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THE ABUSE OF WEIGHT-LOSS METHODS IN ATHLETICS

By
Daryl Walter Moss

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Daryl Moss

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Approved:

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Dr. Daniel G. Gibson III, Advisor

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weight loss

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03E005I: Abuse of Weight Loss Methods in Athletics

Reference: 03E005I
Title: The Abuse of Weight Loss Methods in Athletics

Student: Moss, Daryl Walter
Advisor: GIBSON, D. G. (BB)

The growing epidemic of abuse of weight-loss methods among athletes is investigated, based on a review of the literature and on interviews with athletes and coaches. Fad diets, diet pills, diuretics, and eating disorders in amateur and professional athletics are discussed. Regulations, monitoring, and sanctions used to curb such practices/compulsions are also reported and analysed. I concluded that regulations need revision and more "teeth," and that more education on the serious effects of inappropriate weight loss methods is needed.

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Daniel G. Gibson III, Ph.D.
Assistant Professor
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Introduction

The focus of this project is to investigate and report the findings on abuse of weight loss methods in sports and the consequences of their abuse. The abuse of weight loss methods is high among many sports where a competitive edge can be obtained through weight loss. The loss of weight may be necessary to obtain a certain look that is perceived by the sport to be ideal, to improve athletic performance, or in some cases both (i.e., diving). No matter what the circumstances driving the abuse of weight loss methods there are life-threatening consequences that should be considered, from organ failure to psychological problems.

The abuse of weight-loss methods can be placed into two basic categories: weight-loss through dehydration, and weight-loss through the loss of body fat. Dehydration is most commonly the result of one of the following methods: exposure to heat; use of a sauna; excessive exercise; exercising while exposed to heat; practicing in a heated room or while wearing a rubber suit; the abuse of diuretics; and the restriction of fluids (Al-Zaki, Talbot-Stern, 1996; Caldwell, Ahonen, Nousiainen, 1984; Clarkson, Thompson, 1997; Lakin, Steen, Oppliger, 1990; Oppliger, Landry, Foster, Lambrecht, 1993; Steine, 1993; Sturmi, Rutecki, 1995). The loss of body weight through dehydration is quick, if cyclical, and once the methods of dehydration are no longer abused the body weight is regained over a relatively short period of time. Dehydration is abused by sports that involve weight limits such as wrestling and boxing, or jockeying, and sports like bodybuilding where dehydration is used to reduce bloating to show off muscularity (Al-Zaki et al., 1984; Clarkson et al., 1997; Lakin et al., 1990; Oppliger et al., 1993; Steine, 1993; Sturmi et al., 1995).

The loss of body fat as a method of weight loss often leads to the development of eating disorders which most commonly afflict young females whether they participate in athletics or not. The preoccupation with fitting the stereotypes set by society or stereotypes specific to their sport to look a certain way places these girls at risk for developing serious problems in the future. The reduction of body fat by athletes to improve performance and the way they look often becomes an obsession and results in the development of pathological conditions including the eating disorders anorexia nervosa and bulimia nervosa. The development of these eating disorders typically occurs in female athletes participating in sports such as: gymnastics; ballet; figure skating; swimming; rowing and distance running (Bale, Goodway, 1990; Dummer, Rosen, Heusner, Roberts, Counsilman 1987; Estok, Rudy 1996; Garner, Garfinkel, Rockert, Olmsted 1988; Gleaves, Williamson, Fuller 1992; Hulley, Hill 2001; Prussin, Harvey 1991; Rosen, McKeag, Hough, Curley 1986; Rosen, Hough 1988; Skolnick 1993; Thornton 1990; Taub, Blinde 1992).

While these weight-loss methods are justified by abusers for their assumed enhancement of performance, quite often the opposite result is obtained. Not only can weight-loss negatively affect permormance, it can also be life threatening, even for non-athletes. Lasting effects can manifest in later development of pathological conditions or physiological anomalies (Baleet al. 1990; Dummer et al. 1987; Estok et al. 1996; Garner et al. 1988; Gleaves et al. 1992; Hulley et al. 2001; Prussin et al. 1991; Rosen et al. 1986; Rosen et al. 1988; Skolnick 1993; Thornton 1990; Taub et al. 1992).

Methods of abuse and their risks, the sports that are prime for such abuse, and present and future regulations on unsafe weight loss practices will all be reviewed in this

project. Athletics are assumed to have healthy and beneficial effects on character, but the unwise, unsafe, and sometimes illegal, methods of weight loss are at odds with the goals of athletic competition.

