



Impact of some Nutritional Supplement and Testosterone Hormone Used in Sports Training Centers on some Blood Parameters and HbA1C% in Male Albino Rats

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ABSTRACT

The study aimed to clarify the effect of using some nutritional supplements (NS) and testosterone hormone on blood parameters added to HbA1C% in the blood serum of male rats, and the change in these parameters upon exercise training. 80 male albino rats were used, divided into 8 groups, each group 10 rats. The 1st group get standard feeding only (control); the 2nd group subjected to special exercise program using a treadmill; the 3rd group administrated NS+ standard feeding; the 4th group injected IM. with testosterone Blend; the 5th group administrated NS and injected with testosterone; the 6th group administrated NS and subjected to exercise program; the 7th group was injected with testosterone and exercise the 8th group administrated NS and injected with testosterone and subjected to exercise program. Our results showed a significant decrease in the number of RBCs, WBCs, Hb concentration and PCV% in the group of rats treated with the NS and testosterone, with a significant increase in platelets and HbA1C% compared to the rest groups at a significant level $P \leq (0.01)$, while exercise led to a significant increase in the values of (RBCs, WBCs Hb, PCV%) with a significant decrease in the numbers of platelets and HbA1C% compared to the treated and non-exercise groups. In conclusion, the study revealed that treatment with the NS and testosterone hormone, those usually used in sports training centers showed to cause negative effects on various blood parameters and HbA1C%, while doing exercise resulted in a positive improvement in the studied parameters as well as HbA1C%, i.e. the rat group that practicing exercise have better control over the studied parameters.

Keywords: Nutritional supplements, exercise training, RBCs, WBCs, %HbA1C.

INTRODUCTION

Nutritional supplements (NSs) are food ingredients, not foods such as protein, that are commercially accessible and consumed in addition to the diet, they include also vitamins, amino acids, minerals, herbs, caffeine, folic acid, creatine, calcium, iron, and omega-3 (Act, 1994; Food and Drug Administration, 2015; Knapik *et al.*, 2016; Thomas *et al.*, 2016; Alqrache *et al.*, 2021). The history of these nutritional supplements' dates back to 776 BC, when they were used in the ancient Greek Olympic Games. At that time, various natural substances were used as a source of energy for participants in these tournaments, such as dried figs, wet cheese, and wheat during their training, but there was no prior scientific evidence (Grivetti and Applegate, 1997). These natural derivatives are found in several types, such as proteins, which are usually in the form of a palatable powder, such as whey protein or rice protein, which is usually used for muscle growth and recovery (Al Nozha and Elshatarat, 2017). They often manufactured in different pharmaceutical forms, such as capsules, powders, tablets, and drinks (Alqrache *et al.*, 2021). Excessive and irrational use of these nutritional supplements may increase harmful effects and cause health harm (Naqvi *et al.*, 2018). There are some considerations about the long-term use of these supplements which can be associated with more severe adverse effects, ranging from minor physical discomfort to life-threatening diseases (Suzic *et al.*, 2011; Kamangar and Emadi, 2012). NS have been used at all levels of sport by athletes, indicating their widespread use in society. It has been noted that the use of these supplements is most common among children and adolescents who exercise (Calfee and Fadale, 2006). The difference in frequency of use also depends on the type of age group, especially adolescents, the type of exercise, with weightlifting being the most common, as well as bodybuilding, and gender, with men consuming these supplements more than women (Pereira *et al.*, 2003; Maughan *et al.*, 2004). Half of the adult population of the United States uses one of these types of non-starch nutritional supplements (Bailey *et al.*, 2011). Despite the widespread random use of these non-starch nutritional supplements as a source of energy, there is no scientific evidence to prove the effectiveness and safety of these nutritional supplements, not only among athletes (Huang *et al.*, 2006; Heikkinen *et al.*, 2011), but also among people who engage in recreational physical exercise, especially the young category of athletes who They generally aspire to build their bodies, with the aim of obtaining quick results through the use of hormones, steroids, steroids and medications unwiring of health risks that may resulting from their use (El Khoury and Antoine-Jonville, 2012). In addition to the potentially high risks that are perceived when these steroids are taken in high doses without medical supervision (Harrison *et al.*, 2004), physiologically, many side effects can be observed, including disruption of the body's natural hormonal balance resulting from the effect of anabolic androgenic steroids, including cardiovascular problems, reproductive system abnormalities, and liver damage (Phan, 2004). Indiscriminate use of testosterone has also led to suppressing of the hypothalamic-pituitary axis, thus leading to erectile dysfunction, violent tendencies, and decreased libido, in addition to sexual dysfunction resulting from anabolic steroid abuse and anabolic caused hypogonadism, which cover azoospermia and testicular atrophy (Rahnema *et al.*, 2014; Grant *et al.*, 2023). Men who abuse androgens are estimated to have a two-fold increased risk of infertility compared to users of non-androgenic steroids (Horwitz *et al.*, 2019; Henriksen *et al.*, 2023). The study aimed to investigate the effect of using certain dietary supplements and testosterone hormone on blood parameters and the percentage of HbA1C% in the serum of male rats.

