CHANGES IN RESTING METABOLIC RATE AND DIETARY INTAKE AMONG HIGH SCHOOL WRESTLERS FROM PRE-SEASON TO POST-SEASON

By

LAUREN KAYE BRADLEY

Bachelor of Science in Nutritional Sciences

Oklahoma State University

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CHANGES IN RESTING METABOLIC RATE AND

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SCHOOL WRESTLERS FROM

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Thesis Approved:

Dr. Lenka H. Shriver

Thesis Adviser

Dr. Nancy Betts

Dr. Doug Smith

Dr. A. Gordon Emslie

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Wresting is a sport with its existence dating back to the first ancient Olympics (Horswill, 1992). It continues to attract numerous competitors of all ages and can be found in over 9,500 high schools today (National Federation of State High School Associations, 2007). The sport requires speed, agility, power, strength and stamina, therefore requiring the athlete to be in top physical and mental condition in order to be successful. Wrestling is one of the few sports where competitors are required to weigh in and perform at a certain body weight in order to compete. The purpose of assigning weight classes in wrestling is to allow wrestlers of different sizes and shapes to compete fairly, and to decrease injuries that could potentially occur from wrestlers being paired against someone larger or smaller than themselves (Horswill, 1993; National Federation of State High School Associations, 2007). It is well known that wrestlers often compete in weight classes much lower than their normal body weight to gain a competitive advantage. To maintain an extremely low body weight wrestlers engage in behaviors such as fasting, food and fluid restriction, diet manipulation, spitting, diuretic use, and excessive exercise (Horswill, 1993; Kiningham & Gorenflo, 2001)

Studies are starting to find that continual weight restriction and patterns of weight loss and gain affect multiple components of the body, and the overall health of the

athlete. Decreased muscle strength and recovery (Roemmich & Sinning, 1997), decreased kidney function, altered plasma and blood volumes, electrolyte imbalance, and the possibility of heart disease and obesity in the future are all areas of concern for athletes partaking in extreme weight loss practices (McCargar & Crawford, 1992). The effects of weight loss that attract the most attention are related to alterations in metabolic rate, and nutrient intake.

Previous research has conflicting opinions as to the affect weight loss and cycles of weight loss and regain have on a wrestler's metabolic rate. Some studies have found that repeated weight loss was associated with a lowered metabolic rate (Steen, Oppliger, & Brownell, 1988). Others have shown no significant change in metabolic rate over the course of a wrestling season (McCargar & Crawford, 1992; Melby, Schmidt, & Corrigan, 1990). It is important to note that little research is available examining adolescent wrestlers, and most studies examined took place at a collegiate institution, or had surveys mailed out to former collegiate athletes. Due to the fact that adolescents are going through periods of growth and development, and metabolism playing a large role in weight management efforts, it is important that more research examine if weight loss and the activities wrestler's partake in such as diet restriction, influence their metabolic rate.

With wrestling being such a physically demanding sport, it is necessary that the athletes, particularly adolescent athletes, replenish their energy stores daily to ensure proper growth, muscle repair, and make up for losses due to training and competition. Failure to do so can result in energy conservation efforts, making it difficult to lose weight, decreased glycogen stores and synthesis, and decreased power and strength (Brownell, Steen, & Wilmore, 1987; Horswill, 1992; Roemmich & Sinning, 1997).

Repeated calorie restriction has also been suggested to predispose wrestlers to the development of eating disorders either during their wrestling career or later in life (Lakin, Steen, & Oppliger, 1990). Nutritional knowledge of wrestlers appears to be minimal with most getting their information from coaches and parents, instead of a qualified individual such as a physician or dietitian (Kiningham & Gorenflo, 2001). Very few studies have been done examining the composition of a wrestler's diet, and the studies that have been done have shown that wrestler's diets are not adequate to meet their high energy needs (Horswill, 1992; Short & Short, 1983; Steen et al., 1988).

Significance of the Study

Some research has examined the effects of weight cycling and dieting on metabolic rate, but minimal knowledge is available specifically concerning adolescent athletes who are still growing and developing. Most research focuses on collegiate wrestlers. There are possibilities and speculation that weight cycling and dieting over a long period of time can alter metabolic rate making it difficult to lose and maintain weight in the future, as well as changing the way your body uses its energy sources (Brownell et al., 1987; Melby et al., 1990). Specifically, dietary restriction may have negative impacts on strength performance, glycogen synthesis, and future eating behaviors possibly leading to eating disorders (Horswill, 1992; Roemmich & Sinning, 1997). Information about what wrestlers are consuming throughout the wrestling season is minimal, and it is critical to figure out what nutritional needs are being met and where deficiencies exist so adolescent wrestlers can stay healthy while still competing to the

best of their ability. Thus, the purpose of this study was to describe and evaluate changes in resting metabolic rate and dietary intake that occur in a sample of high school wrestlers throughout the course of a year from pre-season to in-season and post-season.

Objectives of the Study

1. To compare resting metabolic rate within each wrestler from pre-season to in-season to post-season.
2. Evaluate the wrestlers' dietary intake in terms of total calories, calories coming from carbohydrate, calories coming from fat, and calories coming from protein.

Limitations of the Study

1. Due to the use of a convenience sample, results may not accurately represent a larger population of wrestlers, decreasing the extent to which the results can be generalized.
2. Multiple wrestlers dropped out before the study's completion and one wrestler joined the study after it had begun, providing the researcher with an incomplete data set
3. The sample size was small, consisting of 25 high-school wrestlers. Having a small sample size limits the ability to generalize and extrapolate results to the general population.
4. Dietary information collected from the 24-hour recall was not specific enough in some cases (i.e., food preparation techniques, additional condiments) which may have potentially affected the accuracy of the results.

Definition of Terms

Adolescence**:** Growth and development occurring from age 13 through 20, although no physiological characteristics define a specific end point of adolescence (Driskell & Wolinsky, 2002).

Body Mass Index: An expression of the association between an individual's weight and stature. It is found using the ratio of weight (kilograms) to height (meters squared) (Driskell & Wolinsky, 2002).

Energy Efficiency**:** Ratio of weight change to ingested calories.(Brownell et al., 1987)

Indirect Calorimetry**:** A method for measuring energy expenditure. Oxygen is required for energy production so in this method oxygen uptake is measured and energy production is estimated through mathematical conversions (Driskell & Wolinsky, 2002).

Lean Body Mass: The amount of metabolically active tissue present in the body (Driskell & Wolinsky, 2002).

Multiple Pass 24-Hour Recall: A multiple stage dietary recall. The interviewer first asks respondents to recall all beverages and foods consumed throughout the previous 24 hours. Then respondents are asked by the interviewer to clarify and also elaborate upon

some of the reported food and beverages. The interviewer also aids the subject in recalling any additional items that may have been overlooked such as snacks. Finally the respondents are asked specific questions to find out what kind of cooking methods were used as well as any additional condiments or ingredients the subject may have had trouble remembering (United States Department of Agriculture, 1998).

Resting Metabolic Rate (RMR) or Resting Energy Expenditure (REE**):** This is the minimal energy necessary to maintain normal body functions in a resting state. Two thirds of the bodies daily energy expenditure is accounted for with the REE (Driskell & Wolinsky, 2002).

Respiratory Quotient: The ratio of carbon dioxide production to oxygen consumption. RQ reveals the macronutrient being used for energy production. Carbohydrate has an RQ of 1.0, and fat has a RQ of 0.7 (Driskell & Wolinsky, 2002).

Thermic Effect of Food: Energy required for the processes of digestion, absorption, and the creation of new substrates after eating (Driskell & Wolinsky, 2002).

Thermic Effect of Physical Activity: Energy required and expended for exercise and activities beyond what is required for activities of daily living (Driskell & Wolinsky, 2002).

Abbreviations

AAP- American Academy of Pediatrics

AMDR- Acceptable Macronutrient Distribution Range

ATP-Adenosine Triphosphate

BMI- Body Mass Index

DRI- Dietary Reference Intake

Kcal- Kilocalorie

NWCA- National Wrestling Coaches Association

OSSAA- Oklahoma Secondary School Activities Association

PC- Phosphocreatine

REE- Resting Energy Expenditure

RMR- Resting Metabolic Rate

RQ- Respiratory Quotient

CHAPTER II

REVIEW OF LITERATURE

History and Characteristics of the Sport of Wrestling

Wrestling is a sport that can be traced back thousands of years, with signs of its existence seen on tomb walls of the Chinese, and in books containing ancient hieroglyphics (Horswill, 1992). Best known as one of the first events in the ancient Olympics, wrestling today still resembles that of the Greeks and Romans and can be found in almost every country and culture around the globe (Horswill, 1992). Although new styles and scoring systems have developed over time, the ultimate goal of the competition remains the same, and that is to takedown or establish physical control over the opponent (Horswill, 1992). In the United States, approximately 9,500 high schools have a wrestling program and it is the sixth most popular sport among high school boys (National Federation of State High School Associations, 2007). Power, strength, and endurance all are traits required for a wrestler to meet the demands of competition. Wrestling matches are not particularly long, but require continuous small, rapid, and explosive movements, exhausting both the aerobic and anaerobic energy systems (Utter, O'Bryant, Haff, & Trone, 2002). Aerobic endurance allows the wrestler to continue through the duration of the match (Utter et al., 2002), and

possibly multiple matches within a single day depending on the setting of the competition (Kraemer et al., 2001). Anaerobic energy provides the wrestler the necessary power for sudden, forceful, quick activities (Utter et al., 2002). Training for this type of competition, which requires upper and lower body strength and endurance, can have various effects on body weight. Aerobic training tends to decrease body weight, and reduce body fat through long periods of exhaustive energy expenditure. Lifting weights for power and force tends to increase lean tissue, increase muscle size, and possibly increase body weight (Horswill, 1992). When wrestlers attempt to lose weight for competition over a short period of time, they can negate their attempts to increase their lean body mass (Horswill, 1992).

In order to decrease injuries and allow athletes of various sizes and abilities to compete on levels that are fairly equal (Horswill, 1993), state and local associations have established weight classes that usually vary from 103 pounds to 285 pounds (National Federation of State High School Associations, 2007). Wrestlers are required to weigh-in within a specific time frame before their wrestling match to make sure they are at their assigned weight, and not above, otherwise they are not able to compete (Horswill, 1993). Ideally, wrestlers would compete at their natural weight, but many athletes choose to wrestle at a weight class below their normal body weight in order to have the advantage of power, bulk, and strength over their opponent. Moreover, many wrestlers hope that their opponent has not done the same so they have a competitive edge over them (Horswill, 1993).

