

# The effect of Creatine Supplementation During Strength Training on the development of Physical Performance and Hypertrophy in Wrestlers

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## Abstract:

**Background:** Creatine is a nutritional supplement used to increase strength and muscle mass and is helpful for delaying fatigue in high-intensity and short-term exercises. Wrestling is a heavy and severe activity that it needs to certain physical and physiological such as anaerobic and it is a power-speed exercise that doing strength training is necessary to improve the performance of the athlete. The aim of the present investigation was to explore the effect of creatine supplementation during strength training on the development of physical performance and hypertrophy in wrestlers.

**Materials and Methods:** Thirty men freestyle wrestler randomly were divided into three groups: Experimental group 1: (Creatine + 8 weeks strength training), Experimental group 2: (Creatine+ without training) and Control group. We measured factors of physical performances (Weight, BMI, Speed, Vo2max, BF%, 1RM, Muscular Strength, Power) and Hypertrophy (Volume of muscles). Duration strength training was 8 weeks; 3 sessions per week, and each session last 55-70 minutes with the intensity of 60-75 percent of one Repetition maximum. Data analysis for pre and posttest that measured by repeated ANOVA with post hoc test and IBM SPSS Statistics 22. Significance level of  $p \leq 0.05$  considered.

**Results:** ANOVA showed a significant effect for Weight, BMI, 1RM and no significant for Speed, Vo2max, BF% in both experimental groups compare to pretest and control group. We observed a significant increase in Muscular Strength, Power and Hypertrophy only in experimental group 1 compared to the pre-test and control group ( $p < 0.05$ ).

**Conclusion:** Strength training could increase power, but for increase in strength, weight and hypertrophy in wrestling, creatine is necessary. Creatine is a dietary supplement that increases muscle performance in short-duration, high-intensity resistance exercises, which rely on the phosphocreatine shuttle for adenosine triphosphate in wrestlers.

**Key Word:** Creatine, VO2max, Speed, Muscle Strength, Freestyle Wrestling.

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## I. Introduction

In today's world in which science is progressing at a high rate and new gates of science are opening to people every day, sports sciences and physical education is not an exception to this category and it uses all relevant sciences in order to achieve its goals. Different experts attempt to help athletes to gain the best performance by deriving benefit from sciences related to sports. An athlete cannot obtain all required nutrition necessary for his/her body from daily foods, due to some limitations, therefore, investigators have studied about the consumption of supplements required for athlete's body; and it was revealed that their right consumption could be useful. One of these supplements is creatine supplement.<sup>3</sup>

Creatine is a nutritional supplement used to increase strength and muscle mass and is helpful for delaying fatigue in high-intensity and short-term exercises.<sup>2,17</sup> One of the issues considered by athletes since long time ago is improving sport performance. Hundreds of special nutritional supplements have introduced for athletes in the market in recent years. Creatine is among these supplements. Extensive studies have investigated the effects of supplements on sport performance.<sup>31</sup> The commercial supplements consumption and high-intensity resistance exercises are increasingly to increase muscle mass with the goal of improving the physical appearance, success in the competitions, or gaining strength in women. Nonactive people may participate in resistance exercise programs to improve physical body appearance, but many people start exercise with losing weight and aim of improving general health fitness.<sup>6,16</sup> Creatine is a nutritional supplement used to increase

strength and muscle mass, access to instant energy in the muscles, increase athlete performance, and help for fatigue delay in performing high-intense and short-term strength exercises.

Creatine has been widely used in recent years, especially in weight lifting and bodybuilding athletes. Creatine is similar to an amino acid, which produced in liver and stored in muscles.<sup>2,23</sup>. Creatine is an amino acid found naturally in the skeletal muscle of the body. When a high-intensity and short exercise is performed a specific chemical reaction occurs to provide enough energy to the muscles. Creatine plays a major role in this reaction.<sup>11,26</sup>. As the major part of the energy provides by Adenosine triphosphate (ATP) and creatine phosphate during heavy activities and before the start of anaerobic glycolysis process, it seems that an increase in creatine phosphate stores may increase the amount of energy produced during high intense activity.<sup>13,29</sup>

