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The Effect of Creatine Loading on the Isokinetic Properties of the Knee Extensors in Male Athletes

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ABSTRACT

The purpose of this study was to examine the effect of five days of creatine loading on the isokinetic properties of the knee extensors in male athletes. Thirty active, healthy subjects voluntarily participated in the study and were divided into three groups of 10 subjects; that is, creatine, placebo, and control. First, the isokinetic parameters of the knee extensors of the preferred leg were measured by Biodex isokinetic dynamometer at the speed of 180 d/s. These parameters include peak torque, time to peak torque, rate of peak torque development, and peak power. Creatine supplementation was conducted for five days, 20 grams daily in four consecutive meals. For the placebo group, glucose supplementation was given in the same way as the creatine. Afterwards, the parameters of knee extensors were measured again. Mixed 2×3 *analysis of variance and Tukey's post hoc tests were applied for data analysis. The results showed that after creatine loading, peak torque increased by 10.5% ($P < 0.05$), rate of peak torque development increased by 26% ($P < 0.05$) peak power increased by 11% ($P < 0.05$), and time to peak torque decreased by 12% ($P < 0.05$). In conclusion, five days of creatine loading significantly improved the mechanical properties of the knee extensors as well as most of the properties of isokinetic contractions.*

Keywords: Creatine loading, peak torque, peak power, time to peak torque.

INTRODUCTION

Achieving top athletic performance is the chief goal of athletes and coaches. Thus, using supplements for optimizing athletic performance has become very prevalent. Creatine is one of the supplements that have recently been widely consumed by strength and sprint athletes [1]. It is assumed that creatine supplementation can increase phosphocreatine stores and improve performance in activities where the phosphagen system is the main energy source [2 & 3]. The effect of creatine supplements on sport performance differs with regards to training models and the duration and amount of supplementation [4-7]. Most studies have been carried out on the effect of creatine on peak power and total generated power [7, 8, & 9]. Yet, peak power and total generated power in an activity cannot represent all the mechanical properties of muscle contractions; rather, muscles act in a skeletal system and kinetic properties such as peak torque (PT), time to peak torque (TTPT), rate of peak torque development (ROPTD), and peak power (PP) can well elaborate the mechanical properties of muscles during contraction [10]. Kinugasa et al. (2004) prescribed 5 grams of daily creatine supplementation for a short-term period and did not observe any significant difference in sprint performance [17]. Hoffman et al. (2005) did not observe any significant difference between active men in peak power and mean power during a low-dose, short-term supplementation of creatine [11]. Okudan and Gokbel (2005) reported that short-term supplementation of creatine monohydrate (20 grams) increases power output by 7.6% during repeated Wingate tests with 2-minute intervals between the each test [9]. Findings show that with high-dose creatine supplementation during a period of 4-6 days, muscle creatine remains at a high level for several weeks which can improve the performance of athletes in high-intensity exercises, in particular interval training [1 & 12]. Various studies have investigated the effect of creatine supplementation on some factors such as power, strength, speed, and muscle mass. However, none of these studies have examined the effect of creatine supplementation on the mechanical properties of muscles so as to reveal which one of these properties is more greatly affected by creatine. This study can help researchers have a better insight into the mechanisms underlying the effectiveness of creatine. Considering the prevalent consumption of this supplement among athletes with different mindsets and on the other hand the contradictory results of previous research which has led to bewilderment among researchers, coaches, and consumers of this prevalent supplement, the present research was carried out to study the effect of creatine loading on the isokinetic properties of the knee extensors in male student athletes.

MATERIALS AND METHODS

With regards to the purpose of the research, the research method and design were quasi-experimental. The research design was of pretest-posttest type with placebo and control groups.

Subjects

The population of the present research consisted of all the students of Physical Education and Sports Science in Tarbiat Moallem University who were studying in the period 2009-2010. From all the individuals voluntary to participate in the study, 30 healthy, active subjects with no specific diet nor any record of disease or taking any supplementation and who only worked in the scientific departments of the faculty were selected. The subjects were randomly divided into the creatine (n = 10), placebo (n = 10), and control (n = 10) groups.

