

ABSTRACT

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This study looked at the chance of error that a wrestling and weightlifting workout had on the proximity of body fat percent measurements of wrestlers. The study compared a pretest measurement to the following posttest measurements: immediate, 30, 60, and a 90 minute posttest. A second part of the study compared the effects on body fat percent between a wrestling and weightlifting workout. The body fat percent was determined by using the Wisconsin Interscholastic Athletic Association (WIAA) standards by using skinfold measurements. There were three sites used (triceps, subscapular, and umbilical) to determine the wrestler's body fat percent. Subjects were 19 college wrestlers ranging from 18 to 24 years of age. A paired t-test was performed to compare the effects of pretest to posttest measurements on body fat percent. A paired t-test was also used to compare the effects on body fat percent between a wrestling workout and a weightlifting workout. The body fat percent for the wrestling workout and the weightlifting workout was significantly different ($p < .05$) from the pretest measurements during the following posttest times: 30, 60, and 90 minutes after each workout. The body fat percent was significantly different ($p < .05$) when the wrestling workout was compared to the weightlifting workout during the following measurements: pretest, immediate, 30, 60, and 90 minute posttests. These data suggest that each workout had an effect on skinfold measurements taken following the workout. The body fat percent decreased with each time period following both workouts. However, the immediate posttest for both workouts was not significantly different. This is contrary to what the WIAA suggests, which is not to take skinfold measurements immediately after a workout. Despite what has been found, it would be best to take skinfold measurements before a workout or on a separate day of a workout.

**A COMPARISON OF THE EFFECTS OF A WRESTLING PRACTICE
AND A WEIGHTLIFTING WORKOUT ON THE
BODY FAT PERCENT OF WRESTLERS**

**A THESIS PRESENTED
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THE GRADUATE FACULTY
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CHAPTER I

INTRODUCTION

Wrestling is one of the few sports that relies on body composition. Wrestlers compete against other wrestlers of equal body weight. Therefore, when competing against wrestlers of similar weight, it would be most beneficial for a wrestler to have the least amount of body fat possible. It is to the wrestler's advantage to be as lean as possible because this may enhance the wrestler's quickness and agility.

Frequently wrestlers use weightlifting to help build or maintain their strength, while decreasing their percentage of body fat. Wrestlers need to combine power with quickness and agility. Therefore, it is most beneficial to have as little body fat as possible.

There has been a substantial amount of research reported on the effects of weight training and wrestling on body composition. However, there has been little, if any research reviewed on body composition over a period of time following a workout. This study required wrestlers to have their body composition (by skinfold measurements) tested before a wrestling workout and before a weightlifting workout. Each workout lasted 1 hour. Skinfold measurements were taken: immediately, 30, 60, and 90 minutes after the

workout (weightlifting or wrestling) was completed. Measurements taken after the workout were intended to inform the Wisconsin Interscholastic Athletic Association (WIAA) how much of an affect a wrestling and a weightlifting workout has on skinfold testing. These data could also inform the WIAA how long after a workout they should wait before skinfold testing.

Weight training can be very influential in meeting the need for strength and power. The ideal training regimens as far as sets and repetitions, length of contractions, types of contractions, frequency, and rest intervals are constantly changing. For athletes to attain their goals in the weight room, it is difficult to develop the "ideal" workout (Trojack, 1986).

There have been different circuit weight training programs developed to elicit changes in body composition. A 10 week program, with both men and women working out 3 days a week, found no change in relative or absolute body fat (Drumm, 1985). Another, a 20 week circuit weight training study with all males between the ages of 18-35, found significant positive changes in body composition (Maneval, 1981). These studies tested body composition, pre- and posttested, over a period of 10 and 20 weeks, respectively.

The weight training program that was utilized for the present study was a superset method. This is a combination of two or three different exercises for the same muscle

group. The exercises are performed one after another without a rest period in between (Weider, 1989). This allowed the wrestlers to get a good workout for all of the major muscle groups in a short period of time (see Appendix A). Time is also an important factor if the wrestlers stand around too long between sets and lose "blood engorgement" that they usually get after lifting weights. This could significantly affect the results of the skinfold measurements. The subjects were wrestlers from the University of Wisconsin-La Crosse wrestling team. The wrestling workout consisted of a regular wrestling practice lasting 1 hour in length. It was performed on a separate day of the weightlifting workout. This workout contained regular wrestling matches (three matches each 7 minutes in length) and drilling on specific moves. This type of workout is physically demanding, even for the highly trained athletes. Every major muscle group was used in this workout. This type of practice was designed by the University of Wisconsin-La Crosse wrestling coach, Greg Lonning. These were the same wrestlers who performed the weightlifting workout.

Statement of the Problem

This study looked at the chance of error that a wrestling and weightlifting workout had on the proximity of skinfold measurements every half hour for 90 minutes after each workout. A second part of the study compared the

effects of a wrestling workout to the effects of a weightlifting workout on the body fat percent measurements. This comparison was done to see if there was a difference in body fat percent measurements between the two workouts.

