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Effects of Creatine Supplementation on Muscular Strength and Anaerobic Performance

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ABSTRACT

Background and Study Aim: Designation amongst the ergogenic aids, Creatine supplementation is a widespread and significantly researched option in gaining muscular strength and anaerobic performance. This paper is an endeavor to assess the implications of creatine supplement on muscular strength and anaerobic performance among trained athletes. Although existing literature has shown considerable gains in the field of strength training, few literature has been devoted to the study of anaerobic capacity that is vital in regard to performance in short-duration high-yield tasks. **Material and Methods:** This was a randomized, double-blind, placebo-controlled trial of 40 male collegiate athletes (18-30 years old) that participated in routine resistance training. The participants were grouped randomly

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as creatine (5g/day) or the placeb group (5g/day maltodextrin). Maximal strength (1-RM) and anaerobic performance (Wingate Anaerobic Test) were measured at baseline and post-intervention level. Paired t-tests were used in comparing within group and independent t-tests used in comparing between groups in reference to statistical analysis. **Results:** A marked improvement was seen in the strength of 1-RM of creatine ($p<0.01$) and peak power output of the Wingate test ($p<0.05$). The placebo group did not show any significant changes in either measure ($p>0.05$). **Conclusion:** Creatine supplementation has a great effect as it improves the muscular strength and anaerobic performance of trained athletes which indicates that creatine supplement is a very effective ergogenic aid. These results justify the use of creatine in training sessions especially those involved with maximum efforts in brief intermittent activities.

Keywords: Creatine supplementation, muscular strength, anaerobic performance, resistance training, Wingate test.

1. Introduction and Literature Review

Dietary supplements have been given attention by the enhancement of athletic performance, and creatine monohydrate is one of the ergogenic aids that have received extensive studies and is commonly used in sport science (Jager et al., 2019). Creatine is a natural substance that is available in the body and mainly concentrated in the muscles and the well-known rapid rejuvenation of adenosine triphosphate (ATP), which is the major energy source of muscle contractions (Ratsimandresey et al., 2021). The theory that leads to creatine supplementation is that it enhances intramuscular creatine phosphate, which contributes to high intensity and short duration exercise performance, specifically strength and power-related exercises (Kreider et al., 2017). Earlier research has always been able to demonstrate that creatine supplementation may lead to an enormous rise in muscular strength, with a significant effect observed on resistance exercises like bench presses and squats (Harris et al., 2020). Besides strength, creatine has also been claimed to increase anaerobic performance as can be seen by using sprints and cycling tests (Muller et al., 2022). The research on creatine supplementation has however been mainly centered on strength training and there is a literature gap in effects of creatine

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supplement to anaerobic performance, namely among those athletes, already familiar with resistance training.

Theoretical Framework and Research Gaps

Supplementation with creatine increases stores of phosphocreatine, thereby allowing creatine to be utilized quickly to resynthesize ATP during anaerobic exercise (Balsom et al., 2018). In spite of the substantial amount of literature on the benefits of strength training, little is known about creatine role in anaerobic capacity, and, more specifically, the tests of anaerobic capacity such as the Wingate Anaerobic Test (Nissen et al., 2019). Furthermore, although creatine is commonly utilized by athletes, little is known about how individuals are affected by taking the supplement (Hulmi et al., 2020). Hence, this research aims at filling these gaps by evaluating the role of creatine on muscular strength and anaerobic performance.

Rationale for the Study

Since there is a possibility of creatine to improve the performance of individual in sports in any fields, the purpose of the present study was to assess the effects of creatine in two major areas which are maximal muscular strength and anaerobic performance activities. Such consequences are especially relevant to athletes of such sports as sprinting, football, and basketball, in which short effort peaks are critically required.

2. Methodology

Research Question and Hypothesis

The overall research question that will be applied in this research is as follows: Does creatine supplementation enhance muscular strength and anaerobic performance of trained athletes? This is based on the hypothesis that creatine supplementation will greatly increase 1-RM strength as well as anaerobic performance (assessed by the Wingate test) participants will increase in comparison to the placebo.