Research Procedures

Three days before starting the research, the subjects presented themselves at the laboratory of Tarbiat Moallem University and a summary of the research was given to them. Then, they became familiar with the Biodex Isokinetic System; each subject was placed in the position of isokinetic contraction testing and performed knee extension several times with maximum strength. During the same session, their height and weight were measured. Three days after the introductory session, pretest isokinetic contractions were performed. Then the experimental group underwent creatine loading. The placebo group also took glucose supplements and the control group continued their regular diet and exercise. Creatine and placebo supplementation were single-blind. Finally, the posttest related to the mechanical properties of the knee extensors was administered immediately after the cessation of the loading period.

Creatine Loading and Placebo Supplementation

Creatine supplementation was administered for five consecutive days. The subjects maintained their diet during the supplementation period and abstained from consuming any material containing caffeine as well as excessive amounts (more than 300 grams per day) of white and red meat. Creatine and glucose supplement (as a placebo) were apportioned in 5-gram packs and each 20 packs was placed in a plastic bag. Overall, 20 bags were distributed among the subjects 10 of which contained creatine and the other ten contained glucose and the subjects consumed 4 packs from their share of 20 in four consecutive meals. The subjects were recommended to solve the content of each pack in 250 cc (a Coke bottle) of lukewarm water and to consume it with their breakfast, lunch, dinner, and before sleeping.

Measuring the Parameters Related to Knee Extensor Torque

The parameters related to the mechanical properties of the knee extensors of the preferred [10] were measured using Biodex Isokinetic System at an angular speed of 180 d/g. To measure the parameters, the subject sat on the chair of the Biodex System and was fastened from above the joint of interest via special bands so that the agonist muscles in other joints would not be used while performing the movement. The subjects were verbally praised for making the maximum effort. To obtain the kinetic parameters of the knee extensors, the Isokinetic System was set in a way that the subject performed knee extension at an angular speed of 180 d/s six times and with maximum power [10 & 13]. The measured parameters were valid only if the coefficient of variation (the uniformity coefficient of the repetitions recorded by the system) was less than 15 [10 & 13]. The peak generated torque was taken as subject's strength and considering the effect of weight in strength, peak torque was divided by the weight of the subjects and multiplied by 100 to yield the torque for each kilogram of body weight multiplied by 100 (%Nm/Kg). The resulting data were used for calculating peak power and rate of peak torque development. Peak power was calculated as the product of peak torque for each kilogram of body weight and the angular speed at which contraction occurred so as to yield peak power in watt per kilogram of body weight multiplied by 100 (%w/kg) [14]. The rate of peak torque development was calculated by dividing peak torque by time to peak torque. The torque data normalized to body mass was used to calculate this parameter. To calculate the parameters related to muscle torque, the test was repeated three times and the maximum torque and parameter values were taken as the main data.

Data Analysis

The data were described using descriptive statistics of mean and standard deviation and as well the mixed 2×3 analysis of variance with one between-group variable (group with three levels) and a within-group variable (time; that is, pretest and posttest with two levels) and Tukey's post hoc tests were applied to study the effect of creatine loading on the mechanical parameters of knee extensor contractions. Further, the significance level was assumed to be 0.05.

RESULTS

The results of analysis of variance showed that the interaction between group and time is significant for peak torque ($F_{2,27} = 91.63, P = 0.000$). Moreover, the main effects of time ($F_{1,27} = 113.65, P = 0.000$) and group ($F_{2,27} = 3.42, P = 0.048$) were also significant. Table 1 presents the peak torque of knee extensors for the creatine, placebo, and control groups in the pretest and posttest as well as the results of Tukey's post hoc tests.

