EFFECT OF CREATINE SUPPLEMENTATION COMBINED WITH RESISTANCE TRAINING ON PHYSICAL FITNESS OF BASEBALL PLAYERS

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(NUTRITION)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2008

Thesis
Entitled

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EFFECT OF CREATINE SUPPLEMENTATION COMBINED WITH RESISTANCE TRAINING ON PHYSICAL FITNESS OF BASEBALL PLAYERS

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science (Nutrition)
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ACKNOWLEDGEMENTS

I would like to express my deepest gratitude and sincere appreciation to my major advisor, Professor Surat Komindr, for his kindness, excellent advice, and encouragement throughout my study. His support is successfully complete this thesis.

My sincere gratitude is also extended to my co-advisors, Dr. Orawan Puchaiwattananon for her kindness, suggestion, support and helping me for everything until complete the thesis.

My sincere gratitude has been contribute to my examiner, Assoc. Prof. Nusiri Lerdvuthisopon for being the chair of my external examiner and Assoc. Prof. Thyon Chentanez, for their kindness and valuable guidance to make my thesis complete.

I am particularly indebted to Faculty of Graduate Studies, Research Grant from the Faculty of Medicine Ramathibodi Hospital, Mahidol University and Dr. Chareonthat Jintanaseri, cheif of Aoiy Katsigh for sport science fund and committee for the scholarship which has enabled me to undertake this study.

Many sincere thanks go to Assoc. Prot. Sirirat Hirunrat and Dr. Gene Charoonruk for their suggestion in this thesis, Miss. Narumon Sudjai for her advice in the statistical analysis, team manager and coach for their help in cooperation and connection athletes during my study, all official of sport science and physical fitness testing division of Sport Authority for their helping and suggestion.

I would like to thank all of Thai national baseball and softball players, my subjects for their excellent cooperation throughout my study.

Finally, I am very grateful to my parents and older brother for their care, love, moral support, understanding, encouragement, very nice advice, helping me for everything until complete the thesis and everything given to me throughout my life.

Nawarat Witthawatsukol

EFFECT OF CREATINE SUPPLEMENTATION COMBINED WITH RESISTANCE TRAINING ON PHYSICAL FITNESS OF BASEBALL PLAYERS

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ABSTRACT

Creatine supplements have been widely used by athletes and in various sport circles. However, research on its effect among baseball and softball players is lacking. The objective of this study was to assess the effect of creatine supplementation in combination with resistance training on physical fitness performance and body composition among Thai national baseball and softball players. The study was a group-matched, randomized, single-blind, case-control study. Thirty-two male baseball and softball players from 16-34 years old (23.50 $\pm$ 5.24 years) were recruited and were placed on a regular weight training program for 9 weeks (Periods 1-4). During this period, all subjects were instructed to ingest post-exercise snacks after each weight training session. Subjects were matched for VO_2 max, body weight, height and age. After 30 days of weight training (Period 2) and ingesting post-exercise snacks, subjects were allocated to two randomly assigned groups (16 cases and 16 controls). Cases were given 20 g/day of creatine monohydrate and controls were given 40 g/day of glucose supplement (placebo) for the first 5 days as a loading period (Period 3). During the maintenance period (Period 4: day 7 to day 58) 5 g/day and 10 g/day of creatine monohydrate and glucose were given to cases and controls, respectively. Body composition assessment, physical fitness test and dietary assessment were measured at baseline (day 0), after weight training (day 31), after loading (day 37) and maintenance (day 59) periods. Side effects of creatine supplementation were continually monitored throughout the study period and were assessed and documented after loading and maintenance periods. No difference in body composition parameters were observed among the 32 subjects when compared with baseline after 30 days of weight training. However, daily nutrient intakes for energy, carbohydrate and protein were significantly increased. There was a significant improvement in the runtime of the shuttle run test and VO_2 max after weight training in all 32 subjects. After loading (day 37) and maintenance (day 59) periods, a significant increase in body composition was observed among the cases. However, no change was observed for fat mass and percentage of body fat. Dietary intake did not change during creatine supplementation. In the physical fitness test, only the power of vertical jump during the maintenance period for creatine supplement was significantly better than during weight training period (no supplements). The reported side effects of ingesting 20 g/day of creatine monohydrate included severe muscle cramps (12.5%), severe muscle soreness (18.8%), severe muscle tightness (25%), and acute diarrhea (25%). These side effects decreased in severity and disappeared during the maintenance period.

This study demonstrate that creatine supplementation increased body water, body protein mass, skeletal muscle mass and the power of vertical jump while no change was noted in other physical fitness tests. Side effects occurred in 12-25 % of cases at loading period and decreased or disappeared over time.

KEY WORDS: CREATINE/ NUTRITION SUPPLEMENT/ ERGOGENIC AID/ PHYSICAL FITNESS TEST/ BASEBALL/SOFTBALL

130 pp.

ผลของการเสริมครีเอทีนร่วมกับโปรแกรมการเสริมสร้างกล้ามเนื้อต่อสมรรถภาพทางกายของนักกีฬาเบสบอล
(EFFECT OF CREATINE SUPPLEMENTATION COMBINED WITH RESISTANCE TRAINING ON PHYSICAL FITNESS OF BASEBALL PLAYERS)

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บทคัดย่อ

ครีเอทีนเป็นที่รู้จักในนักกีฬาและวงการกีฬาอย่างแพร่หลายรวมถึงมีการศึกษาวิจัยที่เกี่ยวข้องมากมาย แต่อย่างไรก็ตามยังมีกีฬาที่มีรูปแบบที่น่าสนใจอย่างเบสบอลและซอล์ฟบอลซึ่งยังขาดการวิจัยอยู่ ดังนั้นวัตถุประสงค์ของการศึกษาครั้งนี้เพื่อศึกษาผลของการเสริมครีเอทีนร่วมกับโปรแกรมการเสริมสร้างกล้ามเนื้อต่อสมรรถภาพทางกายและองค์ประกอบของร่างกายของนักกีฬาเบสบอลและซอล์ฟบอลชายทีมชาติไทย รูปแบบการศึกษาแบบ Group-match fashion, randomized, single-blind, case-control study ถูกนำมาใช้ในการวิจัยครั้งนี้ โดยมีนักกีฬาเบสบอลและซอล์ฟบอลเข้าร่วมจำนวน 32 คน อายุระหว่าง 16-34 ปี (23.50 ± 5.24 ปี) ถูกจัดให้เข้าร่วมโปรแกรมการเสริมสร้างกล้ามเนื้อและได้รับอาหารหลังการเสริมสร้างกล้ามเนื้อตลอดระยะเวลา 9 สัปดาห์ ซึ่งผู้เข้าร่วมในการวิจัยจะถูกแบ่งเป็น 2 กลุ่ม ตามความสามารถในการใช้ออกซิเจนขณะออกกำลังกาย น้ำหนัก ส่วนสูง และอายุ ที่ใกล้เคียงกัน หลังจาก 30 วัน ของการเสริมสร้างกล้ามเนื้อร่วมกับการเสริมอาหาร ผู้เข้าร่วมการวิจัยจะถูกแบ่งเป็นกลุ่มที่ได้รับครีเอทีนและกลุ่มที่ได้รับสารหลอก โดยแบ่งเป็น 2 ช่วง คือ loading period (20 กรัม/วัน ระยะเวลา 5 วัน) และ maintenance period (5 กรัม/วัน ระยะเวลา 21 วัน) ส่วนอีกกลุ่มจะได้รับกลูโคสในปริมาณที่เท่าเทียมกัน การวัดผลประกอบด้วยการวัดองค์ประกอบของร่างกาย ประเมินการรับประทานอาหาร และการทดสอบสมรรถภาพทางกาย ซึ่งทำในช่วงก่อนเข้าสู่การศึกษา หลังจากเสริมสร้างกล้ามเนื้อ 30 วัน หลังจาก loading period และ หลังจาก maintenance period ส่วนผลข้างเคียงของการได้รับครีเอทีนจะประเมินใน 2 ช่วงสุดท้าย เมื่อเปรียบเทียบผลหลังจาก 4 สัปดาห์ ของการเสริมสร้างกล้ามเนื้อกับช่วงก่อนเข้าสู่การศึกษาของผู้เข้าร่วมวิจัยทั้ง 32 คน พบว่าไม่มีความแตกต่างกันของผลองค์ประกอบของร่างกาย ขณะที่ผลการประเมินอาหารพบว่ามีการเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติของปริมาณพลังงาน คาร์โบไฮเดรตและโปรตีน ส่วนผลการทดสอบสมรรถภาพทางกายพบว่ามีความแตกต่างกันทางสถิติของเวลาในการวิ่งเก็บของและความสามารถในการใช้ออกซิเจนขณะออกกำลังกายที่พัฒนาขึ้น หลังจากการเสริมครีเอทีนพบว่าผลองค์ประกอบของร่างกายทั้งช่วง loading และ maintenance period มีความแตกต่างกับช่วง 30 วัน ของการเสริมสร้างกล้ามเนื้ออย่างมีนัยสำคัญทางสถิติ ยกเว้นมวลไขมันและเปอร์เซ็นต์ไขมัน ผลการทดสอบสมรรถภาพพบว่ามีเพียงพลังกล้ามเนื้อในการกระโดดสูงในช่วง maintenance period เท่านั้น ที่มีความแตกต่างทางสถิติกับช่วงการเสริมสร้างกล้ามเนื้อ พบผลข้างเคียงของครีเอทีนบ่อยที่สุดในช่วง loading period โดยพบว่ามีตะคริวเกิดขึ้นร้อยละ 12.5 ปวดกล้ามเนื้อร้อยละ 18.8 ตึงกล้ามเนื้อร้อยละ 25 และท้องเสียร้อยละ 25 ซึ่งค่อยๆ ลดลงหรือหายไปในช่วงของ maintenance period

จากผลการศึกษานี้แสดงให้เห็นว่าการเสริมครีเอทีนนั้นส่งผลให้น้ำในร่างกาย โปรตีน กล้ามเนื้อ เพิ่มขึ้น รวมทั้งมีพลังกล้ามเนื้อในการกระโดดสูงเพิ่มขึ้น ในขณะที่ไม่มีการเปลี่ยนแปลงของสมรรถภาพทางกายในด้านอื่นๆ ส่วนผลข้างเคียงนั้นพบว่าการเสริมครีเอทีนในขนาดสูง ทำให้มีอาการท้องเสีย ปวดตึงกล้ามเนื้อ และเป็นตะคริว ซึ่งดีขึ้นหรือหายไป เมื่อปริมาณของครีเอทีนลดลง

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LIST OF ABBREVIATIONS

ADP	Adenosine diphosphate
ATP	Adenosine triphosphate
AGAT	Arginine:glycine amidinotransferase
BP	Blood pressure
Cr	Creatine
CreaT	Creatine transporter
CrM	Creatine monohydrate
ECW	Extracellular water
GAMT	S-adenosylmethionine:guanidinoacetate N-methyltransferase
GFR	Glomerular filtration rate
GLUT-4	Glucose transporters
HR	Heart rate
ICW	Intracellular water
K_m	Kinetic of many enzymes
Kcal	Kilocalories
mmol	Millimol
PCr	Phosphocreatine
tCr	Total creatine
µM	Microgram
1 RM	One repetition maximal
TBW	Total body water
VO_2max	Maximal oxygen uptake

CHAPTER I
INTRODUCTION

Background and significance of the study

All sport societies have high competition for achievement. Trainers and coaches attempt to find methods or substances for their athletes to win the match. These include excellent such as sport coaching, exercise physiology, sport biomechanic, sport psychology and sport nutrition. At present, sport nutrition is being interested by every sport. Taking supplements in athletes is very popular. The most promising and popular ergogenic substance being widely used to improve athletic performance is creatine.

Creatine was discovered in 1832 by a French scientist named Chevreul from a meat extract (1). Since then creatine was interested by many researchers. Normally, body can synthesize creatine. Liver, pancreas and kidney synthesize creatine from arginine, glycine and methionine. However, half of the amount of creatine in human body is derived from foods. Major source of creatine is meat and fish. Creatine is needed to increase the performance, so it is impractical to get those amounts from food. Creatine in supplement form is an alternative for athletes. In 1994, Creatine is classified as a "dietary supplement" under the 1994 Dietary supplement Health and Education Act (2).

Creatine has mild side effects. Among them, weight gain is the most consistent adverse effect reported. Water retention is one reason of weight gain and also gastrointestinal discomfort (3). Moreover, many researchers attempt to demonstrate side effects of creatine supplementation on kidney function, hepatic function, heat exhaustion, thermoregulation and muscle cramp. The study about short-term and long term of creatine supplementation on kidney and hepatic function expressed that creatine monohydrate has no long-term detrimental effects on kidney or liver functions

(4-10). Research about heat exhaustion and thermoregulation found that creatine does not have a negative effect on thermoregulatory responses during exercise but it increases sport performance (11-16). So, creatine is a supplement that is legal for use in amateur and professional sport and is approved by International Olympic Committee (3). It is a nutritional supplement used by many young athletes. The prevalence of use in some sports is greater than 70 % (17- 21) and the annual sales exceeds $400 million in the United States alone.

Creatine is used by physically active people in single and repetitive high intensity, short-duration exercise tasks such as weightlifting, sprinting and cycling (22). Approximately 70 % of studies report that creatine supplementation significantly increase muscle strength and lean body mass and improve sport performance (23). Liam P. Kilduff et al. demonstrated that creatine supplementation can increase muscle strength (24). A short-term, double-blind, placebo-controlled study examine the effect of 28 days of creatine supplementation on body composition, strength and sprint performance in 25 football players found that body mass, fat-free mass, bone-free mass, strength and sprint performance were all increased (25).

Numerous researches supported effect of creatine supplementation on increase muscle strength, lean body mass and improve performance. A meta analysis about effect of creatine supplementation on body composition and performance reported that body composition was greater for changes in lean body mass following a short-term creatine supplementation (26). Creatine was also shown to decrease muscle fatigue in some studies (3)

The effect of creatine to physical performance are varied and controversed. Some study have demonstrated that creatine increase endurance performance (23) but van LooN LJ et al. reported that creatine dose not increase endurance performance and long-term exercise (27). Another research examined the effects of creatine supplementation on intermittent high-intensity exercise activities, consisting of a counter-movement jump test, a repeated sprint test and intermittent endurance test, they found that creatine loading supplementation favorably affected repeated sprint performance and limited the decay in jumping ability after the intermittent endurance test in highly trained soccer players. While intermittent endurance performance was not affected by creatine (28).

It is noted that although creatine is studied in many kinds of sport but there are lack of the study in baseball and softball. Baseball and softball have similar pattern of skills. Moreover, it is the mixed type of movements such as batting, sprinting, throwing, pitching, catching and jumping. It is a long-term game in the field too. So, baseball and softball render the opportunity to verify the effect of creatine on various kinds of activities.

The only research about the effect of creatine loading on muscular strength and endurance of female softball players found that twenty gram creatine supplementation a day for a week to the trained females did not improve maximal static strength and dynamic peak torque but improve the mean strength and endurance of repeated contraction (29). Although there is scanty research in about baseball and softball players but creatine is widely used by baseball players in the National Collegiate Athletic Association World Series Teams (30).

Since numerous studies showed that effect of creatine on female was not so great as those found in male athletes (29), Thai national male baseball and softball players were chosen in this study. Many research showed that creatine supplementation combined weight training program increase lean body mass higher than weight training only (25, 31 ,33) and Green et al. reported that ingesting a high dose of carbohydrate (90 g) with creatine can increase muscle creatine accumulation (34-35). So, the design in this study used benefit in previous studies to enhance creatine efficiency.

Interesting point is that skill movement pattern could influence the response to creatine supplementation and conclude research is lack and little side effect of creatine that approve by International Olympic Committee with not banned (3). The objective of this study was to examine the effect of creatine supplementation combined with resistance training in comparison on body composition, dietary intake and physical fitness in baseball and softball players.

CHATPER II
OBJECTIVES

The objectives of this thesis were to investigate in Thai national baseball and softball players on the following:

1. Effect of weight training and post-exercise snack supplement for 30 days on body composition and physical fitness performance.

2. Effect of creatine supplementation, 20 g loading dose/day for 5 days and followed by 5 g maintenance dose/day for 21 days combined with weight training and post-exercise snack supplement on body composition and physical fitness performance.

3. Side effects of creatine supplementation during loading period and maintenance period.

CHAPTER III
LITERATURE REVIEW

1. Creatine biosynthesis

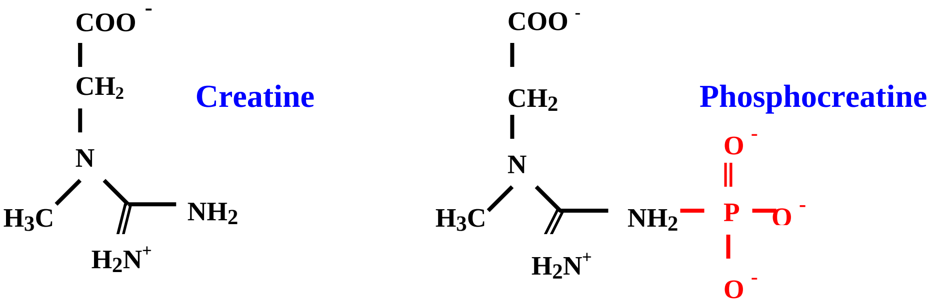
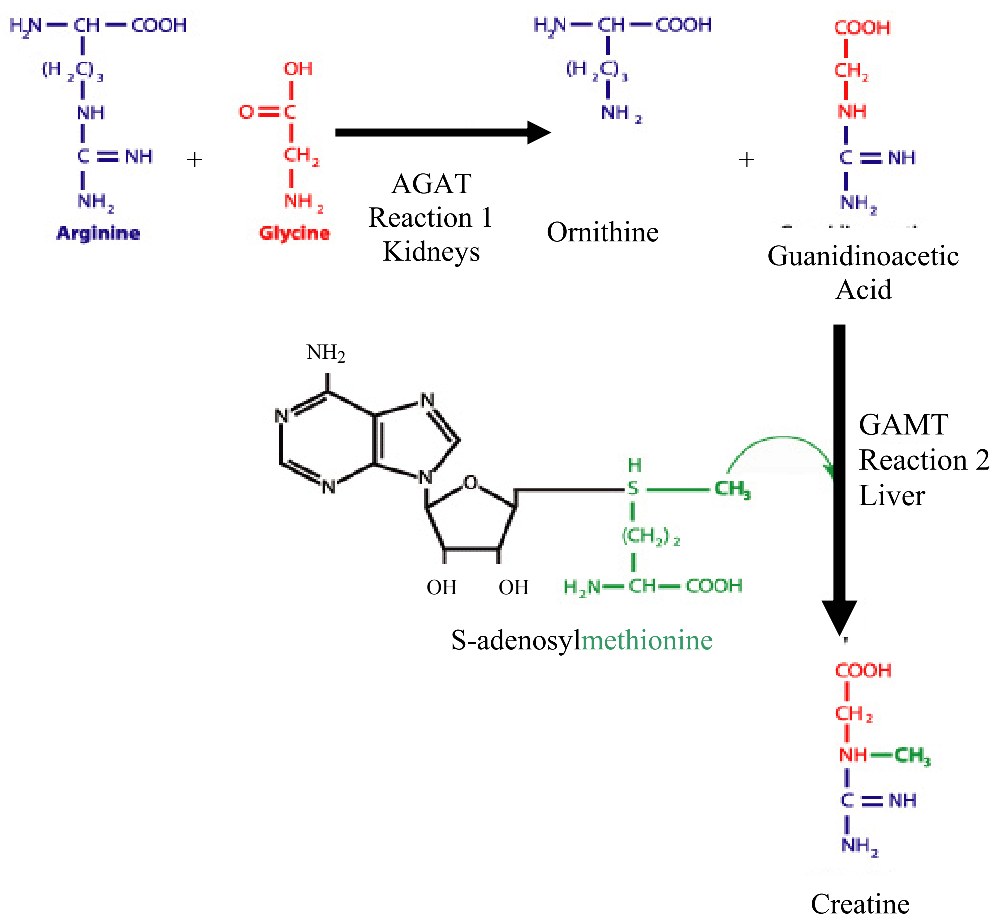


Figure 3.1 Creatine structure

The molecular weight of creatine is 131.13 g/mol. Creatine structure are shown in Figure 3.1. Creatine (α-methyl guanidino-acetic acid) is a nitrogenous organic compound that synthesized 2 % by the liver, pancreas, and kidney from the amino acids arginine, glycine and methionine (Figure 3.2). The main path wary of creatine synthesis in humans occurs in the liver and kidney (35-36). In the kidney, guanidinoacetate and ornithine is formed from arginine and glycine in a reaction catalyzed by arginine:glycine amidinotransferase (AGAT) (31,35-37). Then guanidinoacetate is transferred via blood circulation to the liver (36). The second step of synthesis occurs in the liver. A methyl group of S-adenosylmethionine is transferred to guanidinoacetate by S-adenosylmethionine:guanidinoacetate N-methyltransferase (GAMT) and creatine is formed (35,38). This step can be feed back inhibited by creatine. It is suggested that the inhibition mechanism is though the step before the translation of AGAT mRNA. The rate limiting step in creatine synthesis is the formation of guanidinoacetate by AGAT (35-36). Other factors that have been shown to regulate creatine synthesis are thyroid hormone, growth hormone, testosterone, ornithine, and the deficiencies of some nutrients (e.g., fasting, vitamin E) (35-36). Creatine is distributed via blood circulation and is taken up by the target tissues (39).