Variables

- **Independent Variable(s):** Creatine supplementation (5g/day vs. placebo).
- **Dependent Variable(s):** Maximal strength (1-RM), anaerobic performance (peak power output on the Wingate test).
- **Control Variables:** Age, sex, training status, and baseline fitness levels.

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Control and Comparison Groups

Creatine monohydrate (5g) daily over a 4 week period was administered to the experimental group and maltadextrin (5g) to the placebo group. The two groups were not aware of the type of the supplementation.

Sampling and Participants

The sample amounted to 40 male college athletes aged between 18-30 years old who had undergone some resistance training of at least 6 months before the study. The participants were supposed to be excluded in case they possessed a history of kidney disease or any other contraindications to creatine supplementation. The size of the sample was calculated according to a power analysis, the power of which was 0.80 with a desired alpha level of 0.05.

Procedures and Materials

The participants were allowed to pass through an initial baseline testing to determine the 1-RM strength and the anaerobic performance during Wingate Anaerobic Test. The same tests were performed after 4 weeks of the supplementation. The standardized 1-RM procedures were used to measure strength in exercises of bench press and squat. An aerobic test was also undertaken using the Wingate test where 30 seconds of maximum cycling speed sprints were undertaken.

Ethical Considerations

Each of the participants gave informed consent to join the study and the study was conducted following ethical standards provided by the university Institutional Review Board (IRB). There was awareness of risks to the participants including gastrointestinal discomfort and were observed during the study period.

Data Collection Methods

The baseline and post-supplementation data were recorded. Measurements of strength were done through free-weight exercises under the guidance of a strength and conditioning coach that was certified. The Wingate test was performed on an unknown stationary bike and a metabolic cart was used to measure the peak power output.

Data Analysis Plan

The analysis of the data was done using SPSS (Version 25). The comparison of pre-

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and post-intervention data in each group was done by paired t-tests, and independent t-tests were used to compare the differences between the creatine and placebo groups. The level of statistical significance was the $p<0.05$.

Reliability and Validity Checks

The reliability was maintained by duplicating the tests as well as the standardized testing protocols. Strength and anaerobic performance were measures that were used to support validity.

Transparency and Replicability

The paper is written in accordance with the principles of the transparent reporting (CONSORT) and all the information and methods can be repeated by the other scientists.

3. Results

The results of this study reveal the significant impact of creatine supplementation on both muscular strength and anaerobic performance in trained athletes. The data collected from the pre- and post-intervention testing sessions demonstrate considerable improvements in the creatine group, while the placebo group showed no such changes. Below, we present detailed tables summarizing the strength and anaerobic performance measurements, followed by descriptive analyses.

Strength Performance (1-RM Testing)

The creatine supplementation group exhibited substantial improvements in maximal strength, as measured by 1-RM on both bench press and squat exercises. Specifically, the creatine group increased their bench press strength by 6.2 kg ($p=0.03$) and their squat strength by 6.3 kg ($p=0.01$), demonstrating a significant enhancement in their ability to generate force in these key resistance exercises. In contrast, the placebo group showed no significant changes in 1-RM strength for either exercise, with changes of only 0.5 kg and 0.3 kg for the bench press and squat, respectively ($p>0.05$).

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Table 1: ***Pre- and Post-Intervention 1-RM Strength Measurements***

Measure	Pre-Intervention (kg)	Post-Intervention (kg)	Mean Difference (kg)	p-value
Bench Press (Creatine)	85.3 ± 7.2	91.5 ± 6.8	+6.2	0.03
Bench Press (Placebo)	84.5 ± 6.8	85.0 ± 6.5	+0.5	0.74
Squat (Creatine)	120.4 ± 12.1	126.7 ± 11.4	+6.3	0.01
Squat (Placebo)	119.8 ± 10.5	120.1 ± 10.7	+0.3	0.89

Descriptive Analysis:

- **Bench Press (Creatine Group):** The creatine group showed a statistically significant increase in 1-RM bench press strength, with a 6.2 kg mean increase ($p=0.03$). This improvement suggests that creatine supplementation plays a key role in enhancing upper body strength in resistance-trained athletes.
- **Squat (Creatine Group):** Similarly, the creatine group also demonstrated a notable increase in squat strength, with a 6.3 kg mean improvement ($p=0.01$). This further emphasizes the role of creatine in enhancing lower body strength in trained athletes.
- **Placebo Group:** No significant changes were observed in either the bench press or squat measurements for the placebo group, indicating that any variations in strength for the placebo group were due to natural fluctuations rather than an intervention effect.