Weight loss and wrestling have become somewhat synonymous with wrestlers trying to reduce body fat and body weight, while losing lean muscle and not even being

aware of it (Horswill, 1992). The belief of some coaches and wrestlers is that reducing weight and competing in a lower weight class is required in order to be successful (Horswill, 1992). Not all wrestlers try to lose weight, and the extent to which wrestlers go to control their body composition and weight differ from one wrestler to the next (Horswill, 1993). Because weight loss has become such a prevalent issue in the sport, state school associations and national committees have been making rule changes to help combat against weight loss practices (Ransone & Hughes, 2004). Some of these rules adopted by the National Collegiate Athletic Association Wrestling Committee and the Safeguards and Medical Aspects of Sports Committee include establishing weight classes in the first week of December for wrestlers to compete in over the duration of the season; requiring weigh-ins on every day of tournaments that span more than one day; eliminating sweat suits, steam rooms, and saunas as a way of reducing weight; requiring weigh-ins to take place one hour before each match; and increasing the weight of each current weight class by six pounds (Ransone & Hughes, 2004).

Weight Cutting and Weight Cycling

"Weight cutting" refers to the practice of drastic weight reduction in order to gain some competitive advantage over the opponent, as well as to meet the required weight limit for the weight class wrestlers compete in (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). Weight cycling is similar to cutting weight in that it consists of losing weight rapidly (Horswill, 1993). A wrestler usually has a period of weight loss before competition followed by a period of weight gain post weigh

in or post competition. The athlete tries to recover from the previous weight loss period through activities such as rehydration and energy intake. This cycle of weight loss and weight gain can happen over a short period of time during a competitive season as well as long term throughout a wrestler's career which is also why it is referred to as weight cycling (Horswill, 1993). In a study done by Nitzke, Voichick and Olsen (1992), the researchers surveyed 60 former college wrestlers and more than half of them reported "almost always" losing weight before wrestling matches in order to qualify for their weight class. The wrestlers also indicated that the greatest amount of weight they lost in a one week time period was a range from 4 to 30 pounds with the mean being 13.2 pounds.

Another survey study was done by Steen and Brownell (1990). The researchers administered a questionnaire to 63 current collegiate wrestlers and 368 current high school wrestlers. The results indicated that on average, wrestlers started cutting weight for wrestling at the age of 14, including both high school and collegiate athletes. At any one point during the wrestling season, the mean for the largest amount of weight lost was approximately 16 pounds for college wrestlers and approximately 12 pounds for high school wrestlers. During the wrestling season, high school wrestlers' weight cycled an average of 8.8 times while college wrestlers' averaged 15 times (Steen & Brownell, 1990). In post-season, all the college wrestlers gained weight, while only 87% of the high school wrestlers gained their weight back (Steen & Brownell, 1990). What seems alarming is that 89% of college wrestlers and 68% of high school wrestlers had to lose weight in order compete in their appropriate weight class, and college wrestlers had to lose an average of 9.7 pounds in 3 days while high school wrestlers had to lose an

average of 7.3 pounds in 4.5 days in order to meet the appropriate weight (Steen & Brownell, 1990).

The high prevalence of weight cycling among wrestlers is apparent from several studies. According to Steen & Brownell (1990), 35% of the college wrestlers engage in weight cycling over 100 times in their competitive lives, and 22% lose and gain weight between 21 and 50 times over their competitive lifetime. Similarly, 18% of high school wrestlers engage in weight cycling anywhere between 6 and 10 times during their competitive lives (Steen & Brownell, 1990).

Weight Loss Approaches among Wrestlers and Their Consequences

In order to lose weight, wrestlers partake in a variety of unhealthy weight loss techniques in order to shed pounds for competition. Some common methods used to lose weight include fluid restriction, use of diuretics and laxatives, constant spitting, saunas, and exercising in rubber suits or heated exercise rooms (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). The methods mentioned are basically dehydration techniques that result in the loss of body water and rapid decreases in body weight (Fogelholm, 1994). In a sauna, 2% to 5% of body weight can be lost in less than 2.5 hours (Fogelholm, 1994).Other weight loss methods commonly used by wrestlers include: restricting calories, increasing training, and limiting food and beverage intake. Many wrestlers chose to limit carbohydrates, vomit, exercise excessively, diet gradually, fast, and starve themselves (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). One study showed that 73% of former college wrestlers used

combinations of five or more techniques in order to lose the desired amount of weight for competition (Nitzke, Voichick, & Olson, 1992). In the same study done by Nitzke et at. (1992), 37% of the wrestlers reported that their main weight loss technique was restricting food intake. Twenty-two percent said that they increased exercise in order to lose weight (Nitzke et al., 1992).

Steen and Brownell (1990) surveyed high school and college wrestlers to examine weight loss methods they used and 30% of the collegiate wrestlers used a sauna once a week, 26% exercised in a rubber of plastic suit 3-4 times a week, 52% restricted food 3-4 times a week and 52% fasted once a week. Twenty-six percent of the high school wrestlers fasted once a week, 13% used a sauna once a week, and food was restricted daily by a quarter of the 368 high school wrestlers surveyed. Methods of weight loss tend to vary from wrestler to wrestler and also vary based on the level of competition the wrestler performs at (Horswill, 1992).

Some of the consequences of weight loss and weight cycling are known and have been studied, while more consequences are still being speculated and discovered. There are limitations to drawing conclusions from studies because wrestlers' performance on tests produced in the lab can not always reflect performance in an actual competitive environment (Horswill, 1992). One area that has been studied frequently is the effect dehydration has on performance (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). Dehydration is often one of the easiest ways for wrestlers, or any athlete, to lose weight quickly because the body does not store up fluids and electrolytes, so any time an athlete engages in vigorous activity in which large amounts of sweat are lost and not replaced, the body will reduce it's water content (American Academy of

Pediatrics Committee on Sports Med and Fitness, 2005). Different percentages of dehydration produce different symptoms. When adults lose 2-3% percent of body weight through dehydration, they will experience reduced muscle strength, lower endurance and reflex activity along with decreases in maximal oxygen uptake (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). Muscle recovery time is affected by dehydration due to the decrease in blood flow, waste removal, and nutrient exchange between muscle contractions (Horswill, 1992). Also, body temperature will be increased .1 to .4 degrees Celsius for every 1% loss in weight (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005), because the sweating process becomes compromised (Steen & Brownell, 1990). At losses greater than 8% heat cramps, heat exhaustion, and heat stroke become prevalent, and could endanger the life of an athlete (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). Kidney and renal function can also be affected by dehydration. Dehydration produces a decrease in plasma volume resulting in reduced blood flowing to the kidneys (Horswill, 1992). Dehydration also increases the production of the kidney enzyme leucine amino peptidase which leaks into the urine and has been associated with slight renal ischemia (Horswill, 1992). At this time there does not seem to be evidence showing that dehydration results in long term kidney damage in wrestlers (Horswill, 1992).

Dehydration from rapid weight loss does not seem to have a major negative impact on the anaerobic energy system, or the adenosine triphosphate (ATP)-phosphocreatine (PC) system; however some studies have shown contradictory findings (Horswill, 1992). Repeated or continual performance at a slightly sub-maximal effort lasting longer than 30 seconds has shown to decline with rapid weight loss. This is

thought to be due to decreased blood flow to the muscle when the wrestler is dehydrated which slows waste removal, heat dispersion and nutrient exchange, hindering muscle recovery (Horswill, 1992). Muscle concentrations of ATP and PC seem to remain the same as before weight loss (Horswill, 1992, 1993). With wrestling mainly consisting of movements requiring the anaerobic energy system, large amounts of lactate build up in wrestlers' muscles; acid-base balance in the body is then disturbed. This disruption in the balance can have an effect on muscle contraction ability, but this has not been proven (Kraemer et al., 2001). In a study done by Roemmich and Sinning (1997) power and strength were measured pre-season, late in-season and post- season by performing flexion and extension exercises on the right elbow and knee. Results showed decreases in peak torque for elbow extension and elbow flexion, all knee strength and power along with peak arm power from pre-season to in-season. From in-season to post-season all knee strength and power variables increased (Roemmich & Sinning, 1997).

In a study done by Steen and Brownell (1990) looking at college and high school wrestlers, the researchers found that losing weight and trying to make weight for competition had an impact on the psychological health of the wrestlers. Sixty six percent of the college wrestlers experienced anger with trying to lose weight, 33% felt isolated, and 45% of the high school wrestlers felt anxious. Depression was reported by 24% of both the groups and 12% of college and high school wrestlers indicated they experienced low-self esteem (Steen & Brownell, 1990). Constant weight loss and regain can lead wrestlers to partake in unhealthy weight loss practices, and become frustrated with losing weight, especially if their body is trying to conserve energy after long periods of weight cycling (Steen et al., 1988).

Further research is warranted on the effect of weight loss and weight cycling on normal growth and development among wrestlers, especially those of high school age and younger (Steen & Brownell, 1990). Since only a few longitudinal studies have been conducted so far, it is unknown if growth is impaired permanently or only in the short term. It is also unknown if an adolescent can recover from any short term growth impairment resulting from weight cycling and weight loss (Steen & Brownell, 1990). Some research suggests that reduced body fat and constant weight cycling have the potential to hinder growth (Fogelholm, 1994), along with weight that is reduced due to dietary restriction (Roemmich & Sinning, 1997). Fogelholm (1994) believes that stunted growth due to diet restriction does not seem likely because the diet restrictions are temperamental and periodic with wrestlers increasing their energy intake post-competition and post-wrestling season (Fogelholm, 1994). He and others all suggest that more information is needed, and research looking at dietary intake, training and growth over multiple years of wrestling is necessary in order to see if relationships do exist (Fogelholm, 1994).

Resting Metabolic Rate

Little is known about the metabolic effects of weight loss and weight cycling among wrestlers (Horswill, 1993). Resting metabolic rate (RMR) also known as resting energy expenditure (REE) is the energy that is required by the body to maintain normal function at rest. Two thirds of an individual's daily energy expenditure can be accounted for from the RMR (Driskell & Wolinsky, 2002). For accurate measures of RMR it should

be measured in the morning, with the person lying down, after a normal evening's rest, after a 12 hour fast and no exercise have taken place12 hours before the measurement (Driskell & Wolinsky, 2002). The other components that make up part of one's total daily energy expenditure are the thermic effect of food, and the thermic effect of physical activity. During extended periods of calorie restriction and reduction it has been observed that the body's natural response is to lower and reduce RMR (Melby et al., 1990). However, further research is needed to determine the metabolic adaptations the body makes with continual brief fasting and refeeding that are common among wrestlers (Melby et al., 1990).