MATERIALS AND METHODS

Study location

The study was conducted at the animal facility, In College of Sciences Research Center, Department of Biology at the University of Mosul, in Iraq.

Nutritional supplementation

The research involved a nutritional supplement (NS) often taken by bodybuilders and beginners, in sports training facilities centers. The supplement known as mass attack that is

manufactured in the European Union (Poland) by fitness authority Sp.z o.o. situated at ul.Konna 40 80 174 Otomin Poland and reproduced to Iraq by the authorized distributor Meryas group, in Baghdad. This powder supplement was dissolved in drinking water. Given to the groups of adult male rats orally at a dose of 2.4 gram/ rat/day using a feeding needle.

The nutritional supplement used in this study contained the following components:

Protein: 70 g, carbohydrates: 78 g, energy: 646 KCAL, branched-chain amino acids (BCAA): 12.6 g, -glutamine: 9.4 g, creatine: 10 g, tribulus terrestris, fenugreek, and D-aspartic acid (DAA): 3 g

Testosterone hormone administration

To assess the impacts of steroids, on rats in the study conducted by using Sustanon (testosterone blend) a common testosterone formulation popular among athletes and bodybuilders was utilized for this purpose. The steroid in question was obtained from BOOY TECH in Germany, that is available as a vial containing 250 mg/ml of the substance. The male rats received injections of testosterone into their thigh at a dosage of 1 mg/kg every 10 days over a three-month period as, per the guidelines provided by (Frankenfeld *et al.*, 2014; Jwad and Mohammed, 2017).

Experimental animals

The study was conducted in the Department of Biology, College of Science, University of Mosul. 80 New Zealand white rats' males, aged between two and three months and weighing between 250 and 400 grams, were subjected to medical examinations to ensure their health. The rats were housed in metal cages in a controlled environment, with a temperature ranging between 25 and 28°C, with a 14-hour light cycle and adequate ventilation. Before the experiment began, the animals were given a 10-day period to make rats acclimate to their environment and diet. During the study, the rats were fed a pelleted diet and given water in special bottles.

Biochemical analysis

Blood samples were taken at intervals during the study using tubes with anticoagulant (EDTA) to collect blood from a vein, near the eye called orbital venous plexus before being split into two parts;

- The 1st part (which's 1 ml) is put into EDTA tubes for blood related evaluations.
- The 2nd part (2 ml) was transferred to gel-based tubes without anticoagulants to enable serum separation. Then left at room temperature for 15 minutes, for clotting before being spun at 4500 rpm for 6 minutes via centrifugation process to obtain the serum, which was later divided into Eppendorf tubes and preserved at 20°C until biochemical tests were carried out.

The blood analyzer, from Sysmex in Germany was used to measure factors such as hemoglobin concentration (abbreviated as Hb) red blood cell count (abbreviated as RBC) white blood cell count (abbreviated as WBC) packed cell volume (indicated as PCV %) platelet count (denoted as PLT) and glycated hemoglobin (known as HbA1C %).

Ethical consecration

The research was carried out following research protocols. Received approval, from the institutional animal care and use Committee at the College of Veterinary Medicine, in the University of Mosul (Reference Number UM.VET.2023.071 Date: August 17 2023).