Enzymes:
AGAT = L-Arginine:glycine amidinotransferase
GAMT = S-adenosyl-L-methionine:N-guanidinoacetate methyltransferase

Figure 3.2 Creatine biosynthesis

2. Creatine transportation

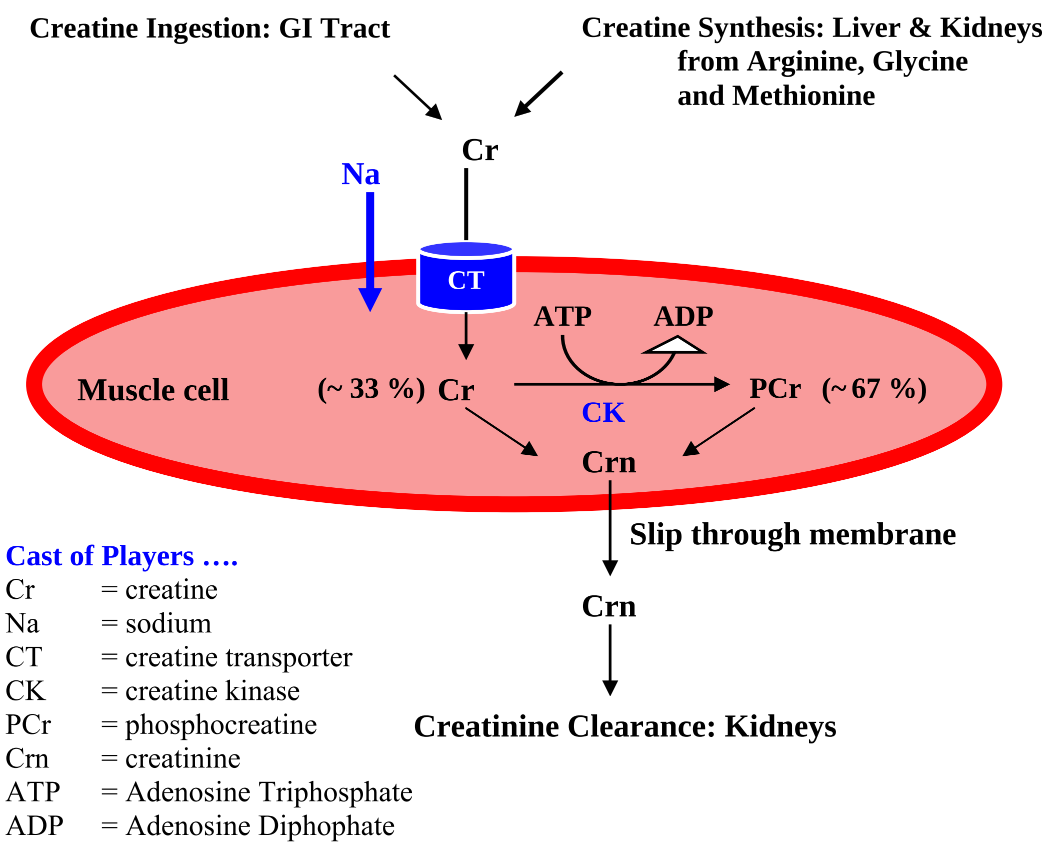


Figure 3.3 Creatine transportation

Creatine enters to muscle cell either through an active or facilitated passive transport process using a special Na-dependent transporter, or against a concentration gradient through the creatine transporter (33-34,40). Creatine transporter is similar to the transporters for dopamine, guanidino γ-aminobutyric acid and taurine (40). So, any agent that causes sodium influx should likewise increase the transport of creatine into the muscle cell. Physiological agents that are well known to increase sodium efflux include insulin and epinephrine. Creatine transporter is shown in Figure 3.3.

Creatine uptake is influenced by multifactor, for examples, muscle fiber type, exercise and transporter. It was hypothesized that exercise stimulated creatine uptake by enhancing blood flow and may increase the translocation of creatine transporter to the muscle membrane in the same manner as GLUT-4 translocation during exercise (37, 41-42). The K_m for creatine transporter ranges form 20 to 160 μM depending on species and location of transporter as summarized in Table 2.1 (37,39,43-48).

Table 3.1 Values for blood levels of creatine and creatine transporter K_m across species (37)

Species	Blood creatine (μM)	K_m (μM)
Bovine		187 [a]
Dog	30,000 50–100	
Human	50–100	15 [a], 20 [f], 30 [c]
Mouse	200	45 [d], 110 [e]
Rabbit	150	35 [a]
Rat	500–600	22 [a], 46 [a], 73 [b], 160 [b], 500 [b], 40–60 [e] , 45

a Cloned transporter. *d* Astroglia.

b Intact muscle. *e* Cell culture (L6 or G8).

c White blood cell. *F* Red blood cell.

Creatine transportation needs two sodiums to accompany each creatine molecule being transported inward. Therefore, doubling the driving force for sodium inwardly will effectively increase creatine transport by 50%.

Finally, due to its electrical charge creatine will be trapped once transported within muscle cell. Phosphocreatine is even more highly charged and likewise is trapped once it is produced. Creatinine, on the other hand, lack of electrical charges at physiological pH and hence is able to escape across the muscle cell membrane.

3. Creatine and carbohydrate

It has been known that insulin enhances the transport of creatine from the circulation into the muscle of rats (49-50). Numerous researches found that creatine supplementation combined with simple sugars would produce blood insulin spike and then increase muscle creatine uptake.

In combination with a high dose of carbohydrate - containing solution (about 90 grams, 4 times/day), the report also showed the reduction of creatine losses in urine (34). Support to Preen et al. who established that creatine supplementation in combination with 1 gram of glucose per kilogram of body mass twice per day increased muscle total creatine by 9 % higher than creatine supplementation alone (52).

Steenge et al. demonstrated that insulin can enhance creatine accumulation in human skeletal muscle but only when present at high or supraphysiological concentrations (51). However, high dose of simple carbohydrate is unfourable for athletes because of its high calories. The earlier study showed that the ingestion of creatine with 50 g of protein and 50 g of carbohydrate gave a similar results were shown by result when creatine was ingested with approximately 100 g of carbohydrate (53). The similar results were shown by Cribb PJ et al (54) who studied the effect of 0.1 g/ kg/day of creatine monohydrate supplement in combination with 1.5 g/kg/day alone or protein plus carbohydrate. They showed that creatine in combination with both protein and carbohydrate had greater improvements in one repetition maximum strength, lean body mass, fiber cross-sectional area and contractile protein than protein alone or protein in combination with carbohydrate.

4. Creatine accumulation

Creatine is accumulated in the body in 2 forms, a free form and a phosphorylated form called phosphocreatine or creatine phosphate. 70% of creatine deposit is phosphocreatine. The majority of the body creatine/phosphocreatine pool is located within the muscle. Creatine is distributed throughout the body with 95 % of creatine found in skeletal muscle (35,37,57). The remaining 5 % of the creatine/ phosphocreatine pool is located in the brain, liver, kidney and testes (35,37). Type 2 fiber has higher levels of creatine and phosphocreatine (58-60). In humans, intramuscular level of creatine has been found to be about 125 mmol/kg/dry muscle with about 60 % of total creatine in the form of phosphocreatine (37,41,60-62).

5. Creatine metabolism

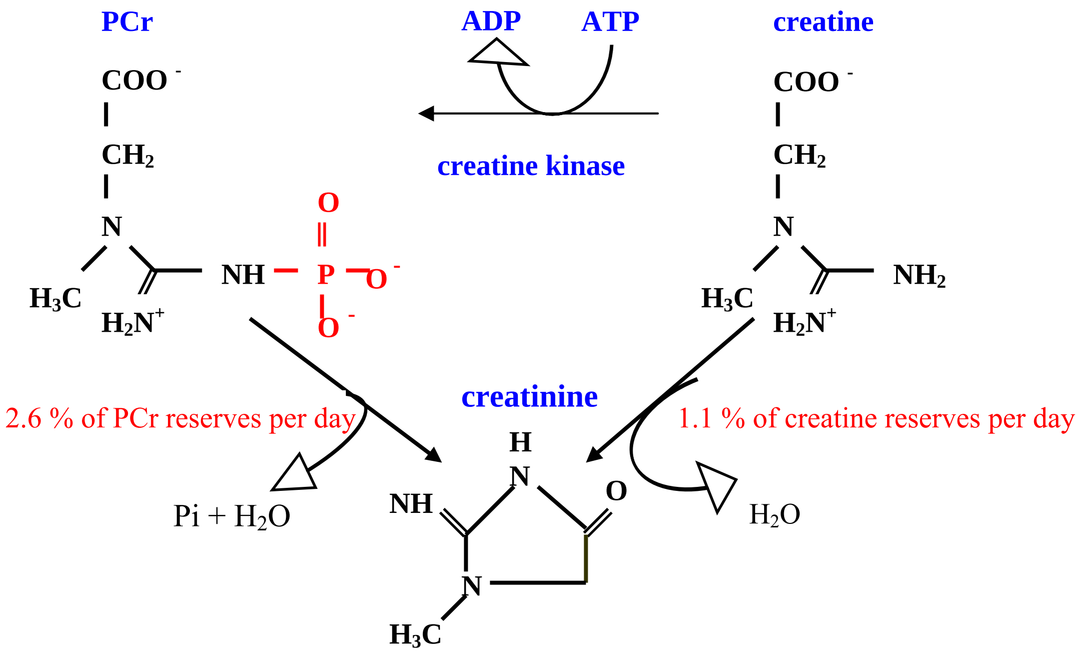


Figure 3.4 Metabolism of creatinine

Creatinine is the end product of creatine metabolism. It is formed by the nonenzymatic conversion from phosphocreatine and creatine (35, 55). Creatine is degraded into creatinine and excreted in the urine at a rate of about 2 g/day for average adult. The dietary intake and endogenous production of creatine matches the spontaneous degradation of phosphocreatine and creatine to creatinine at a rate of 2.6 % and 1.1 % per day, respectively (35). Thus, creatinine production from creatine and phosphocreatine are 2 g/day. Rate of creatinine excretion in female is slower than male subjects. Degradation of creatine is shown in Figure 3.4.

Creatine is cleared from blood via two parallel pathways. The first pathway is a saturable uptake into various organs and cells (37). The second pathway is renal elimination (37). Creatine uptake depend on multifactor. Clearance of creatine from the blood is dependent on intramuscular total creatine levels, hormone levels, muscle mass and kidney function [glomerular filtration rate] (37).

The presence of charged groups on creatine and phosphocreatine prevent them from transversing the muscle membrane. Creatinine has no charge. Thus, it is able to freely slip through the muscle membrane escaping to the outside. This leakage pathway sets our requirement for creatine (about 2 g/day). Also noted that most of the muscle creatine is in the form of phosphocreatine, which also degrades at twice the rate of creatine. Hence, degradation rates should be quite appreciable under resting conditions.

However, creatine can be reabsorbed at renal tubular cells once it was filtered through the kidney. This may explain the lack of creatine found in urine of healthy, unsupplemented conditions, fasting or even in muscle degradation (37,56). In addition, creatine transporter is found in the kidney and may be involved in the reabsorb of creatine (36-37).

6. Physiology of creatine in exercise

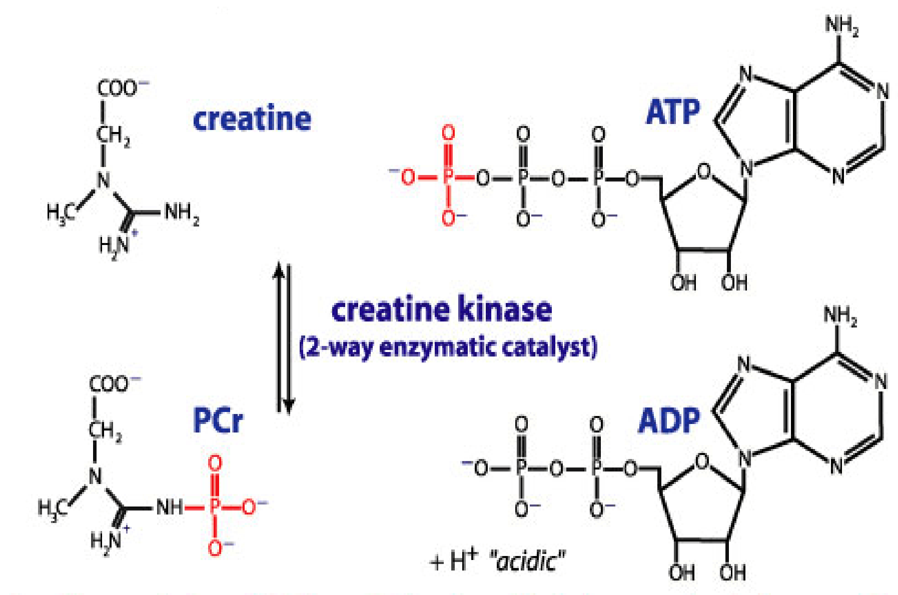


Figure 3.5 Mechanic of creatine

Muscle cells generate mechanical work from an energy liberating via chemical reaction. ATP is the energy storage molecule of all cells and exclusively required for muscle contract. ATP is hydrolysed to ADP and phosphate by ATPase enzyme during muscle contraction. ATP can be used by muscle cells very quickly, but there is only an extremely limited supply of ATP in cytosol usually only enough for a few seconds of high intensity work. In the real situation, body has several ways to convert ADP back to ATP. The converting system is so quick that it guarantees the sufficient amount of ATP within the cell.

Physiology of creatine in exercise is shown in Figure 3.5. After donating energy, the reversible reaction of ATP synthesis need phosphate to phospholylate ADP reverse to ATP that phosphate come from phosphocreatine and catalyzed by creatine kinase. Phosphocreatine produces polar to lock creatine in the muscle and maintains the retention of creatine because the charge prevents partitioning through biological membranes. Creatine kinase is the enzyme responsible for swapping the phosphate groups between phosphocreatine and ATP. The upward reaction predominates during strenuous exercise when energy (ATP) is needed to fuel explosive movements. The downward reaction primarily takes place during moments of rest and recreates phosphocreatine reserves.

7. Source of creatine

There are two major sources of creatine, de novo synthesis and diet. Although creatine are found in meat and fish (57), but the amount of creatine in food is not enough to give an ergonomic effect (see Table 3.2). Thus, the third source of creatine as supplement form is required. In normal subjects, creatine is obtained about 1 g/day from diet and about 1 g/day from de novo synthesis.

Creatine monohydrate (Cr_2H_2O) is widely used among athletes. It is present in various in forms, for examples, capsule, liquid, gum and powder. Popular form of creatine is powder. Creatine monohydrate is white powder, no flavour nor odor.

Table 3.2 Creatine Content in Selected Food (57)

Food	grams Cr/lb	gram Cr/kg
Cod	1.4	3.0
Beef	2.0	4.5
Herring	3.0-4.5	6.5-10.0
Milk	0.05	0.1
Pork	2.3	5.0
Salmon	2.0	4.5
Shrimp	Trace	Trace
Tuna	1.8	4.0

8. Adverse effect of creatine supplementation

Side effects from creatine supplementation have been reported both anecdotally and in the scientific literature. Briefly, creatine supplementation has been documented as being associated with weight gain, gastrointestinal distress, renal dysfunction and anecdotally reported to cause muscle cramps and hepatic dysfunction.

8.1 Weight gain has previously been attributed to an increase in total body water. Water retention in skeletal muscle cells is due to an increase in cellular osmolarity (27,31,62). Whereas, some investigators suggest that cell swelling may represent the stimulation of protein synthesis since cell swelling has been identified as an universal anabolic signal (63).

8.2 Gastrointestinal discomfort is identified as diarrhoea, stomachache, and distress. The cause of gastrointestinal discomfort could be derived from those sugars which are often co-ingested in an excessive amount. High sugar concentration may increase bowel movement as due to its high osmolarity, and thus, reduce absorptive capacity of the gut.) (31). The stomach upset as referred to “distress” was reported in 4 of 12 male subjects experienced at postexercise when they took a creatine load during exercise, whereas no “distress” was reported when they took placebo (31,64). One possible explanation is that undissolved creatine powder may cause gastroenteritis (65).

8.3 Renal and hepatic function

The breakdown product of creatine before elimination from the body is creatinine. Creatinine is excreted though kidney (4). Humans with healthy kidneys is able to excrete the excess creatinine provided that daily hydration is adequate (4). Numerous researches have studied the effect of creatine supplementation on kidney and hepatic function both short-term and long-term.

In short term supplementation, many researcher found that kidney is vulnerable to creatine supplementation. There was a case-control study on the effect of 20 g creatine ingestion/day for 5 days in normal men. Although urine excretion rate was 90-fold increased in these men, but there were no effect on the level of creatinine in urine. The glomerular filtration rate (creatinine clearance) and the total protein and albumin excretion rates remained within the normal ranges (10). The creatine supplement did not affect plasma level of creatinine. The either, as was shown in the similar studies (12,67).

Some researcher studied short-term effect of creatine supplementation on liver function. Crossover design was used to study effect of creatine at 20 g/day for 5 days with a 28-day washout between treatments on hepatic function. Supplementation had no effect on hepatic function as indicated by no change in blood parameters of liver function (i.e., creatine kinase, urea, aspartate aminotransferase, alanine aminotransferase, γ-glutamyl transferase, lactate dehydrogenase) (66). Other research explained that the elevation of plasma transaminases (aspartate aminotransferase, alanine transaminase) and lactate dehydrogenase, though after creatine supplementation, cannot be definitely counted for altered hepatic function, since exercise can, normally, induce many tissue degradation resulting in the elevation of those enzyme as well (25,27).

Numerous investigators had research studied long term effect of creatine supplementation on both kidney and liver function. The periods of supplementation were ranging from ten months to five years. None of the results were statistical differences between the experimental groups for plasma contents, urine excretion rates and other laboratory abnormalities (5,7,9).

Some researcher studied the effect of creatine supplementation both short-term and long term. Twenty g/day for 5 days and 10 g/day for 51 days was examined in both males and females. Blood was tested at baseline, week 4 and week 8 after supplementation, and week 12, 4 weeks after withdrawal. There were no significant changes in total protein, serum creatinine, bilirubin and blood urea nitrogen or serum enzymes (aspartate aminotransferase, alkaline phosphatase, gamma glutamyl transpeptidase, lactate dehydrogenase and creatine phosphokinase) both males and females. However, when analyzed by gender, there was a significant increase in serum creatine kinase in males at week 8 and returned to normal at week 12 following withdrawal. Moreover, female demonstrated a significant increase in blood urea nitrogen at week 8 and returned to normal following withdrawal (4). Robinson TM et al (6) studied five days (20 g/day) to nine weeks (3 g/day) found that serum creatinine concentration tended to be increased the day after creatine supplementation. However, values had returned to baseline six weeks after the cessation of supplementation. These increases were probably attributable to increased creatinine production rather than renal dysfunction. No indication of impairment to the haematological indices, hepatic function or muscle damage was apparent after creatine supplementation. Moreover, Kreider RB et al (8) studied the effect of 15.75 g/day of creatine monohydrate for 5 days and 5-10 g/day doses over 21 months. A 69 item panel of serum and whole blood (metabolic markers, muscle and liver enzymes, electrolytes, lipid profiles, hematological markers and lymphocytes) and urinary markers were indicated that long-term creatine supplementation does not appear to have adverse effect on health in athletes undergoing intense training in comparison to athletes who do not take creatine.