I. Diet fads and diet pills

The natural loss of weight from the body is accomplished through a series of reactions collectively known as beta-oxidation. Beta-oxidation is the catabolism of fatty acids, which occurs within the mitochondria. This degradation is the result of removing two carbon atoms at a time from the fatty acid and attaching them to molecules of coenzymeA, resulting in the formation of acetylcoenzymeA (acetyl-CoA). Acetyl-CoA is then used in the production of adenosine triphosphate (ATP) through oxidation, the Krebs cycle, and the electron transport chain (Tortora et al., 2001). ATP is the energy compound used throughout the body and can be generated from any food: carbohydrates, proteins or fats. To lose weight one could limit the ingestion of foods, to keep the body from storing the excess, or to eliminate those already being stored; energy requirements may be increased through increased physical activity. Cells cannot store ATP so the excess will be used to reform the two-carbon molecules into fatty acids and fats.

Fad diets are often based upon the restriction from certain foods or are based upon the consumption of one type of food. Fad diets are an ever-changing aspect of weight loss, usually short-lived concepts with no real scientific basis; a select few of these will be discussed. High protein diets have long been popular among competitive athletes, the most popular example being the Atkins diet developed during the 1970's (http://magazines.ivillage.com/goodhousekeeping/print/0,,290212,00.html). The Atkins diet is based upon the principle that the overproduction of insulin is a result of eating

carbohydrates, and this excess of insulin was said to prevent the body from burning fat. This diet encourages the unlimited intake of foods high in protein with little regard to fat and caloric intake; foods with high quantities of refined sugar or starches such as pasta and bread are eliminated. High protein diets including red meat are often high in saturated fats and cholesterol, the leading causes of heart disease, but they may also result in damage to the kidneys by causing them to work harder to process and excrete the nitrogen found in protein (http://magazines.ivillage.com/goodhousekeeping/print/0,,290212,00.html).

Some diets such as "The Zone" and food combining are based upon the use of percentages when planning meals, an example of a diet plan according to the zone may require that 40% of your caloric intake be from carbohydrates, 30% from protein, and the remaining 30% be from fats. Food combining dictates that throughout the day 70% of what you eat be fruits and vegetables and 30% from starches and animal proteins, but more importantly this diet says to eat these food types during separate meals to ensure proper digestion. A few problems exist with this diet theory, the first is that there is no scientific evidence to support the idea that the body processes certain food combinations any better than foods eaten randomly, and also that the protein intake is so low that this diet promotes the break down of muscle and vital-organ tissue if it is maintained for more than ten days. (http://magazines.ivillage.com/goodhousekeeping/print/0,,290212,00.html)

Grapefruit diets are a spin-off from the Hollywood diet, which originated during the 1930's. The Hollywood diet called for a meal plan consisting of "a few select vegetables, small amounts of protein, and grapefruits." (http://magazines.ivillage.com/goodhousekeeping/print/0,,290212,00.html) The reason

why grapefruits were so important to the Hollywood diet and the numerous grapefruit diets that evolved because of it was that grapefruits were "believed to contain a special fat burning enzyme." (http://magazines.ivillage.com/goodhousekeeping/print/0,,290212,00.html) A typical day on the Hollywood diet would call for a caloric intake of approximately 800, the major problem with this diet is that it does not provide many necessary nutrients, such as calcium, iron, folic acid, and most vitamins ((http://magazines.ivillage.com/goodhousekeeping/print/0,,290212,00.html).

Liquid diets use shakes as meal replacements, these shakes that were introduced during the 1970's have developed into nutritionally balanced alternatives to meals. A typical liquid diet calls for the replacement of two meals and a snack with a 200 calorie shake for each, as well as a third meal of 600 calories for a total daily caloric intake of 1200 calories for the day. The problems with liquid diets include the lack of phytochemicals derived from plant sources that are responsible for helping prevent disease, and that the dieter does not learn proper diet and nutrition habits (http://magazines.ivillage.com/goodhousekeeping/print/0,,290212,00.html).

Diet pills as a quick, simple, and dangerous method of weight loss have been growing in popularity over recent years. Diet pills claim to work in a number of different ways, some work as an appetite suppressant, others speed up the metabolism, and some claim to block the absorption of certain types of food. Some popular brands of diet pills include Hydroxycut, Stacker 2, and Xenadrine. The active ingredient found in diet pills in the past was an alkaloid derived from the leaves of the family of ephedra plants.

Ephedrine, also known as ephedra or Ma Huang, has become the target of numerous studies by the FDA and other organizations.

In 1997 the combination of the diet pills fenfluramine and phentermine, commonly known as fen-phen, was discovered to have led to the development of heart-valve problems (Connolly et al., 1997). Neither of these drugs was intended as a weight loss drug, one being a Serotonin specific reuptake inhibiting antidepressant and the other an amphetamine-like stimulant.

http://216.239.51.104/search?q=cache:T0wCNw8QBKsJ:www.gasnet.org/esia/pdf/1996/esia9612.pdf+phenteramine+original+use&hl=en&ie=UTF-8

"Off-label" uses of drugs, e.g. amphetamines for weight loss instead of alertness, can often lead to unanticipated problems. Ephedrine has been connected with the February 2003 death of 23-year-old Steve Bechler, a pitching prospect for the Baltimore Orioles, attributed to heat stroke and heart trouble (http://www.allnaturalalternatives.com/diet_pill_warning.htm?source=overture). The NCAA, NFL, and the Olympic Committee have banned the use of ephedrine and its related products. Ephedra has been connected to heart attacks, seizures, strokes, and is reported to have caused hundreds of deaths. Psychological effects of ephedrine include depression, nervousness, insomnia, and rapid heart rate (http://www.allnaturalalternatives.com/diet_pill_warning.htm?source=overture). Diet pills intended to block the absorption of certain types of foods work in theory, but the dose size would be too large to be practical because non-absorbed food can cause severe gastrointestinal problems (personal communication, Dr. Dan Gibson, WPI).