Experiment design

The rats were separated into eight groups, for the experiment; each group had 10 animals in it. Received specific treatments as outlined below for three months:

1. Control group: Standard feed and water (3 months).
2. Exercised group: Subjected to treadmill exercise three times per week for three months while receiving standard feed and water.
3. NS group: Nutritional supplement (2.4 g/rat/ daily).
4. Testosterone group: Injected intramuscularly with testosterone blend (1 mg/kg) every 10 days for three months.
5. NS + testosterone group: 2.4 g/rat/day of the supplement orally and injected with Testosterone blend (1 mg/kg every 10 days).

6. NS + exercise group: 2.4 g/rat/day of the supplement and subjected to treadmill exercise three times per week.
7. Testosterone + exercise group: Testosterone Blend (1 mg/kg every 10 days) and subjected to treadmill exercise three times per week.
8. NS + testosterone + exercise group: 2.4 g/rat/day of the supplement, injected with testosterone blend (1 mg/kg every 10 days), and subjected to treadmill exercise three times per week for three months.

Statistical analysis

The information was examined with the help of SAS software (SAS, 2001). Was carried out based on a random design method known as completely randomized design (CRD). Variances, among the groups were assessed using Duncan's multiple range test with a level $P \leq (0.01)$ (Hinton, 2014).

RESULTES AND DISCUSSION

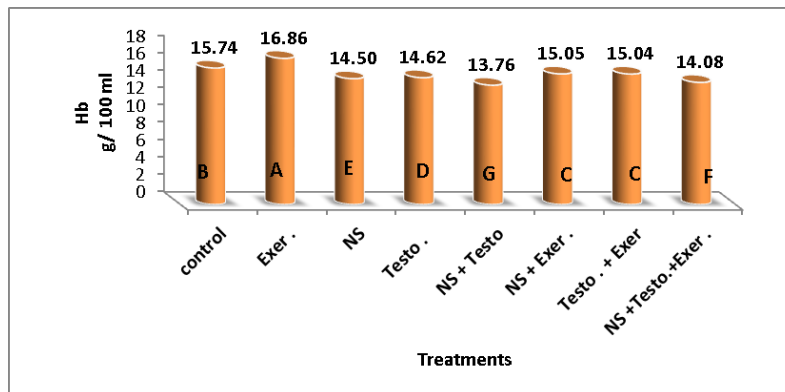
Haemoglobin (Hb) concentration in the blood of male white rats

As illustrated in Fig. (1) significant variations in hemoglobin (Hb) concentration among the different treatment groups of rats were found. The exercise group exhibited the highest Hb concentration (16.86 ± 0.04) g/100 ml, which was significantly higher than all other groups at a probability level of $P \leq (0.01)$. The control group had an Hb concentration of (15.74 ± 0.03) g/100 ml, which was lower than the group subjected to exercise program but higher than most other treatment groups.

Rats treated with both the nutritional supplement (NS) and exercise showed an Hb concentration of (15.05 ± 0.06) g/100 ml, which was not significantly different from the group treated with testosterone blend and exercise (15.04 ± 0.09) g/100 ml. However, a significant reduction in Hb concentration was observed in the groups injected either by testosterone blend alone (14.62 ± 0.02) g/100 ml or treated with the NS alone (14.50 ± 0.10) g/100 ml, indicating that these treatments may have contributed to a decline in Hb levels.

The group treated with the combination of NS, testosterone blend, and exercise exhibited a further reduction in Hb concentration (14.08 ± 0.03) g/100 ml, while the lowest Hb concentration was recorded in the group treated with NS and testosterone blend without exercise (13.76 ± 0.04) g/100 ml. This significant decline suggests a possible suppressive effect of the combined supplementation on Hb levels compared with both control and exercised groups.

Generally, the present results indicate that exercise alone significantly enhances Hb concentration, whereas the combination of NS and testosterone blend may contribute to a decline in Hb levels.



- Values for mean (\pm) standard deviation / number in group = 10.

- Distinct letters indicate a considerable at $P \leq (0.01)$.