Need for the Study

Skinfold testing is one way to determine body composition. It can be very accurate if performed by someone who is properly trained. In many clubs, gyms, and schools, skinfold testing may be the only means of measuring body composition. In order for this to be accurate, an experienced tester should conduct the test and should be aware of any factors that might effect or cause testing error. If lifting weights or wrestling affect the size of skinfolds within 90 minutes after a workout, then the skinfold testing should be conducted on a separate day or before a wrestling/weightlifting workout.

The reason wrestlers were chosen for this study was because they rely on the results of skinfold measurements to determine how much more weight they can safely lose. There is a possibility that a wrestler may lift weights or wrestle prior to having his skinfold measurements tested. Since a chance of error exists, and skinfolds are affected by lifting weights or wrestling, some other means of determining body composition should be measured.

The WIAA requires a wrestler to drop no lower than 7% body fat (Clark, Kuta, & Oppliger, 1990). If a skinfold

measurement is affected by a wrestling workout or a weightlifting workout, it should be determined how long after the workout the WIAA officials should wait before they take skinfold measurements. If the measurement is larger than what it should be, then the wrestler may be able to lose more weight even though they may already be at 7% body fat. If the measurement is smaller than what it should be, then a wrestler who may be above 7% body fat may be required to stop losing weight. This would all be due to an error in skinfold measurements.

This study may also help determine what factors should be considered before conducting a skinfold test. An individual's somatotype may also have an affect on skinfolds after lifting weights (Behnke & Wilmore, 1974).

Purpose of the Study

The purpose of this study was to compare a pretest skinfold measurement taken before the workout (wrestling and weightlifting) to posttest measurements taken after the workout. The posttest measurements were taken: immediately, 30, 60, and 90 minutes after the workout. A second part of the study compared the effects on skinfold measurements between a wrestling workout and a weightlifting workout.

Hypotheses

The following null hypotheses were tested at the $p < .05$ level of significance. A paired t-test was used to test the hypotheses:

1. There is no significant difference between body fat percent measured before a wrestling workout and:
 - A. The body fat percent measured immediately after the workout.
 - B. The body fat percent measured 30 minutes after the workout.
 - C. The body fat percent measured 60 minutes after the workout.
 - D. The body fat percent measured 90 minutes after the workout.
2. There is no significant difference between body fat percent measured before a weightlifting workout and:
 - A. The body fat percent measured immediately after the workout.
 - B. The body fat percent measured 30 minutes after the workout.
 - C. The body fat percent measured 60 minutes after the workout.
 - D. The body fat percent measured 90 minutes after the workout.
3. There is no significant difference between body fat percent before a wrestling workout and:
 - A. The body fat percent before a weightlifting workout.

- B. There is no significant difference between body fat percent immediately after a wrestling workout and immediately after a weightlifting workout.
- C. There is no significant difference between body fat percent 30 minutes after a wrestling workout and 30 minutes after a weightlifting workout.
- D. There is no significant difference between body fat percent 60 minutes after a wrestling workout and 60 minutes after a weightlifting workout.
- E. There is no significant difference between body fat percent 90 minutes after a wrestling workout and 90 minutes after a weightlifting workout.

Delimitations

The following were delimitations of this study:

1. Subjects were selected from the University of Wisconsin-La Crosse wrestling team.
2. Skinfold measurements were taken at the following sites: triceps, subscapular, and umbilical. These are the same sites the WIAA uses when measuring skinfolds.

Limitations

The following were limitations of this study:

1. Only males were studied.
2. The testing sample was not randomly selected.
3. The minimum age of the sample was 18 years.

Assumptions

The following were assumptions regarding this study:

1. Subjects understood procedures and gave maximal effort.
2. Subjects followed procedures as prescribed.
3. Subjects were in good physical condition.
4. Subjects lifted in Mitchell Hall weight room.
5. Subjects understood each exercise.
6. The researcher was properly trained in laboratory techniques for skinfold testing.

Definition of Terms

The following terms were used in this study:

Body Composition - deals with what percent of the body is lean tissue (muscle, bone) and what percent of the body is made up of adipose (fat) tissue (Stone & Kroll, 1991).

Circuit Weight Training - a series of resistance training exercises or lifts done one right after the other with minimal rest (15-20 seconds) between exercises (Fleck & Kraemer, 1987).

Duration - the length of time a workout takes (Stone & Kroll, 1991).

Extension - increase the angle at a joint. The return position from flexion (Stone & Kroll, 1986).

Flexion - decrease the angle at a joint. A muscle is flexed when it contracts and becomes shorter (Stone & Kroll, 1986).

Frequency - the number of workouts in a day or week (Stone & Kroll, 1991).

Harpenden Calipers - instrument used to measure skinfolds.

Intensity - the perceived difficulty of the workout, which includes the amount of weight used, sets, and repetitions. (Stone & Kroll, 1991).