II. Dehydration

Dehydration as a method of weight loss is popular among sports where lower weight is desired such as wrestling, or where the body has to be displayed in the leanest possible condition to show all of its muscular definition, as in bodybuilding. Weight loss caused by dehydration is most commonly accomplished through: exposure to heat, use of the sauna; excessive exercise; exercising while exposed to heat, practicing in a heated room or while wearing a rubber suit; the abuse of diuretics; and the restriction of food and fluids (Caldwell et al., 1984). This last method, defined as less than 16 ounces of fluids per 24 hours, simply depends on water loss through the usual body processes.

The above methods are practices commonly employed by athletes who participate in sports that are based upon weight class, wrestling being the classic example. Wrestlers often exercise in addition to practice by either running or riding a stationary bicycle, and quite often rubber suits are worn during this period of exercise to increase fluid loss. The method of practicing in a heated room was used in wrestling for many years to increase fluid loss, although the NCAA has now banned this method. The NCAA has classified a "hot room" as a room with a temperature above 79 degrees Fahrenheit (http://thepost.baker.ohiou.edu/archives/011598/rules.html).

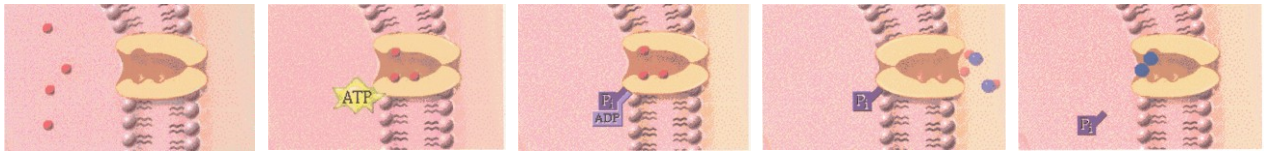
Dehydrated wrestlers commonly experience a decrease in aerobic and anaerobic capacity as well as a decrease in upper-body strength (Steine, 1993), but they also put themselves at risk of suffering more severe consequences. The deaths of three wrestlers that occurred in the months of November and December of 1997 caused the NCAA to make an emergency change in their rules, banning the use of saunas, rubber suits, and diuretics for any reason (http://thepost.baker.ohiou.edu/archives/011598/rules.html). All three of the deaths were of wrestlers that were trying to lose weight, as much as 6 pounds, in

order to make their weight class. Two of the deaths occurred while the athletes were wearing rubber suits while riding on stationary bicycles; the cause of death was failure of the heart resulting from kidney failure (http://thepost.baker.ohiou.edu/archives/011598/rules.html).

IIa. The role of the Kidney in Dehydration

The human kidneys are small organs, only 0.5% of the body's weight, but they consume an astonishing seven percent of the total-body oxygen intake (Goodman and Gilman, 1996), most of this energy is expended in the operation of the sodium-potassium pumps used in the transport of sodium ions (Tortora and Grabowski, 2001). The function of the sodium-potassium pump (Figure 1.) is to maintain the sodium and potassium concentration difference across the cell membrane, it does so by pumping sodium ions from the inside of the cell to the outside in exchange for potassium ions (Guyton and Hall, 1996). The sodium-potassium pump contains three receptor sites for the bonding of sodium ions internally, and two receptor sites for the bonding of potassium ions externally. In close proximity to the sodium receptor sites is the base for ATPase activity, this is where the energy required for active transport is developed. When the three sodium ions are bonded to their receptors, the ATPase activity is activated. One molecule of adenosine triphosphate is split into adenosine diphosphate and phosphate, the energy derived from this split is then used to move the three positively charged sodium ions out of the cell and the two negatively charged potassium ions in. This exchange of

Figure 1. Function of the Sodium-Potassium Pump



(a) **(b)** **(c)** **(d)** **(e)**

(a) The pump is empty awaiting sodium ions.

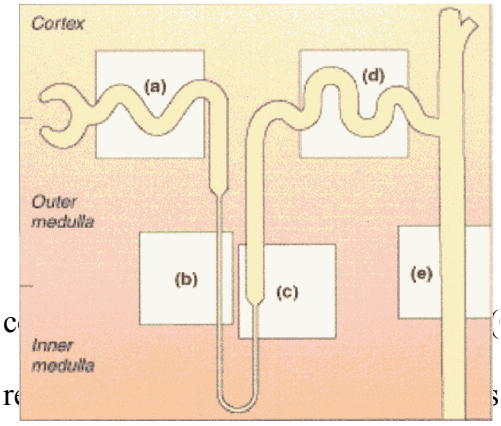
(b) Three sodium ions from the cell interior are bonded to the receptors, ATPase activity is activated.