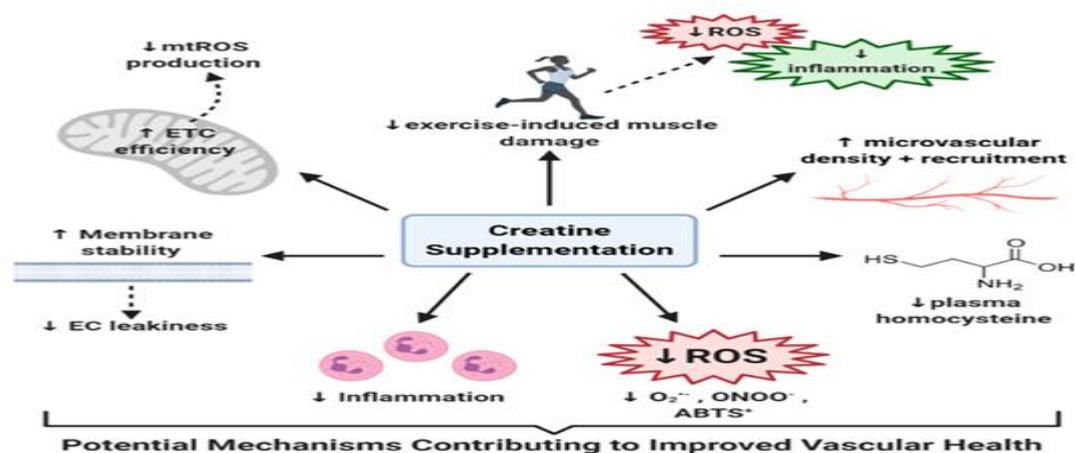


Figure1. Potential mechanisms contributing to improved vascular health: ROS = reactive oxygen species, ABTS+ = 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid), ETC = electron transport chain, mtROS = mitochondrial specific ROS, EC = endothelial cell, O<sub>2</sub><sup>-</sup> = superoxide, ONOO<sup>-</sup> = peroxynitrite.

In summary, throughout this review we have highlighted studies that have not only shown potential benefit of using creatine to improve vasculature function, but have also elucidated the potential of creatine to alleviate the various factors that contribute to the development of CVD (Figure 1).<sup>27</sup>

Limited studies have been conducted and different results have been reported on the effect of Creatine Supplementation During Strength Training on the development of Physical Performance and Hypertrophy in Wrestlers. In addition, most of the previous studies evaluated the effects of supplements without exercise. Wrestlers in some of competition and many other athletes used forbidden and harmful supplements, conducting such this kind of this research can be an effective scientific step in recognizing the effects of supplements in enhancing the performance of athletes in all sport fields.

Wrestling is a heavy and severe activity that it needs to certain physical and physiological such as anaerobic and it is a power-speed exercise that doing strength training is necessary to improve the performance of the athlete.<sup>24</sup>. In wrestling, repetitive forceful muscle contractions are required during most of sport's maneuvers and the upper-body anaerobic power of an athlete is considered an important factor influencing competitive success.<sup>1</sup>. To this end, the findings of Branch<sup>7</sup> suggest that wrestlers may benefit from creatine supplementation, but surprisingly there are only a few previous studies which have examined the impact of creatine on physical performance indices in competitive wrestlers. Nevertheless, Koçak<sup>21</sup> and Karli<sup>18</sup> demonstrated significant increases in mean power and peak power attained in a 30-s Wingate test after compared to before creatine supplementation in elite male Turkish wrestlers. Ziegenfuss<sup>33</sup> et al studied elite male and female power athletes, including eight male wrestlers, and demonstrated significant improvement in repeated cycling sprint performance following short-term creatine supplementation. Ööpik<sup>25</sup> et al found that creatine supplementation during 17-h recovery from rapid body mass loss stimulated the regain of physical working ability in a performance test simulating wrestling match in well-trained wrestlers. The limitations in the data regarding the impact of creatine supplementation on physical performance in trained wrestlers are due to studies employing nonwrestling-specific test protocols or use extremely limited sample sizes (n = 5). A wrestling tournament usually lasts for many hours and in order to win a wrestler has to defeat on average four to five opponents. Whether creatine supplementation helps a wrestler to better maintain the ability to perform powerful action. The aim of the present investigation was to explore the effect of creatine supplementation during strength training on the development of physical performance and hypertrophy in wrestlers.