There are a variety of factors that can influence a person's resting metabolic rate. Ingesting food, especially a meal mixed with carbohydrates, fats, and protein raises RMR by approximately 5-10% and has its peak impact one hour after eating (Driskell & Wolinsky, 2002). The amount of lean body mass, or in other words the amount of metabolically active tissue, that a person has directly affects RMR (Driskell & Wolinsky, 2002). Having a greater percentage of lean tissue as opposed to fat tissue can increase metabolic rate because lean tissue is more metabolically active than fat (Steen et al., 1988). Size and shape of the body affect RMR with stout and heavier individuals having lower rates than those that are tall and thin having the same weight. This is due to the amount of surface area where heat can be lost, with the taller individual needing to produce more heat to keep their body temperature regulated (Driskell & Wolinsky, 2002). Age also plays an important role in a person's metabolic rate. Children have a greater RMR per unit of body weight than adults and this is related to development, growth, and activity level of children. Once children stop growing, their RMR will slow about 2% per

year for the remainder of life (Driskell & Wolinsky, 2002). Changes in RMR also seem so to be affected by gender, with the greatest noticeable difference occurring about the time children reach 10 years of age or puberty. With males starting to develop more lean muscle mass and females acquiring a greater proportion of fat mass, males then tend to have higher resting metabolic rates (Driskell & Wolinsky, 2002).

Exercise at high intensity rates over extended periods of time has been associated with increases in RMR (Melby et al., 1990; Schmidt, Corrigan, & Melby, 1993). It is still being researched what effects acute and moderate exercise has on metabolic rate (Schmidt et al., 1993). Since exercise tends to raise RMR, it is thought it may counteract any decreases in metabolic rate that could occur from reduced caloric intake (McCargar & Crawford, 1992; Melby et al., 1990). In many studies done in both humans and animals, it has been found that RMR decreases with a reduction in caloric intake and the body becomes more energy efficient; what is unknown is what occurs with cycles of caloric reduction and then re-feeding (Melby et al., 1990; Schmidt et al., 1993).

Few studies have investigated the influence of weight cutting, weight cycling, training and the impact these weight management techniques have on metabolic rate in wrestlers. Little is known in this area but many hypotheses exist, and results have varied between the previous studies that have been done. Most of the studies believe that the cycle of weight loss and regain can lead the body to conserve energy and make alterations as to how energy is expended at rest (Melby et al., 1990).

One of the first studies examining metabolic effects of repeated weight loss and regain was published by Steen et al in 1988. The researchers examined previous animal studies and other human studies which showed that dieting cycles increased food

efficiency and lowered energy requirements (Steen et al., 1988). Based on those findings they hypothesized that wrestlers who weight cycle would have lowered metabolic rates than wrestlers who did not cycle (Steen et al., 1988). They examined 27 high school wrestlers who were classified as weight cyclers or non weight cyclers based on their survey responses. Both groups were matched for age, weight, height, body mass, and percent fat. RMR was taken one time on each subject while they were participating in a summer wrestling camp at a stable weight (Steen et al., 1988). Results showed that cyclers had a lower mean resting metabolic rate than non-weight cyclers, and they concluded that a decreased RMR appeared to be associated with weight cycling but no cause and effect relationship could be determined (Steen et al., 1988).

Two years following Steen's study, Melby et al., (1990) published a study comparing RMR in weight cycling wrestlers with non-weight cycling control subjects. They compared 12 collegiate weight cycling wrestlers with 13 physically active non-wrestlers who maintained stable weight (Melby et al., 1990). The study's objectives were to see if weight cycling wrestlers would produce a lower RMR than non-weight cycling active controls, and if weight cycling would reduce metabolic rate over a wrestling season (Melby et al., 1990). Both groups had similar weight, height, fat free weight, and percentage of body fat at the time of recruitment for the study. There were three data collection periods with one being before wrestling season, during wrestling, and after wrestling season. Results showed that wresters exhibited a higher baseline RMR than the non-wrestlers, RMR decreased in the wrestlers during the in-season measurement, but post- season the wrestlers had RMR values comparable with their pre-season measurements and still higher than the non-wrestling controls (Melby et al., 1990). The

control group showed no significant differences in RMR during the three data collection periods (Melby et al., 1990). Melby et al (1990) concluded that weight cycling did not lower RMR in wrestlers over the wrestling season, as had been suggested by Steen (Melby et al., 1990).

The previously mentioned study by Melby et al. (1990) was then extended a second year for the purpose of providing more information and further investigating long term influences weight cycling might have on RMR (Schmidt et al., 1993). Six non-weight cycling college wrestlers were added to the study so a better comparison could be made between the two groups of wrestlers. Six of the previous weight cycling wrestlers were retained as well as 12 of the non-weight cycling physically active controls (Schmidt et al., 1993). Data collection was done pre-season and post-season with the non-weight cycling wrestlers only having measurements from the second year of the study. The study results revealed that even after the second year, weight cycling wrestlers still had higher RMR values than the non-wrestling controls and RMR was not lowered in weight cyclers. In comparing the two wrestling groups, both had higher RMR values than the control group, but no significant differences in RMR existed between the two (Schmidt et al., 1993).

Another study conducted by McCargar and Crawford (1992) evaluated the effects of cycles of weight loss and regain on metabolic rate, and thyroid hormone among collegiate wrestlers. Since thyroid hormone helps to regulate the body's metabolic rate, it was of interest to see if calorie restriction has an influence on thyroid hormone (McCargar & Crawford, 1992). Measurements of RMR and thyroid hormone were taken three times over the course of a one year period. One measurement was pre-season, one

was during the competitive season and the final measurement was taken once the season was completed. The participants in the study consisted of national and international collegiate wrestlers, 8 of whom were weight cyclers and 6 who were non-weight cyclers. Results showed that there was no significant change in RMR over the course of the one year study period or between the two different groups of wrestlers (McCargar & Crawford, 1992). The weight cyclers did have a slightly lower post-season metabolic rate but it was not a significant result (McCargar & Crawford, 1992). As for thyroid hormone, serum triiodothyronine, it decreased significantly in both cyclers and non-cyclers from pre-season to post-season (McCargar & Crawford, 1992).

Based on the studies mentioned, there is still no clear answer to what the short or long term effects are of weight loss and weight cycling. There are concerns that repeated weight cycling could lead to hypertension, possible heart disease, decreased renal function and electrolyte balance and obesity in the future (McCargar & Crawford, 1992; Nitzke et al., 1992; Steen et al., 1988). There are also beliefs that over a long period of weight loss and regain, the type of weight regained could contain a greater proportion of fat, which could be detrimental to athletes trying to maintain low levels of body fat (McCargar & Crawford, 1992). Also, it has been found in some animal studies that over time the body will adapt to the weight cycling by increasing food efficiency and make it more difficult to lose weight in repeated cycles and weight regain will occur more rapidly (Schmidt et al., 1993; Steen et al., 1988).

Dietary Intakes among Wrestlers

To help prevent decreases in RMR, wrestlers need to make sure they consume adequate calories for their given activity level and body size (Horswill, 1993).Given that calorie restriction, starvation, and dehydration are common weight loss methods used by wrestlers it is important to determine the quality of dietary intakes and food habits of both high school and collegiate wrestlers (Horswill, 1992). Yet only a few studies have examined the type and nature of wrestlers' diet.

Most athletes, including wrestlers, have high calorie needs due to their demanding training and competition requirements (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). While athletes participate in sports they have to make sure they are consuming enough calories to repair and fabricate new muscle tissue, they need to eat in order to ensure adequate growth, and they need to make sure they consume enough to cover the calories burned during everyday activity and training (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). A study by Kiningham and Gorenflo (2001) showed that 1 in 4 wrestlers cut back their calories a minimum of 3-4 times per week (Kiningham & Gorenflo, 2001).

According to the AAP (2005), a diet most suitable for athletes would consist of around 55-65% of all calories coming from carbohydrate sources, 15-20% of total intake coming from protein, and the remaining 20-30% coming from fat sources (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). The Academy also recommend that athletes who are wanting to lose weight should consult with either their physician or a registered dietitian who has a background working with athletes as to what a proper diet should consist of so they do not harm their body or compromise performance (American Academy of Pediatrics Committee on Sports Med and Fitness,

2005). Two studies were done on college wrestlers and examined the make up of a collegiate wrestler's diet (Horswill, 1992).The first study done by Short and Short in 1983, examined 10 men's and 6 women's athletic teams from one college university over a span of 4 years (Brownell et al., 1987). In wrestlers, they found that the make up of their diet on average was 40-53% carbohydrate, 29-39% fat, and the remaining protein correlating to more than 1 gram of protein per kilogram of the wrestler's body weight (Horswill, 1992). Wrestlers consumed on average more calories post-season (3667 kcal/day) and pre-season (2634 kcal/day) than they did during the season (1964 kcal/day) (Horswill, 1992). During the season when wrestlers were trying to lose weight they exhibited deficiencies in vitamin C and A, along with riboflavin, niacin, thiamine, calcium and iron (Horswill, 1992).

The second study was done by Steen and McKinney (1986) and looked at college wrestlers from multiple universities. The average intake of carbohydrates was 43-47% of total calories, protein made up 15% of the diet, and fat composed the rest of the diet at 33-37% (Horswill, 1992). Intakes varied throughout the season with the researchers noting that during calorie restriction, 37% of the collegiate wrestlers took in less than two thirds of their recommended dietary allowance for total energy intake (Horswill, 1992). The wrestlers were not meeting their daily energy needs and it was found that they were also deficient in vitamin A and C, zinc, magnesium, thiamine, B6 and iron (Horswill, 1992). The authors in both studies observed eating patterns whereby wrestlers' food intakes were extremely low the day before a wrestling competition (334 kcal) and then after they weighed in they consumed huge quantities of food (4214 kcal) (Horswill, 1992).

Not a lot of information is known about high school athletes and their dietary intake patterns but Horswill et al.(1990) looked at differences between preseason intakes and calories consumed during the season (Horswill, 1992). During the competitive wrestling season the athletes were only consuming approximately 27 kcal/kg with lowered carbohydrate and fat intakes from the pre-season measurements (Horswill, 1992). Pre-season measurements showed that wrestlers were consuming about 41 kcal/kg, with 52% of the diet coming from carbohydrates, 34% coming from fat, and 14% coming from protein (Horswill, 1992).

Decreased Caloric Intake and Energy Efficiency

Energy efficiency appears to be critical for maintaining a stable body weight among healthy individuals (Brownell et al., 1987). Energy efficiency is a measure of how many calories a person has to consume in order to sustain a stable body weight or body composition (Brownell et al., 1987). When an individual has to decrease the amount of calories consumed in order to maintain a stable weight then energy efficiency has occurred (Brownell et al., 1987). This is a potential problem for wrestlers trying to lose weight who have gone through repeated cycles of weight loss and regain. One of the body's natural defenses against reduced caloric intake is to become more efficient and get the most from the calories that are being ingested by the athlete (Brownell et al., 1987). It

has been hypothesized that athletes whose body weight is below their natural weight or those whose weight fluctuates frequently, experience increased energy efficiency (Brownell et al., 1987). Further research in this area is warranted to determine whether energy efficiency in these types of athletes is heightened compared to other athletes.