Some research concluded that creatine supplementation appears safe when used by healthy adults at the recommended loading (20 g/day for 5 days) and maintenance doses ($\leq$ 3 g/day). In people with a history of renal disease or those taking nephrotoxic medications, creatine may be associated with an increased risk of renal dysfunction. Creatine supplementation may increase creatinine levels, it may act as a false indicator of renal dysfunction (69). The similar experiment Pline KA et al. (68) reviewed that creatine supplementation minimally impacts creatinine concentrations and renal function in young healthy adults. Although creatinine concentrations may increase after long periods of creatine supplementation, the increase is extremely limited and unlikely to affect estimates of creatinine clearance and subsequent dosage adjustments.

Liver and kidney dysfunctions have also been suggested on the basis of small changes in markers of organ function and of occasional case reports, but well controlled studies on the adverse effects of exogenous creatine supplementation are almost nonexistent. In addition, mild elevation of plasma creatinine concentration even if absence of creatine supplementation due to large muscle masses, and/or exacerbated with high meat intake, of individuals in some strength sports (27,70-72). Thus, there is no apparent health risk associated with creatine supplementation to healthy people when it is ingested in quantities that have been scientifically proven to increase muscle creatine stores.

8.4 Muscle cramp, muscle strain and muscle injuries

Muscle cramps from creatine supplementation may enhance intramuscular water content and dilute electrolytes (4). Muscle tight may be associated with intracellular swelling could predispose to muscle strains (4). However, anecdotal reports indicated creatine supplementation may lead to muscle cramps and possible muscle strain (27,4).

Even if some researches expressed that creatine supplementation increase muscle cramp. However, Volek JS et al (12) who found that subjects consumed 0.3 g/kg creatine monohydrate or placebo for 7 day in environmental control showed no reports of muscle cramping during supplementation or exercise. The similar experiment studied effect of creatine supplement on incidence of cramping or injury observed during 3 years. Data expressed that creatine supplementation does not appear to increase the incidence of injury or cramping in Division IA college football players (73). Surprisingly, the following research of Michael Greenwood et al (74) expressed that 0.3 g/kg/day for 5 days followed by an average of 0.03 g/kg/day after workouts, practices and games had significant less cramping, muscle tightness, muscle strains and total injuries than nonusers.

In additionally, Watsford ML et al (75) studied effect of creatine supplementation on musculotendinous stiffness. In this study, it was hypothesized that the rapid fluid retention and "dry matter growth" evident after creatine supplementation may cause an increase in musculotendinous stiffness and chance of injury during exercise. Even if, anecdotal evidence suggesting that creatine supplementation causes muscular strain injuries is not supported by this study.

Thus, muscle cramp and injuries is anecdotal report. However, athlete ingested creatine supplementation should consume adequate water and electrolytes (27).

8.5 Heat exhaustion and thermoregulatory

There is no direct evidence that creatine supplementation contributes to the development of dehydration or heat exhaustion. So, researchers attempted to prove effect of creatine supplementation on heat exhaustion and thermoregulatory.

Many researchers were interested to study effect of short-term creatine supplementation such as Mendel RW et al (11), Volek JS et al (12), Kilduff LP et al (13), Weiss BA et al (14), Wright GA et al (15), Branch JD et al (16) and Watson G et al. (76). All researchers found that subjects exercise in heat and ingested creatine supplementation in loading dose 20 g/day for 5 days or 0.3 g/kg/day for 7 days or 20 g/day for 7 days or 20 g/day for 6 days and 21.6 g/day for 7 days showed no significant alterations in core temperature, rectal temperature, mean body temperature, mean skin temperature, sodium and potassium and sweat loss. Moreover, Kilduff LP et al (13) and Mendel RW et al (11) expressed that creatine supplementation reduced rectal temperature and core temperature when compare before received creatine supplementation. However, Wright GA et al (15) determined effect of creatine loading (20 g/day for 6 day) on thermoregulation response and intermittent sprint exercise performance in a hot/humid environment found that core temperature increase, a loss of body water and a relative change in plasma volume after ingested creatine loading when compared before consumption, but there were no significant difference between groups. Moreover, Branch JD et al (16) found that tympanic temperature increased, but similar change were seen in creatine and placebo supplementation.

Therefore, data from many researches expressed that short-term creatine supplementation did not increase the incidence of symptoms or compromise hydration status or thermoregulation in dehydrated exercise in the heat. Though creatine supplementation is not the reason of thermal stress and heat exhaustion, athletes in period of weight control and strenuous exercise in hot environment should avoid creatine supplementation. Particularly, if there is high dose of creatine supplementation (31).

8.6 Cardiovascular

Effect of short-term creatine supplementation on cardiovascular system. There have been a few anecdotal reports. Mihic S et al (67) found that creatine loading 20 g/day for 5 days did not affect blood pressure both systolic and diastolic blood pressure. The similar experiment Volek JS et al (12) examined the influence of 0.3 g/kg/day for 7 days creatine supplementation on acute cardiovascular and fluid-regulatory hormonal responses to exercise for 35 min in the heat found that heart rate, blood pressure responses to exercise were not significantly different between groups. Cortisol, aldosterone, renin, angiotensin I and II, atrial peptide and arginine vasopressin significant increase from exercise. Watson G et al. (76) expressed that subjects consumed creatine monohydrate 21.6 g/day for 7 days in control temperature and relative humidity. Cardiorespiratory system not was altered.

However, Kilduff LP et al (13) examined effect of 20 g/day for 7 days creatine supplementation on cardiovascular and on the capacity of trained humans to perform prolonged exercise in the heat. Result showed reduced cardiovascular response (heartrate). Contrast to Branch JD et al (16) who used cross-over design in creatine loading for 5 days found that heart rate, systolic blood pressure, perceived exertion, lactate, cortisol and aldosterone concentrations to be increased. However, the increases were similar between baseline period, creatine supplementation period and placebo period.

Murphy AJ et al (77) determined the effect of 20 g/day creatine supplementation for 7 days followed by 10 g/day for a further 21 days on cardiovascular structure and function both. They found that there were no changes in any of the echocardiographic or blood pressure measured in either group.

9. Creatine and body composition

Numerous researches studied the effect of creatine supplementation on body composition both short-term and long-term. Branch JD et al (26) revealed 96 English-language, peer-reviewed papers (100 studies) found that creatine supplementation was greater for changes in lean body mass following short-term creatine supplementation.

Mihic S et al (67) found that 20 g/day of creatine supplementation for 5 days increased fat-free mass and total body mass ($P < 0.05$) as compared with placebo group. The observed mass changes were greater for men versus women. Wright GA et al (15) determined the effect of creatine loading (20 g/day for 6 days). Six days of creatine supplementation produced a significant increased in body weight.

Van Loon LJ (27) studied effects of both creatine loading (20 g/day for 5 days) and prolonged supplementation (2 g/day for 6 weeks) on body composition. Result revealed that in creatine group creatine loading increased in body mass 1.2 kg following creatine loading and was maintained after 6 weeks of continued supplementation, the body mass was increased 1.1 kg. Fat mass showed no significant difference within and between groups. Fat-free mass increased after 6 weeks of supplementation in creatine group when compare to baseline. The similar experiment M. Daniel Becque et al (78) examined 20 g/day for 5 days and continued 2 g/day. Body mass and fat-free mass for creatine increased ($P < 0.01$) but no change in placebo group. There were no changes in fat mass and percent body fat for either group. Kutz MR et al (80) found that the effects of 30 g/day creatine monohydrate supplementation for the initial 2 weeks and 15 g/ day for the final 2 weeks increases total body weight, body water content for the creatine group ($P = 0.05$). No significant changes were found in percent body fat in the creatine group. No significant changes were noted for the placebo group. Moreover, numerous researches indicating that creatine supplementation can increase body mass or lean mass and body water in creatine group (12,24,79)

Some researches interest on the effect of resistance training coupled with creatine supplementation, Volek JS et al (82) found that 0.3 g/kg/day of creatine monohydrate while performing resistance exercise (5 days/week for 4 weeks) followed by a 2-week maintenance phase increased body mass and lean body mass in the legs by the end of the 6 weeks period. Moreover, Ferguson TB et al (81) who examined 0.3 g/kg for 7 days and 0.03 g/kg/day for 9 weeks while performing a resistance training program 4 days/week in women trainees. Significant increased ($P < 0.05$) occurred in both groups for lean body mass. The result indicated that creatine supplementation combined with 10 weeks of concurrent resistance training may not improve strength or lean body mass greater than training only.

Additionally, some researchers found that creatine supplementation had no effect on body composition. Chilibeck PD et al (83) found that 0.1 g/kg/day creatine supplementation during 8 weeks reduced body mass (P = 0.05), fat mass (P < 0.05) and a trend for an increase in lean tissue mass (P = 0.07) with no differences between groups. Besides, Silva AJ et al (84) 2007 assessed 20 g/day of creatine monohydrate for 21 days in 16 female swimmers. Results expressed that no differences were found in variables related to body composition between groups.

Francaux M and Poortmans JR (85) studied the effect of creatine supplementation on the size of the extra and intracellular compartments. Subjects were divided into 3 groups consisted of control group, placebo group and creatine group. Both placebo and creatine groups were given strength training program while control group not any training. Control group and placebo showed no change in body mass during the entire experiment period while the body mass of the creatine group was increased by 2 kg. This change can be attributed partially to an increase (P = 0.039) in the body water content (+1.11), and increased (P < 0.001) in the volume of the inter-cellular compartment (+0.61). Nevertheless, the relative volumes of the body water compartments remained constant and therefore the gain in body mass cannot be attributed to water retention, but was probably due to dry matter growth accompanied with a normal water volume.

10. Creatine and physical fitness performance

Creatine supplementation was claimed to be nice for exercise which used very short period of time less than 30 seconds. So, one of the methods to prove efficiency of creatine is physical fitness testing. It consists of muscle strength test, sprinting test, power test and endurance test. Even though, creatine supplementation improve performance, 10 % of people do not response to creatine.

10.1 Creatine and muscle strength

Kilduff LP et al (24) examined effects of 20 g /day of creatine + 140 g/day glucose for 7 days in loading phase and followed by 5 g/day creatine + 35 g/day glucose for 21 days in maintenance phase on body composition after 4 weeks of resistance training. These results indicated that creatine supplementation can increase muscle strength (allied with 4 weeks of strength training) but only in subjects whose estimated creatine uptake and body mass are significantly increased; the greater the creatine uptake in association with increasing body mass, the greater the performance gains. Moreover, many researches assessed the upper body muscle strength such as hand strength and found no conclusive result. Kurosawa et al (100) interested in the effect of 5 g/day for 2 weeks creatine supplementation on high and low intensity grip exercise performance. Subjects trained the non-dominant forearm for 6 sessions/day isometrically to exhaustion. Before and after training, high-intensity (measured in nm/second) and low-intensity grip performances (time to exhaustion using the training protocol) were measured. Significant increases of 20 and 35% in high-intensity grip strength were observed in both the non-trained and trained arms, respectively. They concluded that 2 weeks of creatine enhanced high intensity exercise performance. Mihic S et al (67) found that creatine loading 20 g/day for 5 days did not affect hand grip strength.

10.2 Creatine and agility

Mujuka I et al (28) found that 20 g/day for 6 days creatine supplementation favorably affected consistently faster average 5 meters and 15 meters in creatine group. Similar experiment Skare OC et al (86) who evaluated 20 g/day of creatine supplementation combined with glucose 20 g/day in 18 well trained male sprinters. Results found that creatine supplementation increased the 100 m sprint velocity and reduced the total time of 6 intermittent 60 m sprints.

In addition, some researches expressed that creatine supplementation in short-term had no effect on running velocity both single running and intermittent running (87-89).

10.3 Creatine and cardiovascular fitness

VO_2max is maximal oxygen uptake that indicates performance which uses oxygen while exercise. It is an indicator for endurance. Stroud et al (96) suggested that creatine supplementation may modify substrate utilization and possibly improve performance during prolonged and submaximal exercise. However, numerous researches expressed that creatine had no effect on endurance performance.

Murphy AJ et al (77) demonstrated that creatine ingestion improves submaximal cycling efficiency. Contrast to Balsom et al (98), Barnett et al (99) and Engelhardt M et al (97) studied the effect short-term creatine supplementation on maximal oxygen uptake (VO_2max). Result was found no increase VO_2max and no influence on the cardiovascular system.

10.4 Creatine and anaerobic performance

Numerous researches indicated short-term creatine supplementation increased anaerobic performance (90-91,94-95). However, some study expressed that creatine did not enhance results of the Wingate test. Odland LM et al (93) found that 20 g/day creatine supplementation for 3 days did not make any differences either peak power, mean 10 seconds, mean 30 seconds power output and percent fatigue between the control and the treatment group. Similar results were reported by Hoffman et al (92) examined 6 g of creatine monohydrate/day for 6 days. They found that there is no significant ($P > 0.05$) between the groups or duration differences were observed in peak power, mean power, or total work of three 15 second Wingate Anaerobic power tests. However, the change in the rate of fatigue of total work was significantly ($P <$ 0.05) lower in creatine group than placebo group.

11. Energy system

Each sport uses different energy system depending upon intensity and duration of exercise. Energy system during exercise can be classified into 2 major systems as anaerobic and aerobic.

11.1 Anaerobic energy system can be classified into 2 systems

- Anaerobic alactic system

(ATP-PC system or Phosphagen system or Immediate energy)

Each kilogram of skeletal muscle contains 3 to 8 mmol of ATP and 4 to 5 times more PCr (101). This system supplies energy for metabolism in exercise only 8-10 seconds from ATP accumulate in muscle. However, ATP is used up within 3 seconds. Therefore, PCr deposit in muscle is used to synthesis ATP for ATP turnover. PCr accumulation in body is about 24 mmol/kg which is much higher (x 5) than creatine.

- Anaerobic lactic system

(Glycolysis system or Anaerobic glycolysis or Short term energy)

This energy system is used during 10-15 seconds of exercise following the end of ATP-PC system. Short term energy system will lysis glucose and glycogen in glycolysis and glycogenolysis processes, respectively. At the end of the process cell receives 2 ATP/1 molecule of glucose and lactic acid and supplies energy about 2-3 minutes.

11.2 Aerobic energy system (Oxidative metabolism or Long term energy)

This system lysis glucose, glycogen, triglyceride and amino acid depend on oxygen. The process supplies 36 ATP/1 molecule of glucose or 460 ATP/1 Molecule of triglyceride. However, oxidative metabolism process uses in the long term. So, while aerobic energy system is creating most energy, the body uses immediate energy from anaerobic glycolysis.

Baseball energy supplier consists of 3 energy systems. ATP-PC system is responsible for 80 %, glycolysis 15 % and aerobic 5 % (102). Both baseball and softball use ATP-PC system as the major source of energy because skills of both sports consist of throwing, batting, sprinting and jumping.

12. Effect of creatine supplementation on baseball and softball players

Only one research about the effect of creatine supplementation in both sports could be found. Ayoama R et al (29) studied the effect of 20 g/day for 7 days of creatine loading on muscular strength and endurance of female softball players and found that creatine loading to the trained females did not improve maximal static strength and dynamic peak torque but improved the mean strength and endurance of repeated contraction.

13. Researches about effect of creatine supplementation in Thailand

Pisut Saichundee (103) studied the effect of low dose (10 g/day in 2 divided dose/day) creatine supplementation on 400-meter swimmers and found that the sprinting time in the last 50 meters of 400 meters was less than control group. Moreover, the result in Wingate test comparing between pretest and posttest expressed that creatine group was significantly different from pretest. Thus, creatine supplementation in this study increased the physical performance.

Suwat Luangtrakool (104) studied effect of 20 g/day for 5 days of creatine supplement on muscle performance in Muay Thai athletes. They found that arm Wingate test 30 seconds and 60, 180 and 300 degree/second of isokenetic testing in creatine group increased higher than control group. Except for the 300 degree/second of isokenetic flexion which showed less than control group.

Sirilak Nuttamonwarakul (105) studied double-blind cross-over design of effect of 2 dose of creatine supplementation, 5 g/day and 20 g/day, in males and females. Results showed that two doses of creatine supplementation had no effect on body composition and creatinine level. However, after ingestion of 20 g/day for 5 days subjects increased their anaerobic capacity and decreased their fatigue index. Moreover, both low dose and high dose increased the speed in 50 meters swimming.

CHAPTER IV
MATERIALS AND METHODS

4.1 Experimental design

The method was group-match fashion case-control study. This aimed to examine the effective of creatine supplementation on elite males athletes. The study lasted 59 days and was consisted of two phases, phase I which was classified as weight training with post-exercise snack (Day 0 – Day 31) and followed by phase II, creatine supplement phase (Day 32 – Day 59).

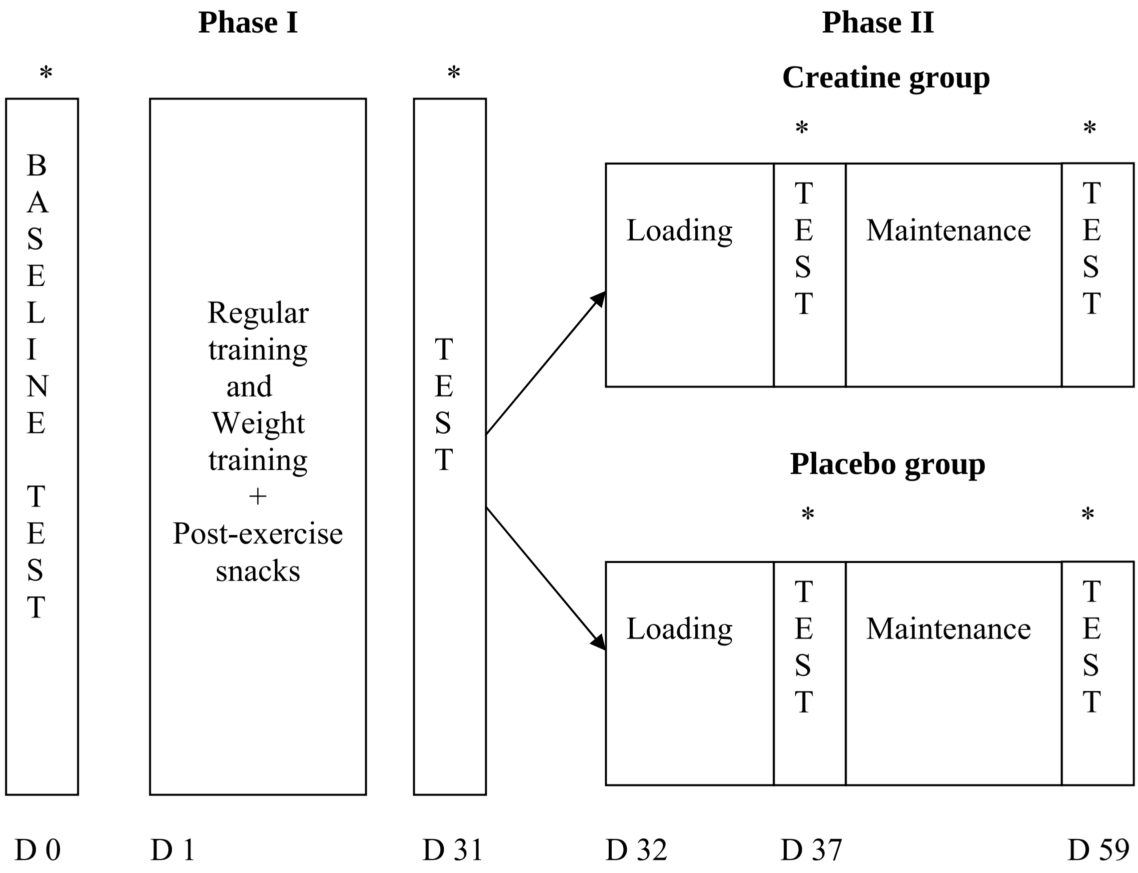
4.2. Subjects

The study was performed in 32 elite males from the baseball and softball players. The participants were aged varies from 16-34 years old, which were selected from professional athletes in Thai National players. The study project was approved by Ethical Clearance Committee on Human Rights related to Faculty of Medicine, Ramathibodi Hospital and Mahidol University.