One-Repetition Maximum - the maximum amount of weight lifted one time with correct form during the performance of a predetermined weightlifting exercise (Stone & Kroll, 1991).

Repetition - the number of times a movement is performed using a barbell or weight machine (Stone & Kroll, 1991).

Spot - to observe someone performing a lift to make sure they are using the proper technique (Stone & Kroll, 1991).

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

There are 13 different weight classes in high school wrestling. The intent of these weight classes is to equalize competition by limiting body weight differences between competitors (Tipton, 1990). Wrestlers feel that losing weight and reducing body fat percent will enhance their performance during competition.

The review of related literature for this study is divided into three main sections. The first section discusses different types of resistive training. The second section includes measurement of body composition. The third section discusses the relationship between resistive training and body composition.

Resistive Training

There are many different types of resistive training, ranging from the use of machines and free weights to doing a push-up or chin-up, using one's own body weight. Weight training, using both machine and free weights, was the method used in this study. There are many different systems in weight training that vary in number of sets and repetitions, intensity, percentages, and rest interval. The following are selected systems of weight training.

Delormes Principle. This is a regimen that consists of three sets of 10 repetitions of a 10 repetition maximum (RM) (Stone & Kroll, 1986). As the sets increase, so does the percentage of weight, for example:

1st set - 10 reps, 50% of 10 RM

2nd set - 10 reps, 75% of 10 RM

3rd set - 10 reps, 100% of 10 RM

Circuits. This consists of a series of resistive training exercises or lifts done one right after the other with minimal rest (15-30 seconds) between exercises. The repetitions range from 10-15 at 40-60% of a 1 RM. The major goal is to improve muscular and cardiovascular endurance. This is ideal for individuals with limited time (Fleck & Kraemer, 1987).

Set System. This method consists of two or more sets of a combination of exercises for every rest period (Fleck & Kraemer, 1987). It can either be performed within the same muscle group or with antagonistic muscle groups. Below are examples:

a) super-set - involves two exercises, one after the other, and then a rest interval:

1. bar curls (1 x 8)
2. tricep extension (1 x 8)
3. rest interval

(1 set)

- b) tri-set - consists of groups of three exercises.

May concentrate on same muscle group or antagonistic muscle groups.

1. bar curls (1 x 6)
2. tricep extension (1 x 6)
3. military press (1 x 6)
4. rest interval

(1 set)

Exhaustion. This is performing each set to exhaustion or failure. The maximum number of repetitions is dictated by a chosen goal. The following are different variations:

- a) set to failure - each set is performed to failure.

Two - three sets are usually performed. This system recruits more muscle units which creates a greater training stimulus.

example: leg extension (set #1 - 16 reps)

(set #2 - 8 reps)

(set #3 - 6 reps)

- b) forced reps - after a set has been performed to its maximum reps, the training partner assists the lifter just enough to force out 3-4 more reps.
(Stone & Kroll, 1991).

These are just a few of the different systems of weight training. There are many other systems used by athletes for various reasons such as power, endurance, and flexibility.
(Stone & Kroll, 1986). There is a system that is specific

for whatever area an athlete needs to improve. This study used a superset workout to prepare the subjects for their skinfold test.

Body Composition

Skinfold testing is a method of measuring one's body composition. It involves measuring the thickness of the subcutaneous fat layer using calipers. There are many different sites on the body where these measurements are taken. The following are some common sites: chest, subscapular, triceps, abdominal, and thigh (Housh, Johnson, Housh, & Kenney, 1990). The following is a formula by Lohman (1981) that the skinfold measurements may be inserted into:

$$BD = 1.0982 - (0.000815 \times [X_s] + (0.00000084 \times [X_s]^2)$$

BD = body density

X_s = sum of chest, subscapular, tricep, abdominal, and thigh.

To determine the body percent fat, body density can be inserted into Brozek, Grande, Anderson, & Keys (1963) equation:

$$\% \text{ Fat} = \frac{4.570}{BD} - 4.142 \times 100 \quad (\text{Berg, 1991})$$

Resistive Training and Body Composition

There have been numerous studies reviewed on the effect of resistive training on body composition. Some studies have found that weight training cannot favorably effect body

composition, while other studies show that weight training does have a positive effect (Evans, 1985).

One study involved a 10 week program of circuit weight training to see if it elicited any changes in body composition in 16 men and 16 women. The subjects trained on the universal gym, three circuits (out of 10) a day, three days a week. Body composition was assessed eight times by the underwater weighing technique. The study concluded that no changes were found in relative or absolute body fat (Drumm, 1985).

Another study was conducted using the universal gym and circuit weight training technique. This study was conducted for 20 weeks, three times a week and used 70 male volunteers between the ages of 18 and 35 years. Body composition was determined by the underwater weighing technique. When compared to a sedentary control group, significant positive changes were found in body composition (Maneval, 1981).

These two studies showed two different outcomes with the use of resistive training. The differences may have resulted from the number of subjects in each study and the number of weeks each study was conducted. However, there is support for and against the use of resistive training to alter body composition. There have not been any studies found on the immediate effects of a wrestling practice on skinfold measurements.