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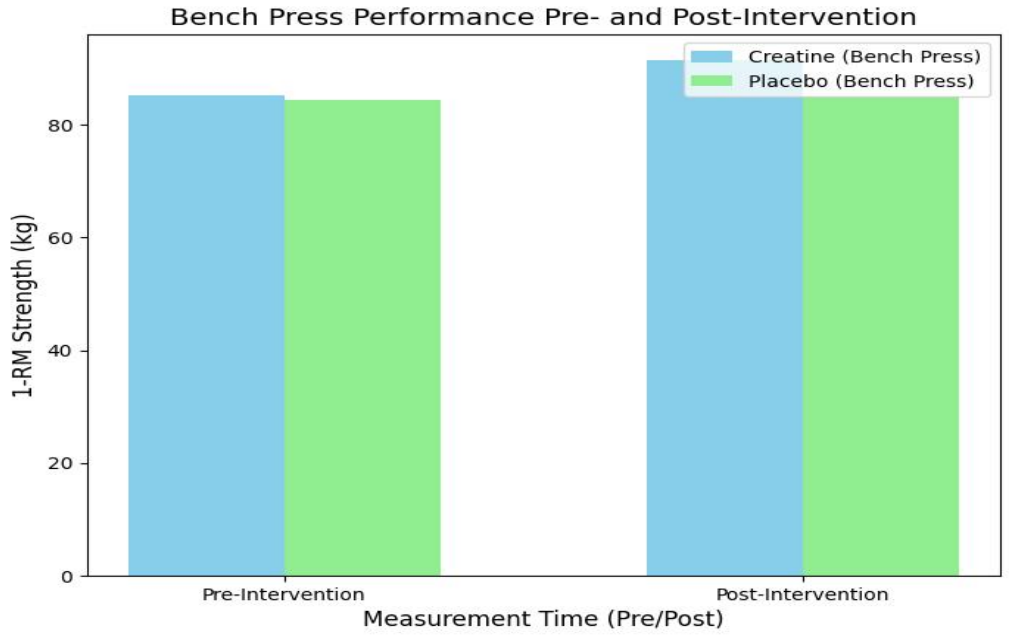