## II. Material And Methods

This prospective comparative study was carried out on young men freestyle wrestler of Wrestling club in Mazandaran, Iran. A total 30 young subjects (male) of aged  $\geq 20$ , years were for in this study.

**Study Design:** Prospective open label observational study.

**Study Location:** Fitness club of Samen in Behshahr, Iran.

**Study Duration:** August 2022 to September 2022.

**Sample size:** 30 Wrestlers.

**Sample size calculation:** The sample size was estimated on the basis of a single proportion design. The target population from which we randomly selected our sample was considered 30. We assumed that the confidence interval of 10% and confidence level of 95%.

**Subjects & selection method:** The study population was men wrestlers from Iran. Thirty men freestyle wrestler randomly were divided into three groups.

samples don't have any regular physical activity, especially.

Participant characteristics are presented in Table 1.

With dyslipidemia were as follows:

Experimental group 1 (N=10), Creatine + 8 weeks strength training

Experimental group 2 (N=10), Creatine+ without training

Group C (N=10), without Creatine and training

### Inclusion criteria:

1. Wrestlers
2. Men
3. Aged  $\geq 20$  years,
4. Recruited via an advertisement in the local newspapers, email contact and direct contact

### Exclusion criteria:

1. Young Wrestler;
2. Without any cardiovascular diseases, types of diabetes and joint problems for the past two years Patients who are physically inactive.
3. Subjects without a history of drug or alcohol abuse.

**Table 1. Participant characteristics**

Participant characteristics	Experimental Group 1	Experimental Group 2	Control Group
N	10	10	10
Age (years)	22.34 $\pm$ 1.22	21.38 $\pm$ 1.14	22.94 $\pm$ 1.63
Height (m)	1.79 $\pm$ 0.44	1.77 $\pm$ 0.08	1.76 $\pm$ 0.77
Weight (kg)	76 $\pm$ 3.44	79 $\pm$ 4.87	78 $\pm$ 2.96
BMI (kg/m <sup>2</sup> )	22.33 $\pm$ 1.04	23.6 $\pm$ 1.52	21.1 $\pm$ 3.73
Body Fat (%)	0.09 $\pm$ 0.01	0.22 $\pm$ 0.05	0.32 $\pm$ 0.2
1RM	88.1 $\pm$ 8.24	86.5 $\pm$ 7.54	85.6 $\pm$ 6.42

Note: Data are mean  $\pm$  standard deviation (SD)

### Procedure methodology

After explaining the objectives of the study and process steps, informed consent obtained. Place of training and measurements were the same for pre, mid and posttests. A Physical Activity Readiness Questionnaire Plus will used to assess any other health reasons for exclusion from participating in the study.<sup>4,30</sup>. The present study simulated an experimental design was used to conduct this study. All the testing was conducted in the Fitness club of Samen in Iran. Participants were matched into either the Experimental group 1 and 2 or control group based on the consumption of Creatine supplementation. During the familiarization session and following informed consent, a research nutritionist and a professional strength and fitness trainer met with each participant and explained in detail of strength training as well as the nutritional and supplement requirements for the study period.

Initially, the subjects will be familiar with the Strength training, characteristics of research, measuring the variables, training protocol, pretest and posttest, instructions for participants, possibilities and limitations of time and place research. The variables measured for all samples before and after the exercise protocol for both groups. We measured factors of physical performances (Weight, BMI, Speed, Vo2max, BF%, IRM, Muscular Strength, Power) and Hypertrophy (Volume of muscles). Duration of training was 8 weeks; 3 sessions per week, and each session lasted 55-70 minutes with the intensity of 60-75 percent of one reparation maximum. At the beginning and end of training, warm-up and cool-down performed for 10 min (Table 2).<sup>31</sup>

**Table 2. Strength Training**

Training sessions	Training movements			
Chest, Biceps, Triceps (First Session)	Bench Press, Incline barbell bench press, Machine fly, Triceps push-down, Biceps Barbell curl			
Shoulder, back (Second Session)	Lateral dumbbell raises, Dumbbell shoulder press, Lift dumbbell, Lat pull-down, Seated pulley row			
Leg, Abdominal (Third Session)	45-degree leg press, Machine leg extension, Machine leg flexion, ball crunch, Side bend			
Week	Set	Repeat	1RM	Rest between set
First and second	3	12-14	60 %	30 s – 1 min
Third and fourth	3	12-14	65 %	30 s – 1 min
Fifth and sixth	3	12-14	70%	30 s – 1 min
Seventh and eighth	4	13-15	75 %	1 min – 2 min