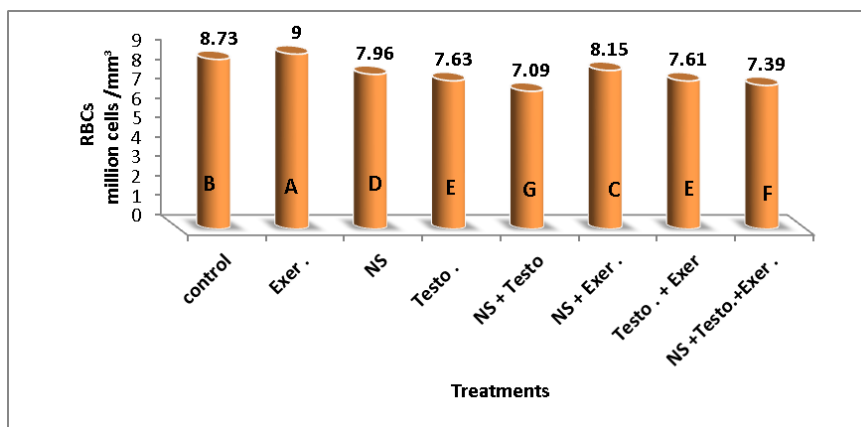
Fig. 1: Impact of NS and testosterone blend on the hemoglobin (Hb) in the blood of male white rats.

Total number of Red Blood Cells (RBCs) in the blood of male albino rats

Fig. (2) shows a significant difference in the red blood cell (RBC) count among the eight experimental groups $P \leq (0.01)$. The exercise group exhibited the highest RBC count (9.00 ± 0.07) million cells/mm³, significantly surpassing all other groups. The control group recorded an RBC count of (8.73 ± 0.05) million cells/mm³, ranking second after the exercise group.

In Rats group subjected to NS + exercise, RBC count of (8.15 ± 0.08) million cells/mm³, which was higher than the group receiving the nutritional supplement (NS) alone, in which RBC count was (7.96 ± 0.09) million cells/mm³, which was lower than the control group. Similarly, the group treated with testosterone Blend alone exhibited a significant reduction in RBC count (7.63 ± 0.16) million cells/mm³ but not significantly different from the testosterone + exercise group (7.61 ± 0.36) million cells/mm³, while for the group of rats treated with the NS + testosterone blend + exercise, the arithmetic mean was (7.39 ± 0.27) million cells/mm³, and the lowest RBC count was observed in the group receiving both NS + testosterone blend (7.09 ± 0.13) million cells/mm³, indicating a suppressive effect when both treatments were combined.

The upward findings suggest that exercise alone significantly enhances RBC levels, while testosterone blend, particularly when combined with NS, tends to decrease RBC count. This statistical evaluation highlights the potential impact of exercise and supplementation on hematological parameters.



- Values for mean (\pm) standard deviation / number in group = 10.
- Distinct letters indicate a considerable at $P \leq (0.01)$.

Fig. 2: Impact of NS and Testosterone Blend on the total number of (RBCs).

Total White Blood Cells count (WBCs) in the blood of male albino rats

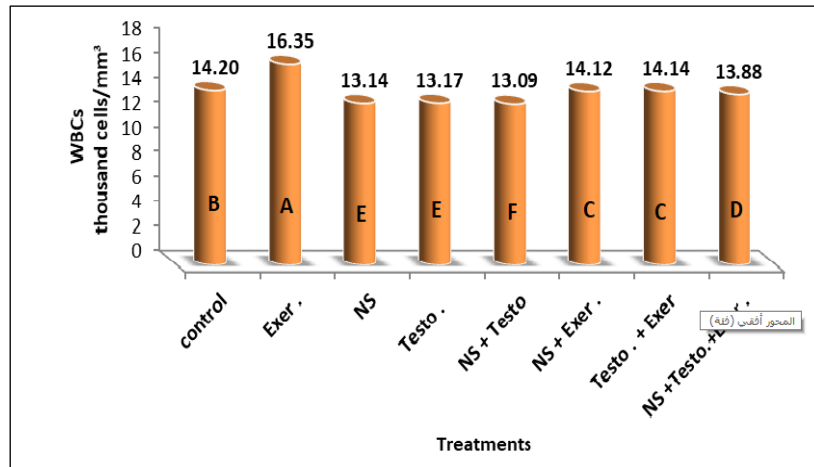
A significant difference in white blood cell (WBC) count among the experimental groups $P \leq (0.01)$ were observed between the treated rats in the 8 rat groups, considering WBC count (see Fig. (3)). The exercise group exhibited the highest WBC count (16.35 ± 0.03) thousand cells/mm³, significantly exceeding all other groups. The control group had a WBC count of (14.20 ± 0.07) thousand cells/mm³, ranking second after the exercise group.