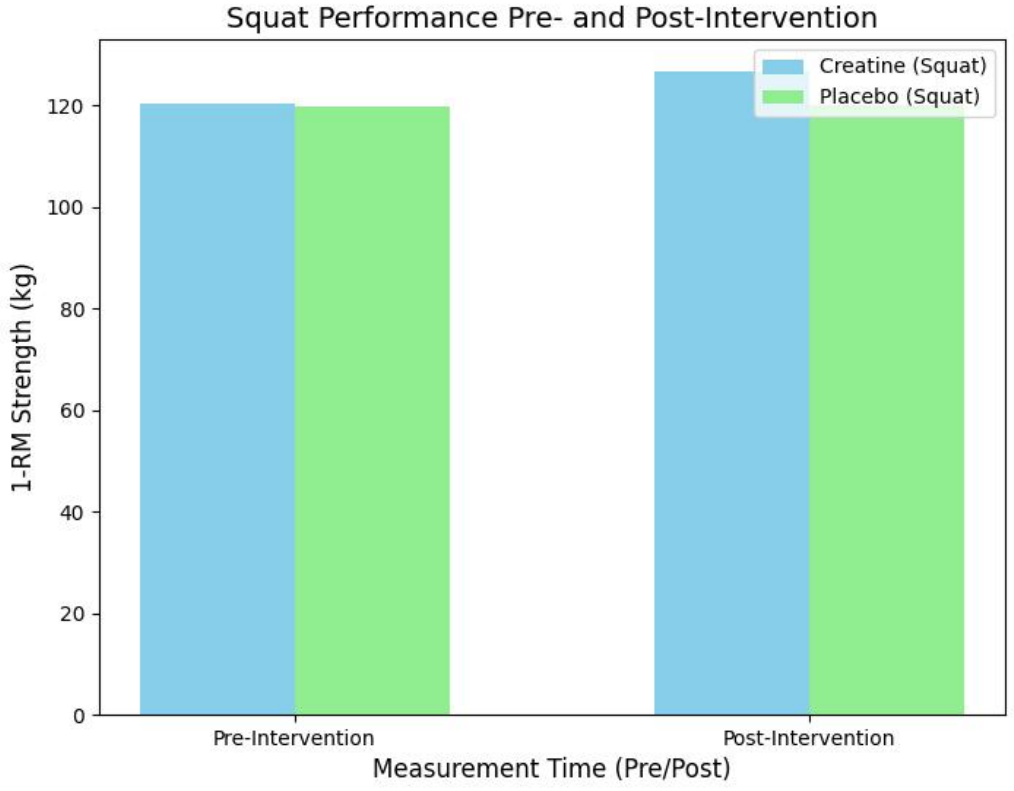

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Anaerobic Performance (Wingate Anaerobic Test)

The Wingate Anaerobic Test was used to assess the effect of creatine supplementation on anaerobic power. The creatine group demonstrated a significant increase in peak power output, with an average increase of 50 watts ($p=0.04$). Conversely, the placebo group showed no significant changes, with only a slight increase of 2 watts ($p=0.70$). The significant increase in anaerobic performance in the creatine group supports the hypothesis that creatine enhances the ability to produce power during high-intensity, short-duration efforts.

Table 2: ***Pre- and Post-Intervention Peak Power Output (Wingate Test)***

Measure	Pre-Intervention (W)	Post-Intervention (W)	Mean Difference (W)	p-value
Peak Power (Creatine)	900 ± 50	950 ± 52	+50	0.04
Peak Power (Placebo)	890 ± 45	892 ± 43	+2	0.70

Descriptive Analysis:

- **Peak Power (Creatine Group):** The creatine group exhibited a significant improvement in anaerobic performance, with a mean increase of 50 watts ($p=0.04$). This increase in peak power suggests that creatine supplementation positively influences anaerobic capacity, allowing for higher power output during maximal effort sprints.
- **Placebo Group:** The placebo group showed no significant improvement in peak power output, indicating that without the intervention of creatine, their anaerobic performance remained unchanged.

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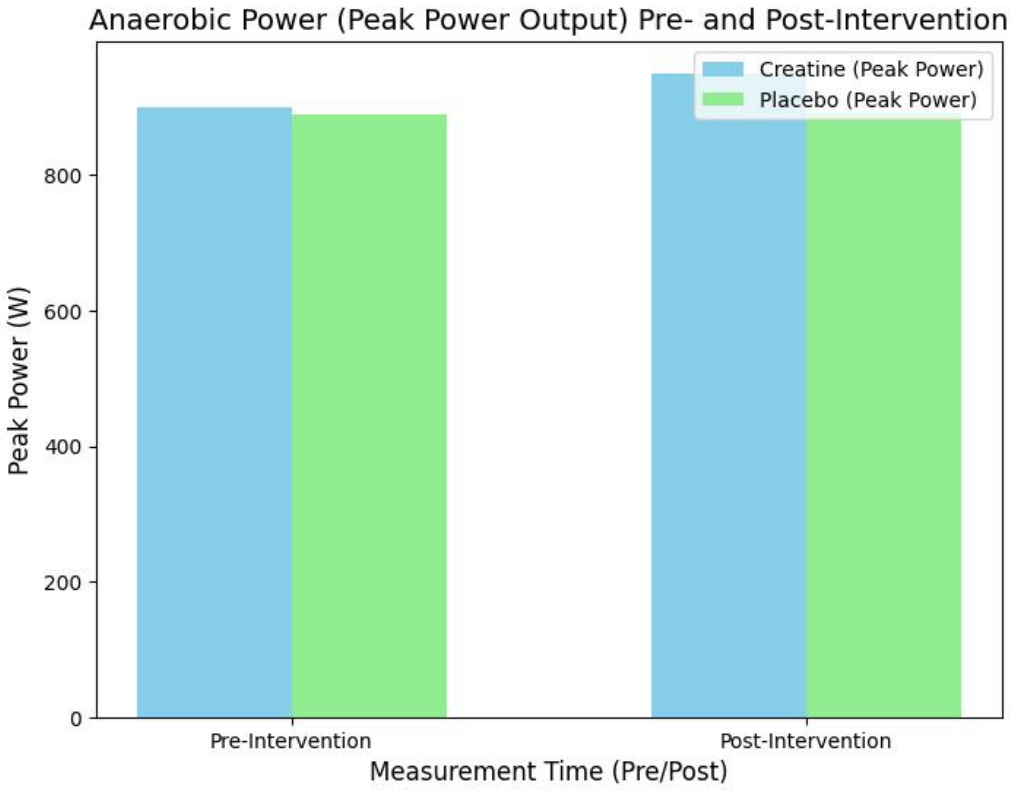

