

# Systematic Review Article: A Systematic Review of the Relationship Between Sex Hormones and Leptin and Insulin Resistance in Men

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## ABSTRACT

The present study systematically investigated the relationship between sex hormones and leptin in men. In this study, 70 articles were reviewed and the subject was investigated by searching the words "Leptin", "Patients undergoing surgery" and "Sex hormone". Leptin is a hormone derived from adipose tissue that plays a major role in the pathogenesis of obesity. Hyperinsulinemia and insulin resistance are among the complications of obesity. Hyperinsulinemia is one of the factors that seems to affect the leptin hormone level. Few studies have investigated the relationship between leptin and insulin resistance in obesity in children and adolescents. Leptin is made by fat cells, and for this reason, with the presence of these cells and the increase in messaging, when the leptin hormone increases, the message of satiety is sent to the brain; As a result, the person reduces his food consumption. However, sometimes due to the excessive increase of leptin caused by eating sweet and fructose-containing foods, the brain loses its sensitivity to the leptin hormone and does not receive the message of satiety. For this reason, leptin hormone and obesity are related to each other; But their relationship cannot be considered linearly. In many cases, after testing the obesity hormone leptin, the doctor concludes that a person who is overweight has developed a strong resistance to the hormone leptin; Therefore, by prescribing some solutions, such as reducing the amount of fruit consumption, increasing the regularity and hours of rest and sleep, reducing the consumption of sugary foods and changing the diet, as well as consuming enough water, it tries to increase the sensitivity of the brain to the leptin hormone. The results of the recent study showed that the relationship between leptin and insulin resistance was weak and after controlling for body mass index, the relationship disappeared.

## Introduction

**L**nsulin resistance is defined as an incomplete response of glucose to a certain amount of insulin. In many of these patients, to compensate for this deficiency, to maintain glucose

levels, circulating insulin levels increase [1-3]. Based on studies, there is a close relationship between insulin resistance in the liver and the risk factors of cardiovascular diseases [4]. As Pirola et al in a research in this regard concluded that there is a significant relationship between hyperinsulinemia as a predictor of coronary

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artery disease [5]. Also, leptin levels in the blood can be mentioned among other predictors of coronary artery diseases. Leptin hormone is produced by the OB gene and consists of 129 amino acids with a molecular weight of 16 kDa. In addition to regulating energy balance and metabolism, which controls body weight, leptin affects the central nervous system, especially the hypothalamus, by reducing food intake and stimulating energy consumption. The amount of fat stored in the body regulates the level of leptin, and the fatter cells a person has, the more leptin in the blood. Studies have also shown that leptin levels are directly related to body mass index [6-8].

Exercise and physical activity help in eliminating insulin resistance. In this context, in relation to the effect of exercise and proper diet on the control of cardiovascular risk factors, metabolic disorders, increased prevalence of glucose tolerance disorder, diabetes and blood lipid disorders, about the positive effect of a regular exercise program on the improvement and regulation of endocrine status. There are conflicting results [9]. Akel and colleagues (2014) by comparing the effect of aerobic exercise and combined exercise (resistance-aerobic) showed that both types of exercise caused a significant decrease in leptin levels, and this decrease showed a more significant difference in the combined group [10]. Jina et al. (2013) in a study that examined eight weeks of aerobic exercise for 180 minutes per week with an intensity of 40-55% of peak oxygen consumption, concluded that leptin levels decreased significantly and insulin sensitivity also decreased. There was a significant increase after training [11-13]. Van Lang et al (2013) showed that leptin levels decreased significantly compared to the control group after eight weeks of moderate-intensity training on a treadmill, and there is a direct relationship between leptin levels and body mass index [14]. If Rahmani Nia (2009) stated that short-term exercises of less than 60 minutes with energy consumption of less than 800 kcal have no effect on leptin level [15].

Considering the fact that cardiovascular disease is known as the most important cause of death and accounts for a large part of deaths worldwide; And according to the report of the

World Health Organization, at least 15 million deaths due to cardiovascular diseases have occurred in the world every year [16], which is 30% of all deaths. However, due to the importance of the role of physical activity in the prevention and treatment of many diseases, especially cardiovascular diseases, experts suggest exercise and nutritional counseling to treat these patients before starting drug therapy [17-19]. Research has shown that doing aerobics activities along with diet is one of the factors that leads to a decrease in insulin levels and improves glucose utilization and insulin sensitivity, and can reduce body fat [20].

