

ORIGINAL RESEARCH

WEIGHT CYCLING AND DIABETES: A POSSIBLE LINK IN COLLEGIATE WRESTLERS

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ABSTRACT

Introduction: Weight gain and weight fluctuation have been shown to increase risk for type 2 diabetes mellitus (T2DM). Little is known about the implications of repeated weight cycling and risk for T2DM in athletes. This study aimed to look at the link between weight gain through weight cycling in healthy, athletic individuals and measures of fasting plasma glucose (FPG) as a precursor to T2DM.

Methods: Fifty-eight male college students volunteered to participate. Participants included 28 members of a collegiate wrestling team (W) and a comparison group (C) of 30 non-weight-cycling males. A glucometer was used to test FPG levels in- and post-season for the W group and once for the C group. Body mass measures were recorded. T-tests were used to evaluate between- and within-group differences in FPG and body mass.

Results: In-season FPG of the W group (80.6 ± 7.8 mg/dL) was not significantly different than post-season values (82.4 ± 6.2 mg/dL, $p = 0.084$). Both values were significantly different ($p < 0.05$) than FPG values of the C group (76.5 ± 6.7 mg/dL). Paired sample t-tests indicated a significant difference ($p < 0.05$) in body mass of the W group from in-season (75.8 ± 14.7 kg) to post-season (78.9 ± 14.3 kg). Body mass of the C group (81.5 ± 13.5 kg) was higher than in-season values ($p = .018$) but not different than post-season values of the W group.

Discussion: While between-group differences in FPG were noted, neither group exhibited FPG values suggesting pre-diabetes. However, higher FPG values exhibited by the wrestlers suggest that weight cycling cannot be ruled out as a contributor to increased FPG values.

Conclusion: Future research should look at habitual weight-cycling in athletes to determine whether long-term effects on FPG eventually leads to a diagnosis of pre-diabetes or diabetes.

INTRODUCTION

Weight cycling (also referred to as *weight cutting* or *yo-yo dieting*) is one of many components in the sport of wrestling. Each wrestler must compete at a certain weight class and the competitive weight is often achieved through forms of strict dieting or extensive dehydration. Weight loss of 2-3 kg/week by high school and collegiate wrestlers is not uncommon, with some wrestlers reporting cuts of over 10 kg per season.^{1,2} Frequently, the weight is lost, re-gained, and lost again—a process known as weight cycling—which is not unlike the pattern of yo-yo dieting often seen in people who are overweight. Over 30% of wrestlers report weight cycling at least 10 times per season.¹ Repeated weight cycling is associated with a number of adverse consequences which may negatively impact growth, health and performance.^{1,3} In an effort to minimise the short and long term dangers to participating athletes, the National Collegiate Athletic Association (NCAA) has implemented rules to discourage the practice of weight cycling.⁴

A review article on the long-term effects of weight cycling delineates the wide range of health implications related to these practices. Montani et al. (2006) noted that fluctuations in heart rate, blood pressure, blood glucose and blood lipids are among the consequences of weight cycling. While values may decrease/improve with weight loss, authors noted that these cardiovascular risk variables may overshoot above normal values during periods of weight gain. When repeated over time, the recurring fluctuations in weight may increase stress on the cardiovascular system.⁵ In addition to cardiovascular stress, there is also evidence that weight cycling may lead to incident weight gain and possible obesity.^{6,7} Saarni et al. (2006) conducted a long-term follow-up study of 1838 elite Finnish male athletes, including 370 participants who had participated in sports which promoted weight cycling (boxing, weight lifting, and wrestling). Surveys were conducted during 1985, 1995, and 2001 to calculate weight change after the age of 20 years, along with prevalence of overweight and obesity as determined by Body Mass Index. Athletes' results were compared with 834 matched controls who had not

participated in athletics. At all three follow-up points, weight-cycling athletes were 3-5 times more likely to be obese than the other athletes. When compared with controls, the relative risk of obesity for weight-cycling athletes was two times that of the controls in 1985 and 1995, but not different in 2001. Authors reported that extra weight gain in the weight-cyclers was independent of other health habits such as smoking, alcohol use, inactivity, or use of high-fat milk. It was concluded that people who participate in repeated weight-cycling were more likely to become obese.⁶ In another study looking at weight changes and weight cycling as predictors of weight change, Kroke et al. (2002) followed 6689 men and 11312 women for 2 years. After controlling for confounding factors, these researchers found that a history of weight cycling was the strongest predictor of weight gain for men (odds ratio [OR] 4.84; 95% confidence interval [CI] 3.34-7.02) while previous weight loss was the strongest predictor of weight gain in women (OR 4.77; 95% CI 3.63-6.03).⁷