The researcher introduced the study’s objectives and procedure to each participant, and after discussing any questions, the participant provided informed consent. The participant then completed a training which demonstrated the low and high demand tasks. Performance feedback was provided during the training. After the participant confirmed that they felt comfortable with the task, the researchers worked with them. The experimental groups started using Creatine supplements during strength training (Table 4,5).<sup>31</sup>

**Tables 4. The combination of nutrients in the Supplements creatine monohydrate (Compounds: (every 100 grams)**

Calories (g)	0.0 g
Protein (g)	0.0 g
Carbohydrate (g)	0.0 g
Fat (g)	0.0 g

**Tables 5. The consumption of creatine monohydrate**

Sections	Day / Week	Gr	Meals
Loading	5 days	100 gr	4 meals (Before breakfast/ before lunch, 30 min before training, immediately after training)
Rest	2 days	----	----
Normal Consumption	7 weeks	490 gr	Training session (30 min before training, immediately after training)
			Days Without training (Before breakfast/ before lunch)

### Measurement of Physical Performance and Hypertrophy

A scale in kg measured the weight of subjects. The body mass index calculated by formula of weight (kg) on the square of height (m<sup>2</sup>).<sup>22</sup> Body fat percentage measured by USA Lafayette Model caliper.<sup>32</sup>

Order to measure the speed index, the subjects have asked to a pedal ergometer in 10 turns with a maximum speed of 6 seconds (6 × 10 seconds) after 5 minutes of warming. The subjects had an inactive rest for 30 seconds between each repetition. The ergometer used in this research was a Techno Gym model (made of Italy). The maximum speed recorded every 6 seconds as rounds per minute. The mean of 10 numbers, each of which indicates the maximum speed at one turn (6 seconds) of pedaling, was the mean of maximum speed of pedaling.<sup>10</sup>

Maximal oxygen consumption (VO<sub>2</sub> max) was measured during a continuous treadmill test to exhaustion on a motorized treadmill using the modified Bruce protocol. The treadmill speed was adjusted during the warm-up period elicit a heart rate that was approximately 70% of age predicted maximal heart rate. The speed of the treadmill was held constant during the test and the grade of the treadmill was increased two percent every two min until volitional fatigue. Objective evidence that maximal rate of oxygen uptake had been achieved was the attainment of at least two of the following: plateau in oxygen consumption with increased exercise intensity, heart rate within 10 beats per min of age-predicted maximal heart rate and respiratory exchange ratio exceeding 1.10.<sup>15</sup>

for measurement of 1RM, subjects warmed up for eight to ten minutes. In this test, subjects were under researcher and they recorded leg press and estimated by the formula of Brzeski.<sup>30,32</sup>

Weight ÷ (1.0278 - (0.0278 × Number of repetitions))

Also, power of subjects used by chest press and the Hypertrophy (muscle volume) of the subjects measured and recorded in the areas arm and thigh areas at the right of the body by using a flexible tape meter with McBride et al. method.<sup>20</sup>. Horizontal movement used to assess the muscular endurance by Sargent Jump test used to measure the strength of subjects.<sup>8</sup>. The measured items in the previous research before and after the intervention also measured in this study.

### Statistical analysis

Data was analyzed using SPSS version 22 (SPSS Inc., Chicago, IL). All dependent variables were checked for normality of data (using Kolmogorov– Smirnov test) and equal variance. Data analysis for pre and posttest that measured by repeated ANOVA with post hoc test. The level  $P < 0.05$  was considered as the cutoff value or significance.