Considering the importance of the positive effect of physical exercises in rejuvenating and increasing the empowerment of patients, especially the elderly with cardiovascular lesions and returning them to normal daily activities and considering the fact that the risk of cardiovascular diseases due to aging in this age group intensified and also considering that the effect of combined exercises (aerobic-resistance) as much as aerobic exercises on reducing insulin levels, insulin resistance index and serum leptin among new cardiovascular risk factors is not emphasized and about the intervention of combined exercises are doubts about the reduction of these factors [21]; The aim of this study was to investigate the effect of eight weeks of combined exercises (aerobic-resistance) on insulin levels, insulin resistance index and serum leptin in inactive middle-aged men [22].

The results of this research showed that eight weeks of aerobic training in middle-aged men led to a significant decrease in the serum leptin levels of middle-aged men, which the results of this research are consistent with the findings of Akel et al. (2014), Ghadiri et al. (2012) [23-25]. But it is not consistent with the results of Bijeh et al. (2012) and Kamboli et al. (2008). Akel et al. (2014) compared the effect of aerobic exercise and combined exercise (resistance-aerobic) in obese adolescents aged 15-19 years and showed that both types of exercise caused a significant decrease in leptin levels, which was more significant in the combined group [26]. Qadiri et al. (2012) in a study that investigated the effect of aerobic exercise intensity on serum leptin levels in obese and overweight women with

lower intensity (45-50% of maximum heart rate) and aerobic exercise with higher intensity (70-75% of heart rate) (maximum reserve heart) during a training period of 10 weeks with three sessions and each session was 60 minutes [27]. They concluded that aerobic exercise with two different intensities affects body weight, body mass index, waist to hip ratio, fat percentage and levels serum leptin has a significant effect [28]. Bije et al. (2012) in a study that measured the effect of six months of aerobic training on C-reactive protein and leptin levels in middle-aged women concluded that there was no significant change in C-reactive protein and leptin levels [29]. Kamboli et al. (2008) who investigated the effect of aerobic exercise on obese children showed that 12 months of aerobic exercise does not cause a significant decrease in leptin levels of these people. Among the reasons for the contradiction of the findings, we can mention the different exercise protocols, the type of subjects and especially the duration of the exercises [30]. Another reason for the difference in the findings can be attributed to the time of blood sampling from the subjects according to the theory of delayed reduction in leptin affected by exercise.

Endurance training alone, especially at high intensity, stimulates lipolysis and facilitates the release of fat from fat stores by increasing the level of catecholamine's and improving the sensitivity of beta-adrenergic receptors in adipose tissue. Resistance training also increases muscle protein synthesis and increases body muscle mass, and increases total energy consumption during rest and reduces body fat, which is effective in preventing leptin secretion. In this research, the reason for the decrease in leptin levels can be attributed to the simultaneous effect of both types of endurance and resistance training [31].

The results of the current research on insulin levels and serum insulin resistance indicators showed that aerobic exercises led to a significant decrease in these indicators. These results are consistent with the findings of Su et al. (2011), Haji Dan et al. (2010), Bell et al. (2007), Nesis et al. (2005). Su et al. (2011) in a study that measured the effect of 12 weeks of aerobic and resistance training with a controlled diet on 30 overweight men, concluded that the insulin