Calorie Restriction and Athletic Performance

An area of interest to researchers are the affects calorie restriction has on muscle glycogen stores, also known as stored carbohydrates (Horswill, 1992). Wrestlers who restrict their dietary intake, especially carbohydrates, the week and day before competition could be running on low energy stores. It is believed that to replete muscle glycogen stores after they have been depleted, takes approximately 48 hours (Horswill, 1992). Marathon runners need at least a week of high carbohydrate intake and low impact activity to restore glycogen to pre-competition levels (Horswill, 1993). Wrestlers who try to consume adequate calories after they make weight and before they compete, may not have adequate time to replenish their glycogen stores (Horswill, 1992). Muscle glycogen can begin to regenerate in as little as an hour, but it is believed that only a partial recovery would occur.(Horswill, 1992)

Dietary restriction may also have a negative impact on the strength performance of wrestlers, due to a decrease in lean body mass after drastic weight loss efforts (Roemmich & Sinning, 1997). Previous studies on this topic have found mixed results (Roemmich & Sinning, 1997). Roemmich and Sinning (1997) studied nine wrestlers and seven adolescent active controls to see if any relationships existed between dietary intake

and growth, and look for changes in arm and leg power. The wrestlers' intake was composed of a high-carbohydrate, low-fat diet during the wrestling season, and they had a lower energy intake than controls. Results showed that from pre-season to in-season, wrestlers had large reductions in all knee strength and power variables, and then the numbers increased once wrestlers were in the post-season (Roemmich & Sinning, 1997). Investigators also found that the wrestlers were consuming only about 50% of what was recommended for their daily intake during pre-season and in-season (Roemmich & Sinning, 1997). They found that during the wrestling season there was no day where wrestlers were meeting all of their caloric needs and that they were constantly undernourished (Roemmich & Sinning, 1997).

Calorie Restriction and the Potential for Eating Disorders

Some research suggests that the use of unhealthy eating practices and weight loss techniques may predispose wrestlers to the development of eating disorders, either during their career or later in life (Lakin et al., 1990). Some common unhealthy weight loss methods being used by some are vomiting, compulsive exercise, and binging episodes (American Academy of Pediatrics Committee on Sports Med and Fitness, 2005). In a study done by Steen and Brownell (1990), 63% of college wrestlers and 43% of high school wrestlers surveyed reported that they were always or often preoccupied with food during the wrestling season, with numbers being reduced during post-season (Steen & Brownell, 1990). After a wrestling match is the time wrestlers felt the most preoccupied with food with 29% of the high school wrestlers and 41% of the collegiate wrestlers

feeling this way (Steen & Brownell, 1990). Lakin et al. (1990) used a questionnaire to evaluate bulimic behaviors, weight loss methods, and binge eating in 716 wrestlers. They found that what is still very much an unknown is if wrestling as a sport supports and encourages behaviors that can lead to eating disorders, or if it is the individuals themselves that already have pre-existing patterns of behavior that carry over to the sport in which they are participating (Lakin et al., 1990).

Nutrition and Weight Management Knowledge among Wrestlers

With wrestlers engaging in bouts of weight loss and regain and having a desire to maintain low percentages of body fat, it would be beneficial to them to have adequate nutritional knowledge either themselves or coming from a qualified, reliable source. According to a study by Lakin et al. (1990), wrestlers had a smaller amount of nutritional knowledge than athletes of 18 other sports (Lakin et al., 1990). Another study indicated that college wrestlers were likely to have misunderstandings about food and failed to grasp basic nutrition concepts (Lakin et al., 1990). Short and Short (1983) examined wrestler's diets and nutritional knowledge and found a definite lack of nutrition knowledge (Short & Short, 1983). Some wrestlers thought that salads have excess bulk so they are bad to eat, milk is too fattening, and food that is small is low in calories so choices such as eating candy bars were acceptable. The wrestlers also would ingest soft drinks the day before a match even when they were restricting their fluids (Short & Short, 1983).

In terms of nutrition information sources, one study indicated that 78% of wrestlers received information from their coaches, 42% sought out information from their parents, 37% consulted their doctors, 25% talked to a nurse, and 58% had some sort of other source of information (Kiningham & Gorenflo, 2001). Marquart and Sobal (1994) gave written questionnaires to high school wrestlers and found that the people wrestlers believed to be accurate sources of nutrition information were mainly coaches and doctors. Five percent believed the television and radio were very accurate sources (Marquart & Sobal, 1994). Although the wrestlers thought doctors were good reliable sources, only 7% of them consulted with a doctor to make out a weight loss plan (Marquart & Sobal, 1994). To obtain information on weight loss, wrestlers should consult with their physician or dietitian (Tipton & Tcheng, 1970).

Summary

Wrestling is one of the few sports in which competitors are required to weigh in and perform at a certain body weight in order to compete (Horswill, 1993). It is well known that wrestlers often compete in weight classes much lower than their normal body weight to gain a competitive advantage (Steen et al., 1988) To meet their competition weight, wrestlers often partake in a variety of unhealthy behaviors such as fasting, food and fluid restriction, excessive exercise, and dehydration (Horswill, 1993). Some wrestlers have to lose weight multiple times during a season and repeat their weight loss behaviors over multiple wrestling seasons (Steen et al., 1988). Several studies have suggested that continual weight restriction and patterns of weight loss and gain may

influence multiple body systems negatively, and more research is warranted to discover the short and long term effects weight loss and gain has on the body (Brownell et al., 1987). An area of recent interest is looking at metabolic rate with research being inconclusive at this time as to whether or not continual weight loss and gain lowers metabolic rate (Driskell & Wolinsky, 2002). Wrestlers' diets are also of interest, with little information currently available and the need for athletes to maintain adequate caloric intake to keep their metabolic rate stable (Horswill, 1993). The purpose of this study was to describe and evaluate changes in resting metabolic rate and dietary intake among adolescent wrestlers from pre-season to post-season.

CHAPTER III

METHODS

Study Design and Subject Selection

This descriptive correlational study used a convenience sample of competitive male wrestlers to participate in the research in the fall of 2006 and spring of 2007.The subjects were recruited from two high school competitive wrestling teams in Oklahoma. The research project was approved by the Institutional Review Board at Oklahoma State University (Appendix A). School principals were contacted for initial approval and consent (Appendix B), and then meetings were scheduled with the parents/guardians of the wrestlers, through certified athletic trainers and/or wrestling coaches. The study was described to the parents/guardians in detail during the meeting and written consent forms were administered to each parent/guardian (Appendix C). Once the parent/guardian agreed for their son to participate in the study, assent was obtained from each wrestler because they were under the age of 18. The written assent form filled out by the wrestlers is enclosed in Appendix E. Parents/guardians unable to attend the meeting were sent a packet with a letter (Appendix D) detailing information about the study, consent and assent forms, as well as directions for how to return the materials if they and their son wanted to be a part of the study. All wrestlers participating in the wrestling program at

the school were eligible to participate.

Study Location and Procedures

Data from the wrestlers was collected on three separate occasions in pre-season (October 2006), in-season (February 2007), and off-season (April 2007). The data collection took place in the Department of Nutritional Sciences research laboratory. The first data collection period was prior to the beginning of the competitive wrestling season, while the wrestler's were in training. The second data collection point was during the competitive wrestling season, and the final collection was done during the wrestler's post-season while they were no longer competing. Data collection from both teams was conducted within 2 weeks to decrease the effects of the wrestling season on the main measures of the study.

On the data collection days, wrestlers were asked to arrive to the lab in the morning hours after fasting for at least 8 hours, and abstaining from exercise for at least 12 hours prior to testing. Subjects were given lightweight hospital scrubs to change into for measures of resting metabolic rate, height and weight. Height was measured using a wall-mounted stadiometer (Harpenden, Holtain, Crymmych, Pembrookshire, United Kingdom) and recorded to the nearest 0.5 centimeter then converted into inches. To measure height accurately wrestlers were asked to have their head, back, buttocks and shoulder touching the vertical wall behind them (United States Department of Health and Human Services, 2006). Weight was taken on a standing digital scale (Seca 664,

Hamburg, Germany) with a stable weighing platform and recorded in kilograms and pounds.

Study Variables

The main variables of the study included RMR, and dietary intakes. The RMR was assessed using the Vmax Encore metabolic cart with a ventilated canopy system (Vmax Encore Spectra, Viasys Healthcare Inc., Yorba Linda, CA). The metabolic cart determined the RMR from the amount of oxygen inhaled and the amount of carbon dioxide exhaled and produced by each subject. To measure the RMR subjects were placed in a supine position on a comfortable reclining chair. A clear plastic canopy was placed over their head. The room where RMR measurements took place was well-ventilated, quiet, and darkened throughout the study in order to ensure relaxing and undisturbed environment. The metabolic cart was calibrated prior to each data collection day in the morning hours in order to ensure accuracy of the obtained measurements. Subjects were told to rest but not to fall asleep, and try to breathe as normally as possible during the measurement period. The RMR was measured for a total of 20 minutes. The first 3 minutes of the RMR measurement were discarded for each subject in order to allow the subjects to enter a steady state. The final RMR of the wrestlers was determined using steady state periods only.

In order to determine dietary intake of the wrestlers during pre-season, in-season, and post-season, multiple pass 24-hour recalls were conducted (Appendix F) with each subject (United States Department of Agriculture, 1998). Wrestlers were taken into a

private room where a trained research assistant from the Department of Nutritional Sciences conducted the 24-hour dietary recall interview. Plastic food models, bean bags, and measuring cups were all on hand to maximize accurate recall of food items and portion size eaten on the previous day. The wrestlers were asked what they had consumed over the past 24 hours including beverages, supplements, vitamins, and food. After the wrestlers recalled the food and beverages they had ingested over the last 24 hours, the research assistant asked a few additional questions to probe for more information that the wrestlers may have left out. The wrestlers' dietary intake was examined in terms of their total energy intakes, and carbohydrate, fat and protein content.

Data Analysis

Data was entered into and analyzed using the Statistical Package for Social Sciences (SPSS, 16.0, version for Windows, 2005, Chicago, IL). Descriptive statistics (i.e. means, standard deviations, frequencies) were used to describe different characteristics of the wrestlers that participated in the study. The relationship between metabolic rate and dietary intake was examined using bivariate correlations. Student paired t-tests were utilized to compare the wrestlers' RMR and dietary intakes (i.e. energy and carbohydrate intakes) between pre-season, in-season, and post-season. The level of significance was set at $p<0.05$. The 24-hour recalls were analyzed in terms of total energy intake (kcal), carbohydrate (g and % of total kcal), protein (g and % of total kcal), and fat (g and % of total kcal) intake using the nutrient analysis software Food Processor (Food Processor 8.8, 2006, Salem, Oregon). The food Processor has a database

of more than 22,000 different foods and beverages, and is based on the typical American diet (Food Processor 8.8, 2006, Salem, Oregon).