Table 1 – Mean and standard deviation of peak torque in the three groups and the related post hoc tests

	Creatine (%Nm/Kg)	Placebo (%Nm/Kg)	Control (%Nm/Kg)
Pretest	197.11±6.21	194.70±14.71	198.11±11.90
Posttest	218.90±6.84†‡	195.91±13.32	198.50±13.34

Notes: † Significant difference with the pretest of the same group (P < 0.05); ‡ Significant difference with the posttest of the placebo and control groups

The results of analysis of variance showed that the interaction between group and time is significant for time to peak torque ($F_{2,27} = 93.19, P = 0.000$). Moreover, the main effect of time ($F_{1,27} = 96.86, P = 0.000$) was also significant, but the main effect of group was not significant ($F_{2,27} = 2.88, P = 0.074$). Table 2 presents the time to peak torque of knee extensors for the creatine, placebo, and control groups in the pretest and posttest as well as the results of Tukey's post hoc tests.

Table 2 – Mean and standard deviation of time to peak torque in the three groups and the related post hoc tests

	Creatine (ms)	Placebo (ms)	Control (ms)
Pretest	181.00±18.80	180.80±16.53	187.90±17.44
Posttest	158.50±15.28†‡	181.10±16.64	487.30±16.76

Notes: † Significant difference with the pretest of the same group (P < 0.05); ‡ Significant difference with the posttest of the placebo and control groups

The results of analysis of variance showed that the interaction between group and time is significant for the rate of peak torque development ($F_{2,27} = 324.56, P = 0.000$). Moreover, the main effects of time ($F_{1,27} = 362.24, P = 0.000$) and group ($F_{2,27} = 12.18, P = 0.000$) were also significant. Table 3 presents the rate of peak torque development of knee extensors for the creatine, placebo, and control groups in the pretest and posttest as well as the results of Tukey's post hoc tests.

Table 3 – Mean and standard deviation of rate of peak torque development in the three groups and the related post hoc tests

	Creatine (%Nm/Kg.ms)	Placebo (%Nm/Kg.ms)	Control (%Nm/Kg.ms)
Pretest	1.096±0.087	1.050±0.067	1.060±0.093
Posttest	1.390±0.118†‡	1.085±0.069	1.065±0.099

Notes: † Significant difference with the pretest of the same group (P < 0.05); ‡ Significant difference with the posttest of the placebo and control groups

The results of analysis of variance showed that the interaction between group and time is significant for the peak power ($F_{2,27} = 91.64, P = 0.000$). Moreover, the main effects of time

($F_{1,27} = 113.65, P = 0.000$) and group ($F_{2,27} = 3.41, P = 0.048$) were also significant. Table 4 presents the peak power of knee extensors for the creatine, placebo, and control groups in the pretest and posttest as well as the results of Tukey's post hoc tests.

Table 4 – Mean and standard deviation of peak power in the three groups and the related post hoc tests

	Creatine (%W/Kg)	Placebo (%W/Kg)	Control (%W/Kg)
Pretest	618.89±19.49	611.36±46.17	622.03±37.38
Posttest	678.34±21.47†‡	615.12±41.82	623.30±41.90

Notes: † Significant difference with the pretest of the same group ($P < 0.05$); ‡ Significant difference with the posttest of the placebo and control groups

DISCUSSION AND CONCLUSION

The purpose of the research was to study the effect of creatine loading on the isokinetic properties of the knee extensors at a speed of 180 d/s. In general, the results revealed that after creatine loading, the peak muscle torque, time to peak torque, rate of peak torque development, and peak power of the knee extensors improved at the speed of 180 d/s, but the acceleration time of knee extensors did not change after creatine loading.