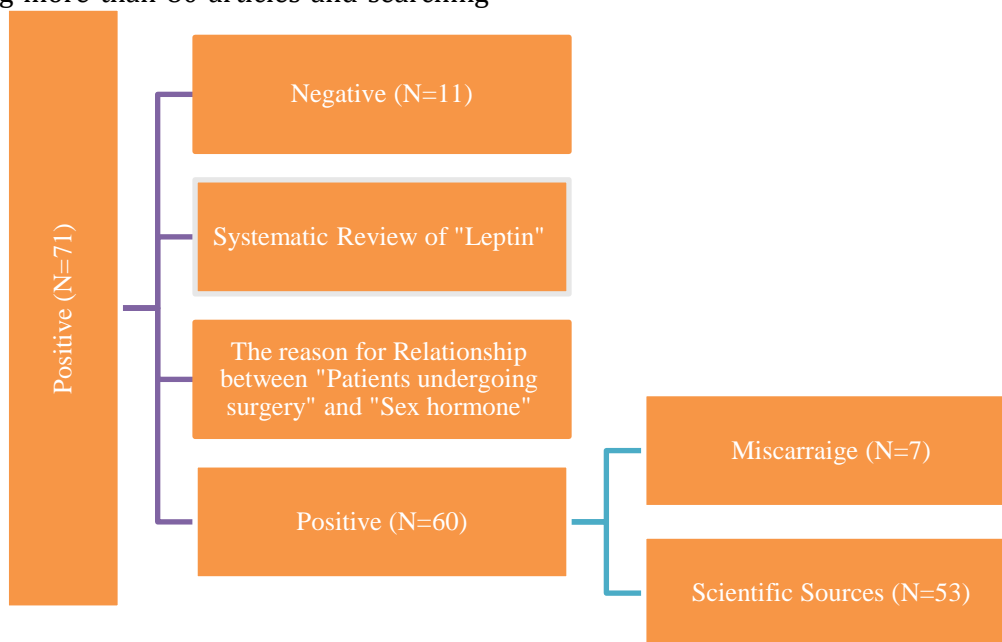
resistance of both groups (aerobic and resistance activity) was significantly higher than group that only had a diet was lower [32-36]. Haji Dan et al. (2010) in a study they conducted on 29 obese male volunteers observed that 12 weeks of aerobic training (4 sessions of 30 minutes per week with an intensity equivalent to 70% of the maximum oxygen consumption) led to a significant increase in the level of physical fitness, there is a significant decrease in insulin resistance index and subsequent decrease in fasting insulin levels [37]. Bell et al. (2007) reported a significant decrease in insulin resistance and waist circumference after eight weeks of aerobic training (3 sessions of 60 minutes per week).

Nesis et al. (2005) reported that 12 weeks of aerobic training (3 sessions of 40 minutes per week) resulted in no change in body weight in inactive overweight women, while insulin resistance in these subjects was significantly decreases [38]. Among the mechanisms that can cause an increase in insulin action after aerobic exercises, an increase in post receptor signaling of insulin; Increased expression of GLUT4 glucose transporter protein; Increasing the activity of glycogen synthetize and hexokinase; Reducing the release and increasing the clearance of free fatty acids; The increase in the release of glucose from the blood to the muscle is due to the increase in the capillaries of the muscle and the change in the composition of the muscle in order to increase the uptake of glucose [39]. Therefore, one of the ways to reduce insulin resistance and reduce the risk of type 2 diabetes, especially in obese people, is aerobic exercise. Insulin resistance may potentially be mediated by alterations in the function of several peptide mediators secreted from adipocytes, including tumor necrosis factor alpha, leptin, and adiponectin. In non-inflammatory conditions, tumor necrosis factor alpha is derived from adipose tissue and its plasma levels are related to body fat mass. Tumor necrosis factor alpha antagonizes signaling by insulin, which does this by reducing signaling through serine phosphorylation. Adiponectin is secreted from adipocytes inversely with body mass index and is a potential tumor necrosis factor alpha inhibitor [40]. The serum level of adiponectin decreases in

obesity, insulin resistance, diabetes mellitus and metabolic syndrome. Another reason for such contradictory findings may be due to the difference in the duration, intensity and level of training of the subjects. The duration of sports activity can affect the change of fat profile.

In a recent study, the topic was investigated by reviewing more than 80 articles and searching

for the keyword's words "Leptin", "Patients undergoing surgery" and "Sex hormone". The results of a recent study on patients showed that current treatments for patients can only reduce symptoms, but cannot completely prevent neurodegeneration (Figure 1) [41].



**Figure 1.** Flow chart of included subjects

### Complications of increased leptin levels in the body

Leptin is also known as obesity hormone. The hormone leptin plays a very important role in regulating appetite and the body's energy consumption. The most important function of this hormone is to send the satiety signal to the brain [42]. Leptin even regulates food absorption and fat storage. An increase in leptin hormone in the body leads to many side effects, including:

#### Difficulty keeping fit

Leptin is a hormone that helps regulate appetite and satiety by sending signals to the brain. If you are overweight or have a condition called leptin resistance, you may need to eat more to feel full. If your body produces too much leptin, the signals sent to the brain make you feel full later than necessary. So gradually you will have difficulty in maintaining fitness [43].

### Lack of control of appetite and energy levels

If your blood leptin levels are out of balance, your body sends confusing signals to the brain. So you feel hungry even if you don't really need to eat. This situation makes it difficult to lose weight. In general, increasing the level of leptin in the body has many side effects. Increased leptin causes increased appetite and obesity. On the other hand, obesity and overweight are associated with various diseases such as diabetes, cardiovascular diseases and metabolic syndrome [44].