CHAPTER IV

FINDINGS

Demographics

Twenty-five male high school wrestlers participated in the study. Sixty-four percent (n=16) of the wrestlers were white, 28% (n=7) of the wrestlers were Native American, 4% (n=1) were African American and 4% (n=1) were Asian/Pacific Islander. Pre-season measurements were completed by 24 out of the 25 wrestlers in October of 2006. Mean age in pre-season was 15.5 ± 0.25 years (Table 4.1). A broken collarbone prohibited one wrestler from participating in the pre-season measurements. For the in-season data collection that took place in February 2007, 20 out of 25 participants were present. Five participants were absent due to illness and/or injury. For the final post-season data collection in April 2007, 17 out of the original 25 wrestlers were able to participate with the remaining eight unable to complete the measurements due to illness and/or injury.

Mean weight of the wrestlers increased slightly from pre-season to in-season, but the difference was not statistically significant. However, the pre-season weight of the wrestlers differed significantly from post-season weight (p=0.001). Another significant

difference in weight was observed from in-season to post-season (p=0.018). The largest numerical gain of 6.7 pounds was observed between pre-season (148.9 lbs) and post-season (155.6 lbs.) weight. Height of the wrestlers increased gradually from a mean of 66.5 inches pre-season, to 67.0 inches in-season, and finally a mean of 67.1 inches post-season, which was expected due to normal growth and development among adolescents. Anthropometric and demographic characteristics of the sample are summarized below in table 4.1.

Table 4.1 Demographics, Weight, and Height from Pre-Season to Post-Season [*]

	Pre-Season	**In-Season**	**Post-Season**
Mean Age (yrs)	15.50 ± 0.25	15.75 ±0.22	15.88 ± 0.27
Mean Weight (lbs.)	148.88 ± 39.87 [a]	149.62 ± 39.54 [a]	155.58 ± 42.53 [b]
Mean Height (in.)	66.54 ± 2.54	67.03 ± 2.63	67.15 ± 2.33
(N)	24	20	17

[*] The presented values are means ± SD
[ab] Pre-season to post-season statistically significant difference (p=.001)
In-season to post-season statistically significant difference (p=.018)

Resting Metabolic Rate

The RMR values for the wrestlers who completed RMR measurements at each data collection period are presented below in Table 4.2. No significant differences in RMR between pre-season, in-season, and post-season were observed in the sample of wrestlers. The RMR was nearly identical in pre-season and in-season (Table 4.2). The greatest numerical difference in wrestlers' RMR was observed between pre-season and post-season (Table 4.2), but this difference was not significant.

Table 4.2 RMR Values from Pre-Season to Post-Season

	RMR [a]	P-Value
Pre-Season vs. In-Season	1781.3 ± 235.4 1767.7 ± 292.5	.803
In-Season vs. Post-Season	1803.9 ± 304.9 1862.0 ± 370.5	.243
Pre-Season vs. Post-Season	1799.6 ± 235.7 1869.4 ± 354.9	.378

[a] The presented values are means ± SD

Dietary Intakes

Wrestlers' dietary intakes were analyzed with specific emphasis being placed on total energy intakes, kilocalories from carbohydrate, kilocalories from fat, and kilocalories coming from protein. The raw energy and macronutrient intakes of all wrestlers who completed either pre-season, in-season and/or post-season measurements are presented in Table 4.3. The comparison of the 24-hour recalls using paired t-tests revealed that the wrestlers' dietary intakes changed significantly during the year. Results of the paired t-tests are presented in Figure 4.1, Figure 4.2 and Figure 4.3. The wrestlers who completed the in-season and post-season measurements consumed nearly identical amounts of energy (2015 vs. 2062 kcal) (Figure 4.2). However, a significant difference in wrestlers' energy intake was observed between pre-season and post-season (1677 vs. 2113 kcal; p=0.023) (Figure 4.1). Overall, the amount of energy that was consumed by the wrestlers ranged from very low calorie intake to very high calorie intake during all three data collection periods. The in-season data exhibited the largest kilocalorie range (449.9-5,224.1 kcal), with a difference of 4,774.1 kcal between the highest and lowest energy intake.

Total energy consumption from carbohydrate was lowest in pre-season (225.1 g) and highest in post-season (274.8 g), with the difference of 50g or 200 kcal of carbohydrates. The difference in carbohydrate intake between pre-season and post-season was significant at p=0.029 (Figure 4.1). The dietary intake of fat was not significantly different from pre-season to in-season and post-season, with wrestlers consuming similar amounts of fat throughout the year. The largest numerical difference in dietary fat intake was observed between pre-season and post-season (Figure 4.1), where the fat consumption increased from 58.5 g to 76.4 g; however, this difference was not statistically significant. In general, energy from dietary fat made up on average 33% of the wrestlers' total diet over all three data collection periods. Protein consumption was numerically lower in pre-season compared to in-season and post-season, but no statistical differences were found between pre-season and in-season (p=0.255), pre-season and post-season (p=0.222), and in-season and post-season (p=0.794). The wrestlers consumed approximately 16% of their total calories from protein at all three data collection periods.

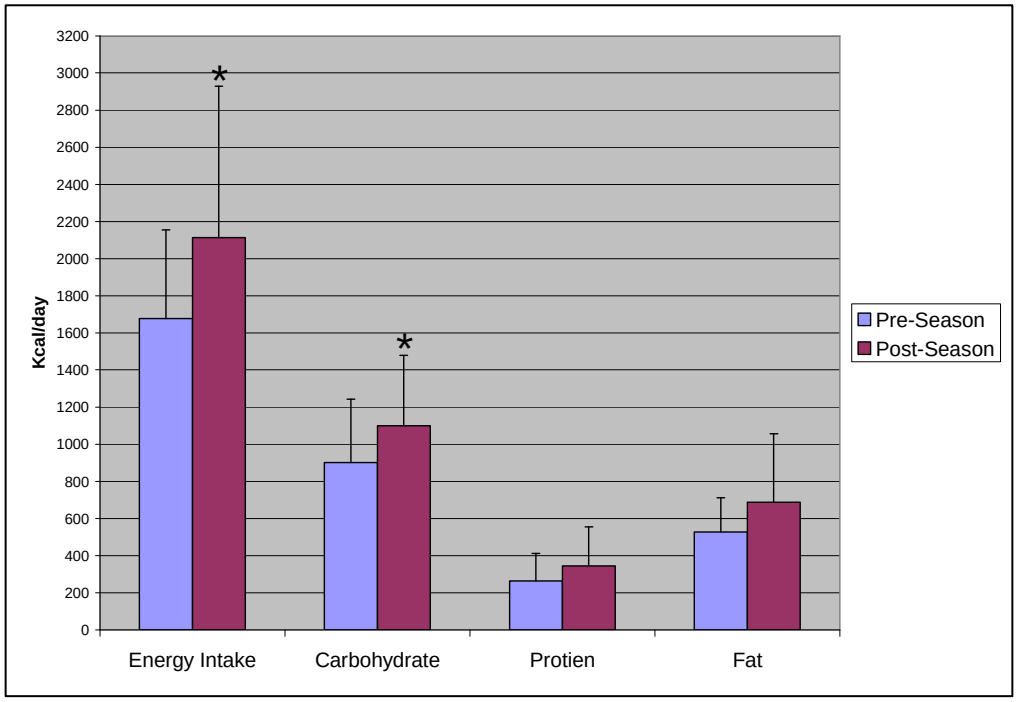
Bivariate correlations were used to see if there were any significant relationships between dietary intake and resting metabolic rate during each data collection period. No significant results were found. Pre-season relationship between total energy intake and metabolic rate exhibited a negative correlation (-.225) at p=.291, in-season exhibited a negative correlation (-.018) at p=.938, and post-season comparisons showed a positive correlation (.017) with no significance noted (p=.950). The bivariate correlations did reveal a statistically significant relationship between the total energy intakes and the total carbohydrate intakes consumed during pre-season (r=0.860), in-season (r=0.946), as well as post-season (r=0.836), with the level of significance at $p<0.01$.

Table 4.3 Overall Raw Energy and Macronutrient Intakes of the Wrestlers in Pre-Season, In-Season, and Post-Season [a]

	Pre-Season	In-Season	Post-Season
Mean Total Kcal	1694.9 ± 724.9	2115.1 ± 1088.7	2113.5 ± 815.5
Kcal Range (min.-max.)	216.8 - 3642.9	450.0 - 5224.1	548.1 - 3729.1
Mean Carbohydrate (kcal)	884.4 ± 422.0	1081.2 ± 632.0	1099.2 ± 380.0
Avg. % Kcal from CHO	52%	51%	52%
Mean Fat (kcal)	567.0 ± 282.6	706.5 ± 450.0	687.6 ± 369.0
Avg. % Kcal from Fat	33%	33%	33%
Mean Pro (kcal)	270.8 ± 146.4	346.8 ± 147.2	343.6 ± 211.2
Avg. % Kcal from Pro	16%	16%	16%

[a] The presented values are means ± SD

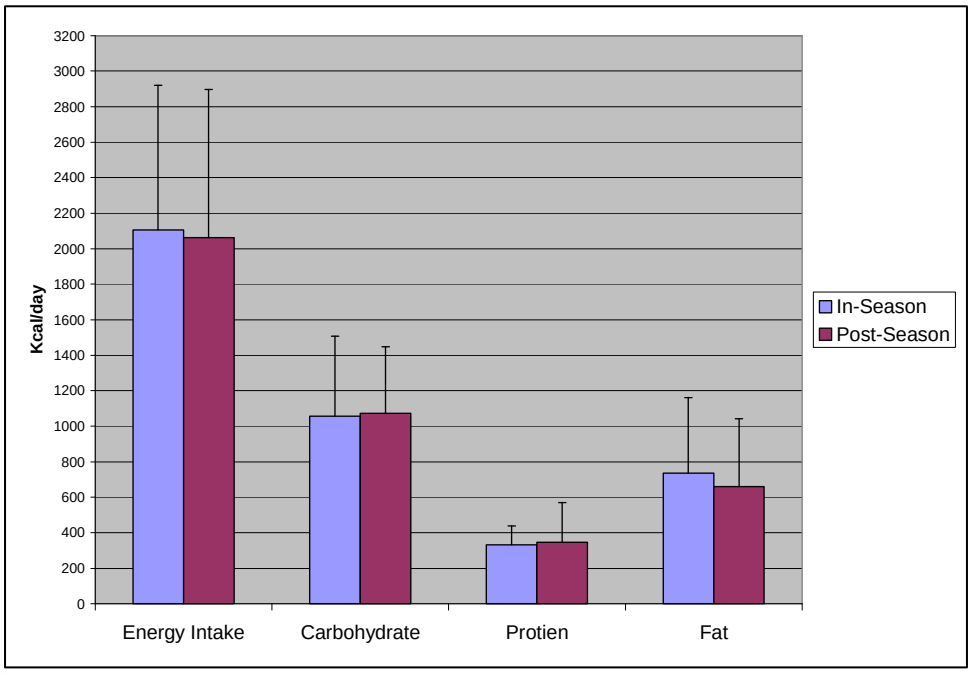
Figure 4.1 Comparisons of Dietary Intakes Between Pre-Season and Post-Season [a]