Overweight and obesity are major risk factors for the development of T2DM, a disease which affects one in twelve people world-wide.^{8,9,10} In one 10-year prospective study of 22171 adult men (baseline age = 40-75years), researchers found that risk for diabetes increased by 7.3% for every kg of weight gained.¹⁰ Other researchers looked at the history of weight change in 1320 adults (age ≥ 40 years) with newly diagnosed T2DM. Average weight gain from age 20 until the time of diagnosis was 14.7 kg, with most of the weight gain in the 10 year period just prior to diagnosis. Authors noted that weight gain was highest for those with the lowest weight at age 20.⁹

A link between weight cycling and insulin resistance has been observed in animal models¹¹ and in humans who experienced weight loss and 'catch-up' growth due to disease or health issues.¹² Lu et al. (1995) looked at the metabolic consequences of weight-cycling in Wistar rats. When rats were exposed to three cycles of high fat diet followed by restricted feeding over 15 weeks, researchers noted hyperinsulinemia and an increase in insulin resistance independent of weight gain or weight

loss. Authors concluded that the weight cycling animals had a higher disposition to diabetes than the control group. Epidemiological evidence suggests that the same response is true in humans. In an article explaining the mechanisms for the link between weight cycling and insulin resistance, Dulloo (2005) points out that weight changes early in life (whether due to disease, gastrointestinal disorders, or 'yo-yo' dieting) may result in catch-up growth, metabolic efficiencies, and fat gain that are associated with metabolic disorders. This would suggest that weight-cycling alone is a risk factor for T2DM. In Saarni's long-term follow-up study of athletes, a history of weight cycling was linked with an increased risk for becoming obese.⁶ However, this group did not look at weight cycling as a pre-cursor to diabetes. Research involving long-term follow-up of wrestlers, specifically looking at development of metabolic disorders such as T2DM was not found.

While the link between weight gain, obesity, and T2DM is well known, research is lacking on the effects of weight gain from yo-yo dieting in healthy, athletic subjects. The purpose of this study was to look at weight gain through weight cycling in a group of healthy, athletic males and to evaluate its link with fasting plasma glucose (FPG) as a possible precursor to T2DM. The specific aim was to look at changes in weight and FPG of collegiate wrestlers over the course of a competitive season and to contrast these values with those of a comparison group of non-weight-cycling males of similar age. It was hypothesised that wrestlers who practiced weight-cycling would have higher FPG values than the comparison group.

METHODS

Design

This pilot study looked at short-term changes in body mass and FPG to determine whether weight cycling in wrestlers is potentially linked to markers for T2DM. Measures of body mass and FPG were collected on collegiate wrestlers once during the competitive season and a second time twelve weeks later during the post season. Body mass and FPG

were also collected on a comparison group of non-wrestling, non-weight-cycling males of similar age. These values were not expected to change in the comparison group and were collected only once. The study design as well as the use of human participants was approved by the institutional review board of the college prior to implementation of the study.

Participants

All members of the collegiate wrestling team were invited to participate. The study purpose and design were explained by the investigator at an organised practice session early in the season while the coaches were not present. A survey and consent form was distributed. The survey was used to collect information about history of weight cycling, personal and family history of diabetes. Those interested in participating in the study as part of the wrestling group (W) returned completed surveys and signed consent forms. Those not interested returned unsigned forms. Participants in the comparison group (C) were recruited via e-mail from three different academic courses offered at the college. Interested participants responded directly to the investigator; the course instructors were not aware of who did or did not participate in the study. Twenty-eight male collegiate wrestlers (age = 20.1 ± 1.3 yrs) and 30 non-weight-cycling, non-wrestling, male students (age = 20.9 ± 1.8 yrs) volunteered to participate.

Measurements

Wrestlers and students who indicated a willingness to be part of the study were contacted by the investigator to schedule individual testing. Body mass was measured and blood specimens were collected in the college's Human Performance Laboratory after an 8-hr overnight fast, without exercise, upon waking. Body mass was determined by weighing the participants to the nearest 0.1 kg on the certified weigh-in scale that the wrestling team uses for meets (A & D Co, Ltd., Korea) while wearing a T-shirt and shorts, with no shoes. Measures of FPG were conducted using the One Touch Ultra2 Glucometer (LifeScan, Inc.) following

the manufacturer's directions. Quality control of the meter was run and validated with hospital grade meters.