All subjects had been in weight training routine including diets and sleep conditions. All the subjects had no medical report of illegal drugs and health problems.

4.3 Experimental protocol

All subjects were in the “precompetitive” phase of training, that is, all testing done prior to their competitive season during which the players were taking part in practices and exhibition games. The order and timeline of testing for this study is illustrated in Figure 4.1



* TEST = Physical fitness test, body composition assessment and dietary record

D = day

Figure 4.1 Experimental protocol

4.3.1 Phase I Weight training with post-exercise snack

Baseline Testing

Prior to study, all athletes completed assessment test such as body composition, dietary assessment and physical performance test. There were four core elements to any effective in physical performance test regimen: muscle strength agility, cardiovascular fitness and anaerobic performance.

Weight training program

The basic weight training program was a 9 weeks indoor progressive workout program designed to get the subjects to improve health, vitality and energy levels. Many of the exercises included in the program were machine weight and free weight (Table 4.1-4.2). All subjects practiced weight training 4 days/week and received post-exercise snacks which consisted of 15 g protein, 100 g carbohydrate and 10 g fat. Following 4 weeks of weight training, all subjects returned to the laboratory to complete another series of performance test, body composition and dietary record.

Table 4.1 Muscle and practice of weight training

	Muscle	Practice
Upper body	- Chest	Bench press, Incline bench press
	- Middle back - Lower back	Bent over row Back hyperextension
	- Shoulders	Shoulder press
	- Latissimus dorsi	Lateral pull down
	- Biceps	Biceps curl
	- Triceps	Triceps pushdown
	- Wrist	Wrist curl Reverse wrist curl
	- Abdominal Rectus abdominis External oblique	 Crunches Oblique crunches
Lower body	- Quadriceps	Leg Extension, Half squat
	- Hamstrings	Lying leg curls, Leg press
	- Calves	Calves raise

Table 4.2 Weight training program

	Practice	Weeks 1-3		Weeks 4-6		Weeks 7-9	
		Set	Reps	Set	Reps	Set	Reps
Upper body Monday	-Bench press -Bent over row	3 3	10 10	3 3	8 8	3 3	8 8
	-Shoulder press -Lat pull down	3 3	10 10	3 3	8 8	3 3	8 8
	-Biceps curl -Triceps pushdown	3 3	10 10	3 3	8 8	3 3	8 8
	-Wrist curl -Reverse wrist curl	3 3	10 10	3 3	8 8	3 3	8 8
	-Crunches -Back hyperextension	3 3	15 15	3 3	20 20	3 3	25 25
Upper body Thursday	-Incline bench press -Bent over row	3 3	10 10	3 3	8 8	3 3	8 8
	-Lateral raise -Front raise	3 3	10 10	3 3	8 8	3 3	8 8
	-Biceps curl -Triceps extension	3 3	10 10	3 3	8 8	3 3	8 8
	-Wrist curl -Reverse wrist curl	3 3	10 10	3 3	8 8	3 3	8 8
	-Crunches -Back hyperextension	3 3	15 15	3 3	20 20	3 3	25 25
Lower body Tuesday and Friday	-Leg extension -Leg press	3 3	10 10	3 3	8 8	3 3	8 8
	-Half squat -Lying leg curls	3 3	10 10	3 3	8 8	3 3	8 8
	-Calves raise	3	10	3	8	3	8
	-Oblique crunches	3	15	3	20	3	25

Intensity of each equipment were adjusted every 3 weeks

Weeks 1-3 Strength Intensity 50 % of 1 RM

Weeks 4-6 Strength power Intensity 60 % of 1 RM

Weeks 7-9 Power Intensity 70 % of 1 RM

Rest period between set 2 minutes

(1 RM refers to the maximum amount of weight lifted one time using proper form during a standard weightlifting exercise (101).)

4.3.2 Phase II Creatine supplementation

The players were allocated to two randomly assigned trials: ingesting creatine monohydrated or placebo supplement 4 x 5 g-dose/day for 5 days as a loading phase and 1 x 5 g-dose/day for 21 days as a maintenance phase. The group were matched (creatine group VS placebo group) for subjects VO_2max, weight, height and age. Group-match fashion was chosen to reduce the difference between groups. This amount of creatine has been shown to produce an optimal increase in total concentration of creatine with in muscle. Subjects in the placebo group consumed the same amount of supplement as the creatine group, however, the supplement only included glucose. Subjects mixed their supplement with 250 ml of fruit drink each time it was consumed. Fruit juice was used because it has been found that carbohydrate increases creatine uptake into skeletal muscle. Supplementation compliance was indirectly monitored by verbal communication and subjects were required to return empty bags to ensure compliance. Compliance was 100 %.

Table 4.3 Assessment schedule

Work	Day 0	Day 31	Day 37	Day 59
Inform consent	+			
History	+			
Body composition assessment	+	+	+	+
Physical fitness testing				
Muscle strength - Hand strength test - Leg strength test	+	+	+	+
Agility - Shuttle run test	+	+	+	+
Cardiovascular fitness - Astrand Rhyming test	+	+	+	+
Anaerobic test - Vertical jump test - Wingate anaerobic cycle test	+	+	+	+

4.4 Side effect assessment

Observation studied the incidence and type of side effects by using both supplements on subjects. Side effects were recorded by subjects in questionnaire and also through daily interviews and were evaluated by examination after 5 days loading period and 21 days maintenance periods. We could verify the results by measuring the changes in muscle cramping, stomach distress, diarrheas and etc.

4.5 Dietary assessment

Prior of the study, each subject was provided with specific verbal and written instructions and procedures for reporting detailed dietary, including how to record portions by using household measures and preparation techniques. Subjects were instructed to consume their normal diet during the study. Subjects were required to complete 3 day food diaries. The dietary data derived from the three days food diary was entered into nutritional analysis software program "INMUCAL PROGRAM VERSION WD. 1.0" Modified for Thai food by the Institute of Nutrition, Mahidol University.

4.6 Body Composition

Body composition assessment (Figure 4.2) is an important factor in exercise sciences and weight management (which body composition analysis is gaining popularity as a way to measure health beyond measuring weight alone). Total body mass, height and composition measurements were made on the day 0, day 31, day 37 and day 59 periodically. Body composition was estimated by bioelectrical impedance analysis determining whole body electrical resistance with tetra polar 8 point tactile electrode at frequency 1, 5, 50, 250, 500 and 1000 Khz. bioelectrical impedance analyzer (Inbody 720, Biospace, Seoul, Korea).

Figure 4.2 Body composition assessment

4.7 Physical fitness test

Physical fitness is the result of regular exercise, proper nutrition and rest for physical recovery within the parameters allowed by the genome. Physical fitness test is divided into the following types are muscle strength, agility, cardiovascular fitness and anaerobic performance. This study before subjects were measured physical fitness tests, they were baseline screen consisted of heart rate and blood pressure.

4.7.1 Muscle strength test

Strength is defined as the ability of a muscle group to develop maximal contractile force against a resistance in a single contraction (106).

4.7.1.1 Handgrip strength test

Hand strength test (106) was used to determine the hand and forearm strength measured with handgrip dynamometer T.K.K. 5001 produced by Takei made in Japan. Before using the handgrip dynamometer, adjust the handgrip size to a position that is comfortable for the individual. Alternatively, subjects can measure the hand width with a caliper, and use this value to set the optimum grip size (107). The individual stands erect, with the arms at the sides. The client holds the dynamometer parallel to the side. With the dial facing away from the body, then squeeze the dynamometer as hard as possible without moving the arm (Figure 4.3). Administration two trials, allowing a 1 minute rest between trials and use the best score is used.

4.7.1.2 Leg strength test

Leg strength test (106) was used to determine leg strength measured with back and leg dynamometer T.K.K. S102 produced by Takei made in Japan. The individual stands on the platform with trunk erect and the knees flexed to an angle for 130-140 degree. The client holds the handbar using a pronated grip and positions it across the thighs by adjusting the length of the chain. Without using the back the client slowly but vigorously extends the knees. Administer two trials with a 1-minute rest interval and the best score is used (Figure 4.4).

Figure 4.3 Handgrip strength test

Figure 4.4 Leg strength test

4.7.2 Agility test

- Shuttle run test

Shuttle run test (108) was used to determine the maximum running speed. Subjects starts from behind the first line and, after the starting command runs to the second line, picks up one wooden block, runs back to the first line, and places the wooden block behind the line. The subjects then runs back and picks the second block, carrying it back across the first line. Subjects are allowed two trials and the best score is selected (Figure 4.5). The unit of this test is second.

Figure 4.5 Shuttle run test

4.7.3 Cardiovascular fitness test

- Maximal oxygen uptake (Astrand-rhyming bicycle ergometer submaximal exercise test protocol)

The Astrand-Rhyming protocol (106) is a single stage test used to predict VO_2max from heart rate response to one 6-minute submaximal work load. A power output was selected at a heart rate range between 130-150 beat/min. The initial work load was usually 600 to 900 kpm/min. During the test, the heart rate was measured every minute and the average heart rate was recorded during the 5^{th} and 6^{th} minute. If the difference between these two heart rates exceeds 5 beat/min, the work bout was extended until a steady-state heart rate was achieved (Figure 4.6). The unit for this test is ml/kg/min.

Figure 4.6
Astrand Rhyming test

4.7.4 Anaerobic fitness test

Anaerobic fitness test consisted of vertical jump test and 30-secound Wingate Test (Wingate Anaerobic Cycle Test)

4.7.4.1 Vertical jump test

Vertical jump test (109) was used to measure explosive of leg power with equipment is yardstick. Validity and reliability for this test were 0.78 and 0.93, respectively. Subjects jump as high as possible with three trials (Figure 4.7). A rest period of 10 to 15 second is recommended between trails. The unit of vertical jump test was expressed in centimeters (cm). Moreover, vertical jump displacement was calculated to find power as follow formula:

$$\text{Power (watt)} = 21.67 \times \text{Body weight (kg)} \times \sqrt{\text{Vertical displacement (m)}}$$

Figure 4.7 Vertical jump test

4.7.4.2 Wingate anaerobic cycle test

Since it was first described in 1974, Wingate test has been used more than any other to assess the characteristics of anaerobic performance (110). This test can be performed with a Monark cycle ergometer. The subject is instructed to pedal as fast as possible for 30 seconds (Figure 4.8). The resistance is adjusted in about 3 to 4 second, after which the revolution counter are activated for a period of exactly 30 seconds (110). 30-second Wingate test interpreted result of anaerobic power as the highest power output observed during the first 5 second of exercise. This test indicates the energy generating capacity of the immediate energy system (ATP-PC system) and the anaerobic capacity is the total work accomplished in 30 seconds. The unit for this test is expressed in Watt/kg.

Figure 4.8 Wingate anaerobic cycle Test

4.8 Statistical analysis

Statistical analysis was performed by the use of the Statistical Package for the Social Sciences (SPSS) for Windows software, version 13.0 (SPSS Inc, Chicago, Illinois, USA).

Results were prescribed as mean ± SD. The paired student t-test was used to assess the difference before (Day 0) and after (Day 31) the study. Differences between groups were tested by the unpaired t-test. One-way repeated-measure analysis of variance was used to test for significant difference between Day 31 value and values at other times (Day 37, Day 59). P-value of less than 0.05 was considered significant.

CHAPTER V
RESULTS

PART I Effects of weight training with post-exercise snack supplementation

5.1 General characteristic of the participants

Thirty-two athletes were recruited in this study. The position of baseball players consisted of 12 infielders, 6 outfielders, 8 pitchers and 6 catchers. Their age range of them was 16-34 years (23.50 ± 5.24 years). Their weight and height ranges were 52.00-98.20 kg (69.37 ± 11.41 kg), 159-180 cm (172.47 ± 5.05 cm), respectively. All athletes were Thai National baseball and softball players in Asian Game 2006 and 24 th SEA game 2007.

5.2 Body Composition

During the 4 weeks of weight training with post-exercise snack supplement, there was no significant difference in body composition parameters. However, the means of protein and skeletal muscle mass tended to be slightly increased whereas fat mass and percentage of body fat tended to be slightly decreased after weight training with supplementation of post-exercise snacks (Table 5.1).

5.3 Dietary intake

Before the study, the average daily macronutrient intake were carbohydrate 52 %, protein 17 % and fat 31 % and energy intake was 1,852 kcal. After weight training with post-exercise snack supplementation for 4 weeks, average daily macronutrient intake were carbohydrate 54 %, protein 16 % and fat 30 % and energy intake was 2,105 kcal. There were significant increases in their energy (kcal), protein (g/d and g/kg/d) and carbohydrate (g/d and g/kg/d) intakes after weight training with post-exercise snack supplement (Table 5.2 and Figure 5.1).

Vitamin and mineral intake are shown in Table 5.3 and Figure 5.2. During the 4 week of weight training with post-exercise snacks, there were no significant changes in their calcium, iron, vitamin B1, C and niacin intake. All participants tended to consume less calcium than DRI (Dietary reference intake). The mean calcium intake for all athletes was 319.50 $\pm$ 133.21 mg/day. However, the iron, vitamin B1 and niacin intake reached requirements. There were significant decreases of vitamin A and B2 intake after 4 weeks of weight training with post-exercise snack supplement.

5.4 Physical fitness performance

Muscle strength

Measure strength and power consisted of handgrip strength and leg strength. There were no significant increase in the handgrip strength and leg strength during 4 weeks of weight training (Table 5.4).

Agility

Agility was reported according to the time of shuttle run test. The tendency was for all players who were performed to improve time of shuttle run test. There was a significant decrease in the runtime for shuttle run test after weight training with post-exercise snack supplement (Table 5.4 and Figure 5.3).

Cardiovascular fitness

Maximal oxygen uptake (Astrand-Rhyming Bicycle Ergometer Submaximal Exercise Test, VO_2max) is used to determine the cardiovascular fitness. There was a significant increase in VO_2max from 40.85 $\pm$ 7.54 to 43.05 $\pm$ 8.02 ml/kg/min after weight training with post-exercise snack supplement for 4 weeks (Table 5.4 and Figure 5.4).

Anaerobic performance

Anaerobic performance test consisted of vertical jump test and Wingate anaerobic cycle test. There were no significant increases in the vertical jump, power of vertical jump, anaerobic power and anaerobic capacity during 4 weeks of weight training with post-exercise snack program. However, vertical jump and power of vertical jump tended to be increased after weight training session (Table 5.4).

Table 5.1 Body composition measurements (mean ± S.D.) during weight training (Day 0-Day 31) session

Parameters	Before weight training (Day 0) (n = 32)	After weight training (Day 31) (n = 32)
Body weight (kg)	69.37 ± 11.41	69.27 ± 10.76
Total body water (l)	42.85 ± 4.98	42.97 ± 4.65
Intracellular water (l)	27.39 ± 3.38	27.57 ± 3.07
Extracellular water (l)	15.46 ± 1.66	15.41 ± 1.63
Body protein mass (kg)	11.84 ± 1.47	11.92 ± 1.33
Skeletal muscle mass (kg)	33.71 ± 4.42	33.95 ± 4.01
BMI (kg/m^2)	23.25 ± 3.07	23.18 ± 2.90
Fat free mass (kg)	58.64 ± 6.93	58.85 ± 6.45
Fat free mass index (kg/m^2)	19.68 ± 1.80	19.72 ± 1.65
Fat mass (kg)	10.73 ± 5.29	10.42 ± 5.03
Percent body fat (%)	14.85 ± 4.92	14.45 ± 4.69

All values are expressed as mean ± S.D., n = number of subjects.

Table 5.2 Daily nutrient intakes (mean ± S.D.) during weight training (Day 0-Day 31) session

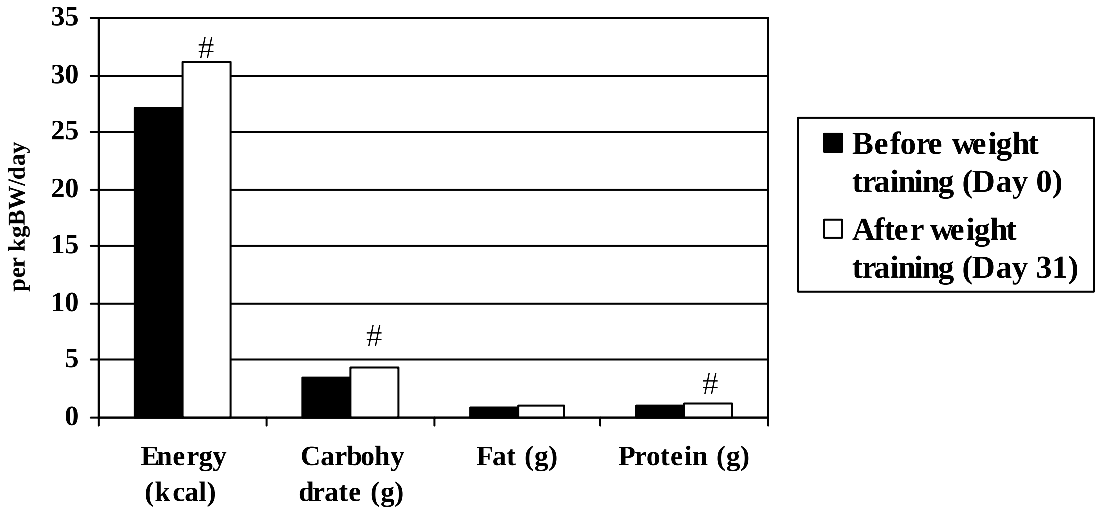
Parameters	Before weight training (Day 0) (n = 32)	After weight training (Day 31) (n = 32)
Energy (kcal)	1852.30 ± 458.16	2105.31 ± 427.41 #
Carbohydrate (g/day)	243.20 ± 62.65	289.88 ± 73.21 #
Carbohydrate (g/kg/day)	3.57 ± 1.02	4.30 ± 1.31 #
Carbohydrate distribution (%)	52.47 ± 5.76	54.14 ± 6.32
Fat (g/day)	64.00 ± 19.66	70.43 ± 21.60
Fat (g/kg/day)	0.93 ± 0.28	1.03 ± 0.32
Fat distribution (%)	30.84 ± 4.46	29.65 ± 5.39
Protein (g/day)	76.97 ± 20.97	84.38 ± 13.33 #
Protein (g/kg/day)	1.13 ± 0.34	1.25 ± 0.27 #
Protein distribution (%)	16.68 ± 2.71	16.21 ± 2.80

All values are expressed as mean ± S.D., n = number of subjects, # Significant difference from Day 0, $P < 0.05$.

Table 5.3 Vitamin and mineral intake (mean ± S.D.) during weight training (Day 0-Day 31) session

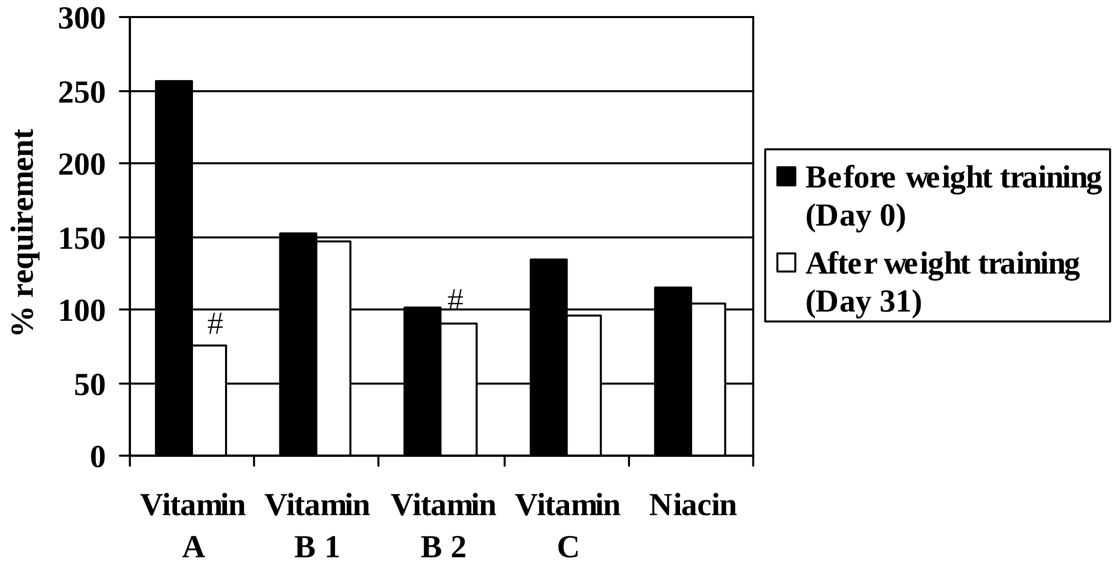
Parameters	Before weight training (Day 0) (n = 32)	After weight training (Day 31) (n = 32)	Reference Thai RDI
Vitamin A (RE/day)	1790.46 ± 2749.55	531.74 ± 622.71#	700
Vitamin B1 (mg/day)	1.83 ± 0.82	1.76 ± 0.71	1.20
Vitamin B2 (mg/day)	1.31 ± 0.43	1.17 ± 0.35 #	1.30
Vitamin C (mg/day)	121.22 ± 109.55	86.52 ± 76.35	90
Niacin (mg/day)	18.31 ± 5.14	16.61 ± 4.02	16
Calcium (mg/day)	319.50 ± 133.21	354.31 ± 148.64	800-1000
Iron (mg/day)	14.60 ± 13.13	12.16 ± 3.15	10.40-16.60

All values are expressed as mean ± S.D., n = number of subjects, # Significant difference from Day 0, $P < 0.05$



Significantly different from before weight training (Day 0)

Figure 5.1 Energy intake (kcal/kg/day), carbohydrate, fat and protein intake (g/kg/day) between before weight training (Day 0) and after weight training (Day 31) session.