[a] The presented values are means ± SD

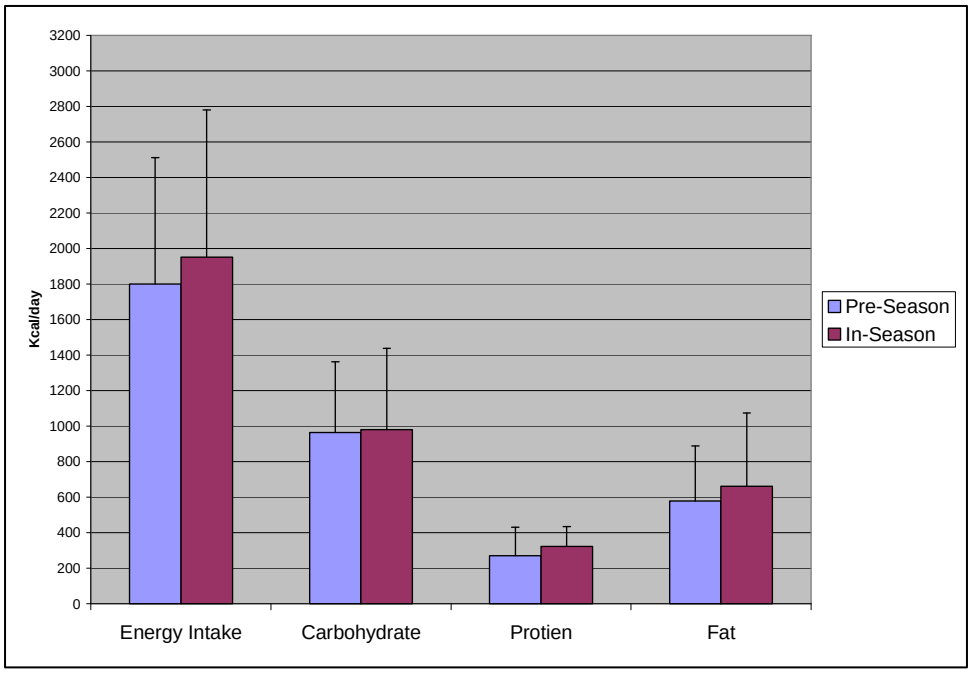
* Statistically significant difference at $p \leq 0.05$

Figure 4.2 Comparisons of Dietary Intakes Between In-Season and Post-Season [a]



[a] The presented values are means ± SD

Figure 4.3 Comparisons of Dietary Intakes Between Pre-Season and In-Season [a]



[a] The presented values are means ± SD

CHAPTER V

DISCUSSION

The purpose of this study was to describe and evaluate changes in resting metabolic rate and dietary intake that occur in a sample of high school wrestlers from pre-season to in-season and post-season. The results of the study indicated that while the wrestlers in our sample experienced no significant differences in their RMR from pre-season to in-season to post-season, their dietary intake changed significantly from pre-season to off-season.

In our sample, the RMRs at all three data collection points were nearly identical among wrestlers, indicating that the wrestlers were able to maintain their RMR while transitioning from pre-season to in-season and post-season. Numerically, the highest RMR was measured in post-season (RMR=1869.4 kcal); however, the difference between pre-season and in-season RMR was insignificant. Previous research suggests that wrestlers may experience decreases in their RMR and that these changes are largely due to severe weight loss efforts, strenuous physical activity and/or severe calorie restrictions during the season (Driskell & Wolinsky, 2002; McCargar & Crawford, 1992). Given the small differences in RMR that we found among the wrestlers in the present study between pre-season, in-season, and post-season, the results of our study do not support this argument. In our sample, wrestlers maintained similar body weight throughout the

season, and in fact gained a small amount of body weight from pre-season to in-season. Pervious studies on RMR among wrestlers found similar non-significant changes in RMR ((McCargar & Crawford, 1992; Melby et al., 1990). However, a majority of these studies examined differences in RMR between wrestlers who were considered weight cyclers and controls with stable weight ((McCargar & Crawford, 1992; Melby et al., 1990; Steen et al., 1988). Thus, a direct comparison between these studies and our findings is not possible. A future research study utilizing similar methodology is warranted to further explore changes in RMR in normal healthy high school wrestlers from pre-season to post-season.

It is well known that wrestlers use a variety of weight loss techniques in order to achieve a desired body weight for competition. A common method used to lose weight is dietary or calorie restriction, therefore one of the objectives of this study was to examine the dietary intakes of the wrestlers to make sure they were consuming adequate calories to meet the demands of training and competition as well as eating enough to ensure growth and muscle repair. Athletes' nutrient and energy needs are based on the training demands and competition requirements of the sport, as well as athletes' age, weight, body composition and gender (Driskell & Wolinsky, 2002). Research suggests that athletes' diets should consist of 60-70% of kilocalories coming from carbohydrate, 10-15% of kilocalories from protein, and 20-30% of kilocalories coming from fat (Driskell & Wolinsky, 2002). The American Academy of Pediatrics (AAP) (2005) adds that adolescent athletes should consume a minimum of 2000 kilocalories a day with 55-60% coming from carbohydrate, 15-20% of kilocalories coming from protein, and 20-30% of kilocalories coming from fat.

Analysis of our data showed significant differences between the pre-season and post-season mean energy and carbohydrate intakes. The wrestlers' total kilocalorie intake was slightly above 2000 kilocalories for both in-season and post-season. In contrast, some wrestlers did not consume an adequate amount of calories prior to the beginning of the wrestling season. Specifically, twelve out of 24 wresters in the present study consumed less than 1600 kilocalories in pre-season. These findings suggest that most of the wrestlers consumed an adequate amount of kilocalories, as recommended by the APA, during in-season and post-season, but did not meet the recommendations for energy intakes in pre-season. Given the new OSSAA rules (Oklahoma Secondary School Activities Association, 2007) that require a minimum weight class for a wrestler to be established prior to the competitive season, it is possible that our wrestlers attempted to restrict their calorie intake in order to reach a low body weight before the official measurements were taken in pre-season rather than cutting weight during the season. This hypothesis is consistent with our findings that wrestlers' body weight slightly increased from pre-season to post-season.

The findings of our study also showed that there was a wide range of calorie intake among the wrestlers during pre-season, in-season, as well as post-season. This is of concern, especially during in-season, when some wrestlers consumed as little as 450 kilocalories. With other wrestlers consuming as many as 5000 kcal a day, our findings suggest that while some wrestlers were starving themselves at some point during the season others were exceeding their energy requirements. Although the body weight of our wrestlers increased only slightly from pre-season to in-season and the overall body weight remained relatively stable throughout the year, attention to dietary intakes and

weight changes of individual wrestlers is warranted in order to prevent and/or reduce potential unhealthy dietary and weight management practices that may occur on an individual basis.

Fat and carbohydrate are the primary energy sources needed by athletes for performance. Based on the AAP (2005), wrestlers should consume approximately 55-65% of their calories from carbohydrate. In our study, the mean percent of total kilocalories coming form carbohydrate was approximately 52% during all three data collection points, falling short of the APA recommendation. Our results are similar to that of Short and Short (1983) who found the average carbohydrate range of collegiate athletes to fall between 40-53% of total kilocalories. Athletes need adequate amounts of carbohydrate especially for the purpose of meeting their energy needs and maintaining sufficient glycogen stores (Driskell & Wolinsky, 2002). Failure to consume adequate carbohydrate can lead to muscle fatigue, and decreased energy over multiple days of deficiency, especially among wrestlers who engage in high-intensity exercise and rely primarily on carbohydrates as their main source of energy (Driskell & Wolinsky, 2002; Horswill, 1992). Thus, the proportion of energy coming from carbohydrates should be higher in the sample of our wrestlers.

Protein and fat intakes for our wrestlers were consistent with other studies conducted by Short and Short (1983) and Steen and McKinney (1986). In their studies, collegiate wrestlers consumed approximately 29-39% of energy from dietary fat and approximately 15% of kilocalories from protein, which was similar to the dietary intake of fat (approximately 33%) and protein (approximately 16%) of the wrestlers in the present study. Although the Acceptable Macronutrient Distribution Ranges of 25-35% of

total kilocalories coming from fat and 10-30% of total kilocalories coming from protein are not specific to athletes, the intake of fat and protein among our wrestlers fell within these general recommendations (National Academy of Sciences, 2005). However, according to the AAP Committee on Sports Medicine and Fitness recommendations, our wrestlers consumed slightly above the recommended 20-30% of total kilocalories coming form fat. Examining wrestler's individual 24-hour recalls, items that frequently were consumed over all three data collection points that perhaps could have contributed to the higher fat intake were pop and soda, candy bars, cookies, breakfast pastries and pizza.

As formerly mentioned, dietary intake can have an influence on metabolic rate, and previous studies suggest that calorie restriction may result in a decreased metabolic rate in order for the body to conserve energy and avoid starvation (Brownell et al., 1987). In our study, we observed no significant changes in RMR among wrestlers from pre-season to in-season and post-season. This finding may be due to the fact that the dietary intakes of our wrestlers remained relatively stable during the study and they consumed adequate amounts of energy during in-season and post-season. Although further case analysis revealed that some individuals consumed very little energy during pre-season, in-season and/or post-season, these individual differences did not translate into an altered metabolic rate of the entire sample. Furthermore, other factors such as age, drastic weight changes, or body composition may have more significant impact on RMR than dietary intake and further studies are warranted in this area. . In our study we did not control for body size and weight so that could have impacted our results. We found no significant associations between RMR and dietary intakes in our study. With the use of only one day 24-hour dietary recall, it is possible that wrestlers overestimated, underestimated, or

incorrectly reported their food intakes which may have contributed to the lack of significant correlations between RMR and dietary intakes.