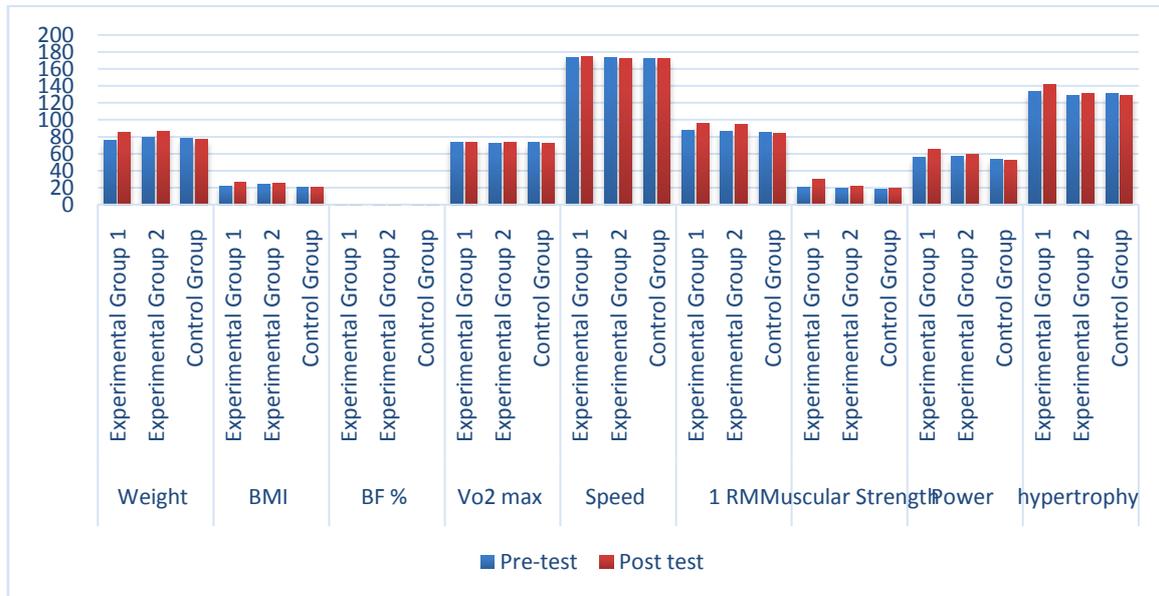
### III. Result

Follow up after 8 weeks of strength training results was found that Based on the results of repeated measure ANOVA, Also, results of this research showed that Creatine has a significant effect on the development of physical performance and hypertrophy in male wrestlers during strength training. ANOVA showed a significant effect for Weight, BMI, 1RM and no significant for Speed, Vo2max, BF% in both experimental groups compare to pretest and control group. Table no 6and Graph 1 Shows metabolic parameters of subjects of the three groups before and after training. Also, we observed a significant increase in Muscular Strength, Power and Hypertrophy only in experimental group 1 compared to the pre-test and control group. ( $P < 0.05$ ).

**Table no 1:**Shows physical performance and hypertrophyof subjects of the three groups Pre and Posttest training.

Variables	Groups	Pre-test	Post test
Weight	Experimental Group 1	76 ± 3.44	85.22±5.44 ₪
	Experimental Group 2	79 ± 4.87	86.74±0.46*
	Control Group	78 ± 2.96	77.20±3.04
BMI	Experimental Group 1	22.33 ± 1.04	26.33±0.77 ₪
	Experimental Group 2	23.6 ± 1.52	25.12±6.07 *
	Control Group	21.1 ± 3.73	21.02±4.63
BF %	Experimental Group 1	0.09 ± 0.01	0.07±2.52
	Experimental Group 2	0.22 ± 0.05	0.24±0.75
	Control Group	0.32 ± 0.2	0.42±2.5
Vo <sub>2</sub> max	Experimental Group 1	74/05±1.45	73.1±8.42
	Experimental Group 2	72.44±2.65	73.55±4.22
	Control Group	73.11±3.73	72.34±1.93
Speed	Experimental Group 1	173.44±5.22	174.804±6.200
	Experimental Group 2	174.01±4.57	172.21±3.854
	Control Group	172.63±3.94	171.954±2.430
1 RM	Experimental Group 1	88.1 ± 8.24	96.12±7.21*¥
	Experimental Group 2	86.5 ± 7.54	95.04±5.65*
	Control Group	85.6 ± 6.42	84.2±3.43
Muscular Strength	Experimental Group 1	20.13 ± 1.23	29.63 ± 3.82 *¥
	Experimental Group 2	19.05 ± 2.09	21.45 ± 2.58
	Control Group	18.63 ± 3.54	19.08 ± 2.35
Power	Experimental Group 1	56.14 ± 1.23	65.23 ± 6.74 *¥
	Experimental Group 2	57.53 ± 2.46	59.09 ± 3.62
	Control Group	53.8 ± 1.69	52.14 ± 3.42

hypertrophy	Experimental Group 1	133.41±2.44	141.33±5.63*¥
	Experimental Group 2	129.04±4.33	131.05±7.88
	Control Group	131.59±2.91	129.32±0.76