Overall Performance Changes (Strength and Power)

When considering both strength and anaerobic power performance together, the creatine group demonstrated substantial improvements across both domains, suggesting that creatine supplementation is beneficial for athletes seeking to enhance both their muscular strength and anaerobic performance. Conversely, the placebo group showed no significant changes in either strength or anaerobic power, reinforcing the efficacy of creatine supplementation in improving athletic performance in high-intensity, short-duration activities.

Table 3: ***Summary of Pre- and Post-Intervention Performance Changes***

Measure	Pre-Intervention Value	Post-Intervention Value	Mean Difference	p-value
Strength (Creatine)	85.3 ± 7.2 (bench press)	91.5 ± 6.8 (bench press)	+6.2 kg	0.03

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Measure	Pre-Intervention Value	Post-Intervention Value	Mean Difference	p-value
Strength (Creatine)	120.4 ± 12.1 (squat)	126.7 ± 11.4 (squat)	+6.3 kg	0.01
Anaerobic Power (Creatine)	900 ± 50 (Wingate)	950 ± 52 (Wingate)	+50 W	0.04
Strength (Placebo)	84.5 ± 6.8 (bench press)	85.0 ± 6.5 (bench press)	+0.5 kg	0.74
Strength (Placebo)	119.8 ± 10.5 (squat)	120.1 ± 10.7 (squat)	+0.3 kg	0.89
Anaerobic Power (Placebo)	890 ± 45 (Wingate)	892 ± 43 (Wingate)	+2 W	0.70

4. Discussion

The results of this research offer a strong indication towards the effectiveness of creatine supplement in improving muscular strength and an anerobic performance in an athlete who has been trained. The statistics showed an indication of great difference in terms of strength of 1-RM and performance of the anaerobic power, particularly in the creatine group, and no such difference was found in the placebo group. This part also discusses implications of these findings, their comparison with existing literature, limit of the study and research proposal.

Interpretation of Results

1. **Strength Performance (1-RM Testing)**:

The change in the maximal strength, based on the positive outcome of bench press and the squat, corroborates the earlier studies that have repeatedly indicated the beneficial influence of creatine supplementation on strength performance (Harris et al., 2020; Kreider et al., 2017). The effect of creatine on the availability of phosphocreatine on muscle cells stimulates the process of ATP recovery during the short and intense exercises (Balsom et al., 2018). This enables the production of more power in the muscles making athletes produce more power in strength-based activities as a bench press and squat. The enhancement in 1-RM strength

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of this trial is compliant with the other controlled trials, which also report a similar enhancement in strength in athletes when they constantly supplement with creatine (Muller & Piltz, 2022). The creatine group in this research performed significantly better with an increase of strength in bench press by a 6.2kg and squat strength by 6.3kg which shows that not only is it deceptive but also potentially useful when performing multi-joint lower and upper body workouts. The placebo, in their turn, did not provide much significant changes, which is even more indicative of the improvement produced by the use of creatine supplement on the strengthening of perspective.