Limitations

For this study a convenience sample using two Oklahoma high schools was used, and thus our sample size was relatively small. With only 25 subjects participating in pre-season measurements and only 15 subjects completing all three data collection periods, it is not possible to generalize the findings to a larger and diverse population of high school wrestles. The study participants were asked to participate in all three data collection periods; however, due to illness or injuries, four wrestlers were able to complete only one set of measurements, six wrestlers completed only two sets of measurements, and only 15 wrestlers completed the entire study. The statistical analysis of the results was thus limited due to a high drop-out rate of the wrestlers. In addition, the last two data collection points of the study, in-season and post-season, were closely spaced to each other due to scheduling conflicts. The lack of adequate time between the two measurements may have influenced the results of this study, including the lack of significant changes in RMR of the wrestlers. Lastly, the results of the RMR measurements may have been affected by human error when working with the VMax metabolic cart. While establishment of a steady state is crucial for accurate assessment of RMR, several wrestlers had problems relaxing during the measurements. Because any type of movement may influence the metabolic rate measurement, the results of the study

may have been influenced by twitching, tapping and restlessness of some of the wrestlers during testing.

Another limitation of the study was the use of a 24-hour dietary recall. It is well known that subjects may under- or over-report what they consumed either intentionally or accidentally, which is typical for many self-reported research tools. They also may forget the amount of food they consumed, how a meal was prepared, or what portion size they consumed (Driskell & Wolinsky, 2002). Another limitation of using a 24-hour recall is that it is not an accurate representation of usual dietary intake because most individuals, especially athletes, have day to day variability in what they consume. Athlete's diets will vary greatly depending on what part of the competitive season they are in, or what their training regimen consists of (Driskell & Wolinsky, 2002). With many wrestlers using dietary restriction as a method for weight loss, 24-hour recalls may not be representative of normal eating patterns especially if taken the day or days before a match or competition (Short & Short, 1983). Several studies have reported using three or four day food records to obtain multiple days of intake while not over burdening the client (Driskell & Wolinsky, 2002; Short & Short, 1983).

Conclusion

Based on the results of this study, we observed no significant differences in resting metabolic rate in our sample of high school wrestlers from pre-season to in-season and post-season, and no significant correlations were observed between metabolic rate and dietary intake from pre-season to post-season. Examination of dietary intakes

revealed that there were significant differences between pre-season and post-season total kilocalorie intake and carbohydrate intakes, with wrestlers consuming more energy and carbohydrates during the post-season. Over all three seasons, carbohydrate intake was below the recommendations from the AAP, protein was within the recommended range and fat was slightly above recommended amounts. Although non-significant, the body weight, energy and carbohydrate intakes were lowest in pre-season when a minimum wrestling weight was established for each wrestler through official measurements. The new weight control program creates the future opportunity for nutrition education to be taught before the wrestling season begins so wrestlers can engage in healthy dietary habits and weight management practices throughout the season.

Implications for Practice and Future Research

Our study contributes significantly to the limited knowledge on changes in metabolic rates and dietary intakes of high school wrestlers from pre-season to post-season. However, future research is warranted in this area to replicate our findings and to continue exploring changes in RMR and dietary intakes among wrestlers. Because our study was limited in size, location, and duration of the study, future studies should include a larger sample of subjects from a variety of high schools and follow wrestlers over the course of multiple competitive seasons. With age influencing metabolic rate, future studies should explore differences in metabolic rate between younger and older adolescent wrestlers (Driskell & Wolinsky, 2002) and determine whether metabolic rate changes occur over the course of multiple wrestling seasons.

Regarding dietary intakes, more research is needed looking specifically at the composition of adolescent wrestlers' diet, especially in pre-season when they may be restricting their food intake in order to establish their minimum weight. As illustrated by the results of our study and several previous studies, carbohydrate and pre-season energy intakes were found to be below current recommendations (Horswill, 1992; Short & Short, 1983). In the future, more accurate and representative dietary data could possibly be obtained from wrestlers using records of multiple day (including weekends) usual dietary intakes for analysis of what wrestler are consuming.

While it is currently not mandatory, the OSSAA and NWCA recommend that all schools develop a nutrition education program for wrestlers and parents (Oklahoma Secondary School Activities Association, 2007). Wrestlers have previously demonstrated a lack of nutrition knowledge or misunderstanding of nutritional information (Lakin et al., 1990; Short & Short, 1983). Because increased nutritional knowledge can be translated into improved dietary intakes and healthier weight management practices of athletes, future studies should be aimed at evaluating the nutritional knowledge of coaches, wrestlers, as well as parents prior to the beginning of the wrestling season. Interventions could then be designed to educate all parties involved on energy and carbohydrate needs, the role of carbohydrates in an athlete's diet, healthy weight management practices and a nutritionally balanced diet aimed at enhancing performance and normal growth and development among adolescent athletes. Negative consequences of unhealthy nutrition practices on performance should also be discussed. Since coaches serve as the main source of nutrition information for their athletes (Kiningham & Gorenflo, 2001; Marquart & Sobal, 1994), it is imperative that they have accurate

information obtained from either physicians or registered dietitians so they can make sure their athletes are not putting their health at risk due to misinformation. Athletes look to their coaches for guidance so therefore coaches have the opportunity and responsibility to influence their athletes to make healthy choices now so they can live long healthy lives in the future.

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APPENDICIES

APPENDIX A

Oklahoma State University Institutional Review Board

Date.	Thursday, October 19, 2006
IRB Application No	HE0690
Proposal Title.	Body Composition Changes of High School Wrestlers During Pre-Season Season and Off-Season
Reviewed and Processed as:	Full Board

Status Recommended by Reviewer(s): Approved Protocol Expires: 10/17/2007

Principal Investigator(s)

Lenka Humenikova
417 HES
Stillwater, OK 74078

Nancy Betts
301 HES
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C. Jacobs, Chair
Institutional Review Board

APPENDIX B

Written Consent of the Principal

Project Title: Body Composition Changes in High School Wrestlers during Pre-season, Season, and Off-season

Project Leaders: Lenka Humenikova, PhD and Nancy Betts, PhD, RD

This research study is being conducted by Dr. Lenka Humenikova and Dr. Nancy Betts from the Department of Nutritional Sciences at Oklahoma State University. The main purpose of this research study is to assess body composition and resting metabolic rate among high school wrestlers, and determine whether changes in body composition and resting metabolic rate occur between pre-season, season, and off-season. The secondary purpose of this study is to evaluate wrestlers' dietary intakes and eating attitudes, and determine the association between body composition, resting metabolic rate, and dietary intakes among high school wrestlers.

As the principal of this school, I authorize Dr. Lenka Humenikova and Dr. Nancy Betts to conduct the proposed research project with the wrestling team in this high school. Parents/guardians will be contacted and informed about the study. A written consent will be obtained from parents/guardians prior to their sons' participation in the study. No information will be collected from wrestlers unless their parents/guardians give consent for their participation. I understand that any wrestler (or parent/guardian) is free to withdraw from the study at any time. I was informed about all parts of the study and I sign my name freely and voluntary. A copy of this informed consent form was given to me. If I have any questions about the study, I can contact Dr. Lenka Humenikova (at 405- 744-8285 or email: lenka.humenikova@okstate.edu) or Dr. Nancy Betts (at 405- 744-5040 or nancy.betts@okstate.edu).

_____ _____ Date:_____

Principal's Name (print) Signature of the Principal

APPENDIX C

PARENT/GUARDIAN PERMISSION FORM

Project Title: Body Composition Changes in High School Wrestlers during Pre-season, Season, and Off-season

Project Leaders: Lenka Humenikova, PhD and Nancy Betts, PhD, RD

We are asking your son to participate in a research study conducted by Dr. Lenka Humenikova and Dr. Nancy Betts from the Department of Nutritional Sciences at Oklahoma State University. The main purpose of this research study is to assess body composition (body fat etc.) and resting metabolic rate, and determine whether changes in body composition and resting metabolic rate occur between pre-season, season, and off-season among high school wrestlers. The secondary purpose of this study is to evaluate wrestlers' dietary intakes and eating attitudes, and determine the association between body composition, metabolic rate, and dietary intakes among high school wrestlers.

Your son is being asked to participate in this study because he is a member of the wrestling team. Your son will have his body fat measured, as required by the new regulations from the Oklahoma Secondary School Activities Association (OSSAA), by an assessor designated by the high school wrestling coach/athletic director/principal prior to the wrestling season. Your son's participation in this study is completely voluntary and is not necessary for meeting the OSSAA's requirements.

During this research study, your son will be invited to visit the Department of Nutritional Sciences at Oklahoma State University in Stillwater three times (during pre season, season, and off-season). The length of time your son will be involved in actual measurements will be approximately 1-1.5 hours. However, each of the three visits may take up to 5 hours because several of his teammates may be evaluated during the same visit.

The following measurements will be conducted with your son during <u>each</u> of the three visits.

1. Your son's body composition will be measured using one Dual Energy X-ray Absorptiometry (DEXA) scan. DEXA is currently the most accurate scan that measures body composition and bone density. Your son will be asked to dress in comfortable clothing (we will provide clothing if needed) and he will be asked to remove any metal that he may be wearing (excluding orthodontic braces). During the scan, your son will lay on an examination table while a machine arm passes over his body. The scan will

take approximately 4-5 minutes (to allow for positioning and adjustment, we estimated 10-15 minutes per scan). Your son should feel no discomfort. The X-rays exposure from DEXA is much smaller than exposure from a dental or chest X-ray and is significantly lower than the amount of radiation individuals receive from natural background radiation.

2. Your son's body composition will also be measured using standard skinfold thickness measurements. A trained researcher will measure your son's body fat using calipers in at least three different places on the body (arm, stomach, back etc.). This measurement will take approximately 5 minutes. Before the body composition measurement, we will ask your son to provide a urine sample to evaluate his hydration status and we will measure his height and weight.

3. Because body composition affects metabolic rate, we will measure your son's resting metabolic rate during each visit. Your son will sit in a chair with a clear canopy placed over his head. Your son will be asked to rest as much as possible or even fall asleep. We will simply measure the amount of oxygen he breaths in and the amount of carbon dioxide he breaths out with each breath for 30 minutes.

4. During each visit, your son will also be asked to recall what foods and beverages he ate during the previous day. This activity will take about 10-15 minutes.

5. Lastly, your son will complete a 5-minute questionnaire about his dietary habits and attitudes related to food and weight.

During one of the three visits, your son will have an opportunity to tour the Wrestling Hall of Fame which is located on the OSU campus in Stillwater. In addition, popular movies and refreshments will be offered to your son while measurements are being taken from his teammates during each visit.

You and your son will benefit from the study by receiving results of the DEXA scan, resting metabolic rate, and skinfold thickness measurements. These results will be made available to you and your son within two weeks of each visit. The investigators will place the results of your son's measurements in a sealed envelope and deliver it to your son's wrestling coach within two weeks of each visit. The wrestling coach will be responsible for giving the sealed envelope to your son at school. You and your son will benefit from the study by obtaining specific information on your son's body composition and resting metabolic rate. We strongly encourage you to visit with your son's physician and discuss the results of the measurements with him/her. If requested by you or your son, we will offer individualized nutrition information to your son based on the findings of the study.