Summary

This chapter was divided into three sections. The first discussed resistive training, the second discussed body composition, and the third discussed whether or not resistive training effects body composition.

This chapter discussed resistive training and body composition separately. The discussion then combined the two to see if resistive training has an effect on body composition. One study accepted the hypothesis, the other study rejected the hypothesis. The study that accepted the hypothesis had 70 subjects, all male, and lasted 20 weeks. The study that rejected the hypothesis had 32 subjects, 16 men and 16 women, and lasted 10 weeks. Because of conflicting results it appears further study is warranted regarding the number of subjects, number of weeks, and the men to women ratio.

CHAPTER III

METHODS

Introduction

The purpose of this study was to compare the effects of a wrestling practice and weight training on body composition (skinfolds) of college age male wrestlers. The subjects participated in a regular wrestling practice for 1 hour and lifted weights for 1 hour, maximum, then had their body composition taken. This chapter was divided into the following sections: 1) subject selection; 2) instrumentation; 3) testing procedures; 4) training; and 5) statistical analyses.

Subject Selection

A total of 30 men, ranging in age from 18-24 years, from the University of Wisconsin-La Crosse wrestling team were subjects in this study. The subjects volunteered for the study. These subjects were selected because this study required subjects who were experienced weightlifters and wrestlers.

The subjects were required to have their initial skinfolds taken with skinfold calipers for determining body composition. On a separate day the subjects lifted weights and then had their skinfold measurements taken again. Then they wrestled on another day and had their skinfold

measurements taken. All subjects were assumed to be in good physical condition and experienced in the weight room.

Potential risks and procedures were explained to the subjects prior to the testing, both verbally and in writing on the informed consent form (see Appendix B).

Instrumentation

The following is a description of the instrument used to obtain the data.

Skinfold Calipers - Harpenden calipers were used to determine the skinfold measurements. The following skinfold sites were used: triceps, subscapular, and umbilical. These sites are in accordance with the WIAA rules of measurement. Harpenden calipers were considered as an accurate caliper for determining skinfold thickness according to the WIAA handbook.

Testing Procedures

Each subject was contacted to set up a day to be tested. They reported to the University of Wisconsin-La Crosse Human Performance Laboratory where their skinfold measurements were taken. At this time they established another time to lift weights and have their skinfold measurements checked again. Other times were set up for them to be tested after wrestling practice. They also had the procedures explained to them verbally and in writing, by the informed consent (see Appendix B). They were not allowed to continue until they had read and signed the informed consent.

After signing the informed consent another testing time was set up. This testing procedure involved lifting weights and wrestling prior to having skinfold measurements taken every half hour for 90 minutes. There were specific lifts (see Appendix A) and percentages for the subjects to follow. After lifting weights at the Mitchell Hall Strength Center the subjects dried off before the skinfolds were measured.

Skinfolds

Skinfold measurements use calipers to measure the thickness of the subcutaneous fat layer. Harpenden calipers were used to measure the skinfolds at the following sites: triceps, subscapular, and umbilical. All measurements were taken by the same tester to reduce the amount of error (Kuta, Clark, Weber, & Ward, 1990). Each site was tested three times and an average of the three was taken if at least two were not equal.

Before the skinfold measurements were taken the subjects dried off with a towel. The skinfold was then firmly grasped between the thumb and index finger. The caliper was then placed perpendicular to the fold and approximately 1 cm from the thumb and index finger. The measurements were taken from the right side of the body of each subject.

The triceps skinfold is a vertical fold on the posterior midline of the upper arm, midway between the acromion and olecranon processes. The elbow is extended and

relaxed. The subscapular skinfold is on a diagonal line from the vertebral border to one to 2 cm from the inferior angle of the scapula. The umbilical skinfold is a vertical fold 3 cm from the midpoint of the umbilicus (Jackson & Pollock, 1985).

The tester who took these skinfold measurements on the wrestlers was trained to measure skinfold measurements. The tester also had approximately 1 year of experience measuring skinfold thickness.

Training

Each subject set up a specific date and time to lift weights and have skinfold measurements tested. They performed the same exercises by following the procedures listed in Appendix A. They were tested two at a time. This allowed for two subjects to workout together so one could spot the other as well as be a motivator. Subjects tested on a particular day would follow the same exercises, repetitions, and percentage of weight increase. This helped maintain the intensity through the workout.

The workout contained two different exercises per body part: chest, triceps, quadriceps, biceps, and back. Each exercise maintained 75% of the wrestler's one repetition maximum with each set, in which there were three sets per exercise. This would give each muscle group a chance to fill up with blood. This workout would take no longer than 1 hour. Each subject was instructed on the proper technique

for each lift before they were tested. As soon as they were done lifting, within the time frame at Mitchell Hall Strength Center, they reported to the wrestling room in Mitchell Hall. There they dried off and had their skinfold measurements taken every half hour for 90 minutes. The wrestling practice was a normal practice for what they were used to doing. This was because practice was difficult to control, and it was more realistic not to control it. The practice lasted no longer than 1 hour.