(c) The ATP molecule is split into adenosine diphosphate and phosphate.

(d) The three sodium ions are exchanged for two potassium ions from the cell exterior.

(e) The two potassium ions are released to the interior of the cell.

ions results in a negative electrical potential within the cell (Guyton et al., 1996). The kidneys are the organs of the body with the major responsibility for: regulation of blood ionic composition, blood volume, blood pressure, blood pH; they also play a role in red blood cell production by producing a stimulating hormone; are necessary in the activation of vitamin D synthesis; and the excretion of wastes and foreign substances (Tortora et al., 2001). Maintaining the balance of sodium ions within the body, which the kidneys are responsible for, is very important, a sustained positive sodium balance, volume overload, results in pulmonary edema, while a sustained negative sodium balance, volume depletion, results in the collapse of the cardiovascular system (Goodman et al., 1996). The nephron (Figure 2.) is the functional unit of the kidney; each human kidney



(a) Primary convoluted tubule

(b) Descending limb, loop of Henle

(c) Ascending limb, loop of Henle

(d) Distal convoluted tubule

(e) Collecting duct

c

re s well as the elimination of wastes and the

production of urine. The function of the nephron may be broken down into three basic processes: glomerular filtration (180 l/day); tubular reabsorption (99% of filtrate); and tubular secretion (dependent on load of secretable substances).

Glomerular filtration occurs at the glomerulus, where blood pressure forces water and solutes from the blood's plasma through a membrane, resulting in glomerular filtrate. Upon moving to the renal tubules the glomerular filtrate becomes known as tubular fluid. It is within the renal tubules and ducts that the body reabsorbs substances, and excess substances are secreted to be eliminated as waste. Substances that are typically filtered are: **Figure 2. The Nephron** ıate ions, glucose, urea, potassium ions, uric acid, amino acids, and creatinine (Totora et al., 2001). Normally sixty-five percent of the filtered solutes that are reabsorbed are done so in the proximal convoluted tubule (PCT), because it is highly permeable to water, and therefore "reabsorption is essentially isotonic", while twenty-five percent of the filtered solutes are reabsorbed in the loop of the Henle, mostly the thick ascending limb (Goodman et al., 1996). The reabsorption of sodium ions greatly influences the reabsorption of many solutes including the following: potassium ions, chloride ions, magnesium ions, and calcium; most diuretics increase the renal output of these solutes (Guyton et al., 1996). "Eighty to ninety percent of filtered potassium ions are reabsorbed in the PCT (diffusion and solvent drag) and thick ascending limb (diffusion)." (Goodman et al., 1996) Approximately seventy percent of the calcium contained in the filtrate is reabsorbed in PCT by means of passive diffusion, while another twenty-five percent is reabsorbed through the thick ascending limb of the Henle

(Goodman et al., 1996). The majority of the magnesium ions are reabsorbed in the thick ascending limb of the Henle, while twenty to twenty-five percent are reabsorbed in the PCT and only five percent in the distal convoluted tubules (DCT) and collecting ducts (Goodman et al., 1996). Excess potassium ions are secreted by the collecting ducts as a response to the production of aldosterone, the amount of this secretion is dependent on the individual's dietary intake. Of these all are reabsorbed except substances that are actively secreted from the surrounding blood into the tubule, they are such things as penicillin, steroids and other substances to make them more soluble and thus more filterable. The liver is the actual site of production of several filterable wastes, such as the nitrogenous waste urea (ornithine cycle (http://www.biochemj.org/bj/312/bj3120649.htm)) and steroids, which are hydroxylated. The renal tubules of the kidney play a very important role in the maintenance of an acid-base balance; this is achieved through the reabsorption of bicarbonate and the secretion of protons, resulting in tubular acidification (Goodman et al., 1996). The filtrate contains no blood cells or plasma protein in a healthy kidney. Their presence in the filtrate indicates that damage has been sustained, usually from hypertension. Because the blood pressure in the glomerulus is the highest of any organ (75mmHg), the kidney is one of the first organs to be affected by hypertension.