### Solutions to reduce leptin in the body

Leptin plays a very important role in body weight management. This hormone is produced by fat cells. Therefore, the amount of leptin is directly related to the amount of body fat. As the body weight increases, the sensitivity of the body to leptin decreases. People who are overweight, their brains send the satiety signal to the brain much later. For this reason, obese

people stop eating later. Increased leptin levels have many effects on the body. The doctor can detect the leptin serum level by performing a simple blood test. If the level of leptin is high, there are various methods that can be used to reduce the level of leptin in the body [45]. Some of the most important of these ways are:

### Changing life style

One of the ways to reduce leptin levels in the body is to make lifestyle changes. Following a balanced diet and regular exercise can help you to a great extent in maintaining the balance of leptin in your body. Leptin is naturally released by fat cells in the body. Therefore, your weight plays an important role in maintaining a healthy body balance. Focus on sustainable changes so you can stick with your diet. Exercise also has a great effect on reducing leptin levels in the body. Start with small activities. For example, go for a walk every day or try to run for 15 to 20 minutes every day. Over time, you will develop lifestyle habits that can help lower your leptin levels [46].

### Follow a low carbohydrate diet

Studies show that reducing the consumption of carbohydrate foods in the diet is very effective in reducing the level of leptin in the body. However, making sudden and dramatic changes in diet and maintaining these changes in the long term can be difficult for many people. Carbohydrates in sweet foods play an important role in increasing leptin in the body. The best option is to make small and gradual changes and try to continue the low-carb diet long-term [47].

### Taking lipoic acid and fish oil supplements

Studies show that people who consume alpha lipoic acid and fish oil are more successful in losing weight. Consuming 0.3 grams of lipoic acid and 1.3 grams of fish oil per day can help you reduce leptin levels in your body. Also, consuming some foods such as almonds can greatly reduce the level of leptin in the body due to their essential fatty acids [48].

### What foods are rich in leptin?

Fats, oils and sugars seem to play a role in leptin resistance. Studies show that fats and oils such as butter, margarine, and coconut oil may

increase lipid and blood sugar levels. Having higher levels of fat and sugar increases blood leptin levels. Be careful of consuming fatty foods, sauces and high-fat dairy products. Also, avoid drinks sweetened with artificial sugars and high-fat foods [49].

### What foods reduce leptin resistance?

When a person becomes overweight and obese, the level of leptin in the blood increases greatly and causes the body's sensitivity to leptin to decrease. This condition is called leptin resistance in medical terms. Leptin resistance can lead to various other diseases such as insulin resistance. The treatment of leptin resistance is very necessary. You can easily manage your weight loss by controlling your body's leptin. Leptin is secreted from fat cells in the body. An increase in body fat also leads to an increase in the hormone leptin. Therefore, you can reduce leptin resistance by following a healthy diet [50]. Foods that can help you reduce leptin resistance include:

### Protein

Consuming foods rich in protein can help reduce the level of body fat stores. Foods such as fish, chicken, beans and soybeans are among the best sources of protein. Among the different sources of protein, the consumption of eggs increases the metabolism of the body due to its high amount of vitamins and minerals and thus reduces the level of resistance to leptin. The appropriate amount of protein consumption for each person depends on the level of activity, age and muscle mass. However, on average, the permissible amount of protein consumption is 0.8 grams per kilogram of body weight [51]. The energy received from protein improves the feeling of satiety. Also, avoid fatty and red meat as much as possible.

### Whole grains, fruits and vegetables

This food group is always a good choice. Whole grains can provide the fiber needed by the body. Also, whole grain bread and whole grains are not only filling and nutritious, but can also help reduce the body's leptin resistance. Among different grains, oats are rich in dietary fibers and are very effective in reducing insulin



resistance [48-50]. Therefore, as much as possible, include a lot of fresh and tasty grains and vegetables in your diet. Following this diet will make you feel full at every meal without increasing blood sugar or fat levels. If you have a craving for a sweet treat [51-53], instead of eating a variety of cakes, cookies or compotes that have a lot of sugar, you can choose a piece of fruit. Studies show that among different types of fruits, apples are very effective in removing resistance to leptin due to the presence of compounds called pectin [54-56].

### Natural solutions to overcome leptin resistance

People who are overweight are very resistant to the hormone leptin. Therefore, to control weight, first of all, you need to eliminate resistance to leptin [57-59].