The results showed that there is a significant difference between the pretest and posttest of the creatine group in peak torque of the knee extensors at the speed of 180 d/s, but these values were not significant in the placebo and control groups. Peak muscle torque of the creatine group increased by 10.5% at the speed of 180 d/s and this change was greater than that of the control and placebo groups. In line with the results of the present research, Greenhaff (1998) showed that peak torque remarkably increased after creatine supplementation [15]. Kilduff et al. (2002) showed that five days of creatine supplementation leads to an increase in maximum power and total generated power [16]. Conte et al. (2003) reported that creatine supplementation leads to an increase in the mean strength of the quadriceps in women during a maximum repetition. Moreover, mean muscle strength during knee flexion significantly increased in the creatine group [17]. Law et al. (2009) studied the effect of two and five days of creatine loading on muscular strength and anaerobic power in trained athletes. Their results indicated that five days of creatine loading along with strength training leads to a significant improvement in mean anaerobic power (30-second Wingate test) and strength (squat) in comparison with sheer strength training. However, they stated that two days of loading is not enough for further improvement in anaerobic power and strength [18]. Nonetheless, the results of most studies were in line with the findings of the present research and agreed on the fact that strength increases as a result of creatine supplementation; although the supplementation method was almost the same in all these studies, the strength tests were different. Researchers consider the reason for such an increase in strength a result of increased creatine phosphate content of the muscle, increased fat-free mass, increased cross-sectional area of muscles, and increased muscle capacity for instantaneous, quick energy generation [15-22]. Increase in creatine phosphate content of the muscle leads to greater availability of this material and considering the mass effect, there will be an increasing uptake of this material for energy generation during activity and it can quickly provide the muscles with much energy; this issue probably leads to improved contractile performance.

The results of the research showed that time to peak torque at the speed of 180 d/s after creatine supplementation significantly differed in the posttest in comparison with the pretest. The decrease in time to peak torque at the speed of 180 d/s was around 12%. Considering the fact that speed is constant in isokinetic contractions, time to peak torque can be used as the speed of the muscle. Muscle speed depends not only on metabolic factors, but also on neural factors. Thus, all the changes in time to peak torque cannot be justified by emphasizing only on metabolic factors. Nonetheless, researchers have studied the effect of creatine supplementation on sprint performance of athletes. Harris et al. (1993) studied the effect of daily consumption of creatine (30 grams) for 6 days on sprint performance of elite runners. The findings showed that in 100-meter runs, only in the last run does a significant change occur in performance. According to their findings, creatine supplementation increases the intracellular concentration of creatine and phosphocreatine and that can improve runners' sprint performance [22]. Anomasiri et al. (2004) reported the significant effect of low-dose (10g) creatine supplementation on decreasing the sprinting time in the last 50 meters of 400 meters swimming competition. Moreover, after creatine supplementation, a significant increase was observed in anaerobic power and fatigue index during Wingate test [23]. Glaister et al. (2006) studied the effect of 20 grams of creatine supplementation on multiple-sprint running performance (15 x 30 m repeated at 35-second intervals) during a period of four days. The findings suggested a 0.7 kg increase in body mass and a 0.4% reduction in body fat, while no significant difference was observed in fastest time, mean time, fatigue, or blood lactate concentration in the posttest in comparison with the pretest [24]. Thus, most of the previous studies, in line with the results of the present research, have shown that short-term creatine supplementation can reduce the time needed for performing a specific activity.

The rate of peak torque development refers to the rate at which torque increases in each time unit. Considering the method for calculating the rate of peak torque development (peak torque divided by time to peak torque), any change in each of the variables of peak torque and time to peak torque is expected to change this biomechanical index. The results of the present research showed that torque increases at the speed of 180 d/s and time to peak torque decreases. Thus, considering the equation through which peak torque is calculated, the rate of peak torque development is expected to increase. The results suggested a 26% increase in the rate of peak torque development. Such an increase can be justified, since both variables of peak torque and time to peak torque had average variation and as a result the changes in the equation for calculating the rate of peak torque development will be much greater.