Significantly different from before weight training (Day 0)

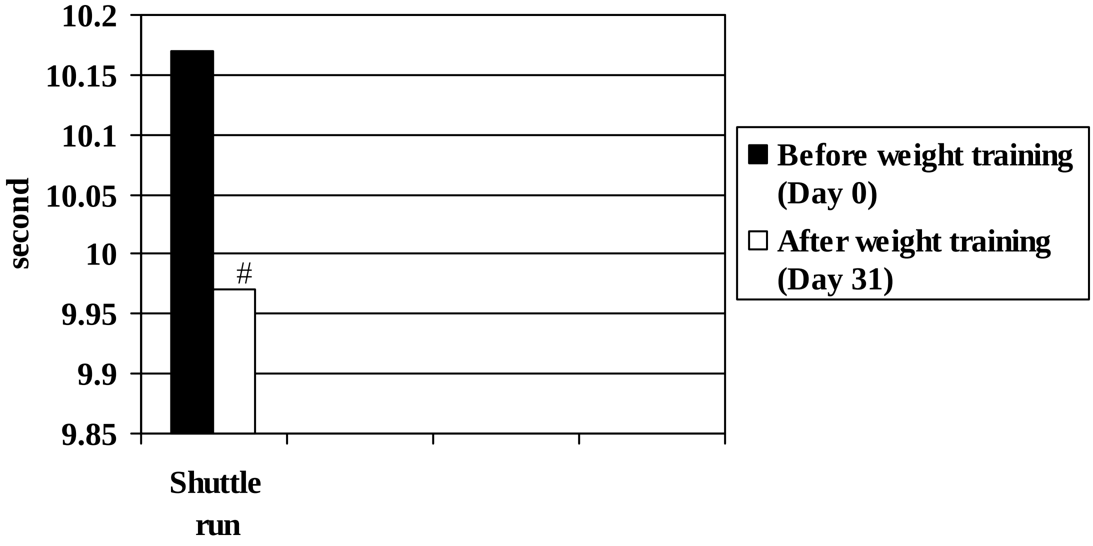
Figure 5.2 Vitamin intake between before weight training (Day 0) and weight training (Day 31) session.

Table 5.4 Physical fitness performance (means ± S.D.) during weight training (Day 0 - Day 31) session

Parameters	Before weight training (Day 0) (n = 32)	After weight training (Day 31) (n = 32)
Muscle strength		
- Hand grip strength (kg/BW)	0.67 ± 0.10	0.68 ± 0.09
- Leg strength (kg/BW)	3.62 ± 0.77	3.57 ± 0.78
Agility		
- Shuttle run (sec)	10.17 ± 0.36	9.97 ± 0.45 #
Cardiovascular fitness		
- VO_2max (ml/kg/min)	40.85 ± 7.54	43.05 ± 8.02 #
Anaerobic performance		
- Vertical jump (cm)	53.41 ± 5.77	54.72 ± 6.41
- Power of vertical jump (watt)	1096 ± 182	1106 ± 172
- Anaerobic power (watt/kg)	11.75 ± 1.07	11.67 ± 0.74
- Anaerobic capacity (watt/kg) x	8.57 ± 0.69	8.52 ± 0.77

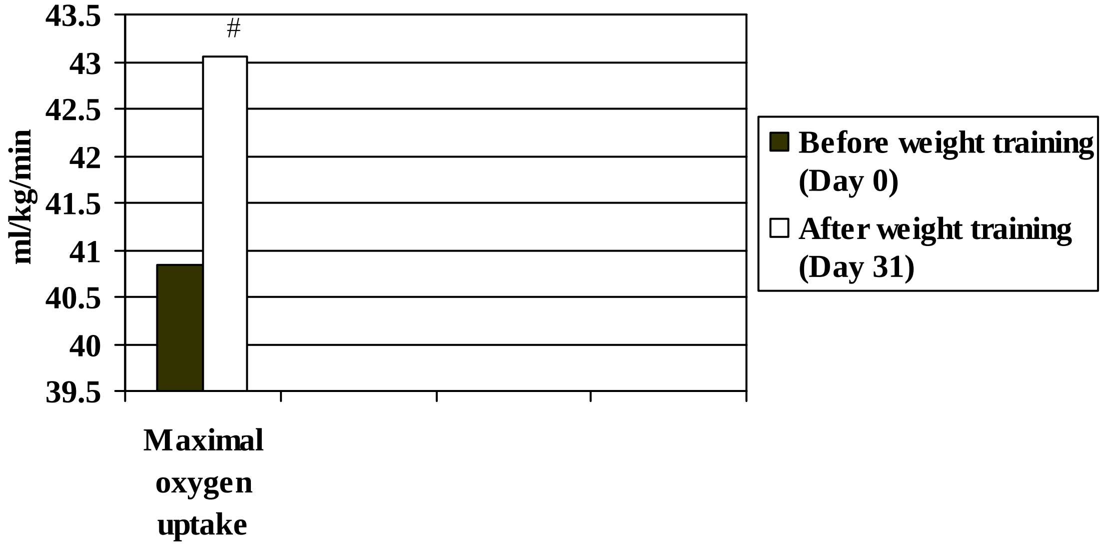
All values are expressed as mean ± S.D., n = number of subjects, x n = 31,

Significantly different from Day 0, $P < 0.05$.



Significantly different from before weight training (Day 0)

Figure 5.3 Shuttle run between before weight training (Day 0) and after weight training (Day 31) session



Significantly different from before weight training (Day 0)

Figure 5.4 Maximal oxygen uptake (VO_2max) between before weight training (Day 0) and after weight training (Day 31) session

PART II Effects of creatine supplementation (Day 37 and Day 59)

5.5 Body composition

The physical characteristics of the two groups of subjects are presented in Table 5.5 and Figure 5.5-5.6. There were no significant differences between groups in body mass or any of the body composition measurements pre-supplementation. In the creatine group, mean body mass increased 0.75 ± 0.17 kg after 5 days (loading period) and 1.08 ± 0.29 kg after 4 weeks of supplementation and training (maintenance period) (Figure 5.15). In placebo group, mean body mass increased 0.47 ± 0.33 kg after loading and 0.64 ± 0.64 kg after maintenance periods (Figure 5.15). The magnitude of change in body mass was greater in the creatine group over the 3 weeks when compared to the placebo group, but there was no difference following the loading and maintenance periods. As with the creatine as a whole, there was a significant increase in body mass following loading and maintenance. The gain in body mass over the loading and maintenance periods was no significantly greater in the creatine compared to the placebo group.

In creatine group, total body water (TBW), intracellular water (ICW) and extracellular water (ECW) increased after loading and maintenance (Table 5.5 and Figure 5.6-5.8, 5.15). There was no change in TBW, ICW and ECW in placebo group after loading and maintenance. The magnitude of change in TBW and ICW was greater in the creatine group compared to the placebo group over the 3 weeks of study. The gain in TBW, ICW and ECW over the loading and maintenance periods was no significant greater in the creatine compare to the placebo group.

In creatine group, body protein mass, skeletal muscle mass, fat free mass and fat free mass index increased after loading and maintenance (Table 5.5 and Figure 5.9 -5.14, 5.16-5.17), while in the placebo group, these parameters were not different from pre-supplementation. The gain in body protein mass, skeletal muscle mass, fat free mass over the loading and maintenance periods were not significantly greater in the creatine compared to the placebo group.

5.6 Dietary intake

Table 5.6 and 5.7 shows daily nutrient intakes and vitamin and mineral intakes in creatine group and placebo group during loading and maintenance period. There was a significant difference between groups in the iron intake at post-maintenance. However, both daily macronutrient intake and any vitamin and mineral intake were not significantly different between creatine group and placebo group.

5.7 Physical fitness performance

Table 5.8 shows physical fitness performance in creatine group and placebo group during loading and maintenance periods. Comparison of the percentage change in physical fitness performance parameters of pre-supplementation to loading period, pre-supplementation to maintenance period and loading to maintenance period between creatine and placebo group was shown in Figure 5.19-5.22.

Muscle strength

There was no difference between groups at pre-supplementation for handgrip strength and leg strength test. The handgrip strength and leg strength tended to be increased in both groups during the study periods but no differences were detected between the creatine and placebo groups. There was no significant difference in the change in performance between the two groups for the hand grip strength and leg strength (Table 5.8).

Agility

There was a significant difference between groups at pre-supplementation for the shuttle run test. However, there was no significant decrease in the runtime for shuttle run test from pre-supplementation in both groups during the study periods. There was no significant difference in the change in performance between the two groups for the shuttle run test (Table 5.8).

Cardiovascular fitness

There was no difference between groups at pre-supplementation for VO_2max. VO_2max tended to be decreased in both groups during the study periods but no difference was detected between the creatine and placebo group. There was no significant difference in the change in performance between the two groups for the VO_2max (Table 5.8).

Anaerobic performance

There was no difference between groups at pre-supplementation for the vertical jump and power of vertical jump. Vertical jump tended to be increased in creatine groups during the study periods but no difference was detected between the creatine and placebo group. In creatine group, average power of vertical jump increase 35.92 $\pm$ 50.14 watt after maintenance period and significant increase when compared to pre-supplementation (Table 5.8 and Figure 5.18), no increase in power of vertical jump was found in the placebo group. There was a significant difference change in power of vertical jump between the two groups (1.33 $\pm$ 2.33 watt in creatine group VS -0.51 $\pm$ 2.61 watt in placebo group) when compared from post-loading to post-maintenance period (Figure 5.19).

There was a significant difference between groups at pre-supplementation for anaerobic power (Table 5.8). Anaerobic power tended to be increased in both groups during the study periods but no difference was detected between the creatine and placebo group. There was no significant difference in the change in performance between the two groups for the anaerobic power.

There was no difference between groups at pre-supplementation for anaerobic capacity. There was no significant increase in anaerobic capacity from pre-supplementation in both groups during the study periods (Table 5.8). There was no significant difference in the change in performance between the two groups for the anaerobic capacity.

5.8 Side effects

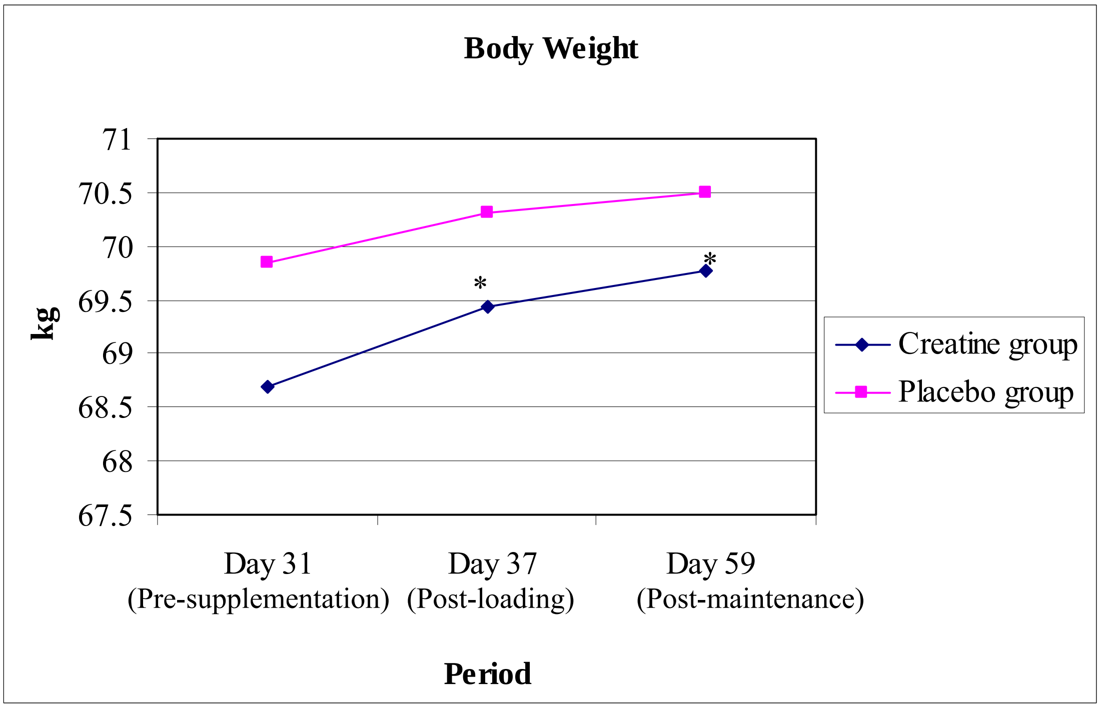
Side effects of creatine supplementation were reported as number of subjects and percentage. Side effects of creatine loading and maintenance are shown in Table 4.9 and 4.10, respectively. During high level of creatine loading period, creatine group had 18.8 % of exhaustion, 12.5 % of stomachache, 25 % of diarrhea, 6.3% of aggressiveness, 18.8 % of altered appetite and 12.5 % of increased thirsty (Figure

5.23). Moreover, side effect on muscle in creatine supplement group showed 12.5 % of muscle cramp, 18.8 % of muscle soreness and 25 % of muscle tightness (Figure 5.23). In placebo group, the only side effect of muscle during high level was muscle tightness present in 6.3 %. Exhaustion, stomach ache and diarrhea during high level of creatine maintenance period were lower than creatine loading period, whereas muscle soreness and muscle tightness in maintenance period were decreased from loading period and there was no muscle cramp (Figure 5.24-5.25).

Table 5.5 Body composition changes (mean ± S.D) during post-loading (Day 37) and post-maintenance periods (Day 59) in creatine group and placebo group

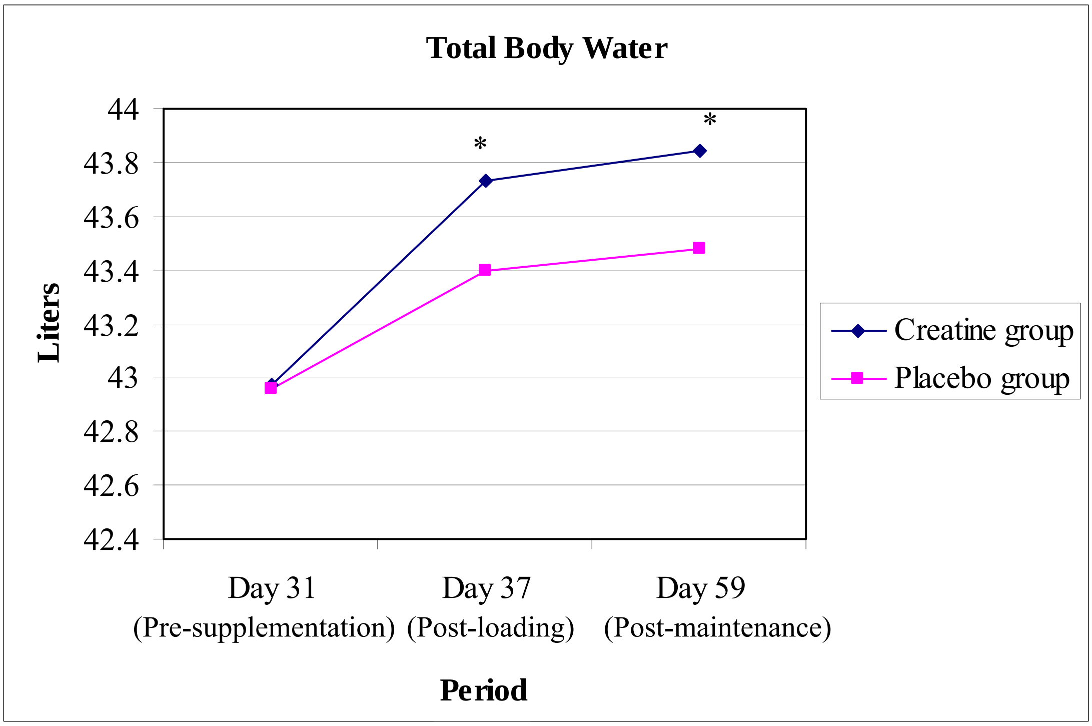
Parameters	Creatine group (n = 16)			Placebo group (n = 16)		
	Pre Supplementation (Day 31)	Post loading (Day 37)	Post maintenance (Day 59)	Pre supplementation (Day 31)	Post loading (Day 37)	Post maintenance (Day 59)
Body weight (kg)	68.69 ± 8.78	69.44 ± 8.61*	69.77 ± 8.49*	69.85 ± 12.71	70.32 ± 13.04	70.49 ± 13.35
Total body water (l)	42.97 ± 3.89	43.73 ± 3.72*	43.84 ± 3.71*	42.96 ± 5.44	43.40 ± 5.61	43.48 ± 5.92
Intracellular water (l)	27.56 ± 2.46	28.00 ± 2.43*	28.23 ± 2.36*	27.57 ± 3.67	27.77 ± 3.64	27.83 ± 3.88
Extracellular water (l)	15.42 ± 1.46	15.72 ± 1.33*	15.61 ± 1.40	15.39 ± 1.83	15.64 ± 2.04	15.64 ± 2.09
Body protein mass (kg)	11.91 ± 1.07	12.09 ± 1.05*	12.20 ± 1.03*	11.91 ± 1.59	12.00 ± 1.57	12.04 ± 1.68
Skeletal muscle mass (kg)	33.94 ± 3.22	34.50 ± 3.15*	34.82 ± 3.09*	33.96 ± 4.78	34.20 ± 4.77	34.29 ± 5.04
BMI (kg/m^2)	22.98 ± 2.29	23.23 ± 2.26*	23.33 ± 2.14*	23.39 ± 3.48	23.54 ± 3.55	23.58 ± 3.62
Fat free mass (kg)	58.86 ± 5.33	59.85 ± 5.14*	60.09 ± 5.10*	58.84 ± 7.58	59.33 ± 7.76	59.46 ± 8.17
Fat free mass index (kg/m^2)	19.72 ± 1.35	20.05 ± 1.34*	20.11 ± 1.18*	19.73 ± 1.95	19.90 ± 2.00	19.91 ± 2.07
Fat mass (kg)	9.83 ± 3.82	9.59 ± 3.97	9.68 ± 3.96	11.01 ± 6.08	10.99 ± 6.23	11.03 ± 6.09
Percentage body fat (%)	13.87 ± 4.10	13.36 ± 4.43	13.44 ± 4.39	15.03 ± 5.29	14.83 ± 5.40	14.91 ± 5.15

All values are expressed as mean ± S.D., * Significantly different from day 31 within group, at $P < 0.05$