IIb. Diuretics

Diuretics are clinically used to treat hypertension; reduce the effects of edema stemming from congestive heart failure or cirrhosis of the liver; and to aid the function of the kidneys in cases of renal failure. Diuretics are used to reduce extracellular fluid volume, resulting in lower blood pressure; this result is obtained by increasing the body's

output volume of urine (Guyton et al., 1996). Most diuretics are used to inhibit the reabsorption of sodium in the renal tubules, having two effects: natriuresis, an increased sodium output; and diuresis, and increased water output (Guyton et al., 1996). Although water output is the primary desired effect of diuretics, it is a secondary effect: "increased water output occurs secondary to inhibition of tubular sodium reabsorption because sodium remaining in the tubules acts osmotically to decrease water reabsorption." (Guyton et al., 1996) Osmotically active compounds other than sodium can produce diuretic effects, as is potassium-sparing diuretics where bicarbonate is excreted, or as in diabetes where the overload of glucose is responsible for diuresis so serious that it can induce coma by reduction of blood pressure. Nearly every section of the nephron can be affected by diuretics, although different diuretics act on different sections: osmotic diuretics and carbonic anhydrase inhibitors act on the PCT; loop diuretics act on the thick ascending loop of the Henle; thiazide diuretics affect the early DCT; while potassium-sparing diuretics act on the late DCT and collecting tubules (Goodman et al., 1996). The body itself has hormones ANP, ADH and aldosterone, which all have an effect on diuresis in the body. Atrial Natriuretic Peptide (ANP) from the atrium of the heart is secreted when blood pressure is high and acts as an internally produced diuretic. Anti Diuretic Hormone (ADH) and aldosterone are produced by the body to counter the effects of diuresis. Diuretics are a popular drug abused by athletes all over the world to achieve a high degree of weight loss by reducing fluid retention. An international survey on the abuse of drugs by athletes indicated that 5.59% of the athletes abused diuretics, the use of diuretics followed anabolic steroids (57.31%), stimulants (22.14%), and narcotics (8.15%). (Al-Zaki et al., 1996) The abuse of diuretics may be found in all sports where

pathogenic weight loss methods are employed, but they are most commonly found in sports where a drastic reduction in weight is desired over a short period of time, the biggest examples being wrestling and bodybuilding.

Wrestling is a sport dependent on the use of weight classes as the means of ensuring fair competition, although, in an effort to increase their opportunity for success, in most cases wrestlers attempt to participate in a weight class lower than what they would qualify for under everyday conditions. The use of diuretics in wrestling is popular because it allows for a dramatic loss of weight the day of weigh-ins, diuretics can cause a body weight loss of 3-4% over a 24-hour period (Clarkson et al., 1997). A survey of collegiate wrestlers found that 16% of wrestlers admitted to using diuretics at least once a week during high school, and that there was nearly a 75% decrease in the use of diuretics from high school to college for the following reasons: the body's weight stabilizes as the athletes mature; diuretics are not as readily available on college campuses; and diuretics are on the NCAA list of banned substances (Steine, 1993).

The abuse of diuretics in bodybuilding is extremely common, they are used "to dehydrate the tissues and give a better definition of muscle shape. The skin shrinks tightly over skeletal muscles." (Al-Zaki et al. 1996) Diuretics are used by bodybuilders to reduce muscle bloating prior to judging, because "the ultimate goal for the competitive bodybuilder is to achieve a high degree of symmetrical body mass and tone." (Al-Zaki et al., 1996) Diuretics allow bodybuilders to achieve the extreme levels of muscular and vascular definition that is required to impress the judges.

Osmotic Diuretics

Osmotic diuretics work by increasing the osmolarity of the tubular fluid by inhibiting the reabsorption of water and solutes. Osmotic diuretics are typically taken orally (enteric pathway) and once absorbed into the blood stream, filter into the tubules. This leads to a "marked increase in the concentration of osmotically active molecules or ions in the tubules. The osmotic pressure of these solutes then greatly reduces water and sodium reabsorption, flushing large amounts of tubular fluid into the urine." (Guyton et al., 1996) Until recently it was believed the primary point of action for this class of diuretic was the PCT, however recent findings suggest that they only have secondary effects in this area, and that they primarily act on the loop of Henle by increasing the delivery of sodium ions and water from the loop of Henle to continue on to the rest of the renal passages (Goodman et al., 1996). There is a decrease in the extraction of water from the descending thin limb which limits the concentration of sodium and chloride ions entering the thick ascending limb as well as limiting the reabsorption of magnesium ions there as well (Goodman et al., 1996). Osmotic diuretics are used to create a rapid decrease in the glomerular filtration rate to counter the effects of a serious problem like acute renal failure.

Carbonic anhydrase inhibitors

Carbonic anhydrase, an enzyme found in the PCT, plays a critical role in the reabsorption of sodium bicarbonate and the secretion of titrable acid (Goodman et al., 1996). Carbonic anhydrase inhibitors inhibit the secretion of hydrogen ions and bicarbonate reabsorption, which, in turn, reduces the reabsorption of sodium ions (Guyton et al., 1996). The secretion of hydrogen ions and the reabsorption of bicarbonate

ions have been linked to the reabsorption of sodium ions. When carbonic anhydrase is blocked, bicarbonate cannot be reabsorbed; therefore decreasing bicarbonate reabsorption and sodium reabsorption (Guyton et al., 1996). Decreasing bicarbonate and sodium reabsorption causes these substances to remain in the tubular fluid, at which point they act as osmotic diuretics. Carbonic anhydrase inhibitors act primarily on the PCT, affecting sodium-bicarbonate reabsorption, but they also have a secondary effect on the collecting duct system and the secretion of titrable acid (Goodman et al., 1996). The disadvantage to the use of carbonic anhydrase inhibitors is that they cause acidosis; the excessive loss of bicarbonate ions through the urine (Guyton et al., 1996). Acetazolamide, commonly known as Diamox, is used for the treatment of edema due to congestive heart failure and for treating drug induced edema.