In this research, peak power was calculated by multiplying the angular speed of the performed movement (in radian) by peak muscle torque. Considering the nature of isokinetic contractions whose speed is constant, the peak generated torque is a determinant of the level of power output. Thus, any change in the peak torque will lead to a change in the peak power. Peak power increased by 11%. Lee et al. (2011) studied the effect of caffeine ingestion after creatine supplementation on intermittent high-intensity sprint performance [25]. They reported that mean and peak power were significantly higher in the "creatine and caffeine" group than the control group [25]. But all the research studies have not reported an increase in the generated power after creatine supplementation. Hoffman et al. (2005) did not observe any significant change in body mass, peak power, and mean power after a short-term creatine supplementation [26]. In the present research, peak power is the same as explosive power and in this type of power generation, the main source of energy is the phosphagen system; thus, increase in the concentration and content of muscle creatine and phosphocreatine and increase in the cross-sectional area of motor units [15-21] can lead to improvement in strength and peak power. Research considers various factors as effective for improvement in sport performance during a period of creatine loading. According to the findings of most research studies, the possible mechanisms for improved performance are: metabolic adaptations [15, 27, & 28], molecular adjustment [2, 29, & 30], exercise-related adaptation [3], cellular membrane stability [31 & 32], hormonal changes [33 & 34], protein synthesis [3 & 35], the buffering effect of creatine [36], and neural factors [36 & 37]. However, all the studies do not agree on the mentioned mechanisms for the effect of creatine supplementation on performance. Some studies disagree with this notion [38, 39, & 40]. Other than the mentioned factors, some factors can justify the inconsistency between the results of the present research and other studies including: subjects, different training and testing models, gender, period, and the level of supplement prescription.

CONCLUSION

In general, the results showed that as a result of five days of creatine loading, peak torque, time to peak torque, rate of peak torque development, and peak power increase at the contraction speed of 180 d/s. it can be suggested that creatine is probably more appropriate for activities that are performed at higher contraction speeds and that creatine is possibly an effective supplement for improving the mechanical properties of muscles.

REFERENCES

[1] Izquierdo, M., Ibanez, J., Gonzalez, J.J., Gorostiaga. EM, **2002**. *Medicine Science and Sports* Exercise. 34: 332-343 .
[2] Williams,M.H.,Kreider,R.B.& Branch, J.D, **1999**. Human Kinetics,Champ.
[3] Rawson Eric S, Adam M. Persky, **2007**. *Sports Medicine Journal*. 8(2), pp.43- 53.
[4]Chrusch, MJ., chilibck, P.D., chand, K.E, Davison, K.S., Burke, D.G, **2001**. *Medicine and Scince in Sports and Exercise.* 330 .2117-2111.
[5] Ahmun, R., Tong, R., Grimshaw, P, **2005**. *Journal of Strength Conditioning Research*. 19(1): 92: 97.
[6] Eckerson, J.M., Stout, J.R., Moore, G.A., Stone, N.J., Iwan, K.A., Gebaur, A.N., Ginsberg, R, **2005**. *Journal of Strength Conditioning Research.* 19(4) : 756-763.
[7] Kelly, V.G., Jenkins, D.G, **1998**. *Journal of Strength Conditioning Research*. 12: 109_115.
[8] Kreider, R.B, **2001**. Presented at the 6th International Meeting on Guanidino Compounds in Biology & Medicine Cincinnati, OH .
[9] Mier'Nelson,87. Mier, R, **1995**. Strength Conditional Coach .30: 10-6.
[10] Dvir, Z, **2004**. Churchill Livingstone. Second Edition. P: 25-49
[11] Apostolos, S., Theodorou B, **2001**. Dissertation for the degree of doctor of philosophy in Metropolitan university.
[12] Cooke, W.H., Baranes, W.S, **1997**. *Journal of Applied Physiology*. 22(5): 454-467.
[13] Kannus, P, **1994**. *International Journal Sports Medicine*. 15:11–18.
[14] Anna, I., Vasilos, B, **2005**. *Journal of Sports Sciences*. 23(10): 1121 – 1127.
[15] Green, H., and J.A. Timmons, **1998**. *In Exercise and Sport Science Review*. 26: 1-30.