Statistical Analyses

Once all the testing was completed, the skinfold sites (tricep, subscapular, and umbilical) for each time period were analyzed to find the means, standard deviations, and standard error of estimates (SEE). A paired t-test was used to detect differences between wrestling workouts and weightlifting workouts. The skinfold values for each time period (every half hour for 90 minutes) were analyzed to determine if there were significant ($p < .05$) differences in the subject's body fat percentages over time, compared to their pretest measurement.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

The purpose of this study was to compare a pretest skinfold measurement taken before the workout to the following posttest measurements: immediately, 30, 60, and 90 minutes after the workout. Another purpose was to determine if there was a significant difference in body fat percent between a wrestling workout and a weightlifting workout. Each subject had his body composition determined at the following WIAA recommended sites: tricep, subscapular, and umbilical. The Lohman equation (1981) was used to calculate the body density, and the Brozek et al. equation (1963) was used to find the body fat percent. The ($p < .05$) level of significance was used to accept or reject the null hypotheses.

Results

Subjects

The subjects ($N = 19$) for this study were males from the University of Wisconsin-La Crosse wrestling team. They ranged in age from 18-24 years. Each subject performed a 1 hour wrestling workout and a 1 hour weightlifting workout.

Comparison of Methods

One of the major focuses of this paper was to compare the accuracy between skinfold measurements before and after

a wrestling or weightlifting workout. Measurements after a workout were taken: immediately, 30, 60, and 90 minutes after the workout.

Hypothesis 1A

Hypothesis 1A stated that there was no significant difference between body fat percent measured before a wrestling workout, and the body fat percent measured immediately after the workout. The test for the difference between the body fat percent (see Table 1) before and immediately after a wrestling workout resulted in a $T_{(-1.554)}$ with no significant difference of $< .138$ (see Table 2). Therefore, hypothesis 1A was not rejected.

Table 1. Fat percent

Measurement	Wres vs lift	Mean	STD deviation	Number
Fat % pretest	wres	10.4771	1.81088	19
	lift	11.1110	2.22618	19
Fat % immediate posttest	wres	10.3529	1.68657	19
	lift	10.9492	2.02764	19
Fat % 30 min posttest	wres	10.2756	1.78904	19
	lift	10.7136	1.84201	19
Fat % 60 min posttest	wres	10.2580	1.78655	19
	lift	10.5652	1.78254	19
Fat % 90 min posttest	wres	10.2848	1.88370	19
	lift	10.5725	1.93100	19

Hypothesis 1B

Hypothesis 1B stated that there was no significant difference between body fat percent measured before a wrestling workout, and the body fat percent measured 30 minutes after the workout. The test for the difference between the body fat percent (see Table 1) before and 30 minutes after a wrestling workout resulted in a $T_{(3,717)}$ with a significant difference of $< .002$ (see Table 2). Therefore, hypothesis 1B was rejected.

Hypothesis 1C

Hypothesis 1C stated that there was no significant difference between body fat percent measured before a wrestling workout, and the body fat percent measured 60 minutes after the workout. The test for the difference between the body fat percent (see Table 1) before and 60 minutes after a wrestling workout resulted in a $T_{(3,209)}$ with a significant difference of $< .005$ (see Table 2). Therefore, hypothesis 1C was rejected.

Hypothesis 1D

Hypothesis 1D stated that there was no significant difference between body fat percent measured before a wrestling workout, and the body fat percent measured 90 minutes after the workout. The test for the difference between the body fat percent (see Table 1) before and 90 minutes after a wrestling workout resulted in a $T_{(3,200)}$ with

a significant difference of $< .005$ (see Table 2).

Therefore, hypothesis 1D was rejected.

Table 2. Wrestling workout

Workout	T-statistic	D.F.	Two-tailed probability
Pretest vs. immediate post	-1.55362	18	0.1377
Pretest vs. 30 minutes post	-3.70686	18	0.0016
Pretest vs. 60 minutes post	-3.20927	18	0.0049
Pretest vs. 90 minutes post	-3.19691	18	0.0050

Hypothesis 2A

Hypothesis 2A stated that there was no significant difference between body fat percent measured before a weightlifting workout, and the body fat percent measured immediately after the workout. The test for the difference between the body fat percent (see Table 1) before and immediately after a weightlifting workout resulted in a $T_{(-1.373)}$ with no significant difference of $< .186$ (see Table 3). Therefore, hypothesis 2A was not rejected.

Hypothesis 2B

Hypothesis 2B stated that there was no significant difference between body fat percent measured before a

weightlifting workout, and the body fat percent measured 30 minutes after the workout. The test for the difference between the body fat percent (see Table 1) before and 30 minutes after a weightlifting workout resulted in a $T_{(3.527)}$ with a significant difference of $< .002$ (see Table 3). Therefore, hypothesis 2B was rejected.

