weight and still maintain high quality workouts and performance.

<u>Research Hypothesis</u>

Ho: A carbohydrate (1g/kg) drink ingested 30 minutes prior to exercise had no effect compared to consumption of a placebo drink on the number of bench press repetitions done during the middle of a resistance training workout or the number of knee extension repetitions done at the end of a resistance training workout for male subjects who consumed 18kcal/kg/d for 3 days.

Ho: A carbohydrate (1g/kg) drink ingested 30 minutes prior to exercise will have no effect compared to consumption of a placebo drink on plasma cortisol and creatine kinase levels for male subjects who consumed 18kcal/kg/d for 3 days.

Ho: Three days of energy restriction (18 kcal/kg/d) will not affect the number of bench press repetitions done during the middle of a resistance training workout or the number of knee extension repetitions done at the end of a resistance training workout.

Ho: Three days of energy restriction (18 kcal/kg/d) will not affect fasting cortisol levels.

<u>Significance of the Study</u>

Athletes often suffer through periods of low energy intake hoping to reduce body weight and fat. This often has negative consequences such as a decrease in performance (Bamman et al. 1993, Housten et al. 1981, Walberg et al. 1988) and lower muscle glycogen levels (Housten et al. 1981).

Resistance trainers often seek erogenic aids to help them improve their physique and performance. Carbohydrate beverages are often marketed to increase the amount of work done in the weight room. There is little evidence to support this claim. It is not know if the positive effects seen during endurance exercise occur during resistance exercise also.

<u>Delimitations</u>

The following delimitations were made:

1. The subjects were trained, healthy male bodybuilders ages 18-26 who agreed to forego all supplements two weeks prior to and during the study.
2. The exercises used for the resistance training program were free weight squats, barbell bench press, and machines for leg press and leg extension.
3. Diet of the subjects was prescribed on the days of blood sampling in order to minimize in order to minimize effects of diet on the dependent measures. The individual calories were based on 3 day diet records completed by the subjects.
4. The hypoenergy diet was a formula diet (Ensure, Ross Laboratories) consisting of 18 kcal/kg per day for 3 days and 54.7% carbohydrate, 21.3% protein, and 24% fat.
5. The independent variables were a carbohydrate beverage (1g/kg of body weight) for the carbohydrate group and an artificially sweetened beverage for the placebo group. The control group did not undergo energy restriction or receive a beverage prior to the last performance test.
6. The dependent criterion measures were: plasma cortisol, creatine kinase, and glucose (carbohydrate and placebo group), number of repetitions during the 5th sets of bench press and leg extensions delimited to 10% of 10RM before and after energy restriction (all three groups).

<u>Limitations</u>

The following limitations of the study were noted:

1. The resistance workout may have differed from what the subjects were accustomed to doing. The baseline period may not have been long enough to completely familiarize the subjects with the workout. Some learning effect may have been occurring even at the end of the study.
2. Subjects were not continuously monitored to see if they were stringently adhering to the study's dietary and resistance training guidelines.
3. The short length of energy restriction (3 days) may not produce the same effects as longer periods of dieting that many athletes endure.

4. Results are limited to a formula diet of 18 kcal kg^{-1} day^{-1} and consisting of 54.7% carbohydrate, 21.3% protein, and 24% fat.
5. The control group was not randomly assigned.
6. RPE values may be limited by the fact subjects overheard each other report RPEs.
7. Results of the study are limited to the carbohydrate beverage utilized (Gatorade) at the dosage of 1 gram of carbohydrate per kilogram of body weight.

Definitions and Symbols

The following definitions and symbols will be utilized:

1. Resistance Trainer: Subjects who engaged in weight training for at least one hour 3-5 times a week for at least one year.
2. Exchange Diet: Diet that was grouped by portion size and nutrient content. It was prescribed for the days before and after energy restriction. The calorie content was based on 3 day diet records that were completed by the subjects. The exchange diet consisted of foods that the subjects reported eating, but the quantities were modified to provide approximately 60% carbohydrate, 15-20% protein, and 25% fat.
3. Hypoenergy Diet: A formula diet (Ensure, Ross laboratories) of 18 kcal kg^{-1} day^{-1} consisting of 54.7% carbohydrate, 21.3% protein, and 24% fat provided for 3 days.
4. Ten Repetition Maximum (10 RM): The maximum amount of weight that can be lifted for ten repetitions.
5. Resistance Performance Test: The performance test consisted on 5 sets of squats, bench press, leg press, and leg extension. The resistance of the sets within an exercise was 80%, 80% 70%, 60%, and 60% of 10RM. For each set, subjects performed 10 repetitions. Subjects rested 2 minutes between sets. The 5^{th} sets of bench press and leg extension were done until failure at 80% of 10RM. These were the dependent performance measures
6. Carbohydrate Group (C): The group of subjects (n=8) who received a carbohydrate beverage (1g/kg) 30 minutes prior to beginning their finale resistance performance test.
7. Placebo Group (P): The group of subjects (n=8) who received a NutraSweet flavored beverage 30 minutes prior to beginning their finale resistance performance test.
8. Control Group (N): The group of subjects (n=6) who followed the same exercise prescription as the other two groups and participated in the resistance performance tests. They did not receive the carbohydrate or placebo beverage. Additionally, this group did not undergo energy restriction or blood draws. The main purpose of this group was to control for effects of repeated testing on the resistance performance tests.

Basic Assumptions

The following basic assumptions were made:

1. It was assumed that all subjects stopped taking nutritional supplements two weeks prior to the start of the study.
2. It was assumed that all subjects had taken no anabolic steroids at least 1 year prior to and during the study.

3. It was assumed that all subjects gave a maximum effort for the resistance performance test.
4. It was assumed that all subjects adhered to the prescribed diets and workouts for the duration of the study.

Summary

Energy restriction may cause several problems for resistance trainers. A decrease in muscle glycogen following energy restriction may be problematic for resistance trainers since muscle glycogen is utilized during resistance workouts. Lower muscle glycogen prior to resistance exercise may result in decreased performance. If carbohydrate supplementation allows some muscle glycogen to be synthesized prior to the workout, there would be more fuel to be utilized during resistance training. Also, the increase in blood glucose following carbohydrate ingestion may spare muscle glycogen.

Separate studies examining fasting and resistance training have reported increases in cortisol levels. Energy restriction combined with resistance exercise may cause even greater increases in cortisol levels. The increase in blood glucose following carbohydrate ingestion may prevent the need for gluconeogenesis therefore reducing the release of cortisol. If less cortisol is released, perhaps there will be less muscle damage as indicated by a lower CK response to resistance exercise.

Consuming a carbohydrate beverage prior to endurance exercise results in lower rates of perceived exertion (Burgess et al. 1991). The same benefit may be seen during resistance training.

The benefits observed during aerobic exercise that are mentioned above have not been examined in subjects that are undergoing energy restriction and engaging in resistance training. Thus, the objective of this study is to exam the effects of a carbohydrate beverage consumed prior to resistance exercise for males in a negative energy balance. This will have implications for resistance trainers who are trying to loose weight but want to maintain high quality workouts and performance.