Loop

The diuretic furosemide, more commonly known as Lasix, is in the family of loop diuretics, a class of powerful diuretics that increases the production of urine at the kidneys. Furosemide is used to inhibit the "the reabsorption of sodium and chloride in the proximal and distal convoluted tubules as well as the ascending loop of Henle," (http://www.nuresspdr.com/members/database/ndrhtml/furosemide.html) increasing the amount of sodium in urine, which removes water from the body consequently by osmosis. As a diuretic, furosemide is used to eliminate water from the body, which in turn reduces pressure in the venous system allowing for edema to drain. Furosemide is used to treat high blood pressure, edema caused by congestive heart failure, cirrhosis of the liver, kidney disease, and in conjunction with other medications to help reduce the accumulation of fluid in the lungs. Because of its effectiveness in removing water from

the body as well as enabling the body to lose a significant amount of weight in a short amount of time, it is often abused by athletes such as bodybuilders, wrestlers, and jockeys, as well as by bulimics.

Thiazide

Thiazide diuretics, such as clorothiazide, inhibit the co-transport of sodium and chloride ions in the luminal membrane of the tubular cells (Guyton et al., 1996). Originally believed to affect reabsorption in the PCT, more recent studies suggest that the primary point of action for thiazide diuretics is in the early DCT, having secondary effects in the PCT (Goodman et al., 1996). Thiazide diuretics are capable of causing 5-10% of the glomerular filtrate to pass into the urine, equivalent to the same amount of sodium ions that are typically reabsorbed by the DCTs (Guyton et al., 1996). Aside from increasing the excretion of sodium-chloride ions, thiazide diuretics also increase the excretion of bicarbonate ions, phosphate, potassium ions, and titrable acid (Goodman et al., 1996). Thiazide diuretics are used to treat problems such as edema caused by congestive heart failure and hepatic cirrhosis, nephritic syndrome, chronic renal failure, acute glomerulonephritis, and hypertension (Goodman et al., 1996). Thiazide diuretics are sometimes abused by bodybuilders, and used in conjunction with potassium sparing diuretics (Sturmi et al., 1995).

Potassium sparing

Potassium-sparing diuretics, as the name implies, promote diuresis, while trying to conserve potassium ions for reabsorption, this is accomplished through the use of two different types: competitive inhibitors of aldosterone and sodium channel blockers. Competitive inhibitors of aldosterone inhibit the binding of aldosterone to

mineralocortiod receptors, reducing sodium-chloride transports, which in turn reduce the secretion of potassium ions and hydrogen ions (Goodman et al., 1996). This type of diuretic act on the epithelial cells of the late DCT and collecting ducts. Aldosterone is a hormone produced by the adrenal cortex whose purpose is to secrete potassium ions and reclaim sodium ions by enhancing the sodium potassium pump. Diuretics like spironolactone and similar substances compete with aldosterone for receptor sites in cortical collecting tubular epithelial cells, therefore reducing the reabsorption of sodium and the secretion of potassium (Guyton et al., 1996). Sodium ions then remain in the tubules and acts as an osmotic diuretic, increasing the excretion of sodium ions and water. The aldosterone antagonist spironolactone, when co administered with either a thiazide or a loop diuretic is used in the treatment of edema resulting from hypertension (Goodman et al., 1996). Spironolactone is used in the treatment of primary hyperaldosteronism, refractory edema, cardiac failure, hepatic cirrhosis, nephritic syndrome, and severe ascites (leakage of fluid from the damaged liver). Sodium channel blockers act directly on the collecting tubules of the epithelial cells to block the entry of sodium into the sodium channels (Guyton et al., 1996), therefore decreasing the activity within the sodium-potassium pumps. The point of action in the late DCT and collecting tubules having an overall effect similar to that of spironolactone. Two examples of sodium channel blockers are amiloride and triamterene, which also inhibit the reabsorption of sodium ions and the secretion of potassium ions. Potassium sparing diuretics have become more popular among athletes wishing to use more mild diuretics than those of the loop variety.

Dehydration in bodybuilding

The goal of the bodybuilder is to display the greatest amount of muscular and vascular definition possible; this is achieved by removing subcutaneous moisture that leaves the body looking bloated in the eyes of the judges. The use of excessive exercise, rubber suits, the sauna, and fluid restriction are found in bodybuilding just as in wrestling, although the prevalence of the abuse of diuretics is much higher in bodybuilding. The use of diuretics by professional bodybuilders is alarmingly high; they are used to remove bloating prior to posing for the judges (Sturmi et al., 1995). The dehydration process begins a few weeks prior to the competition, this includes restricted fluid intake, restricted sodium intake and the abuse of diuretics (personal communication from competitive body builders).