Hypothesis 2C

Hypothesis 2C stated that there was no significant difference between body fat percent measured before a weightlifting workout, and the body fat percent measured 60 minutes after the workout. The test for the difference between the body fat percent (see Table 1) before and 60 minutes after a weightlifting workout resulted in a $T_{(4.200)}$ with a significant difference of $< .001$ (see Table 3). Therefore, hypothesis 2C was rejected.

Hypothesis 2D

Hypothesis 2D stated that there was no significant difference between body fat percent measured before a weightlifting workout, and the body fat percent measured 90 minutes after the workout. The test for the difference between the body fat percent (see Table 1) before and 90 minutes after a weightlifting workout resulted in a $T_{(4.643)}$ with a significant difference of $< .000$ (see Table 3). Therefore, hypothesis 2D was rejected.

Table 3. Weightlifting workout

Workout	T-statistic	D.F.	Two-tailed probability
Pretest vs. immediate posttest	-1.37398	18	0.1863
Pretest vs. 30 minutes posttest	-3.52713	18	0.0024
Pretest vs. 60 minutes posttest	-4.19981	18	0.0005
Pretest vs. 90 minutes posttest	-4.64383	18	0.0002

Hypothesis 3A

Hypothesis 3A stated that there was no significant difference between the body fat percent (see Table 4) before a wrestling workout and before a weightlifting workout. Hypothesis 3A was rejected because there was a significant difference of .001 between the preworkout measurements. The test resulted in a $T_{(3,820)}$.

Hypothesis 3B

Hypothesis 3B stated that there was no significant difference between the body fat percent (see Table 4) immediately after a wrestling workout and immediately after a weightlifting workout. Hypothesis 3B was rejected because there was a significant difference of $< .000$ between the two workout measurements. The test resulted in a $T_{(4,518)}$.

Hypothesis 3C

Hypothesis 3C stated that there is no significant difference between the body fat percent (see Table 4) 30 minutes after a wrestling workout and 30 minutes after a weightlifting workout. Hypothesis 3C was rejected because there was a significant difference of $< .002$ between the two workout measurements. The test resulted in a $T_{(3.534)}$.

Hypothesis 3D

Hypothesis 3D stated that there is no significant difference between the body fat percent (see Table 4) 60 minutes after a wrestling workout and 60 minutes after a weightlifting workout. Hypothesis 3D was rejected because there was a significant difference of $< .001$ between the two workout measurements. The test resulted in a $T_{(4.05)}$.

Hypothesis 3E

Hypothesis 3E stated that there is no significant difference between the body fat percent (see Table 4) 90 minutes after a wrestling workout and 90 minutes after a weightlifting workout. Hypothesis 3E was rejected because there was a significant difference of $< .009$ between the two workout measurements. The test resulted in a $T_{(2.942)}$.

Table 4. Wrestling vs. weightlifting workout

Workout	T-statistic	D.F.	Two-tailed probability
Pretest wrestling vs. pretest weightlifting	3.82091	18	0.0013
Pretest vs. immediate posttest	4.51785	18	0.0003
Pretest vs. 30 minutes posttest	3.53490	18	0.0024
Pretest vs. 60 minutes posttest	4.04918	18	0.0008
Pretest vs. 90 minutes posttest	2.94172	18	0.0087

Discussion

The findings of the present study were not similar to any previous study in current literature. There have been other studies that compared the accuracy between different methods of predicting body composition. However there were no studies found which compared the constancy of skinfold measurements over a period of 90 minutes to determine if a wrestling or a weightlifting workout affected the measurements. The WIAA states that a skinfold measurement should not be taken immediately after a workout, due to a fluid shift to the skin as the body tries to cool itself. This cooling effect may cause a larger than usual skinfold. What the WIAA does not address however, is how long after a workout one should wait before having skinfolds measured.

This is one of the major questions this study attempted to answer. The study also compared the difference between the effect of a wrestling workout and a weightlifting workout, regarding skinfold measurements.

The body fat percent measurements in this study were predicted by using the Lohman (1981) equation for body density, and the Brozek et al. (1963) equation for body fat percent. These are the equations used by the WIAA for predicting body composition. This may be an accurate method, depending upon the experience of the tester, and how much of an effect a wrestling or weightlifting workout has on skinfold testing.

The present investigation used a wrestling workout and a weightlifting workout as the two independent variables for which the skinfold measurements were taken prior to and after each workout. The dependent variables were the three skinfold sites that were used to predict the body composition. Skinfold measurements were taken before each workout, and immediately, 30, 60, and 90 minutes after each workout.

A paired t-test was used to detect differences between the pretest and the four posttests. A paired t-test was also used to detect differences between a wrestling workout and a weightlifting workout. The results demonstrated that there were significant differences: 30, 60, and 90 minutes after a wrestling workout and a weightlifting workout. The

results also showed that there were significant differences between wrestling and weightlifting workouts. The significant differences between the two workouts occurred: prior to, immediately, 30, 60, and 90 minutes after each workout. These results showed that each workout had its own effects on skinfold measurements during the same time periods after the workout.