There are many natural methods that can help you improve leptin resistance, including:

### Follow a balanced diet

The best way to overcome leptin resistance is to stick to a healthy diet. For this, limit the consumption of sugar and fat in your diet as much as possible. This will help you lose weight gradually and maintain your fitness. Maintaining

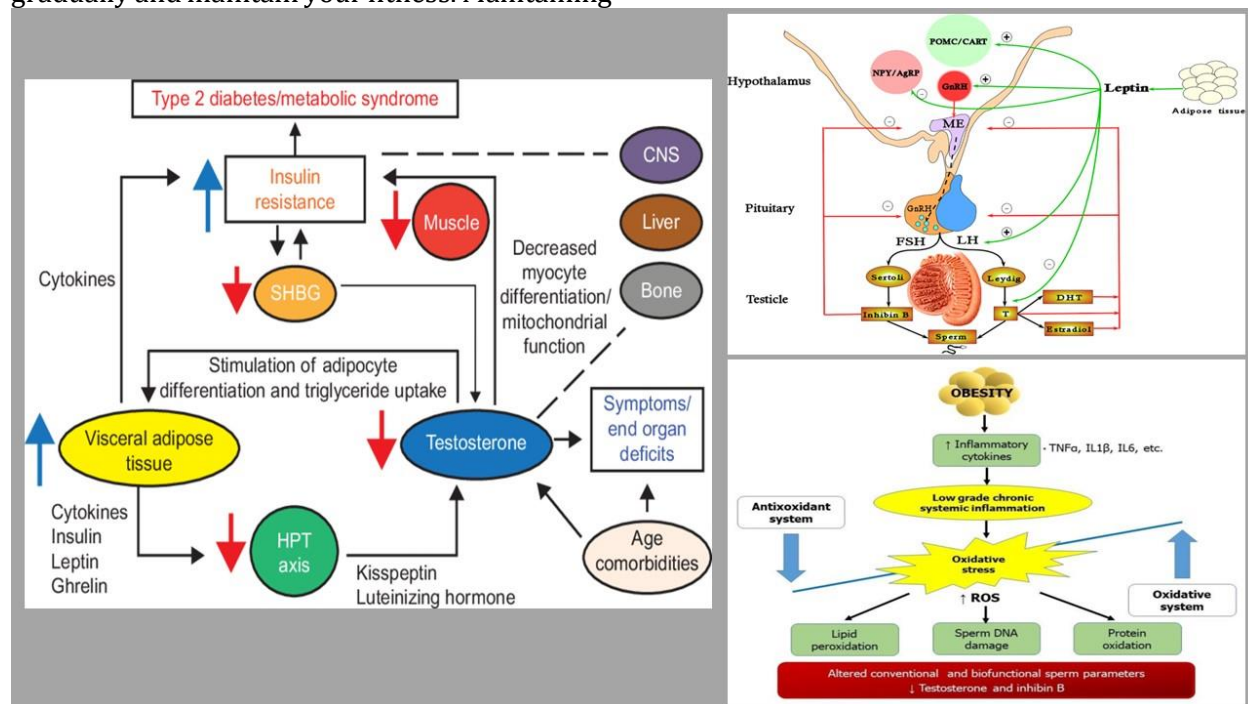
a healthy weight can naturally help balance blood leptin levels [60-62].

### Regular exercise

Regular exercise can help you lose weight and restore the balance of leptin levels in the body. Although maintaining a healthy diet is very important in improving leptin resistance, you can multiply this effect by exercising. Exercise has many health benefits, but one of the main benefits is that it burns fat and promotes weight loss [63-65].

### Is there a drug for leptin resistance?

Yes, but you should talk to your doctor about which ones are safe for you. Leptin can help reduce your appetite (Figure 2). This is why some people take it to help them lose weight. But if leptin supplements are taken in excess, leptin resistance may develop [66-68]. If you have leptin resistance, your doctor can prescribe medications and supplements to help lower leptin levels [69-71]. However, before taking any medication or supplement, you should first talk to your doctor to find the best and safest option for you. It is more important to consult a doctor, especially in people who have underlying diseases such as diabetes or heart disease [72-74].



**Figure 2.** Relationship Between Sex Hormones, Oxidative stress, obesity, and male infertility and Leptin and Insulin Resistance in Men

### Does leptin help with weight loss?

Leptin does not affect weight loss, but this hormone helps regulate your appetite and energy. In fact, with weight loss, blood leptin levels decrease [75-77]. When you are overweight, leptin sends signals to the brain to tell you that you are hungry and need to eat more. However, if the leptin in our body is more than normal, it causes leptin resistance [78-80]. Leptin resistance makes weight loss difficult. So, the key to your health is to keep fit and help improve your body's hormone function by exercising and following a healthy diet [81-83].