Severe dehydration and the abuse of diuretics are attributed to the death of the professional bodybuilder Mohammad Benaziza in October of 1992. Benaziza had stopped taking fluids three days prior to the competition and had been taking "pharmacological doses" of furosemide and spironolactone for weeks (Sturmi et al., 1995). Benaziza was reported as looking "almost paralyzed" and cramped prior to his death, the cause was heart failure leading to cardiac arrest (Sturmi et al., 1995). Heart failure in these cases is due to ion imbalances. Another professional bodybuilder who collapsed shortly after a competition was found to have the same symptoms as Benaziza. Like Benaziza, this bodybuilder had diminished his fluid intake to 48 ounces over a 72-hour period and was abusing the diuretics spironolactone and triamtarene/hydrochlorothiazide (Sturmi et al., 1995). He was diagnosed with severe hyperkalemia (excess of potassium ions); severe dehydration; acute renal insufficiency;

rhabdomolysis (breakdown of muscle tissue); and diuretic and potassium supplement misuse (Sturmi et al., 1995). The similarities between the two cases suggest that the actual cause of Mohammad Benaziza's cardiac arrest was a kidney malfunction caused by the above factors.

III. Eating disorders

Eating disorders are a common occurrence in athletics, where the goal is to be thin in order to improve performance, whether it is an actual weight concern for enhancing performance or if it is a case of needing to fit certain stereotypes on build of the body for judging purposes. Eating disorders are common among both male and female athletes, although there is a higher prevalence among females that participate in sports such as: distance running; ballet; swimming; figure skating; and gymnastics. Males feel the pressure to fit certain standards and therefore have the tendency to develop eating disorders when participating in sports such as: wrestling; diving; horse racing; and body building. Eating disorders are very addictive, once started they are very hard to stop. Denying the body the regular food intake that it requires can result in severe malnutrition or starvation which then increases the risk of: dehydration; infection; cardiac arrhythmia and possibly even cardiac arrest; menstrual irregularities such as delayed menarche (start of menstrual cycle) and ammenorrhea (cessation of menstrual cycle); and infertility (Estok et al., 1996).

Bulimia Nervosa

Bulimia nervosa is an eating disorder that is based upon a cycle of binge eating and compensatory actions to lose weight. Bulimic behaviors can be classified into to categories: purging and non-purging, purging being the more severe of the two.

Following a bingeing session a purging-type of bulimic uses methods such as self-induced vomiting, enemas, laxatives, and other cathartics (medications used to increase the clearing of intestinal contents). (http://jeffersonhospital.org/e3front.dll?durki=5870) The non-purging type of bulimic employs methods such as fasting and excessive exercise as weight-loss methods. Some health consequences of bulimia are: an imbalance in electrolytes caused by dehydration and the loss of sodium and potassium ions from the body which can lead to irregular heartbeats and possibly heart failure; the potential for gastric rupture during periods of bingeing and the inflammation and possible rupture of the esophagus from vomiting; tooth decay and discoloration from vomiting; chronic irregular bowel movements and constipation as a result of laxative abuse; and peptic ulcers and pancreatitis (http://www.nationaleatingdisorders.org/p.asp?WebPage_ID=337). Bulimia is most common among adolescent females, especially of mid to high socioeconomic stature, whether they are athletes or not. It is most prevalent in sports where physical image or weight control is important. Ballet and bodybuilding are examples of the former, distance running, wrestling, and horse racing (jockeying) are examples of the latter. Gymnastics requires weight control for both aesthetics and performance, as does diving.

Anorexia nervosa

Anorexia nervosa is an eating disorder that is based upon self-starvation to induce weight loss. The major characteristics of anorexia include: extreme thinness; a preoccupation with being overweight; lack of food intake; excessive physical activity (Thornton, 1990); loss of menstrual periods in pubescent girls and in women; and an extreme concern with body weight and shape

(http://www.nationaleatingdisorders.org/p.asp?WebPage_ID=337). Some health consequences associated with anorexia nervosa include: abnormally slow heart rate and low blood pressure; increased risk of osteoporosis (reduction in bone density); muscle loss and weakness; severe dehydration, possibly resulting in renal failure; fainting, fatigue and overall weakness; dry hair and skin; hair loss; and the growth of lanugo (downy layer of hair) all over the body as a feedback effect to maintain body temperature (http://www.nationaleatingdisorders.org/p.asp?WebPage_ID=337). Ninety to ninety-five percent of the reported cases of anorexia nervosa occur in women (Thornton, 1990), particularly those in their teens (86% develop the disorder before the age of 20).