Statistical Analysis

A paired samples *t*-test was used to compare in-season and post-season FPG and body mass values of the wrestlers. Independent samples *t*-tests were used to compare each of these values with those of the comparison group. Descriptive statistics and frequency distributions were used to analyse survey results. Regression analysis was used to determine the contribution of body mass and family history of diabetes to the FPG values of the W group. Chi square tests (for categorical data) and independent *t*-tests (for interval data) were used to determine differences between groups. Alpha level was set at $p < 0.05$ to determine statistical significance.

RESULTS

For the W group, in-season body mass (75.7 ± 14.6 kg) was significantly different from the post-season body mass (78.7 ± 14.3 kg, $p = 0.000$). In-season FPG (80.6 ± 7.8 mg/dL) was not different than post-season values of this marker (82.4 ± 6.2 mg/dL, $p = 0.084$). For the C group, body mass (83.7 ± 9.6 kg) was significantly different than the in-season values for the W group ($p = 0.018$) but not the post-season measures ($p = 0.127$). The FPG value of the C group (76.5 ± 6.7 mg/dL) was significantly different ($p < 0.05$) from both in-season and post-season values in the W group (Table 1). Figure 1 shows a comparison of in-season vs. post-season measures of body mass for the wrestlers; in all but four wrestlers there was

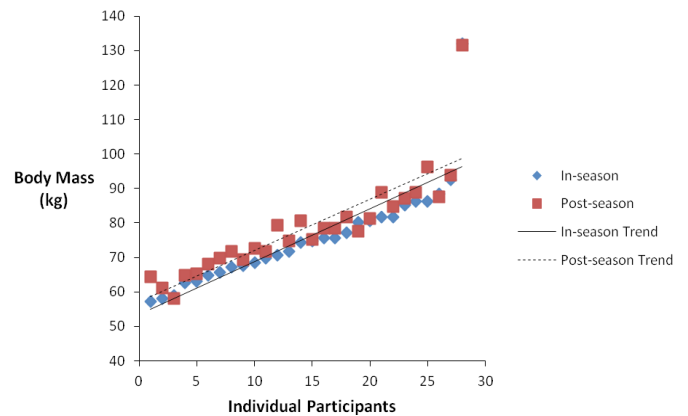


Figure 1. Wrestlers' body mass: In-season vs. Post-season

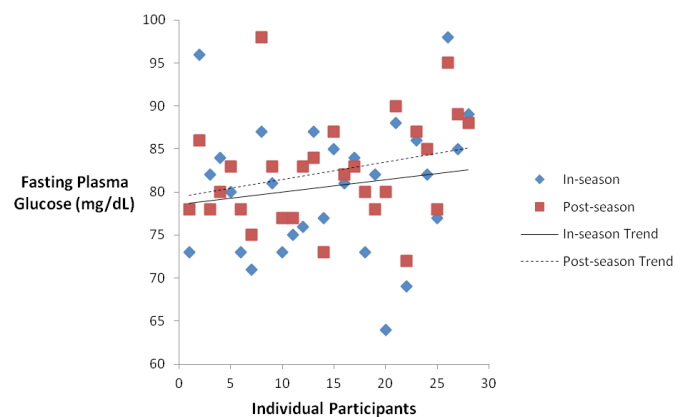


Figure 2. Wrestlers' Fasting Plasma Glucose: In-season vs. Post-season

an increase from in-season to post-season. Figure 2 shows pairs of in-season and post-season FPG values for the wrestlers.

Survey results are presented in Table 2. As expected, 100% of the W group reported habitual weight cycling. For this group, weight loss history averaged 6.05 ± 3.18 kg/year for 6.1 ± 1.9 years. Only 13% (4/30) of C group reported a history of weight cycling with 2.39 ± 0.59 kg lost per year for 2.3 ± 1.0 years. History of weight cycling, amount of weight lost, and years of weight cycling practice

Table 1. Body Mass and Fasting Plasma Glucose (FPG) of Wrestlers vs. Comparison Group

Parameter	Wrestlers (n = 28)		Comparison Group (n = 30)
	In-season	Post-season	
Body Mass (kg)	75.8 ± 14.7	$78.9 \pm 14.3^*$	$81.5 \pm 13.5^*$
FPG (mg/dL)	80.6 ± 7.8	82.4 ± 6.2	$76.5 \pm 6.7^{*\wedge}$

* = $p < 0.05$, significantly different than In-season values

\wedge = $p < 0.05$, significantly different than Post-season values

Table 2. Results of Survey Questions for Wrestlers (W) and Comparison (C) Groups

Question	W Group	C Group	p
Have you ever participated in weight cycling? (Y/N)	28/28	4/30	<0.000
If yes: How many years of weight cycling participation? *	6.1 ± 1.9	2.3 ± 1.0	< 0.000
What was the average number of kg cut per year?*	6.05 ± 3.18	2.39 ± .59	<0.000
Have you been previously diagnosed with elevated glucose levels or diabetes? (Y/N)	0/28	0/30	na
Do you have a family history of diabetes? (Y/N)	7/28	6/30	0.66

*Note: values are Mean ± SD

were all significantly different ($p < 0.000$). None of the study participants reported personal history of diabetes or elevated FPG. Prevalence of family history of diabetes for W group (7/28 = 25%) and C groups (6/30 = 20%) was not significantly different ($p = 0.66$).