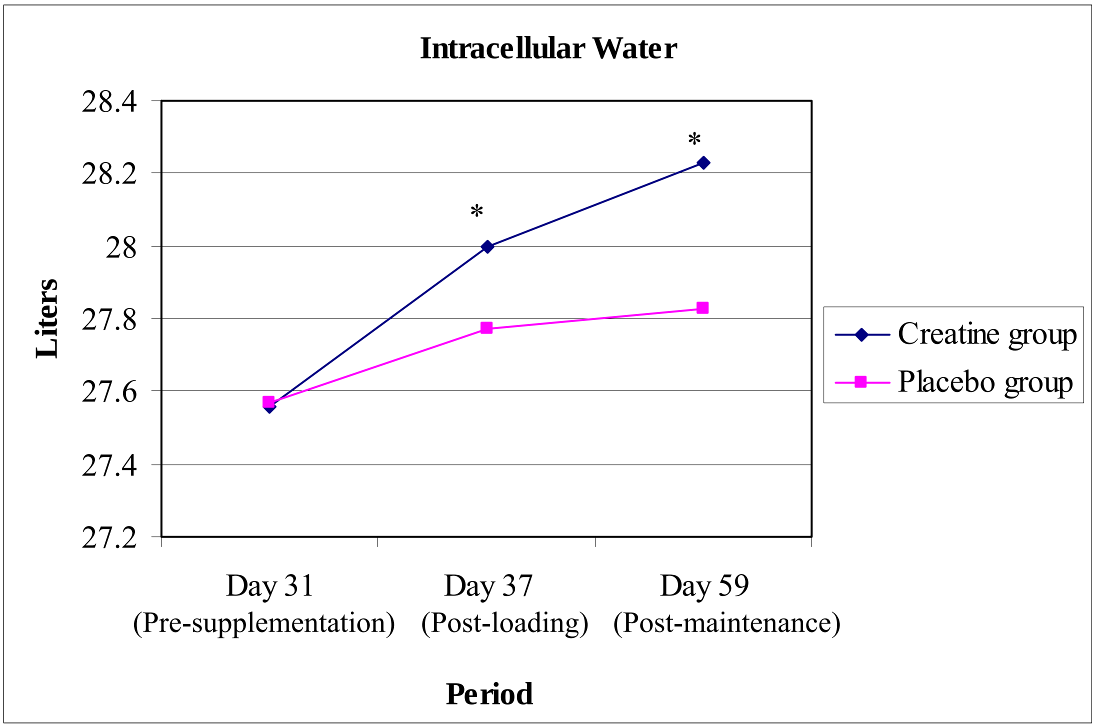
* Significantly different from pre-supplementation (Day 31)

Figure 5.5 Body weight during the study period



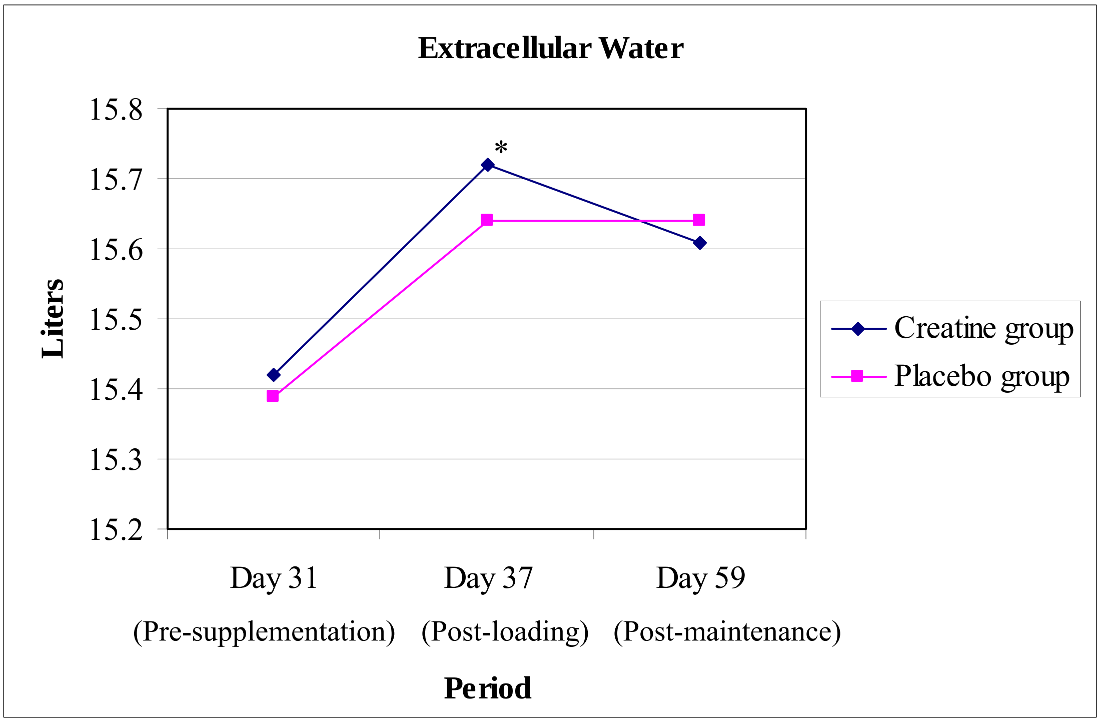
* Significantly different from pre-supplementation (Day 31)

Figure 5.6 Total body water during the study period



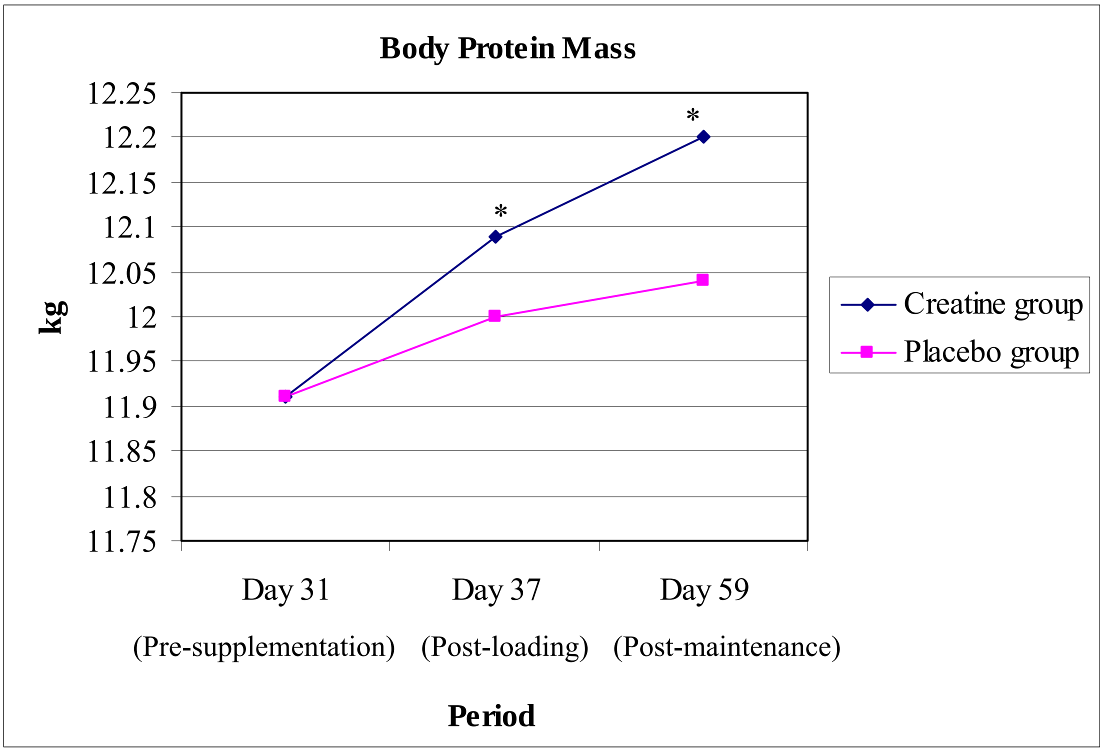
* Significantly different from pre-supplementation (Day 31)

Figure 5.7 Intracellular water during the study period



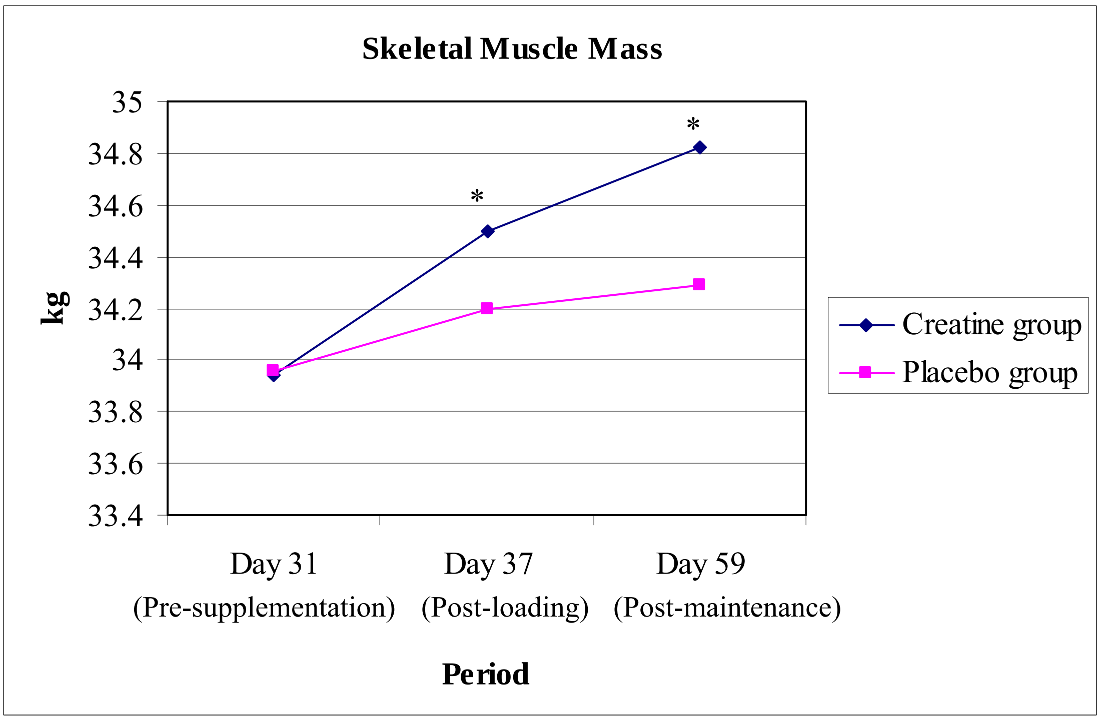
* Significantly different from pre-supplementation (Day 31)

Figure 5.8 Extracellular water during the study period



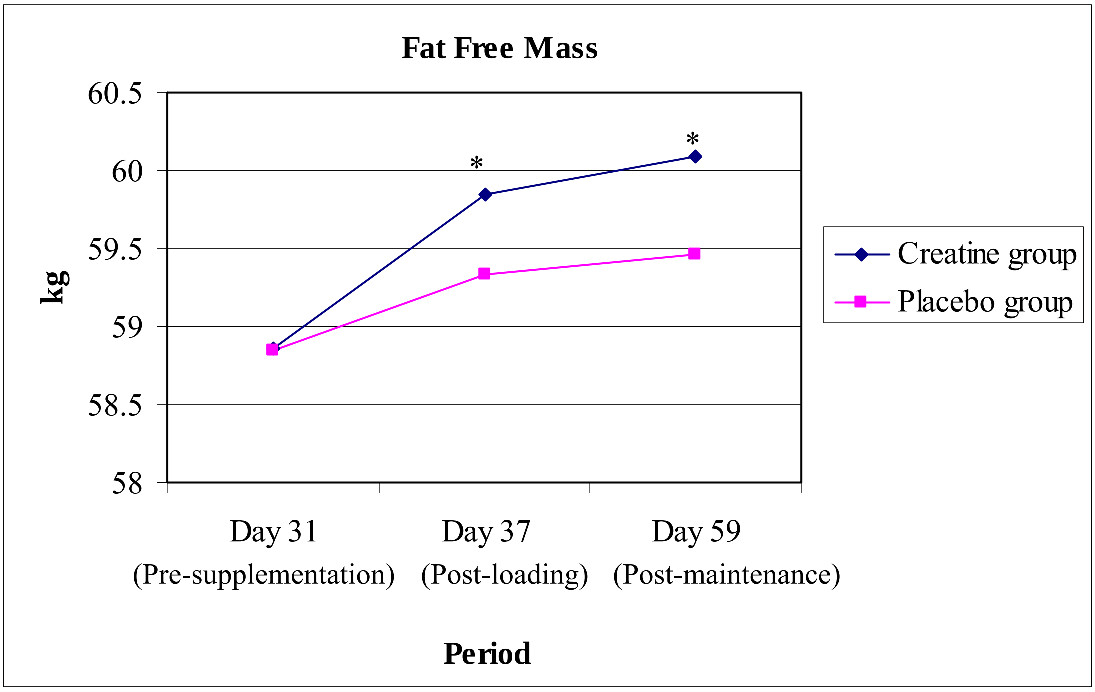
* Significantly different from pre-supplementation (Day 31)

Figure 5.9 Body protein mass during the study period



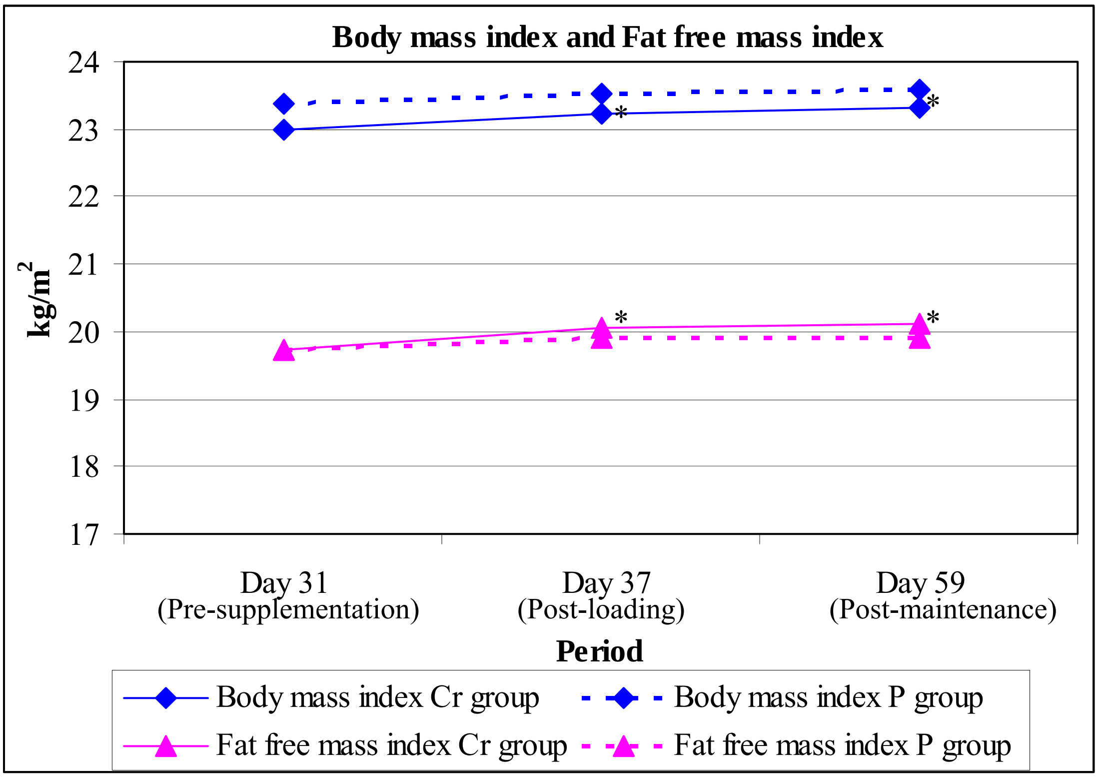
* Significantly different from pre-supplementation (Day 31)

Figure 5.10 Skeletal muscle mass during the study period



* Significantly different from pre-supplementation (Day 31)

Figure 5.11 Fat free mass during the study period



* Significantly different from pre-supplementation (Day 31)