Rats subjected to NS and exercise had a WBC count of (14.12 ± 0.03) thousand cells/mm³, with not significantly different from the testosterone + exercise group recorded (14.14 ± 0.03) thousand cells/mm³. The NS + testosterone + exercise group had a WBC count of (13.88 ± 0.02) thousand cells/mm³.

The groups receiving (NS) + testosterone blend showed lower WBC counts, with values of (13.14 ± 0.03) and (13.17 ± 0.02) thousand cells/mm³, respectively with not significantly different between them. The lowest WBC count was observed in the NS + testosterone group (13.09 ± 0.01) thousand cells/mm³, suggesting a suppressive effect when both treatments were combined.

Overall, these findings indicate that exercise significantly increases WBC levels, while NS and testosterone blend, especially when combined, appear to reduce WBC counts. This suggests that

exercise plays a vital role in enhancing immune response, whereas supplementation and hormone treatments may have immunomodulatory effects.

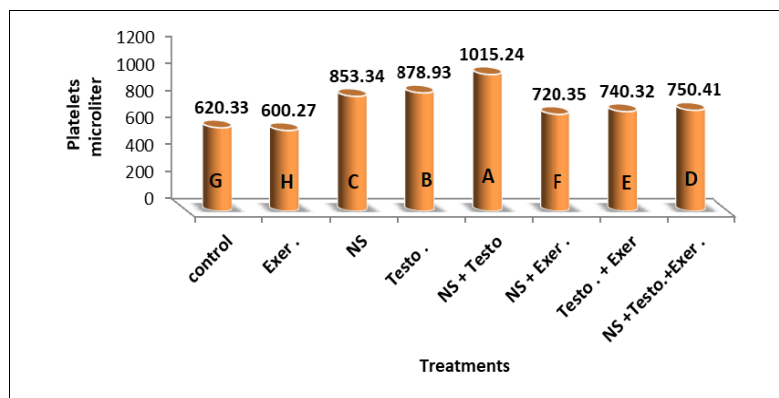


- Values for mean (\pm) standard deviation / number in group = 10.
 - Different letters indicate a considerable difference at $P \leq (0.01)$.

Fig. 3: Impact of NS and testosterone blend on (WBCs) in blood sample of male albino rats.

Total platelets count in the blood of male albino rats

Fig. (4) indicates the significant increment in total number of PLT in the set of rats dosed by NS + testosterone blend in comparison to other groups at a probability level of $P \leq (0.01)$, with an average (1015.24 ± 0.06) PLT / μ L, while the average of PLT count in the group of rats injected with testosterone blend only was (878.93 ± 0.02) PLT / μ L followed by the group of rats treated with the NS only with an average (853.34 ± 0.14) PLT / μ L, while a significant decrease in the total number of PLT (positive improvement) occurred in the groups of rats administered by NS + testosterone blend + exercise program, the group of rats injected by testosterone blend + exercise and the group of rats dosed by the NS + exercise, with an average (750.41 ± 0.05) , (740.32 ± 0.05) and (720.35 ± 0.02) PLT/ μ L, respectively, but it did not reach the level of the control group, in term of platelet count, as its average was (620.33 ± 0.04) PLT / μ L. The lowest average was for the group of rats that practiced sports, as it amounted to (600.27 ± 0.07) PLT / μ L, compared to the rest of the groups.