### Can fasting increase leptin?

Yes, studies show that fasting may increase leptin levels in the body. During the fasting period, your body begins to decrease insulin levels. This problem reverses the natural process of body fat storage [8-86]. As a result, your body increases its production of leptin to help curb hunger. So, if you're trying to lower your leptin levels, fasting may not be a good idea for you [87].

**Table 1.** Forest plot showed the Relationship Between Sex Hormones and Leptin and Insulin Resistance in Men

Raw	Study	Year		Proportion Wight 98%	Weight %	
1	Khidr et al.	2017		0.92	[0.39 - 1.06]	5.03
2	Salem et al.	2021		0.87	[0.54 - 1.02]	6.02
3	Rodríguez et al.	2015		0.88	[0.63 - 1.01]	5.57
4	Mauras et al.	2015		0.60	[0.25 - 1.08]	6.13
<b>Heterogeneity <math>t^2=0.02</math>, <math>I^2= 0.00</math>, <math>H^2=1.02</math></b>				0.95	[0.22 - 1.07]	
<b>Test of <math>\theta= \theta</math>, Q (4) =5.55, P= 0.74</b>						
1	Arhire et al.	2019		0.84	[0.27 - 1.08]	6.08
2	Staiger et al.	2013		0.76	[0.52 - 0.99]	5.82
3	Colaianni et al.	2019		0.11	[0.54 - 0.89]	5.85
<b>Heterogeneity <math>t^2=0.14</math>, <math>I^2= 0.11</math>, <math>H^2=0.42</math></b>				0.77	[0.19 - 1.00]	
<b>Test of <math>\theta= \theta</math>, Q (4) =3.35, P= 0.34</b>						
1	Salem et al.	2021		0.84	[0.27 - 1.08]	6.08
2	Rodríguez et al.	2015		0.76	[0.52 - 0.99]	5.82
3	Mauras et al.	2015		0.11	[0.54 - 0.89]	5.85
<b>Heterogeneity <math>t^2=0.19</math>, <math>I^2= 0.09</math>, <math>H^2=0.16</math></b>				0.77	[0.19 - 1.00]	
<b>Test of <math>\theta= \theta</math>, Q (4) =3.11, P= 0.04</b>						

### Conclusion

In this study, the relationship between sex hormones, leptin and anthropometric indices in men was investigated and the effect of average

weight loss on these variables was studied in obese people. Obesity and thyroid disorders, including hypothyroidism, affect metabolism and body composition. In combination with

inflammatory signals, obesity and thyroid imbalance lead to leptin resistance and weight gain. As seen in obesity, leptin is produced excessively by fat cells, which can lead to the turning off of some leptin receptors. Based on this, resistance to leptin is formed. Obese people have high levels of leptin, which indicates leptin resistance. Obesity and leptin resistance interfere with thyroid function. Obesity increases leptin resistance, and overeating leads to leptin resistance, thus creating a vicious cycle that tells the body to consume more and more food. Leptin resistance also increases as the HPA-T axis and other body systems become increasingly imbalanced. Leptin resistance in overweight people can lead to high blood insulin levels and type 2 diabetes. The only solution to this condition is to reverse leptin resistance. Gaining sensitivity to leptin will strengthen the thyroid and help rebalance the HPA-T axis. Leptin resistance can be reversed through weight loss, especially in people who are obese. Lifestyle factors such as diet and exercise are beneficial for weight loss and regaining leptin sensitivity. Calorie restriction can improve leptin response. Low insulin diets with low glycemic index foods and low amounts of trans fats can be associated with weight loss. Additionally, avoiding fructose can be beneficial because excessive fructose consumption can lead to leptin resistance. Regular physical activity can be significantly beneficial for improving lipid profile (lowering triglycerides, increasing good cholesterol or HDL), cardiovascular fitness, lowering insulin levels, and treating obesity. Also, exercise helps make significant improvements in people with type 2 diabetes, high blood pressure, hyperlipidemia, and metabolic syndrome—conditions associated with obesity and leptin resistance. About eight hours of sleep a night is also considered an important factor because adequate sleep is necessary to maintain leptin levels. The proper functioning of the HPA-T axis and the leptin pathway is a key factor in maintaining a healthy weight and preventing chronic diseases. Whether to prevent obesity or to reverse leptin resistance, monitoring the HPA-T axis and implementing lifestyle changes can help the body achieve optimal performance.

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