Figure 5.12 Body mass index and fat free mass index during the study period

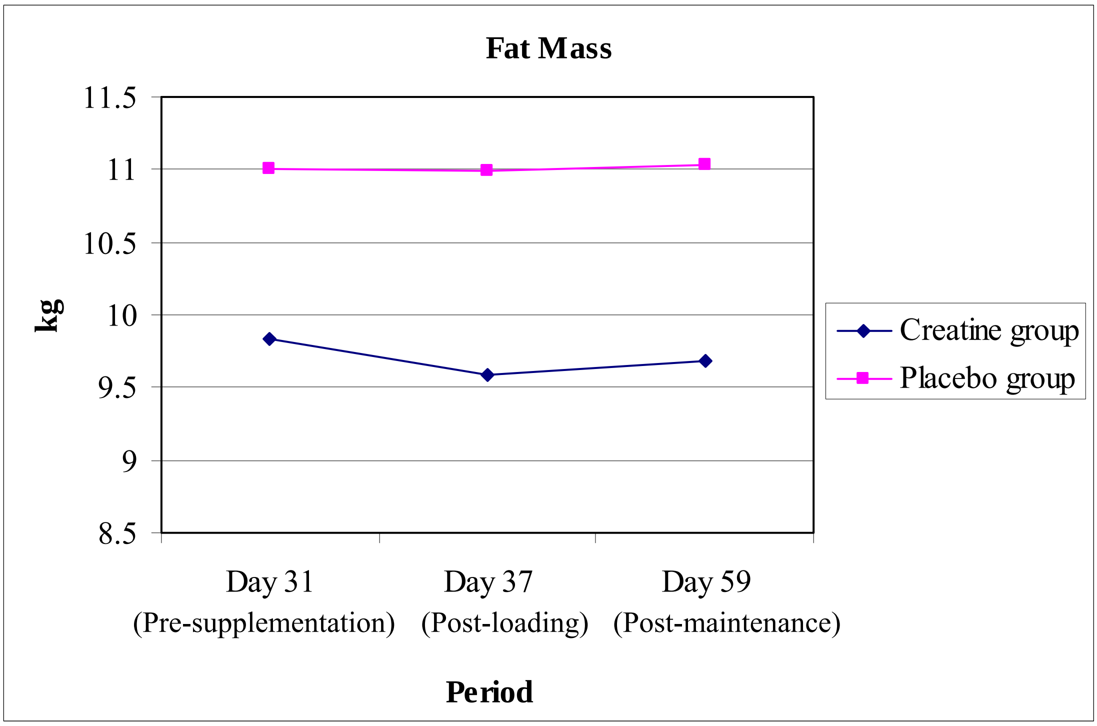


Figure 5.13 Fat mass during the study period

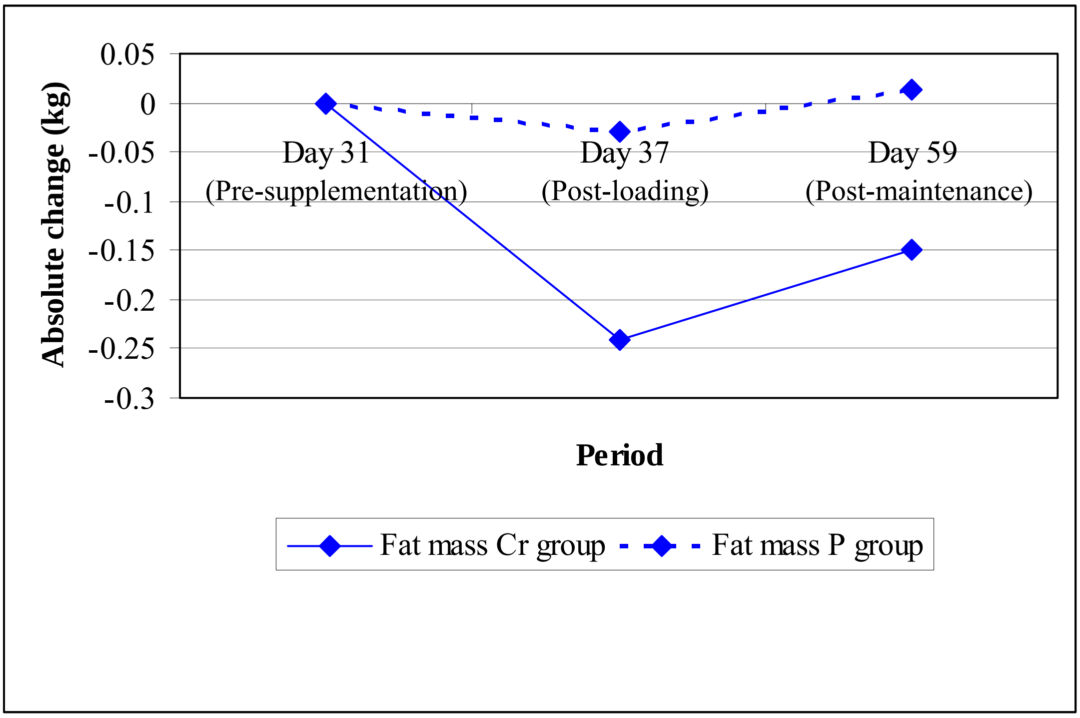


Figure 5.14 Absolute changes in fat mass

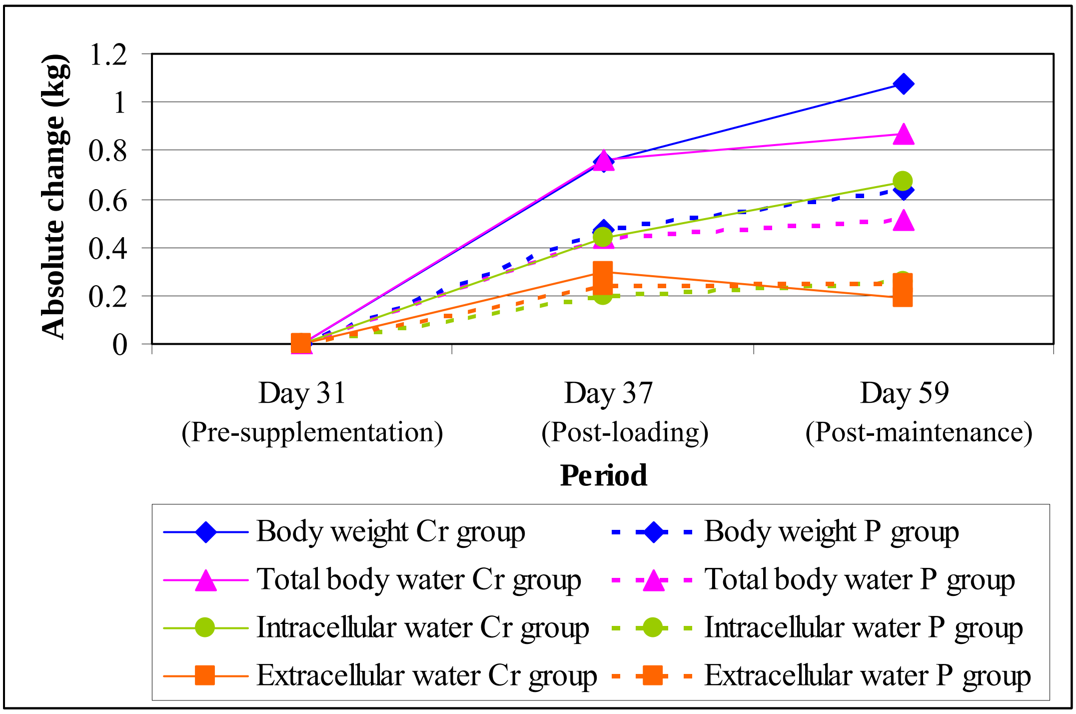


Figure 5.15 Absolute changes in body weight, total body water (TBW), intracellular water (ICW) and extracellular water (ECW) during the study period

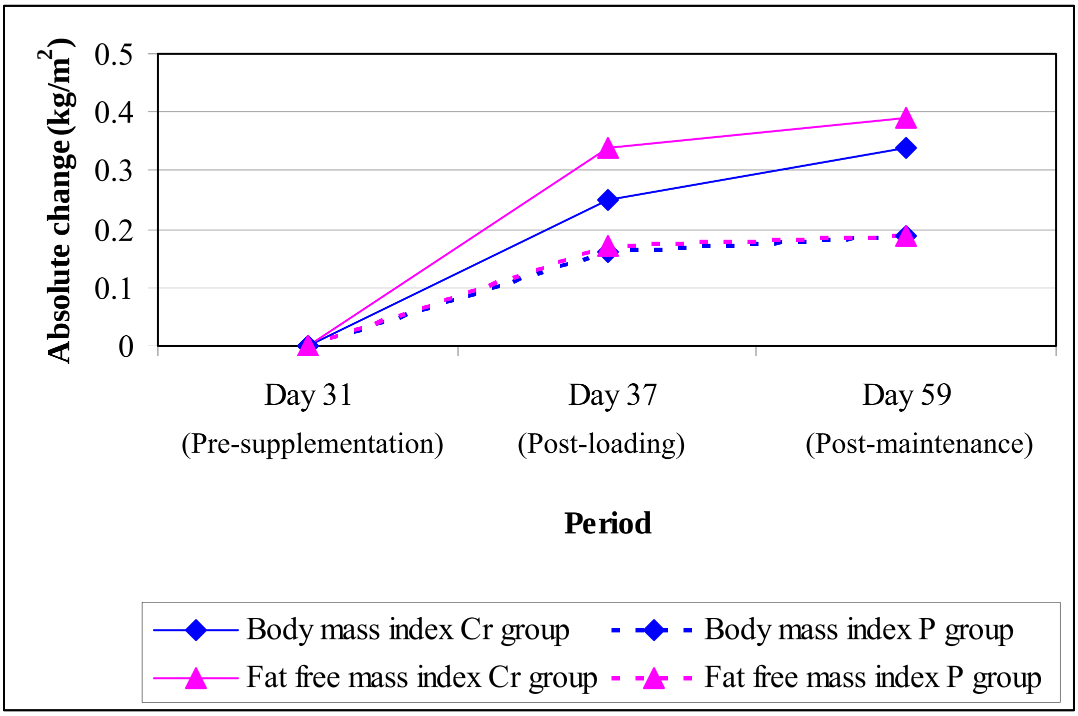


Figure 5.16 Absolute changes in body mass index (BMI), fat free mass index (FFMI) during the study period

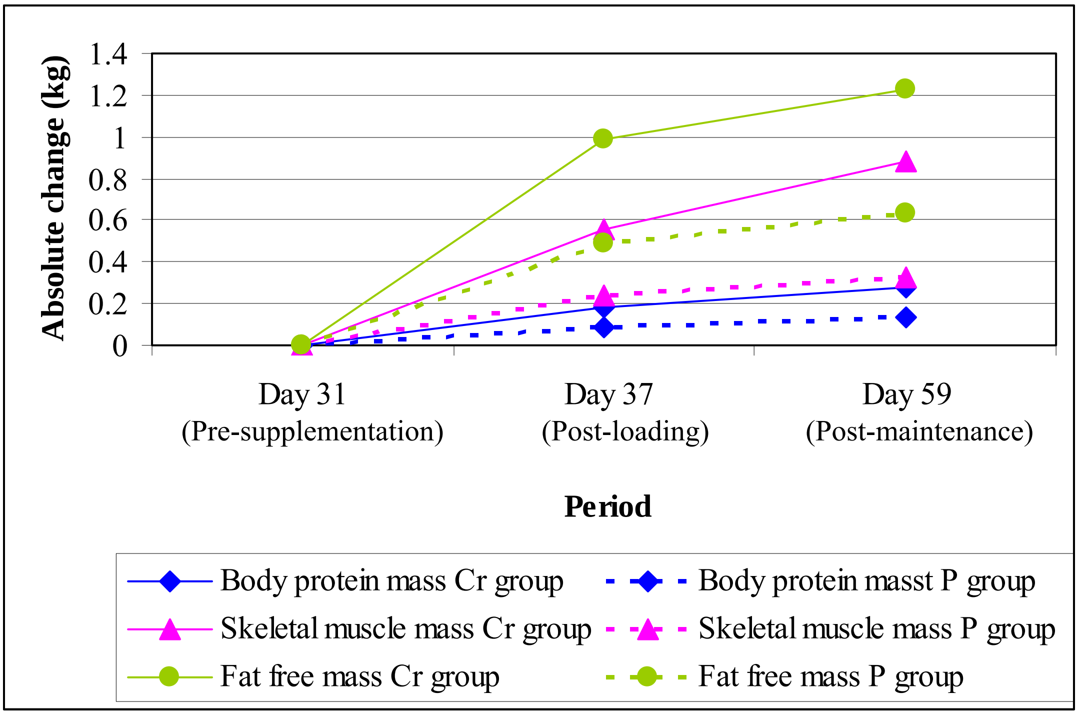


Figure 5.17 Absolute changes in body protein mass, skeletal muscle mass and fat free mass during the study period

Table 5.6 Daily nutrient intakes (mean ± S.D.) during post-loading (Day 37) and post-maintenance (Day 59) periods in creatine group and placebo group

Parameters	Creatine group (n = 16)			Placebo group (n = 16)		
	Pre Supplementation (Day 31)	Post loading (Day 37)	Post maintenance (Day 59)	Pre supplementation (Day 31)	Post loading (Day 37)	Post maintenance (Day 59)
Energy (kcal)	2175 ± 411	2051 ± 393	2181 ± 477	2035 ± 445	1911 ± 388	2457 ± 634 $^{\pi}$
Carbohydrate(g/day)	298.54 ± 61.21	270.76 ± 58.38	291.11 ± 82.97	281.23 ± 84.68	249.67 ± 43.08	320.97 ± 81.82 $^{\pi}$
Carbohydrate (g/kg/day)	4.43 ± 1.11	3.98 ± 1.10	4.26 ± 1.39	4.18 ± 1.50	3.65 ± 0.82	4.65 ± 1.29 $^{\pi}$
Carbohydrate distribution (%)	54.32 ± 5.79	52.22 ± 5.41	52.65 ± 8.43	53.96 ± 7.00	52.30 ± 7.02	53.87 ± 9.47
Fat (g/day)	75.05 ± 25.21	70.78 ± 18.42	78.81 ± 25.58	65.81 ± 16.82	65.41 ± 22.51	78.78 ± 24.84
Fat (g/kg/day)	1.10 ± 0.33	1.05 ± 0.36	1.15 ± 0.41	0.97 ± 0.29	0.95 ± 0.34	1.12 ± 0.27
Fat distribution (%)	30.24 ± 5.74	30.55 ± 5.13	31.99 ± 6.84	29.06 ± 5.14	29.96 ± 5.97	29.04 ± 7.79
Protein (g/day)	83.53 ± 13.77	89.06 ± 23.48	82.79 ± 18.16	85.23 ± 13.27	86.23 ± 24.09	101.26 ± 39.78
Protein (g/kg/day)	1.23 ± 0.24	1.32 ± 0.45	1.22 ± 0.36	1.26 ± 0.30	1.25 ± 0.34	1.43 ± 0.50
Protein distribution (%)	15.43 ± 2.76	17.22 ± 3.31	15.36 ± 3.37	16.98 ± 2.70	17.74 ± 2.40	17.09 ± 4.03

All values are expressed as mean ± S.D., $^{\pi}$ Significantly different from day 37 within group, at $P < 0.05$.

Table 5.7 Vitamin and mineral intakes (mean ± S.D.) during post-loading (Day 37) and post-maintenance (Day 59) periods in creatine group and placebo group

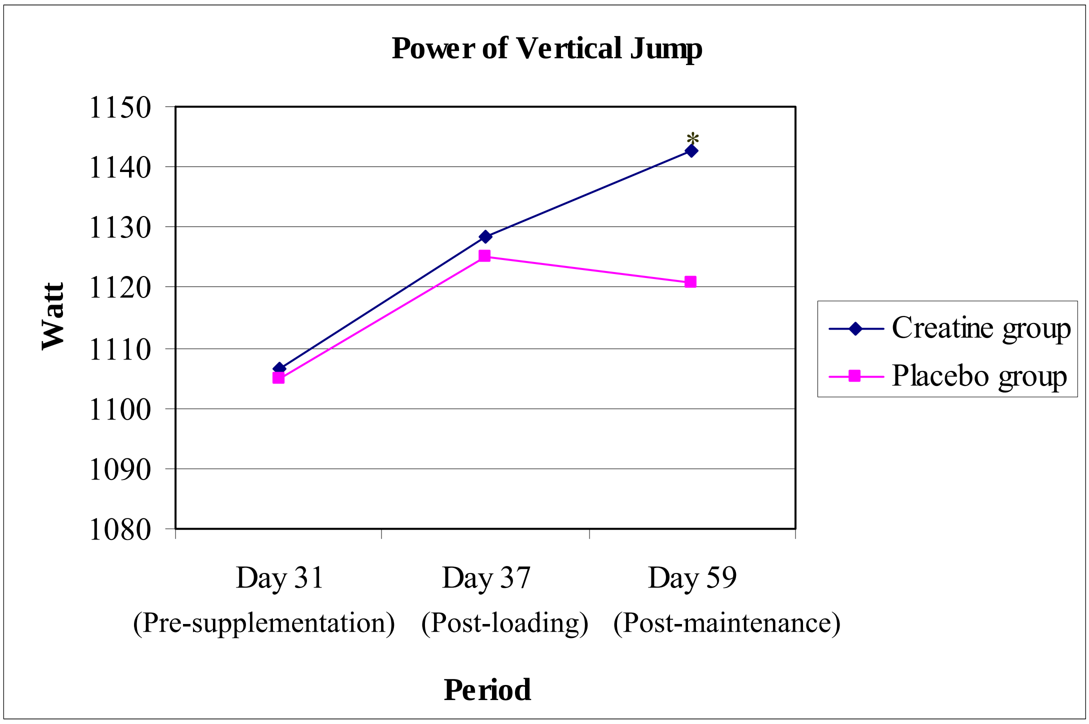
Parameters	Creatine group (n = 16)			Placebo group (n = 16)		
	Pre Supplementation (Day 31)	**Post loading (Day 37)**	**Post maintenance (Day 59)**	**Pre supplementation (Day 31)**	**Post loading (Day 37)**	**Post maintenance (Day 59)**
Vitamin A (RE/day)	634.11 ± 746.75	1116.78 ± 1359.92	1181.01 ± 1295.15	429.37 ± 470.55	603.27 ± 1155.06	1283.79 ± 1262.42 $^{\pi}$
Vitamin B1 (mg/day)	1.66 ± 0.54	2.26 ± 1.67	1.92 ± 1.14	1.87 ± 0.85	1.79 ± 1.09	2.37 ± 1.73
Vitamin B2 (mg/day)	1.16 ± 0.38	1.32 ± 0.55	1.31 ± 0.57	1.18 ± 0.34	1.05 ± 0.37	1.52 ± 0.62 $^{\pi}$
Vitamin C (mg/day)	73.75 ± 63.62	53.19 ± 36.46	61.66 ± 68.16	99.29 ± 87.47	32.04 ± 27.13 *	90.92 ± 80.17 $^{\pi}$
Niacin (mg/day)	16.67 ± 4.65	17.59 ± 6.82	16.42 ± 3.99	16.56 ± 3.44	17.50 ± 7.22	20.88 ± 10.10
Calcium (mg/day)	378.22 ± 134.67	405.08 ± 270.18	388.99 ± 171.91	330.41 ± 162.18	306.73 ± 150.63	410.32 ± 180.14
Iron (mg/day)	12.25 ± 3.28	12.60 ± 3.61	13.52 ± 2.28†	12.07 ± 3.13	12.31 ± 5.31	16.44 ± 4.70† *

All values are expressed as mean ± S.D., * Significantly different from day 31 within group, $^{\pi}$ Significantly different from day 37 within group, † Significant difference between groups, at $P < 0.05$.

Table 5.8 Physical fitness test (mean ± S.D.) during post-loading and post-maintenance periods in creatine and placebo groups

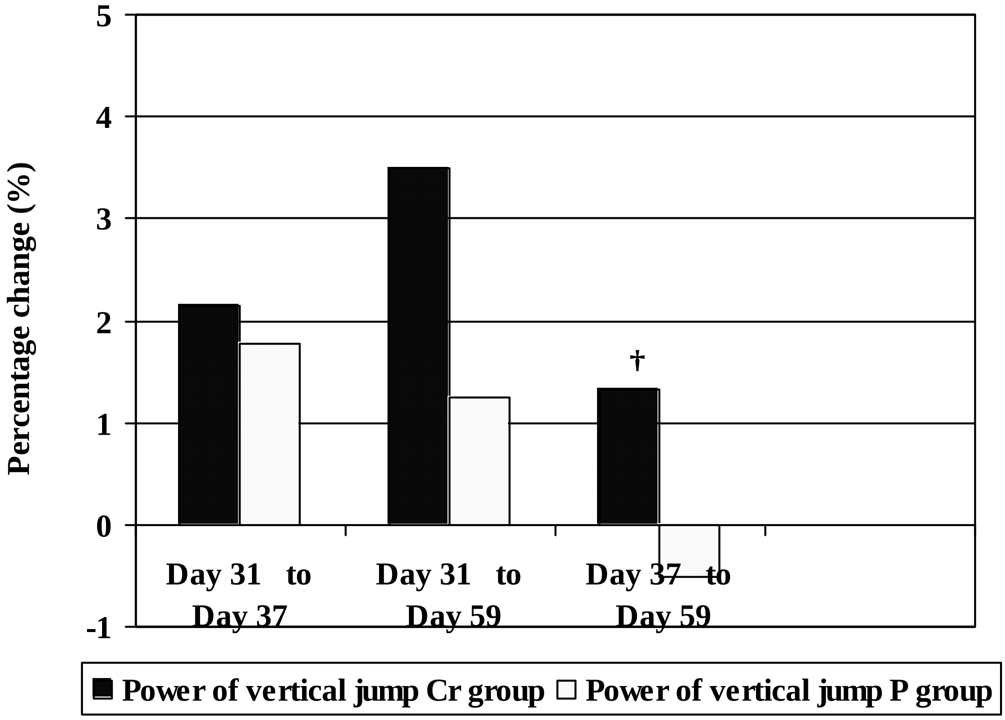
Parameters	Creatine group (n = 16)			Placebo group (n = 16)		
	Pre supplementation (Day 31)	Post loading (Day 37)	Post maintenance (Day 59)	Pre supplementation (Day 31)	Post loading (Day 37)	Post maintenance (Day 59)
Handgrip strength (kg/bw)	0.68 ± 0.08	0.71 ± 0.08	0.70 ± 0.09	0.68 ± 0.09	0.73 ± 0.10*	0.71 ± 0.10
Leg strength (kg/bw)[x]	3.58 ± 0.87	3.70 ± 0.82	3.80 ± 0.92	3.48 ± 0.65	3.55 ± 0.61	3.73 ± 0.78
Shuttle run (sec)	9.81 ± 0.43†	9.81 ± 0.33	9.72 ± 0.38	10.13 ± 0.41†	9.97 ± 0.37	9.88 ± 0.41
VO_2max (ml/kg/min)	44.95 ± 8.05	42.92 ± 7.15	42.32 ± 8.36	41.14 ± 7.77	40.82 ± 6.16	39.80 ± 6.53
Vertical jump (cm)	55.63 ± 6.29	56.69 ± 7.04	57.63 ± 7.61	53.81 ± 6.60	54.94 ± 5.22	54.13 ± 6.49
Power of vertical jump (watt)	1107 ± 152	1129 ± 148	1143 ± 145*	1105± 195	1125± 207	1121±217
Anaerobic power[xx] **(watt/kg)**	11.96 ± 0.65†	12.26 ± 0.55	12.16 ± 0.77	11.36 ± 0.74†	11.79 ± 0.94	12.01 ± 1.11*
Anaerobic capacity[xx] **(watt/kg)**	8.68 ± 0.69	8.82 ± 0.51	8.72 ± 0.58	8.35 ± 0.83	8.51 ± 0.77	8.53 ± 0.78

All values are expressed as mean ± S.D., * Significantly different from day 31 within group, † Significant difference between groups, [x] Leg strength in creatine group (n = 15) and placebo group (n = 16), [xx] Anaerobic power and capacity in creatine group (n = 16) and placebo group (n = 15), at $P < 0.05$.