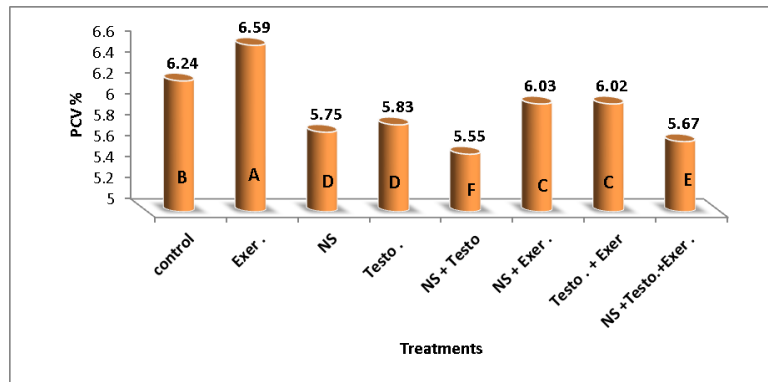
- Values for mean (\pm) standard deviation / number in group = 10.
 - Varied letters indicate a considerable at $P \leq (0.01)$.

Fig. 4: Impact of NS and Testosterone Blend on the total number of platelets in blood.

Packed cells volume (PCV%) in the blood of male albino rats

The provided bar chart represents the packed cell volume (PCV%) in different experimental groups of rats subjected to various treatments over a period of three months. The statistical analysis appears to compare the means of these groups to assess significant differences.

The statistical analysis of Fig. (5) indicates significant increase at ($p \leq 0.01$) in packed cell volume (PCV%) in exercise group (A), showed the highest PCV value (6.59 ± 0.21)%, indicating that exercise alone had a strong positive effect on packed cell volume, control group (B), the baseline PCV was (6.24 ± 0.04)%, while NS + exercise group (C), showed a moderate PCV increase (6.03 ± 0.02)%, testosterone + exercise group (C), had a similar PCV level (6.02 ± 0.06)% to the NS + exercise group, suggesting no significant different between them, testosterone group (D), had a slightly higher PCV (5.83 ± 0.21)% compared to the NS group (5.75 ± 0.09)% but still lower than the control also with out any significant different between them, NS + testosterone + exercise group (E), recorded PCV (5.67 ± 0.03)%, which is lower than the control, indicating a possible counteractive effect of the combination, NS + testosterone group (F), showed the lowest PCV (5.55 ± 0.03)%.

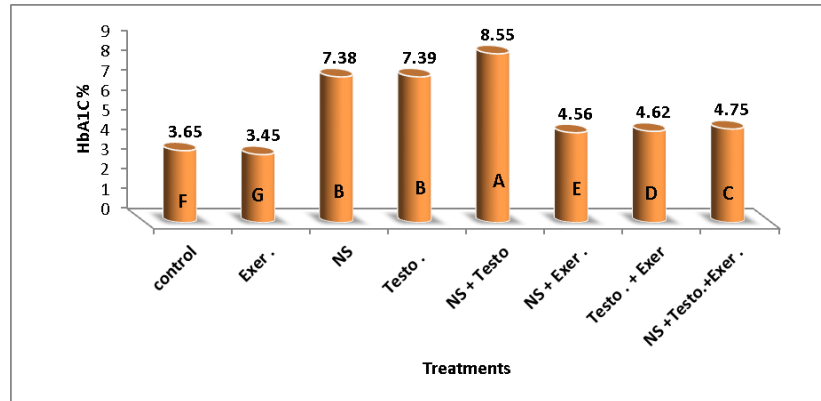


- Values for mean (±) standard deviation/ number in group = 10.
 - Varied letters indicate a considerable at $P \leq (0.01)$.

Fig. 5: Impact of NS and testosterone blend on packed cell volume (PCV%) in blood sample.

Percentage of cumulative sugar HbA1C % in blood sample of male white rats

Results in Fig. (6) indicates a significant increase in the percentage of cumulative sugar in the blood HbA1C % in the group of rats treated with the NS with testosterone blend compared to the rest of the groups at a probability level $P \leq (0.01)$, and with an arithmetic mean of (8.55 ± 0.05)%, followed by the groups of rats treated with the NS only and the group of rats treated with testosterone blend only with arithmetic means of (7.38 ± 0.04) and (7.39 ± 0.07)% respectively, and there is no substantial difference between these two groups, while there was a substantial decrease in the percentage of cumulative sugar HbA1C% (positive improvement) in the groups of rats (dosed with the NS and injected testosterone blend with sport), the group of rats injected with testosterone blend with sport and the group of rats dosed by NS and exercise with arithmetic means (4.75 ± 0.03), (4.62 ± 0.03) and (4.56 ± 0.02)% respectively, but it did not reach the level of the control group, as its arithmetic mean was (3.65 ± 0.01)%, while the lowest among the averages was in the group of rats that practiced sports, as it amounted to (3.45 ± 0.07)% compared to the rest of the groups.



