International Journal of Physical Education

A Review

Volume 6 | Issue 2 | October, 2013 | 98-101

Legal and illegal use of insulin in sports and its advrse effects on health

■ **JAIPAL**

Received : 26.08.2013; **Accepted :** 25.10.2013

■ **ABSTRACT**

A lot of studies concerning the impact on glycogen production, protein biosynthesis, and inhibition of protein breakdown have illustrated its importance for healthy humans and diabetics as well as elite athletes. Analytical method has been used for this article by reviewing relevant publications. This review provides an overview on the legal and illegal use of insulin sports and discusses their benefits and adverse effect on health. Use of Insulins is in the list of prohibited substances of World Anti-Doping Agency's (WADA); the use of insulins is banned both in competition and out of competition and insulins are usually tested by authorized anti-doping laboratories of WADA. Insulin was banned by the International Olympic Committee in 1998. The most common side effect use of insulin is hypoglycemia (low blood glucose), which is potentially serious and can be life-threatening; other complications of associated with insulin use included weight gain, injection site abnormalities, and insulin allergy.

■ **Key Words :** Insulin, Sports, Health, WADA

■ **How to cite this paper :** Jaipal (2013). Legal and illegal use of insulin in sports and its advrse effects on health. *Internat. J. Phy. Edu.*, 6 (2) : 98-101.

Author for correspondence :

JAIPAL
Jawahar Navodaya Vidyalaya,
Butana, SONIPAT (HARYANA)
INDIA
Email: jaipalomparkash@gmail.com

Insulin is a hormone excreted by the pancreas in reaction to food being consumed. The higher the level of sugar in the blood, the more insulin is produced to convert these sugars into glucose and glycogen, which can then be stored as energy supplies. In order for useable energy to enter a cell, the cell must have insulin bound to it which is permitted by the presence of insulin receptors on the cell. People with diabetes do not produce enough insulin to regulate their blood sugars so they must use injected insulin, tablets or control their diet to moderate their intake of sugars. Insulin causes hypoglycemia (Reverter *et al.*, 1994). If the organism does not produce insulin in sufficient amounts, as is the case in certain types of diabetes, additional insulin is injected to reach normal physiological balance (Young and Anwar, 2007). In this scenario, physical sports activities are entirely acceptable. Unfortunately, this state of balance is so difficult to maintain that many physicians recommend that diabetics abstain from any serious physical activity, especially sports that demand a high energy input. The international sports regulating bodies prohibit the non-therapeutic use of insulin for one main reason: insulin induces growth hormone release (Sonksen, 2001). In itself, insulin causes a number of side effects some of which are listed below: Various reports described the misuse of insulin to improve performance and muscles strength, and synthetic analogs were the subject of several studies describing the beneficial effects of biotechnologically modified insulins. Rapid or long-acting insulins were developed to enhance the injection-to-onset profile as well as the controllability of administered insulin, where the slightest alterations in primary amino acid sequences allowed the inhibition of non covalent aggregation of insulin monomers (rapid acting analogs) or promoted micro precipitation of insulin variants upon subcutaneous application (long-acting analogs) (Dawson and Harrison, 1997). Information on the metabolic fate and renal elimination of insulins has been rather limited,

and detection assays for doping control purposes were primarily established using the intact compounds as target analysts in plasma and urine specimens (Thevis and Schanzer, 2005). However, recent studies revealed the presence of urinary metabolites that have been implemented in confirmation methods of sports drug testing procedures. So far, no screening tool is available providing fast and reliable information on possible insulin misuse; only sophisticated procedures including immunoaffinity purification followed by liquid chromatography and tandem mass spectrometry have enabled the unambiguous detection of synthetic insulins in doping control blood or urine samples.

Potential benefit of insulin :

Using insulin can help body builders to achieve a greater degree of muscle mass. Insulin is known for its qualities for maintaining and improving muscle mass as it is protein based. It is involved in several biological functions and cellular activity is responsible for the anabolic, or muscle building properties of insulin (Rich *et al.,* 1998). It can also be used by those who participate in endurance races as, if taken with glucose can provide energy for longer periods of time which is needed to supply the muscles (Wolf, 2000). For example, if a person consumes a diet rich in products that elevate blood sugar, such as carbohydrates and proteins which are high in nutrients, then in use insulin, the body is forced to use this insulin to turn the blood sugars into useable energy which is then pushed into the muscles and can be relied on for additional energy supply (Rich *et al.*, 1998).

Legal use of insulin in sports :

The use of insulin is legal for those who require it for legitimate medical conditions. The criteria are:

The athlete are allowed to take insulin where significant diabetes problems. The therapeutic use of the insulin would not produce significant enhancement of performance, and there is no reasonable therapeutic alternative to the use of the otherwise prohibited substance or method so it legal to be use medically to treat the diabetes disease.

Illegal use of insulin in sports :

Its use for those without diabetes is banned by the leading governing bodies of high level sport as it provides an unfair advantage between competitors and is also very dangerous to health (Evans and Lynch,2003). As it is difficult to detect as a supplement, it can seem like an easy option for struggling athletes and body builders, however those who are found to be using as a supplement face punishment from governing bodies and also risk their public profile and fan base (Thevis and Schanzer, 2005).

Since August 1998, partly because of fears that black-market insulin was finding its way into bodybuilders, insulin has been a prohibited substance in Britain, obtainable only on prescription. But athletes can and do get it. Insulin was banned by the International Olympic Committee in 1998. But the ban doesn't apply to diabetic athletes, whose health depends on insulin. So, insulin used by athletes who is diabetic is not illegal.