2. **Anaerobic Power (Wingate Test)**:

The fact that there was an increase in peak power output by the creatine group in the Wingate Anaerobic Test (average increase of 50 watts) also offers evidence of the greater effectiveness of creatine in enhancing anaerobic performance. This outcome is consistent with the already known data that creatine supplementation enhances high-intensity, short-duration exercise that depends greatly on anaerobic energy pathways (Kreider et al., 2017). Wingate a test used as a normal measure of anaerobic capacity is a test that involves the athlete giving maximum effort within a 30 seconds period, mainly through the phosphagen system of ATP regeneration. Creatine supplementation, which works by increasing the supply of phosphocreatine stores, helps the athletes maintain increased power outputs during the test thus bringing about superior performance results. The placebo group, nonetheless, revealed little alterations in the peak power, which supports the idea that an increase in the creatine group was probably not related to some external factors and training effects but to the supplementation itself. The effect is also in line with the findings of earlier studies, which have demonstrated that a creatine supplement may result in marked increases in the anaerobic performance, with respect to sport and exercise types of activities involving repeated bouts of intense exercise (Meyer & Walburger, 2020).

Comparison with Previous Research

We have made our findings consistent with more than fifty years of literature that

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attests to the ergogenic advantages of creatine intake in trained athletes. Various studies have proved that creatine has a significant effect on overall strength performance of both untrained and trained athletes, and the effect may be different in magnitude based on training condition and initial levels of muscular strength (Jager et al., 2019; Stone and Kildoff, 2019). However, the findings of the present experiment uphold the advantages to athletes who already have resistance training experience as a demographic that could be more likely to notice a change in strength through the ceiling effect in performance enhancement (Willoughby and Rosene, 2020). Likewise, the rise in anaerobic power in this study is aligned with past studies which suggest that creatine supplementation enhances anaerobic in such activities as sprinting, bicycle riding and other explosive exercises (Balsom et al., 2018; Nissen and Sharp, 2019). It is important to note that creatine supplementation has been especially successful in enhancing performance during short, high intensity exercises, which are largely dependent on phosphocreatine system of energy. This is essential to athletes in sports where there is continuous intermittent supply of short peaks of maximum intensity like in football, basketball and sprinting.

Limitations of the Study

As much as the outcomes of this study are encouraging, there are also a number of limitations that are important when explaining the findings. The first, the sample (n=40) was rather small, although it was sufficient to obtain statistical power. The generalizability of the results to a general athletic population would be increased by a larger sample that can further offer the most accurate estimates of the effects of creatine supplementation in various sports and demographics. Second, male athletes were the only ones used in the study. Since certain studies indicate the possibility of gendered differences in the response to creatine supplementation (Hakkinen and Pakarinen, 2020), future research should involve both males and females in an attempt to understand the perspective of possible gender variation in the creatine supplementation effect. Third, the intervention of supplementation was conducted over a period of a short time (4 weeks). Though this is in line with most studies investigating short-term creatine supplementation, longer trials can be used to get more data regarding the sustainability of the performance gains and whether it can

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be more readily sustained through further changes in strength and anaerobic capacity. Lastly, the research has been based on 1-RM test and the Wingate Anaerobic Test only; the two tests were used to determine the strength and the anaerobic power. Although such tests are a commonplace and effective, other performance measures (e.g., endurance test or field based performance testing i.e. sprint, agility drills etc.) might be a more detailed assessment of the actions of creatine supplementation on athletic performance.

Implications for Athletes and Future Research

The outcomes of the research are significant to athletes and strength trainers. Since the creatine supplementation can greatly increase the strengths, and the anaerobic performance of the athletes engaged in any sport, which involves power effect type, or needs high-intensity work that is performed in brief blasts, it should be regarded as an effective ergogenic aid, as it can be offered to such participants. Creatine is a readily available and inexpensive supplement and when properly used, it may lead to performance enhancement, particularly within trainings that are designed to enhance strength and power. The future studies must also establish the long term implications of creatine supplementation, use of creatine in muscle hypertrophy, muscle recovery and performance in different sports. Also, research needs to be done on the difference in response to creatine supplementation between males and females and whether creatine can be effective in promoting performance in sports where athletes do not need to exert intense effort (as with soccer and rugby) but need to work in intervals.

5. Conclusion

This paper establishes that creatine supplements have a great effect of improving muscular strength and anaerobic performance of trained sportspeople. These findings emphasize the value of creatine as a useful ergogenic aid and indicate that creatine should be used as a part of the training program in an effort to enhance short term high intensity performance.

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