- Values for mean (\pm) standard deviation / number in group = 10.
- Different letters indicate a considerable difference at $P \leq (0.01)$.

Fig. 6: Impact of NS and testosterone blend on HbA1C% in blood sample.

Our current study appeared significant decrease at ($p \leq 0.01$) in the number of red blood cells (RBCs), Hb concentration, PCV% and a decrease in the number of WBCs in the group of rats treated with the NS with testosterone blend comparing to rest groups. This decrement may be resulted from the synergistic effect between the NS and testosterone blend, as the NS contains amino acids (Valine, Leucine and Isoleucine), in addition to protein, glutamine and other compounds. These compounds act as factors that raise the sugar level through the process of building glucose from non-carbohydrate sources (Gluconeogenesis) such as amino acids, which causes glycosylation of the membrane proteins of red blood cells and white blood cells and an increase in the formation of lipid peroxidation. In addition, the lack of oxygen (hypoxia) in the interstitial tissue of the kidney led to a decrease in the production of the hormone erythropoietin formed in the fibroblasts surrounding the tubules. The action of these substances may be the same mechanism by which H₂O₂ and alloxan work. Alloxan, which leads to a defect in the formation of white blood cells and immunodeficiency due to high blood sugar levels (Singh *et al.*, 2009), in addition to a defect that leads to a decline in antioxidants such as glutathione and catalase (Lima *et al.*, 2020), or perhaps resulting from a defect in iron metabolism, which affects the formation of red blood cells and a decrease in the concentration of haemoglobin and PCV% (Tang *et al.*, 2019). While our current results showed a substantial increase in the total platelet count in the rats treated with the NS and testosterone blend compared to the rest of the groups, the continuous treatment with this NS and testosterone blend may have led to a cumulative effect that resulted in a dysfunction in the bone marrow function responsible for platelet formation. In addition, these supplements led to inflammation in the blood vessels as a result of the accumulating of free radicals in the tissues of the rats' bodies, especially the liver tissue, which leads to an increase in the number of platelets. The fibrosis that occurs in the tissues of the liver and kidney caused an increase in the number of platelets (Guyton and Hall, 2023) or due to the misuse of testosterone, which in turn led to an increase in the density of human platelet receptors A₂, which resulted in a rise in human platelet aggregation responses. This discovery has led to speculation that testosterone may contribute to thrombogenicity resulting from excessive use of anabolic steroids (Shahani *et al.*, 2009). Our results do not agree with the results of a previous study conducted by (Gabal *et al.*, 2024), which indicated an increase in the number of red blood cells, haemoglobin, and white blood cells in the group of rats treated with oxandrolone, but they agree with our current study in terms of the increase in platelet numbers as well as with the results of a study conducted by (Khetawat *et al.*, 2000). In our current study, exercise led to a substantial increase in the numbers of WBCs, RBCs (PCV%, Hb) for the groups of rats that exercise compared to the rest of the groups, and the reason may be that exercise increases the percentage of oxygen in the blood, which in turn stimulates the bone marrow to produce many red blood cells in a way that is reflected in the concentration of Hb and PCV%, as well as increases the number of WBCs, especially cells that form natural antibodies. Also, exercise training has an anti-inflammatory effect mediated through multiple pathways (Guyton and Hall, 2023). While