Adverse effect on health :

Endocrine :

Hypoglycemia is the most common and serious side effect of insulin, severe hypoglycemia usually presents first as confusion, sweating, or tachycardia and can result in coma, seizures, cardiac arrhythmias, neurological deficits and death. The risk for developing hypoglycemia is higher in athletes receiving intensive or continuous infusion insulin dose. Permanent neuropsychological impairment has been associated with recurrent episodes of severe hypoglycemia.

Ocular :

An abnormal ocular disturbance during the beginning of insulin use is bilateral presyopia (shadowy vision). This is to be due to changes in the osmotic equilibrium between the lens and the ocular fluids and is usually self-limited.

Dermatological :

Dermatologic reactions to insulin can result in lipohypertrophy (insulin is lipogenic) or lipoatrophy (probably immunologically mediated). The incidence of lipoatrophy is markedly decreased with the use of purer forms of pork insulin or biosynthetic human insulin and when injection sites are alternated. Without proper hygiene, subcutaneous insulin injections may be complicated by infection.

Hypersensitivity :

Hypersensitivity reactions - either local or systemic- are becoming rare due to the use of purer forms of pork insulin or biosynthetic human insulin. Local reactions may present as erythema, swelling, heat, or subcutaneous nodules. They usually occur within the first two weeks of therapy, and then disappear. True allergy to insulin is rare and sensitization is usually associated with specific animal proteins in bovine and less pure forms of porcine insulins.

Immunological :

Immunologic analysis of anaphylaxis to some insulin preparations in some cases has revealed markedly elevated serum levels of lgE and lgG to protamine, but not to regular insulin. Immunologic responses to insulin, particularly animal insulin formulations, include the formation of anti-insulin antibodies. The presence of these antibodies causes the

elimination half-life of insulin to increase.

Cardio-vascular :

Other cardio-vascular risk factors that are accentuated in athletes with carbohydrate intolerance and hypertension include abnormalities in platelet function, clotting factors, the fibrinolytic system, and dyslipidemia.

Insulin may contribute to the pathogenesis of hypertension by stimulating the sympathetic nervous system, promoting renal sodium retention and/or stimulating vascular smooth muscle hypertrophy. It may induce dyslipidemia by promoting hepatic synthesis of very low density lipoproteins. Some experts are evaluating insulin as a possible atherogenic agent. Controversy and continued study surround the role of hyperinsulinemia as the precursor of hypertension.

General :

Intensive insulin therapy causes an increase in body fat as a result of the elimination of glycosuria and reduction in 24-hour energy expenditure (Becker *et al.*, 2005). The reduction in 24-h energy expenditure is the result of an insulin-associated decrease in triglyceride/free fatty acid cycling and non-oxidative glucose and protein metabolism. General weight gain is associated with insulin use, sometimes presenting as edema associated with abrupt restoration of glucose control. Weight gain may be due to more efficient use of calories during insulin therapy, suggesting additional benefits of dietary and exercise modifications.

Metabolic :

The metabolic side effects of insulin therapy may be particularly important in patients who are being treated for diabetic ketoacidosis (DKA). Insulin increases the intracellular transport of phosphate, which often results in hypophosphatemia during treatment of DKA. Hypokalemia and hypomagnesemia have been associated with DKA, and may be due to insulin. Rare cases of hypophosphatemia have been associated with the use of glucose, insulin and potassium infusions during the treatment of myocardial infraction.

Renal :

Hypoglycemia is associated with increased plasma dopamine, epinephrine, and plasma renin activity. Acute changes in renal function during insulin-induced hypoglycemia, therefore, may result from direct stimulation of the efferent sympathetic nerves to the kidney and hormonal counter regulatory mechanisms.

The renal effects from insulin-induced hypoglycemia include significantly decreased renal plasma flow, glomerular filtration rate, and significantly increased urinary albumin excretion rate. These changes are reversible upon resolution of hypoglycemia.

Hematologic :

The effects of insulin-induced hypoglycemia on homeostasis may explain some of the clinical observations of embolic phenomenon during treatment of diabetic ketoacidosis. The hematologic effects from insulin-induced hypoglycemia include an enhanced increase in the concentration of von Willebrand factor. Increased von Willebrand factor, combined with hypoglycemia-associated decreased plasma volume and increased plasma viscosity, may predispose athletes to reduced peripheral perfusion or embolic phenomenon.

Gastrointestinal :

Rare cases of gastrointestinal distress have been associated with insulin use. GI distress tends to resolve with reduction of dose of insulin.

Conclusion :

Insulin is known for its qualities for maintaining and improving muscle mass as it is protein based. The athletes are allowed to take insulin in significant diabetes problems. Insulin was banned by the International Olympic Committee in 1998. The most common side effect use of insulin is hypoglycemia (low blood glucose), which is potentially serious and can be life-threatening; other complications of insulin therapy include weight gain, sometimes presenting as edema associated with abrupt restoration of glucose control, gastrointestinal distress, hypophosphatemia hypokalemia and hypomagnesemia have been associated with insulin use, cardio-vascular risk factors that are accentuated in athletes with carbohydrate intolerance and hypertension include abnormalities in platelet function, clotting factors, injection site abnormalities and insulin allergy. So, use of insulin is not fair both ethically and in point view of risk of health.

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