Eating disorders in males

Although the majority of cases of eating disorders are found in females, males are also affected (10-15% of reported cases of bulimia are male (http://nami.org/helpline/bulimia.html)). The behavioral characteristics of a male with an eating disorder may include but are not limited to: excessive dieting; preoccupation with weight lifting; compulsive exercise; frequently self-weighing; and distortion of image of body shape or size (http://www.nationaleatingdisorders.org/p.asp?WebPage_ID=337). The effects of an eating disorder on a male have many of the same consequences as those on a female, but also include lowered testosterone levels (http://www.nationaleatingdisorders.org/p.asp?WebPage_ID=337).

IV. Regulations, monitoring, and sanctions

Organizations such as the National Collegiate Athletic Association (NCAA), the National Federation of State High School Associations (NFSHSA), and the International Olympic Committee are responsible for the regulation of athletes on and off of the field,

dealing not only with the way that the sports are played and officiated, but also monitoring and regulating how the athletes train. The issue of setting regulations for weight loss is basically found only in sports where weight classes are employed, the overwhelming example being wrestling. Most organizations have set regulations dealing with the abuse of drugs, but few deal with weight loss.

The NCAA has developed a stringent weight certification program in an effort to curb the abuse of unhealthy weight loss methods. This weight certification program consists of a six step process to determine each wrestlers Lowest Allowable Weight-One (LAW1), this, this is the lowest allowable weight for the wrestler at 5% body fat. The Lowest Allowable Weight-Two (LAW2) is found prior to the start of regular season competition through a two-step process, at this point which ever is higher, LAW1 or LAW2, is selected as the wrestlers Minimum Wrestling Weight (MWW). The wrestlers are monitored throughout the season; they are allowed to lose 1.5% of their initial body weight per week (NCAA weight certification forms). In an effort to stop weight cycling among high school wrestlers the NFSHSA has adopted several rule changes including moving the weigh-ins to one hour prior to the start of a dual meet and two hours prior to the start of a tournament (http://www.svhs.org/news/01-22-03-Wrestling%20and%20Making%20the%20Weight.htm)

The abuse of weight loss in certain sports is so common that it has become accepted practice, even in sports where regulations exist. One dance instructor at the amateur level said that she had seven-year-old girls exhibiting bulimic behaviors, purging themselves, and not even knowing why they were doing it (personal communication). After speaking with numerous athletic coaches and from personal observations, wrestlers

are still using saunas, even though the NCAA has banned that method some years ago. The education of athletes and enforcement of rules is overwhelmingly the responsibility of the athletic coaches. Even within the NCAA, an organization with some of the strictest rules governing the behavior of athletes, enforcement of the rules becomes the responsibility of the institutions, coaches, and athletes.

The NCAA policy on enforcement of proper training is presented below.

> Creation of a mechanism to enforce the Association's legislation, which all members pledge to observe, occurred in 1952 after careful consideration by the membership.
> This decision established an enforcement program designed to be a cooperative undertaking involving member institutions and conferences working together through the NCAA for an improved administration of intercollegiate athletics.
> Allegations of rules violations are referred to the Association's investigative staff. A preliminary investigation is initiated to determine if an official inquiry is warranted and whether a secondary or major violation has occurred. The institution involved is notified promptly and may appear in its own behalf before the NCAA Committee on Infractions.
> Findings of the Committee on Infractions and the resultant penalty in major cases are reported to the institution, which may appeal the findings or penalty to an appeals committee. After considering written reports and oral presentations by representatives of the Committee on Infractions and the institution, the committee acts on the appeal. Action may include accepting the infractions committee's findings and penalty, altering either, or making its own findings and imposing an appropriate penalty.

(http://www.ncaa.org/enforcement/)

The description of the enforcement of the NCAA rules is ambiguous. It is so vague on both infractions and penalties that it appears that training violations are considered minor offenses compared to recruiting irregularities or point shaving. It is almost expected that football players will take steroids, wrestlers will sweat off weight, and gymnasts will starve and purge.

Leaving the education and regulation of these issues related to weight loss to coaches and athletes is an unacceptable approach. Stricter regulations are needed for *all* sports, not just wrestling, where regulation has been successful; this issue affects a much larger group of athletes than commonly thought. Programs educating coaches and athletes are necessary, as well as much stricter penalties for violations. Athletic regulatory organizations have as much responsibility for regulating the health and well being of their athletes as they do for formulating the rules and sanctions.

Conclusions and recommendations

The abuse of weight loss is a serious issue that encompasses many sports where being lean provides a real or imagined performance edge. Athletes participating in inappropriate weight loss methods are not only risking harm to their athletic performance, but also risking serious health problems that may be with them for life. No matter what the method of choice for weight loss, unhealthy habits not only adversely affect performance, but also lead to electrolyte imbalances causing potentially fatal damage to the systems of the body. While there are some organizations regulating weight loss in certain sports, not enough is being done. More athletic organizations need to address the issue of weight loss and develop programs for the education, monitoring, and regulation of weight loss methods, including plans for strict disciplinary action in cases of violation.

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