our current study showed a substantial reduction in the number of platelets as a result of exercise, this decrease may be due to the adhesion of platelets and their ability to aggregate, which may decrease due to exercise training, but they return to their pre-training state after rehabilitation (Wang *et al.*, 1995). Glycated haemoglobin (HbA1C) % is called glycated haemoglobin because it is a result of the adhesion of glucose in the body to red blood cells (RBCs) when the human body is unable to use glucose effectively and properly, which prompts it to adhere to red blood cells and then accumulate in the body. From the results of our current study, we noticed a substantial rise in HbA1C% in the group of rats that were treated with the nutritional supplement and testosterone compared to the rest of the groups. The reason is the cumulative effect resulting from the use of the NS and testosterone on the metabolism of glucose and fats (Frankenfeld *et al.*, 2014) or perhaps there is a disruption in the work of the endocrine glands, including the pancreas, where the activation of pancreatic beta cells occurs to secrete insulin, thus raising its level in the blood serum (Scarth *et al.*, 2011).

CONCLUSIONS

We conclude from this study that treating rats with NS and testosterone blend has a significant negative effects on blood components by causing a substantial decrease in each of (RBCs numbers, Hb concentration, WBCs numbers and PCV%) and a substantial increase in the percentage of cumulative sugar HbA1c% and PLT numbers, while practicing sports exercises led to a positive effect by reversing these negative effects by reorganizing the levels of these parameters to levels close to the normal level by causing a substantial increase in each of (RBCs numbers, Hb concentration, WBCs numbers and PCV%) with a substantial decrease in platelet numbers and the percentage of cumulative sugar HbA1C%.

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تأثير بعض المكملات الغذائية وهورمون التستوستيرون المستخدمان في مراكز التدريب الرياضي على بعض معايير الدم والسكر التراكمي في ذكور الجرذان البيض

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الملخص

هدفت الدراسة إلى توضيح تأثير استخدام بعض المكملات الغذائية وهورمون التستوستيرون على معايير الدم والنسبة المئوية للسكر التراكمي HbA1c% في مصل دم ذكور الجرذان والتغيير في هذه المعايير عند التدريب على التمارين الرياضية. تم استخدام 80 جرذاً من ذكور الجرذان البيض، قسمت إلى 8 مجاميع، كل مجموعة 10 جرذان، المجموعة الأولى حصلت على تغذية قياسية فقط (مجموعة التحكم)، المجموعة الثانية خضعت لبرنامج تمارين رياضية خاص باستخدام جهاز المشي، المجموعة الثالثة تناولت المكملات الغذائية + التغذية القياسية، المجموعة الرابعة حقنت بالتستوستيرون بلند عضلياً، المجموعة الخامسة تناولت المكملات الغذائية وحقنت بالتستوستيرون، المجموعة السادسة تناولت المكملات الغذائية وحقنت بالتستوستيرون، المجموعة السابعة حقنت بالتستوستيرون مع ممارسة التمارين الرياضية، المجموعة الثامنة تناولت المكملات الغذائية وحقنت بالتستوستيرون وخضعت لبرنامج التمارين الرياضية، أظهرت نتائجنا حدوث انخفاض معنوي في اعداد RBCs، WBCs، تركيز Hb، PCV% في مجموعة الجرذان المعاملة بالمكمل الغذائي مع هورمون التستوستيرون مع ارتفاع معنوي في Platelets و HbA1c% مقارنة مع باقي المجاميع عند مستوى احتمالية (0.01) $P \leq$ ، بينما ادت ممارسة الرياضة احداث ارتفاع معنوي في اعداد (RBCs، WBCs، Hb، PCV%) مع انخفاض معنوي في اعداد Platelets و HbA1c% بالمقارنة مع المجاميع المعاملة والغير ممارسة للرياضة، وفي الختام، كشفت الدراسة أن العلاج ب NS وهورمون التستوستيرون، واللذان يستخدمان عادةً في مراكز التدريب الرياضي، أظهرت آثاراً سلبية على معايير الدم المختلفة ونسبة HbA1c%، بينما أدت ممارسة التمارين الرياضية إلى تحسن إيجابي في المعايير المدروسة وكذلك نسبة HbA1c%، أي أن مجموعة الجرذان التي تمارس التمارين الرياضية لديها سيطرة أفضل على المعايير المدروسة.

الكلمات الدالة: المكملات الغذائية، التدريب الرياضي، RBCS، WBCs، HbA1c%.