#### IV. Discussion

Creatine raises the muscles' power and by delaying fatigue enables the athletes to exercise harder and more intensively and achieve adaptations beyond their muscles' natural capacity.<sup>14</sup> Also; some researchers have mentioned that consumption of creatine increases the power in elders and individuals suffering from muscle or heart diseases. One of the creatine supplements which has become popular and very common is creatine monohydrate (CrH<sub>2</sub>O) which produces energy, influences general health and also raises muscles' mass in athletes. Researchers have conducted a lot of studies in relation with the consumption of creatine supplement in different sports with different time periods and different doses and its influence on increasing of muscles' power and mass.<sup>3</sup>

The main finding of our study was a significant effect for Creatine on the factors of physical performance such as Weight, BMI, 1RM, Muscular strength, Power and hypertrophy. One of the main features of creatine use in this study is weight gain, so that we observed up to 3 kg of weight gain in the first week of creatine use. Its main reason is the movement of water from the blood into the muscle of the skeletal muscle, increasing the volume of the muscle. In general, creatine uses when we need for weight gain and increase the muscle mass, increase strength and help ATP production in the body.

One of the issues considered by athletes since long time ago is improving sport performance. Hundreds of special nutritional supplements have introduced for athletes in the market in recent years. Extensive studies have investigated the effects of supplements on sport performance.<sup>2,9,18,19,28</sup>

Comparison of variables in pre and post-tests of creatine group means shows that a short-term period of creatine monohydrate supplement consumption can improve explosive power of wrestlers which statistically is significant. This Findings of present study confirms those of Lehmkuhl and Jon Yeansub Lim, Eckerson.<sup>12</sup> but these findings are different from those of study conducted by Asadi. Probably the un-similarities about duration and period of supplement consumption, gender, type of sports field, characteristics and physical qualifications of wrestlers, type of exercises or trainings in two studies could cause the differences. Or it may be related to the consumption dose of creatine supplement in a way that in Asadi's study the creatine supplement consumption dose was 0.3grs for per kilogram of body weight but in present study it was 0.7grs.

Also, speed factor is an inherited talent and if athletes are trained or experienced, a short-term period of creatine supplement consumption cannot have significant effect on their records. The results of this study are in agreement with those of Eckerson study, Lehmkuh, and Rudondo. But study by Asadi conducted on female physical education students for one week, with 0.3grs for per kg of body weight did not conform to above ones.<sup>3</sup>

The reason for this difference could be due to gender, consumption dose and duration of creatine monohydrate supplement consumption. The results of leg press test in creatine group revealed that consumption of creatine monohydrate supplement increases muscular power in leg press movement up to 8kgs which is statistically significant. Comparing post-tests of both groups and acquired significant levels may show the

positive effect of creatine monohydrate on increasing muscular power in wrestlers. It should be mentioned that considering the direct impact of creatine supplement on reconstructing energy resources and increasing of phosphor-creatine of muscles and, as a result, the increasing of ATP; in most conducted studies, the increasing of muscular power could be observed.

#### IV. Conclusion

In general, short-term consumption of creatine monohydrate supplement along with performing selected strength training is very useful in improving some physical performances of wrestlers. Creatine as a dietary supplement could improve athlete's performance and help to delaying fatigue in short-duration, high-intensity resistance exercises, which rely on the phosphocreatine shuttle for adenosine triphosphate.

Strength training alone can increase power, but to further increase the strength, weight and hypertrophy in wrestling, long-term consumption of supplements of creatine recommended. A greater undersetting of these pathways and consequences of concurrent consumption creatine supplementation and strength training in males might certainly boost their performance and could use as a dietary supplement to optimize and enhance health outcomes for men wrestlers.