The records of this study will be kept private. The written results of this study will only refer to group findings and will not include information that will identify you or your son. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research. We will protect confidentiality during the project by assigning an ID number to your son. The list of all names and corresponding ID numbers will be kept in a locked drawer and only the project leaders will have access to the list. Your son's measurements will be obtained in a separate room without the presence of other individuals.

The results of the DEXA scans, resting metabolic measurements, and skinfold thickness measurements will be offered only to you and your son within two weeks of each visit. If any other individual wishes to obtain the results of your son's measurements, they will be required to contact you directly, receive your permission, and obtain those results directly from you.

Participation in the study is voluntary. If your son feels uncomfortable while reporting any information, he can choose not to answer any question, or he can withdraw completely from the study at any time. You have also the right to withdraw the consent for your son at any time by notifying the researchers. Your decision will not result in any loss of benefits to which you or your son is otherwise entitled.

If you have questions about the project, please contact Lenka Humenikova by phone at (405) 744-8285 or by email at lenka.humenikova@okstate.edu or Nancy M. Betts by phone at (405) 744-5040 or by email at nancy.betts@okstate.edu. If you have any questions about your son's rights as a research participant, you may contact Dr. Sue Jacobs, Institutional Review Board Chair, 219 Cordell North, Oklahoma State University, Stillwater, OK 74078 by phone at (405) 744-1676 or by email at irb@okstate.edu.

DOCUMENTATION OF INFORMED CONSENT

You are voluntarily making a decision whether or not to allow your son to participate in the research study. Your signature certifies that you have decided to allow your son to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

Parental Signature for Minor

I understand the risks associated with this study and voluntarily choose to participate. I understand that no funds have been set aside by Oklahoma State University to compensate me in the event of illness or injury."

I have read and fully understand the consent form. As parent or guardian I authorize _____(print name) to participate in the described research.

_____ _____

Signature of Parent/Guardian Date

I certify that I have personally explained this document before requesting that the participant sign it.

_____ _____

Signature of Researcher Date

APPENDIX D

LETTER FOR PARENTS/GUARDIANS

Dear parents/guardians,

Dr. Lenka Humenikova and Dr. Nancy Betts from the Department of Nutritional Sciences at Oklahoma State University are conducting a research study titled "Body Composition Changes in High School Wrestlers during Pre-season, Season, and Off-season." The main purpose of this study is to assess body composition (body fat etc.) and resting metabolic rate, and determine whether changes in body composition and resting metabolic rate occur between pre-season, season, and off-season among high school wrestlers. The secondary purpose of this study is to evaluate wrestlers' dietary intakes and eating attitudes, and determine the association between body composition, metabolic rate, and dietary intakes among high school wrestlers.

Your son is a member of the high school wrestling team and we would like him to participate in our research study. The documents enclosed in this envelope include the "Parent/Guardian Permission Form" and the "Assent Script/Form" for your son. The documents provide a detailed description of the study, the nature of your son's involvement and potential benefits and risks associated with participating in the study.

We would like you to review these documents and decide whether you would like your son to participate in the study. If you choose to give your permission, please sign the "Parent/Guardian Permission Form." If your son wishes to participate, he should review and sign the "Assent Script/Form." Please, place both documents in a sealed envelope (in the same envelope the documents were provided to you) and return it to the high school wrestling coach through your son within the next two days. If you have any questions, please contact Dr. Lenka Humenikova by phone at (405) 744-8285 or by email at lenka.humenikova@okstate.edu, or Dr. Nancy Betts by phone at (405) 744-5040 or by email at nancy.betts@okstate.edu.

Thank you for your time.

Sincerely,

Lenka Humenikova Nancy Betts

APPENDIX E

ASSENT SCRIPT AND FORM

Project Title: Body Composition Changes in High School Wrestlers during Pre-season, Season and Off-season

Project Leaders: Lenka Humenikova, PhD and Nancy Betts, PhD, RD

We are conducting this study to measure your body composition and metabolic rate before, during and after the wrestling season. We have asked you to participate because we are conducting a research study involving male adolescent wrestlers and you are a member of the high school wrestling team. Our measurements will also allow us to determine your dietary intake and attitudes about food.

You will be invited to visit the Department of Nutritional Sciences at Oklahoma State University in Stillwater three times (during pre-season, season, and off-season). During each visit, you will be involved in several measurements that will take approximately 1-1.5 hours. If several of your teammates will be measured on the same day, each visit may take up to 5 hours, depending on how many wrestlers will be evaluated on that day.

During each visit, we will ask you to dress comfortably with no metal in your clothes or on you (except for orthodontic braces). To measure your body composition, we will ask you to lay still on an examination table while the body composition machine will scan your whole body. The scan will take about 4-5 minutes. You should feel no pain and you should not experience any discomfort. The scan uses 10 times less X-rays than what you get from a dental x-ray. We will also measure your body fat using skin-fold calipers in at least 3 different places on your body which will take approximately 5 minutes. Before these measurements, we will ask you to provide a urine sample to evaluate your hydration status and we will measure your height and weight. All of these measurements will be conducted one time during each visit (pre-season, season, off-season).

To measure your metabolic rate, we will ask you to sit in a comfortable reclining chair. We will place a clear canopy over your head and ask you to sit quietly for 30 minutes. This exam measures the amount of oxygen you breathe in and the amount of carbon dioxide you breathe out. You should feel no pain and you should not experience any discomfort. We will measure your resting metabolic rate during each visit.

We will ask you to recall all foods and beverages you consumed during the previous 24 hours. This activity will take about 10-15 minutes. In addition, you will be asked to complete a 5-minute questionnaire containing questions about your dietary habits and attitudes related to food. We will complete one 24-hour recall with you and you will complete the questionnaire during each visit.

In addition to one 24-hour recall, we will collect one set of 7-day food records from you during pre-season, season, and off-season. You will be given 7 food record sheets and we are asking you to record your food and beverage intake for 7 continuous days. The food record sheets will be given to you in a sealed envelope during your visits to NSCI department. Instructions will be given to you on how to complete 7-day food records. Within 7-8 days after you receive and complete your food records you will return them in a sealed envelope to your coach/trainer and they will mail them to us at OSU.

We will make arrangements for you to enjoy refreshments while your teammates are being measured during each visit. You should feel no pain and you should not experience any discomfort during any of the measurements. You will be able to stop the measurements at any time by asking the attendant.

Your participation is completely voluntary. You have the right to withdraw from the study anytime. If you decide to withdraw from the study, you just need to inform your parents or one of the researchers involved in the study. If you choose not to participate or if you withdraw at any time, it will not affect your relationship with your team, your coach or anyone at the Oklahoma State University. If you have any questions, please feel free to contact Dr. Lenka Humenikova at (405) 744-8285 or Dr. Nancy M. Betts at (405) 744-5040.

By participating you will have a very accurate measure of your body composition (body fat), and resting metabolic rate. Knowing these measurements will help you and your parents/guardians make decisions about weight loss or weight gain for wrestling. You will benefit from the study by learning more about your body composition and metabolic changes during pre-season, season, and off-season.

If you sign this form it means that you have decided to participate and have read everything that is on this form. You and your parents will be given a copy of this form to keep.

Yes, I would like to participate in the study _____ _____

Name (please print) Signature/Date

APPENDIX F

WRESTLING STUDY

24-HOUR RECALL **DAY: _____**

BREAKFAST	AMOUNT
SNACK	
LUNCH	
SNACK	

DINNER	
SNACK	

ADDITIONAL COMMENTS:

VITA

Lauren Kaye Bradley

Candidate for the Degree of

Master of Science

Thesis: CHANGES IN RESTING METABOLIC RATE AND DIETARY INTAKE AMONG HIGH SCHOOL WRESLTERS FROM PRE-SEASON TO POST-SEASON

Major Field: Nutritional Sciences

Biographical:

Personal Data: Born in Olathe, Kansas, the daughter of Lowell and Teresa Ghosey

Education: Completed the requirements for the Master of Science in Nutritional Sciences at Oklahoma State University, Stillwater, Oklahoma in December,2008. Completed the requirements for a Bachelor of Science in Nutritional Sciences with a Dietetics Option, and Health Promotion minor at Oklahoma State University, Stillwater, Oklahoma in December 2006. Completed the requirements for the Master of Science in Nutritional Sciences at Oklahoma State University, Stillwater, Oklahoma in December 2008.

Experience: Completed the Dietetic Internship at Oklahoma State University in July 2008; passed the registration examination to become a registered dietitian in August 2008; employed by Oklahoma State University, Department of Nutritional Sciences as a research assistant from January to December of 2007; currently employed at Tulsa City County Health Department as a Health Education Specialist and Registered Dietitian.

Professional Memberships: American Dietetic Association, Oklahoma Dietetic Association

Name: Lauren Kaye Bradley Date of Degree: December, 2008

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: CHANGES IN RESTING METABOLIC RATE AND DIETARY INTAKE AMONG HIGH SCHOOL WRESTLERS FROM PRE-SEASON TO POST-SEASON

Pages in Study: 63 Candidate for the Degree of Master of Science

Major Field: Nutritional Sciences

Scope and Method of Study: The purpose of this study was to describe and evaluate changes in resting metabolic rate and dietary intake that occur in a sample of high school wrestlers over the course of a year. The resting metabolic rate measurements and dietary intakes were compared over the duration of a wrestling season (pre-season, in-season, and post-season) for this cross-sectional, descriptive study. The sample consisted of 25 adolescent male wrestlers (mean age=15.5 years) who were participating in the 2006-2007 wrestling season. Resting metabolic rate was measured using the Vmax Encore metabolic cart with a ventilated canopy. Dietary intakes were collected using multiple pass 24-hour recalls and examined in terms of total energy intake, and percent of total calories coming from carbohydrate, fat and protein.

Findings and Conclusions: Based on the results of this study, metabolic rate of the subjects did not change significantly from pre-season to in-season, and post-season. However, wrestlers' dietary intakes changed significantly during the year. Significant differences in their total energy intake ($p=0.023$) and carbohydrate intake ($p=0.029$) were observed between pre-season and post-season. Wrestlers consumed more energy and carbohydrate during the post-season compared with pre-season. Numerically, the lowest body weight, carbohydrate, fat, protein, and energy intakes were observed during pre-season; however, these findings were nonsignificant. No positive correlations were detected between dietary intakes and resting metabolic rate during any data collection periods. Further research on changes in resting metabolic rate and dietary intakes among high school wrestlers are warranted. Future studies should utilize large and representative samples of high school wrestlers and follow them over multiple wrestling seasons. Furthermore, more in-depth dietary analysis based on multiple food records is needed to gain knowledge on food choices and dietary patterns of high school wrestlers during the year.

ADVISER'S APPROVAL: Dr. Lenka H. Shriver