Regression analysis was used to determine the impact of body weight and family history of diabetes on the average FPG of the W group. Change in body mass compared to change in FPG were not significant ($p = 0.24$). The impact of family history of diabetes on average FPG values was also not significance ($p = 0.17$).

DISCUSSION

The primary goal of this study was to evaluate FPG levels in weight cycling wrestlers as possible markers for T2DM. Guidelines for diabetes screening specify that a FPG of 70 – 100 mg/dL is considered normal.^{8,13} Non-diabetic individuals with FPG ≥ 110 mg/dL but < 126 mg/dL are considered to have impaired fasting glucose (sometimes known as pre-diabetes) and any FPG ≥ 126 mg/dL is diagnostic for diabetes. While pre-diabetes does not always lead to development of diabetes, impaired fasting glucose is considered an important risk factor for the development of T2DM. Although none of the participants in this study had FPG values above 100 mg/dL, the significant differences between the C group and the W group, both in- and post-season, are notable.

The wrestlers in this study experienced an average increase in body mass of over 3 kg from in-season to post-season. This weight gain was significant and is consistent with the weight changes typically seen in collegiate wrestlers.¹ The in-season measures, but not post-season measures, of body mass were significantly different from those of non-weight-cycling participants in the comparison group. These results imply that the wrestlers indeed practice weight-cycling as they lose weight during the season and then regain to more standard levels after the season is over. Moreover, wrestlers in our study reported repeated participation in weight cycling for an average of over 6 years. Previous research suggests that the practice of repeated weight cycling puts these athletes at an increased risk for significant weight gain later in life.^{6,7} Furthermore, it is widely recognised that weight gain and impaired glucose tolerance are important risk factors for T2DM.⁸ Thus, weight cycling leading to weight gain has potentially serious health implications for this population. Our purpose was to examine the link between weight-cycling with fasting plasma glucose (FPG) as a possible precursor to T2DM in a group of healthy athletic males. In this short-term study, the FPG levels of the weight-cycling wrestlers were not high enough to be categorised in the range of pre-diabetes. Since exercise is known to have an insulin-like effect in lowering blood sugar¹⁴ it is possible that the strict workout regimen followed by the wrestlers may have prevented these values from being more

elevated. However, because these values were significantly higher than those of the comparison group, our results suggest that we cannot rule out weight cycling as a contributor to increased FPG.

The wrestlers in our study reported a history of weight cycling and experienced weight gain from in-season to post-season; they also exhibited higher FPG values than the comparison group. However, the link between weight cycling and development of T2DM is only speculative. Long-term follow-up is needed to determine if these changes eventually lead to significant weight gain or the development of diabetes.

The present study has a number of limitations, the first being study duration. Second, FPG testing of the C group was only conducted once. While we did not expect changes in FPG related to weight fluctuation in the non-weight-cycling group, one test did not allow for comparisons which could have been influenced by seasonal and climate changes, as well as time-point in the college semester. Third, our results are also limited by a small sample size with wrestlers from one location. Future research could look at the development of diabetes by evaluating a larger population of weight-cycling wrestlers with repeated measures of FPG over time. Alternatively, a retrospective study of former wrestlers, their weight-cycling history, and prevalence of T2DM could provide information about the link between weight-cycling and the development of diabetes.

CONCLUSION

The purpose of this study was to evaluate FPG in weight-cycling wrestlers, looking for possible links to diabetes through insulin resistance. Although the results were not diagnostic for impaired fasting glucose, we did find that FPG of wrestlers was significantly different than the comparison group that did not weight cycle. These results suggest that weight cycling may impact FPG. However, a more extensive long-term study would be needed to determine whether the increased FPG eventually leads to a diagnosis of T2DM.

PRACTICAL APPLICATION

Knowledge about the potential impact of weight cycling is important to individuals including coaches, school administrators, parents and athletes themselves. By raising awareness of possible long-term effects of weight cycling, people will be able to make discretionary decisions about the best methods for making weight or maintaining weight in the sport of wrestling.

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