The results also show that there may have been an error on the part of the tester. This chance of an error was not considered as an affect on the results because the 2 workouts were performed 3 weeks apart. There was a greater chance that the wrestlers lost a percentage of fat within those 3 weeks than there was a chance of tester error. To support this, the results show that the wrestlers had a lower body fat percent during the wrestling workout as opposed to the lifting workout. The wrestling workout was performed 3 weeks after the lifting workout.

Summary

This research project was designed to compare the effects of a wrestling workout and a weightlifting workout on skinfold measurements. It was also designed to compare skinfold measurements between the pretest and posttest periods over a total of 90 minutes after each workout. The accuracy of the skinfold measurements taken before and after each workout was consistent with each other. Each workout

showed significant differences during the same time periods after the workout, whether it was a wrestling or a weightlifting workout.

A wrestling and a weightlifting workout each had their own effect on skinfold measurements between 30 minutes and at least 90 minutes following the workout. Thus, wrestlers should not have their skinfold measurements taken for at least 90 minutes after a wrestling practice or weightlifting workout. If possible, the measurements should be taken on a day separate from the workout to assure the wrestler and tester of the most accurate results possible.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine skinfold measurements before and after wrestling and weightlifting workouts. The measurements were taken over a period of 90 minutes after each workout. A second purpose was to compare the differences between wrestling and weightlifting workouts on skinfold measurements.

College wrestlers (N = 34) from the University of Wisconsin-La Crosse wrestling team volunteered to participate in the study. Each subject's body composition was determined by skinfold measurements. A body fat percent was determined for each time period of both workouts. This helped to determine how much of an affect each workout had on skinfold measurements. A total of 19 of the wrestlers participated in both the wrestling workout and the weightlifting workout. The other 15 original wrestlers were not used as part of the study because they did not stay for the full 90 minutes after practice or weightlifting session or, they did not participate in one of the workouts.

The results showed that the time periods: 30, 60, and 90 minutes after each workout had significantly different ($p < .05$) body fat percent measurements when compared to the

pretest. The results that compared the wrestling workout to the weightlifting workout showed that there was a significant difference during the following time periods: the pretest, 30, 60, and 90 minute posttests. The weightlifting skinfold measurements were higher than the wrestling skinfold measurements. The skinfold measurements were put into the Lohman (1981) prediction equation for body density, and the Brozek et al. (1963) equation to determine the body fat percent.

Conclusions

This study showed that a workout, whether weightlifting or wrestling, definitely had a significant effect on the pre- to postworkout accuracy of skinfold measurements. Skinfold measurements were used because this is the method that the WIAA uses to predict body composition. The results indicate that, even though skinfold testing can be an accurate method, it does lend itself to a chance of error if performed following a workout.

The results also indicated that there was a significant difference in skinfold measurements, between weightlifting and wrestling workouts. The wrestling workout, however, was performed at a later date (approximately 3 weeks) than the weightlifting workout. This may be the reason for the difference in measurements between the two workouts.

Recommendations

The data revealed a significant difference between skinfold measurements taken before a workout, and measurements taken after a workout, for a minimum of 90 minutes. It is recommended that there be a specific time recommendation given as to how long one should wait to conduct skinfold testing. This needs to be done so that the WIAA, coaches, and athletes know exactly how long after a workout they should wait before taking skinfold measurements.

There was a significant difference in measurements between the weightlifting and wrestling workouts. This may have been due to an error on the part of the tester. Most likely though, the difference was due to the fact that the wrestling workout was performed approximately 3 weeks after the weightlifting workout. Both workouts were intense, but because the wrestlers were constantly working hard and cutting weight, there is a good chance that each one lost a percentage of fat within 3 weeks. Because of this, there needs to be a closer comparison done between the two workouts.

The present study showed that a workout, either weightlifting or wrestling, may cause an error in skinfold measurements. Since the only types of workouts used in this study were wrestling and weightlifting further research could be completed with other types of workouts including:

running sprints, variations of weightlifting workouts (i.e., sets and reps.), changing the wrestling format, or even changing the amount of time for each workout.

Once some of these other ideas have been studied there may be a clearer answer regarding skinfold testing times. Hopefully this will help the WIAA to decide on a minimal wrestling weight for high school wrestlers. Skinfold measurements should be taken immediately after practice or require athletes to wait at least 90 minutes prior to body composition testing. The more improved these areas become, the more accurate and useful skinfold testing can become.

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APPENDIX A

WEIGHT TRAINING PROCEDURES

Weight Training Procedures

Chest:

Maximum	Bench Press	(3 X 8)	75%
	Flies		

Back:

Maximum	Lat Pulldown	(3 X 8)	75%
	Seated Row		

Biceps:

Maximum	Straight Bar Curl	(3 X 8)	75%
	Dumbbell Curl		

Triceps:

Maximum	Tricep Pushdowns	(3 X 8)	75%
	Roman Chair		

Quadriceps:

Maximum	Leg Press (Hip Slip)	(3 X 8)	75%
	Leg Extension		

APPENDIX B
INFORMED CONSENT

Informed Consent

A Resistive Training Test of Fitness

I _____, voluntarily consent to engage in a resistive training project to evaluate my body composition system by way of a skinfold test.