[16] Kilduff, L.P., Vidakovie, G., Cooney, R., Twycrosslewis, P., Amund, M., Paker, L., Paul, L.& Pitsiladis, Y.P, **2002**. *Medicine and Science in Sports and Exercise*. 34, 1176-1183.
[17] Kinugasa, R ., Akima, H., Ota, A., Sugura, K., Kuno, S.Y, **2004**. *European Journal of Applied Physiology*. 91(2-3): 230-237.
[18] Law, Y.L., Ong, W.S., Gillian, T.L., Lim, S.C, **2009**. *Journal of Strength Conditioning Research.* 23(3):906-14.
[19] Gotshalk, L.A.,.Volek, R.S., Staron, C.R., Denegar, F.C., Hagerman, W.J., **2002**. *Medicine and Science in Sport and Exercise* .34: 537-543.
[20] Greenhaff, P.L., Bodin, K., Soderlund, K., Hultman, E, **1994**. *American Journal of Physiology*. 266: 725-730 .
[21] Balsom, P.O., suderland, K., blom, B, **1994**. *Sports Medicine*. 4: 268-280.
[22] Harris, S., R.C. Soder, land, K., Hultman, E, **1992**. *Clinical Science*. 83, 367-374.
[23] Anomasiri, W., Sanguanrungsirikul, S., Saichandee, P, **2004**. *Journal Medicine Asspcthia.* 2: 228-232.
[24] Glaister, M., Lockey, R.A., Abraham, C.S., Staerck, A., Goodwin, JE., McInnes, G, **2006**. *Journal of Strength Conditioning Research*. 20(2): 273-7.
[25] Lee, C.L., Lin, J.C., Cheng, C.F, **2011**. *European Journal of Applied Physiology*. [Epub ahead of print].
[26] Hoffman, J. R., Stout, J.R., Falvo, M.J., Kang, J., Ratamess, N.A, **2005**. *Journal of Strength Conditioning Research*. 19(2): 260 – 264.
[27] Preen, D., Dawson, B., Goodman, C., Lawrence, S., Beilby, J., and ching, S, **2002**. *Journal of Sport Medicine and physical Fitness.* 42(3): 320-329.
[28] Wakatsuki, T., Ohira, Y., Yasui, W., Nakamura, K., Asakura, T., Ohno, H., and Yamamoto, M, **1994**. *The Japanese Journal of Physiology*. 44(2): 193-204.
[29] Steen, Olsen., Per, Aagaard., Fawzi, Kadi., Goran, Tufekovic., Julien, Verney., Jens, L, **2006**. *Journal of Physiology*. 573(2): 525-534.
[30] Deidicque, L., Louis, M., Theisen, D, **2005**. *Medicine Science and Sports Exercise*. 37: 731-736.
[31] Saks, V.A., Strumia, E, **1993**. *Current Therapy Research*. 53: 565-598.
[32] Santos, R.V., Bassit, R.A., Caperuto, E.C, **2004**. *Life Science*. 75: 1917-1924.
[33] Volek, J.S., Mazzeti, S.A., fraquhar, W.B., Barnes, B.R., Gomez, A.L., Kraemer, W.J, **2001**. *Medicine and Science in Sport and Exercise*. 33:1110-110.
[34] Schedel, J.M., TErrior, P., Schutz, Y, **2000**. *Japanese Journal of Physiology*. 50: 273-276.
[35] Louis, M., Poortmans, J.R., Francaux, M, **2003**. *American Journal of Physiology and Endocrinal metabolism.* 285: 1089-1094.
[36] Melvin, H., William, J., David, Branch, **1998**. *Journal American College of Nutrition*. 3: 216-234.
[37] Theodorou, A.S., Havenetidis, K., Zanker, C.L., O Hara, J.P., King, R.F., Hood, C., Paradisis, G ,Cooke, C.B, **2005**. *Journal of Strength and Conditioning Research*. 19(2) 265-269.
[38] Mujika, I., Chatard,J.C., Lacoste, L., Barale, F., Geyssant, A, **1996**. *Medicine Science and Sports Exercise.* 28(11): 1435-1441.
[39] Cornish, S.M., Chilibeck, P.D., Burke, D.G, **2006**. *Journal of Sports Medicine and Physical Fitness.* 46(1):90-8.
[40] Chwalbinska–Moneta, J, **2003**. *Journal of Sport Nutrition and Exercise Metabolism*. 13(2): 173-183.