#### References

- [1]. Aedma, M. Short-term creatine supplementation has no impact on upper-body anaerobic power in trained wrestlers. *Aedma et al. Journal of the International Society of Sports Nutrition*. 12:45. 2015. DOI 10.1186/s12970-015-0107-6.
- [2]. Aguiar A, Januario R, Junior R, Gerage A, Pina F, Padovani C, et al. Long-term creatine supplementation improves muscular performance during resistance training in older women. *Eur J Appl Physiol*. 2013.10:987–996.
- [3]. Ahmad H, A. Lashini, H. The effect of short-term consumption of creatine monohydrate supplement on anaerobic performance in male wrestlers (16-20 years old). *Annals of Biological Research*, 2013.4 (9):37-40.
- [4]. Akbari, A. Comparison of the effects of three types of acute endurance training, extreme resistance, and combination on the amount of growth hormone secretion. *British Journal Sport medicine*, Volume 44, Issue Suppl 1. 2010. <http://dx.doi.org/10.1136/bjism.078725.139>.
- [5]. Asdi M, Raheme A, Tarverdizadeh B. Islamic Azad University, karaj branch, 2007, First year, Number one, spring.
- [6]. Bembem, M. G., Bembem, D. A., Loftiss, D. D., & Knehans, A. W. Creatine supplementation during resistance training in college football athletes. *Medicine and science in sports and exercise*, 2001. 33(10), 1667-1673.
- [7]. Branch JD. Effect of creatine supplementation on body composition and performance: A meta-analysis. *Int J Sport NutrExercMetab*.200313:198–226.
- [8]. Candow, D. G., Little, J. P., Chilibeck, P. D., Abeysekara, S., Zello, G. A., Kazachkov, M., ... & Yu, P. H. Low-dose creatine combined with protein during resistance training in older men. *Medicine & Science in Sports & Exercise*, 2008., 40(9), 1645-1652.
- [9]. Chrusch, M. J., Chilibeck, P. D., Chad, K. E., Davison, K. S., & Burke, D. G. Creatine supplementation combined with resistance training in older men. *Medicine and science in sports and exercise*, 2001.33(12), 2111-2117.
- [10]. Cribb, P. J., Williams, A. D., Stathis, C., Carey, M. F., & Hayes, An Effects of whey isolate, creatine and resistance training on muscle hypertrophy. *Medicine & Science in Sports & Exercise*, 2007, 39(2), 298-307.
- [11]. DeNysschen, C. A., Burton, H. W., Horvath, P. J., Leddy, J. J., & Browne, R. W. Resistance training with soy vs whey protein supplements in hyperlipidemic males. *Journal of the International Society of Sports Nutrition*, 2009. 6(1), 8.
- [12]. Eckerson JM, Stout JR, Moore GA, Stone NJ, Lawn KA, Gebauer AN, Ginsberg R. *J Strength Cond Res*, 2005, 19(4), 756 - 63.
- [13]. Ha, E., & Zemel, M. B. Functional properties of whey, whey components, and essential amino acids: mechanisms underlying health benefits for active people. *The Journal of nutritional biochemistry*, 2003, 14(5), 251-258.
- [14]. Hojjat, Sh, SarshinA, Rahimi A, Mahmodi, S. *Annals of Biological Research*, 2011, 2 (6):417-424 .
- [15]. Ilic V and et all. Impact of Body Composition and Vo2 Max on the Competitive Success in Top-Level Handball Players. *I. Antropol*. 2015. 39. 3: 535–540.
- [16]. Jackson, C. G. 2000. *Nutrition and the strength athlete*. CRC Press.
- [17]. Jose A. 2013. The effects of preversus post workout supplementation of creatine monohydrate on body composition and strength. *J Int Soc Sports Nutr*. 2013;10-36.
- [18]. Keri Marshall, N. D. Therapeutic applications of whey protein. *Alternative medicine review*, 2004.9(2), 136-156.
- [19]. Kilduff, L. P., Pitsiladis, Y. P., Tasker, L., Attwood, J., Hyslop, P., Dailly, A., ... & Grant, S. Effects of creatine on body composition and strength gains after 4 weeks of resistance training in previously nonresistance-trained humans. *International journal of sport nutrition and exercise metabolism*, 2003.13(4), 504-520.
- [20]. Kinugasa, R., Akima, H., Ota, A., Ohta, A., Sugiura, K., & Kuno, S. Y.. Short-term creatine supplementation does not improve muscle activation or sprint performance in humans. *European journal of applied physiology*, 2004.91(2-3), 230-237.
- [21]. Koçak S, Karli Ü. Effects of high dose oral creatine supplementation on anaerobic capacity of elite wrestlers. *J Sports Med Phys Fitness*.2003, 43:488–92.
- [22]. Kraemer W, Adams K, Cafarelli, E, Dudley G, Dooly C, Feigenbaum, M. Progression models in resistance training for healthy adults. *ACSM American College of Sports Medicine position stand*. *Med Sci Sports Exerc*, 2002.34(2):364-80.
- [23]. Madureira, A. R., Pereira, C. I., Gomes, A. M., Pintado, M. E., & Malcata, F. X. Bovine whey proteins—Overview on their main biological properties. *Food Research International*, 2007. 40(10), 1197-1211.
- [24]. Mohammadi M, Siavoshy H, Rahimi G H. *National Journal of Physiology, Pharmacy and Pharmacology*. 2018. Vol 8, Issue 2. P 278-284.
- [25]. Ööpik V, Pääsuke M, Timpmann S, Medijainen L, Erelina J, Gapejeva J. Effects of creatine supplementation during recovery from rapid body mass reduction on metabolism and muscle performance capacity in well-trained wrestlers. *J Sports Med Phys Fitness*. 2002. 42:330–9.
- [26]. Pal, S., Ellis, V., & Dhaliwal, S. Effects of whey protein isolate on body composition, lipids, insulin and glucose in overweight and obese individuals. *British journal of nutrition*, 2010, 104(5), 716-723.
- [27]. Spillane M, Schoch R, Cooke M, Harvey T, Greenwood M, Kreider R, et al. The effects of creatine supplementation combined with heavy resistance training on body composition, muscle performance, and serum and muscle creatine levels. *J Int Soc Sports Nutr*. 2009. 10(6):2783-2786.