The resistive training test shall consist of lifting weights in the Mitchell Hall weight room. The weight resistance will gradually increase throughout the test, while the repetitions remain the same. Although this test will require a maximal effort, I understand that I can stop at any time.

As with any exercise, there exists the possibility of injury during the test. However, if any abnormal observations are noted at any time, the test will be terminated immediately. In addition, I will probably feel tired or sore at the end of each test.

All testing sessions will be scheduled at my convenience. The test sessions will all be supervised/conducted by Mark Bergerson who is a graduate student enrolled in the Adult Fitness/Cardiac Rehabilitation Graduate Program under the direction of Alan Freeman, Ph.D. The results of the testing will be thoroughly explained upon completion of the test and all data will be kept confidential. I do however give permission for the data to be used for research purposes.

I consider myself to be in good health and to my knowledge I am not infected with a contagious disease or have any limiting physical condition or disability, especially with regard to my heart, that would preclude my participation in the tests described above. I have read the foregoing and I understand what is expected of me. Any questions which may have occurred to me have been answered to my complete satisfaction. I therefore voluntarily consent to be a subject in this study. Furthermore, I know I may withdraw at any time without any type of penalty.

SIGNATURE OF SUBJECT _____ DATE _____

SIGNATURE OF WITNESS _____ DATE _____

APPENDIX C

FORMULAS FOR CALCULATING MINIMUM WRESTLING WEIGHT USING SKINFOLD (SF) MEASUREMENTS

WISCONSIN INTERSCHOLASTIC ATHLETIC ASSOCIATION

41 Park Ridge Drive • P. O. Box 257 • Stevens Point, WI 54481

Formulas For Calculating Minimum Wrestling Weight
Using Skinfold (SF) Measurements

MALES ONLY

LOHMAN EQUATION

FOR CALCULATING BODY DENSITY (BD)

SUM SF = TRICEPS SF + SUBSCAPULAR SF + ABDOMINAL SF

$$BD = [1.0973 - (\text{SUM SF} \times .000815)] + [(\text{SUM SF})^2 \times .00000084]$$

BROZEK EQUATION

FOR CALCULATING % OF BODY FAT (BF)

$$\% \text{ BF} = (4.57/BD - 4.142) \times 100$$

CALCULATING WEIGHT AT 7% BF

$$\text{WEIGHT AT } 7\% \text{ bf} = \frac{[1 - (\% \text{ BF}/100)] \times \text{Current Weight}}{.93}$$

TO CALCULATE MINIMUM WRESTLING WEIGHT

(WITH 3% ALLOWANCE)

$$\text{MINIMUM WEIGHT} = 7\% \text{ WEIGHT} \times .97$$

APPENDIX D

COMPARISON OF PREDICTED FAT PERCENT

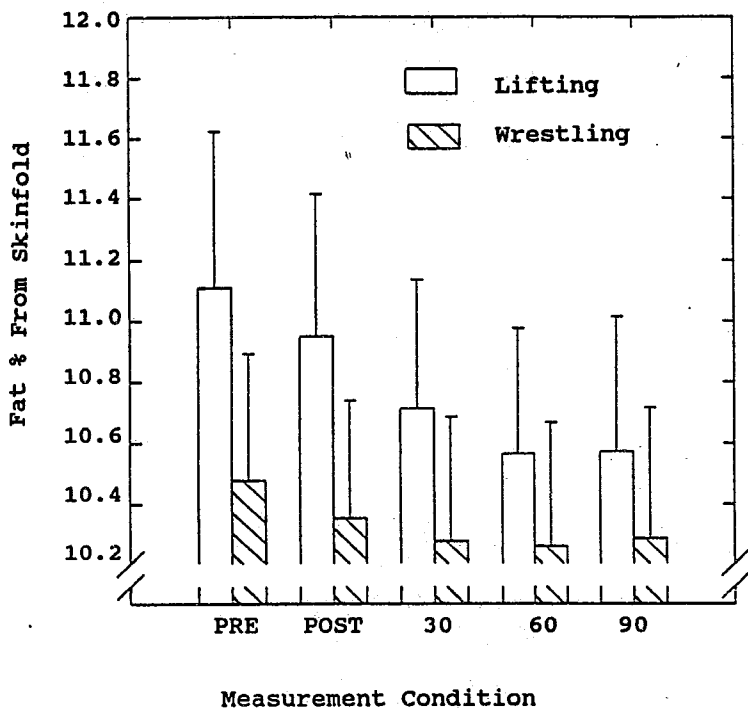


Figure 1 - Predicted fat % from skinfolds for wrestling and lifting workouts. Data are means ($n = 19$). Error bars are SEM.