- [28]. Spillane, M., Schoch, R., Cooke, M., Harvey, T., Greenwood, M., Kreider, R., & Willoughby, D. S. The effects of creatine supplementation combined with heavy resistance training on body composition, muscle performance, and serum and muscle creatine levels. *Journal of the International Society of Sports Nutrition*, 2009.10(6):2783-2786.
- [29]. Traverso, N., Balbis, E., Sukkar, S. G., Furfaro, A., Sacchi-Nemours, A. M., Ferrari, C., ... & Cottalasso, D. Oxidative stress in the animal model: the possible protective role of milk serum protein. *Mediterranean Journal of Nutrition and Metabolism*, 2010.3(2), 173-178.
- [30]. Uziel G, Garavaglia B, Di Donato S. Carnitine stimulation of pyruvate dehydrogenase complex (PDHC) in isolated human skeletal muscle mitochondria. *Muscle Nerve*.1998. 11: 720–24.
- [31]. Zahabi, G et al, The Effect of Whey Protein and Creatine Supplementation on the Physical Fitness Indicators, Velocity and Muscle Hypertrophy of Untrained Women during a Resistance-Training Period. *J Biochem Tech, Special Issue* .2020. (1): 64-70, ISSN: 0974-2328.
- [32]. Zahabi, G et al. Effect of concurrent training on the Serum Paraoxonase-1(PON-1) activity and Lipid Profile in obese men. *International Research Journal of Applied and Basic Sciences*. 2014. 2251-838X / Vol, 8 (9): 1434-1437.
- [33]. Ziegenfuss TN, Rogers M, Lowery L, Mullins N, Mendel R, Antonio J, et al. Effect of creatine loading on anaerobic performance and skeletal muscle volume in NCAA division I athletes. *Nutrition*. 2002.18:397–402.

Ghadir Zahabi, et. al. "The effect of Creatine Supplementation During Strength Training on the development of Physical Performance and Hypertrophy in Wrestlers." *IOSR Journal of Sports and Physical Education (IOSR-JSPE)* 9(6), (2022): pp. 01-08.