* Significantly different from pre-supplementation (Day 31)

Figure 5.18 Power of vertical jump during the different study periods



† = Significantly different between groups

Figure 5.19 Percentage changes of power of vertical jump

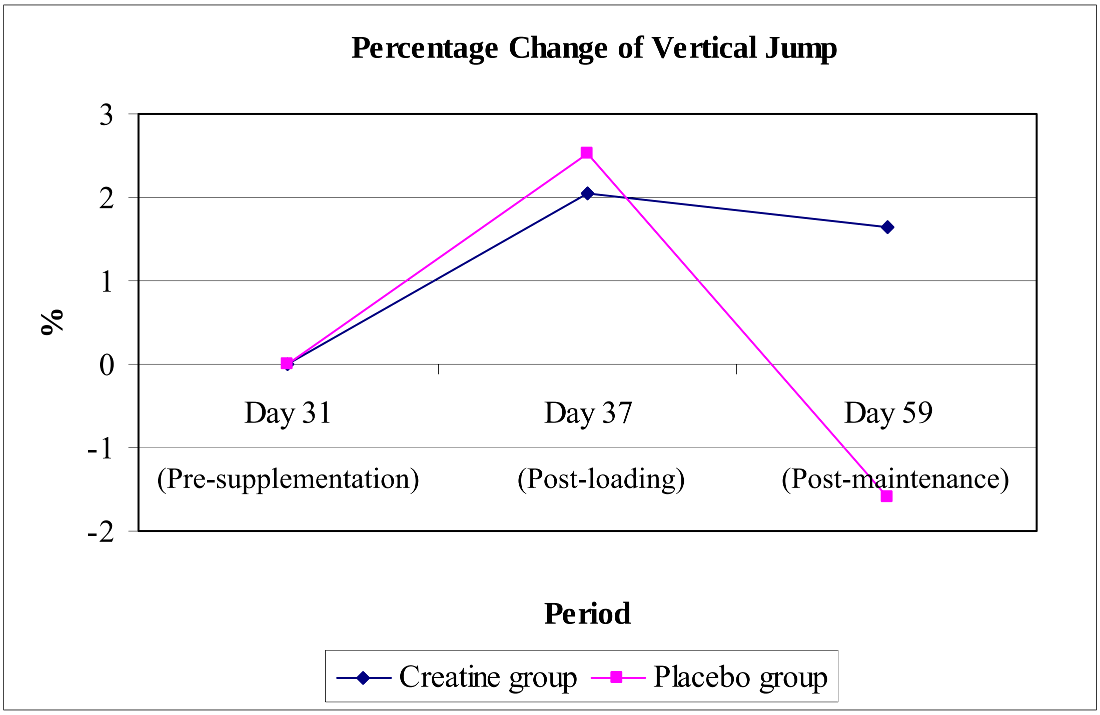


Figure 5.20 Percentage changes of vertical jump during the study period

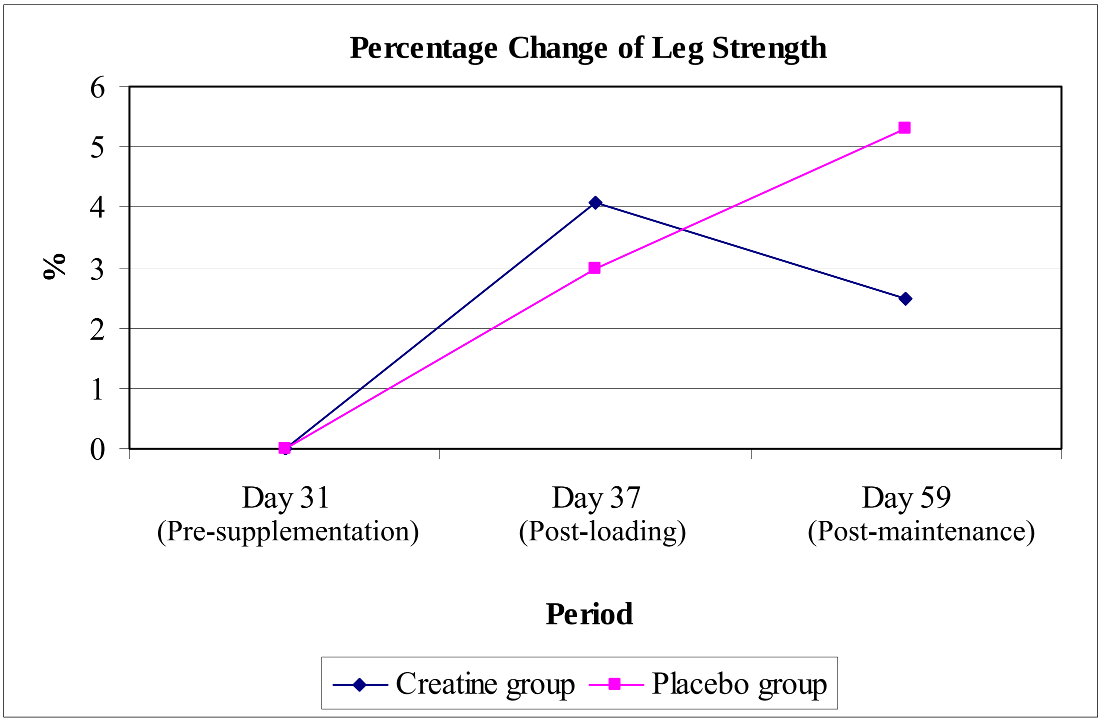


Figure 5.21 Percentage changes of leg strength during the study period

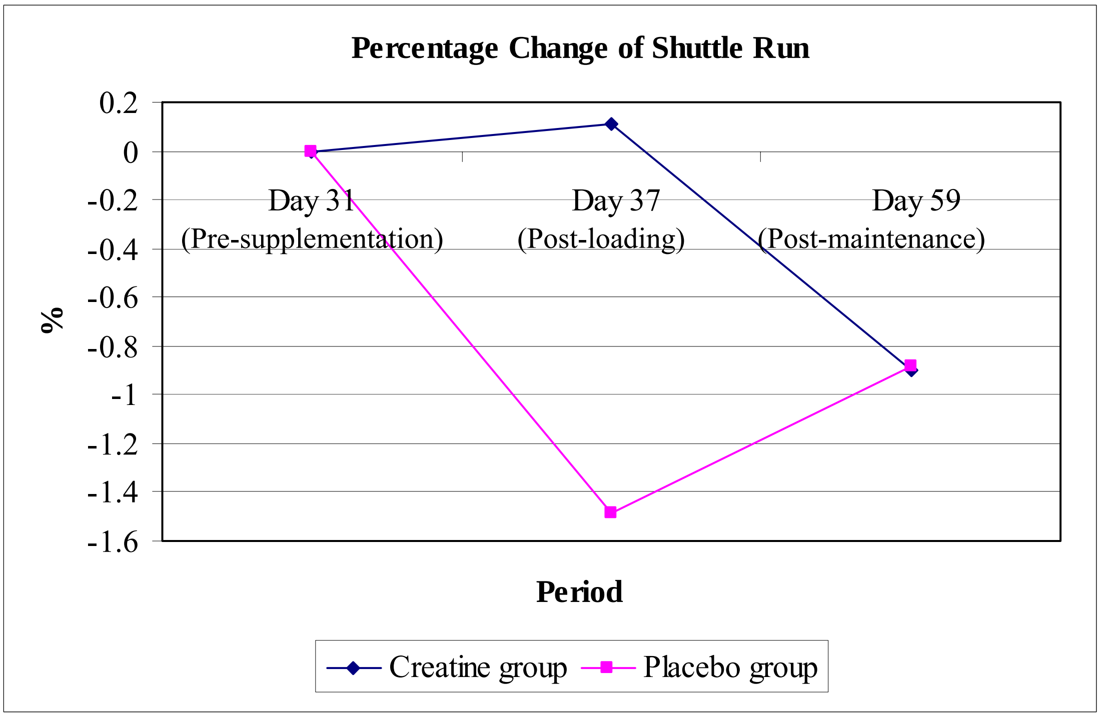


Figure 5.22 Percentage changes of shuttle run during the study period

Table 5.9 Side effect of creatine loading in creatine group (Cr group) and placebo group (P group)

Side Effect	Group	Level (n (%))			
		No	Mild	Moderate	High
Muscle cramp	Cr group	10 (62.5)	1 (6.3)	3 (18.8)	2 (12.5)
	P group	11 (68.8)	3 (18.8)	2 (12.5)	-
Muscle Soreness	Cr group	8 (50.0)	4 (25.0)	1 (6.3)	3 (18.8)
	P group	10 (62.5)	2 (12.5)	4 (25.0)	-
Muscle Tightness	Cr group	5 (31.3)	3 (18.8)	4 (25.0)	4 (25.0)
	P group	9 (56.3)	2 (12.5)	4 (25.0)	1 (6.3)
Stomachache	Cr group	7 (43.8)	6 (37.5)	1 (6.3)	2 (12.5)
	P group	12 (75.0)	4 (25.0)	-	-
Diarrhea	Cr group	9 (56.3)	3 (18.8)	-	4 (25.0)
	P group	7 (43.8)	5 (31.3)	4 (25.0)	-
Exhaustion	Cr group	5 (31.3)	2 (12.5)	6 (37.5)	3 (18.8)
	P group	6 (37.5)	6 (37.5)	4 (25)	-
Thirsty	Cr group	8 (50.0)	3 (18.8)	3 (18.8)	2 (12.5)
	P group	5 (31.3)	2 (12.5)	5 (31.3)	4 (25.0)
Altered Appetite	Cr group	2 (12.5)	3 (18.8)	8 (50.0)	3 (18.8)
	P group	6 (37.5)	7 (43.8)	3 (18.8)	-
Aggressiveness	Cr group	13 (81.3)	2 (12.5)	-	1 (6.3)
	P group	14 (87.5)	1 (6.3)	1 (6.3)	-
Headache	Cr group	12 (75.0)	4 (25.0)	-	-
	P group	12 (75.0)	2 (12.5)	2 (12.5)	-

All values are expressed as number of subject and percentage.

Table 5.9 Side effect of creatine loading in creatine group (Cr group) and placebo group (P group) (continued)

Side Effect	Group	Level (n (%))			
		No	Mild	Moderate	High
Dizziness	**Cr group**	11 (68.8)	4 (25.0)	1 (6.3)	-
	P group	11 (68.8)	2 (12.5)	3 (18.8)	-
Nausea	**Cr group**	11 (68.8)	3 (18.8)	2 (12.5)	-
	P group	12 (75.0)	2 (12.5)	2 (12.5)	-
Vomit	**Cr group**	14 (87.5)	2 (12.5)	-	-
	P group	14 (87.5)	1 (6.3)	1 (6.3)	-

All values are expressed as number of subject and percentage.

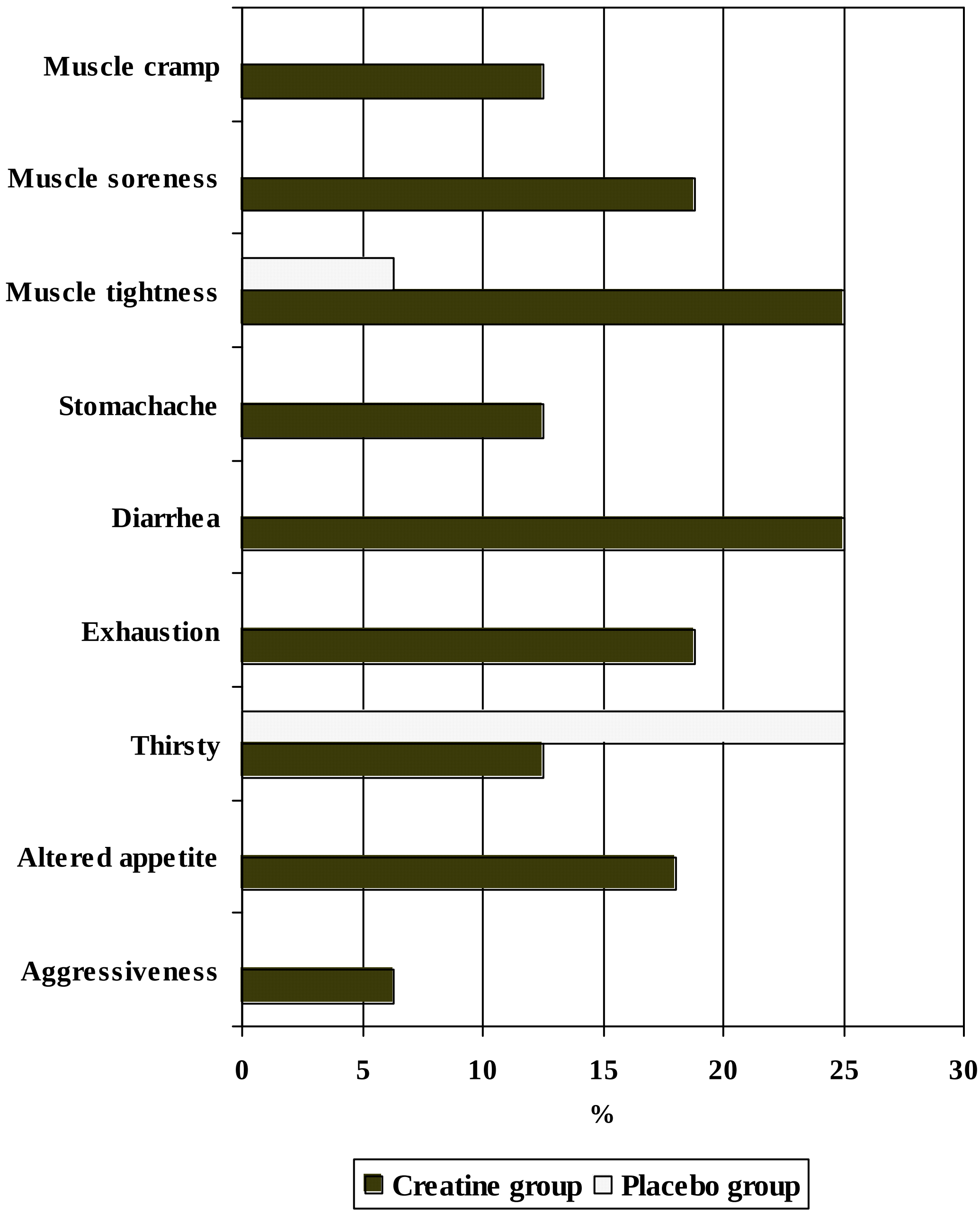


Figure 5.23 Side effects of creatine loading in high level at post-loading period (Day 37)

Table 5.10 Side effect of creatine maintenance in creatine group (Cr group) and placebo group (P group)

Side Effect	Group	Level (n (%))			
		No	Mild	Moderate	High
Muscle cramp	**Cr group**	11 (68.8)	2 (12.5)	3 (18.8)	-
	P group	13 (81.3)	2 (12.5)	1 (6.3)	-
Muscle Soreness	**Cr group**	13 (81.3)	2 (12.5)	-	1 (6.3)
	P group	13 (81.3)	3 (18.8)	-	-
Muscle Tightness	**Cr group**	10 (62.5)	1 (6.3)	3 (18.8)	2 (12.5)
	P group	7 (43.8)	5 (31.3)	4 (25.0)	-
Stomachache	**Cr group**	12 (75.0)	2 (12.5)	1 (6.3)	1 (6.3)
	P group	13 (81.3)	2 (12.5)	1 (6.3)	-
Diarrhea	**Cr group**	10 (62.5)	5 (31.3)	1 (6.3)	-
	P group	11 (68.8)	4 (25.0)	-	1 (6.3)
Exhaustion	**Cr group**	8 (50.0)	5 (31.3)	2 (12.5)	1 (6.3)
	P group	5 (31.3)	9 (56.3)	1 (6.3)	1 (6.3)
Thirsty	**Cr group**	7 (43.8)	4 (25.0)	3 (18.8)	2 (12.5)
	P group	7 (43.8)	2 (12.5)	4 (25.0)	3 (18.8)
Altered Appetite	**Cr group**	5 (31.3)	1 (6.3)	6 (37.5)	4 (25.0)
	P group	7 (43.8)	3 (18.8)	4 (25.0)	2 (12.5)
Aggressiveness	**Cr group**	10 (62.5)	5 (31.3)	-	1 (6.3)
	P group	12 (75.0)	3 (18.8)	1 (6.3)	-
Headache	**Cr group**	14 (87.5)	1 (6.3)	1 (6.3)	-
	P group	14 (87.5)	1 (6.3)	1 (6.3)	-

All values are expressed as number of subject and percentage.

Table 5.10 Side effect of creatine maintenance in creatine group (Cr group) and placebo group (P group) (continued)

Side Effect	Group	Level (n (%))			
		No	Mild	Moderate	High
Dizziness	**Cr group**	11 (68.8)	4 (25.0)	1 (6.3)	-
	P group	11 (68.8)	4 (25.0)	1 (6.3)	-
Nausea	**Cr group**	12 (75.0)	4 (25.0)	-	-
	P group	13 (81.3)	2 (12.5)	1 (6.3)	-
Vomit	**Cr group**	15 (93.8)	1 (6.3)	-	-
	P group	15 (93.8)	1 (6.3)	-	-

All values are expressed as number of subject and percentage.

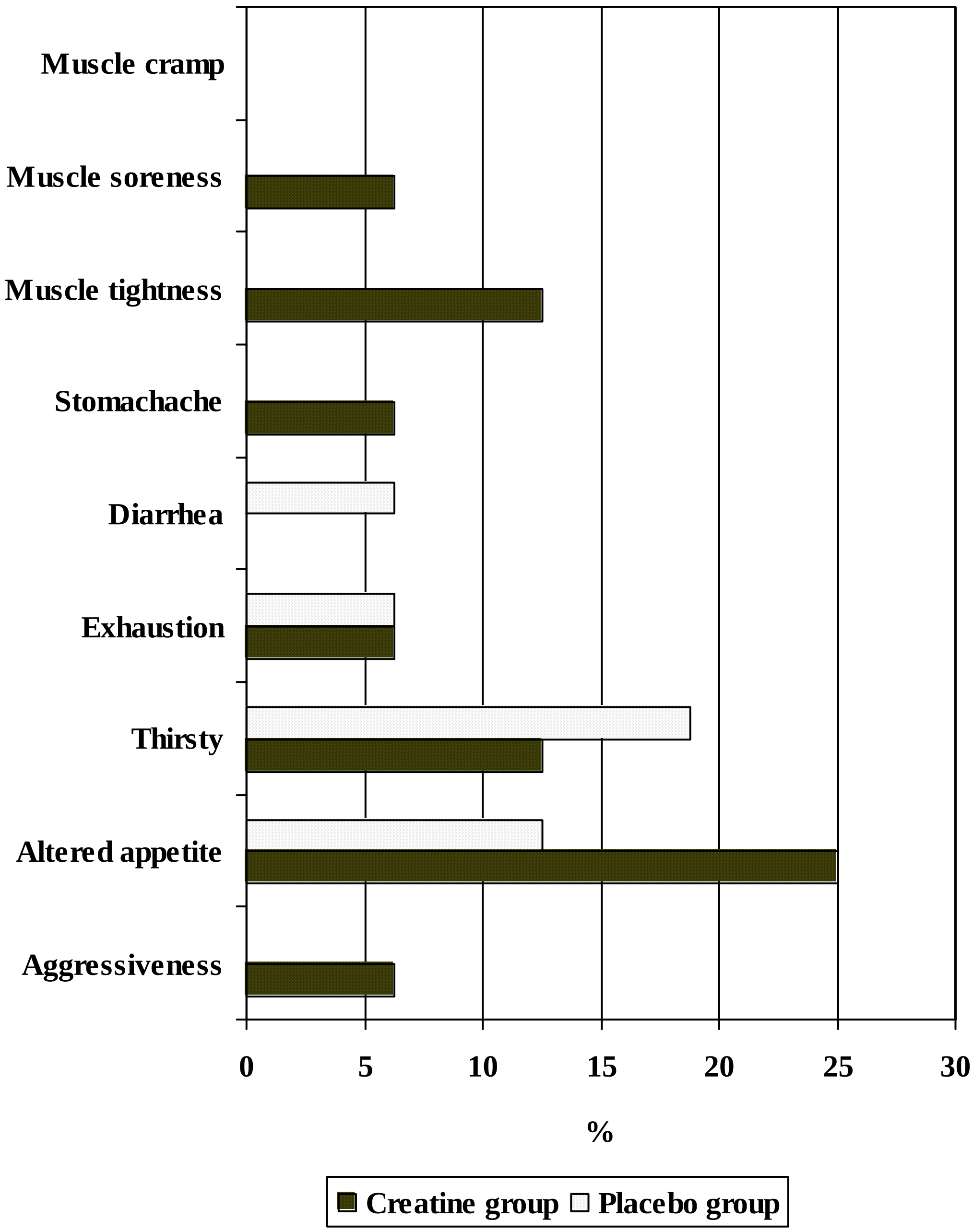


Figure 5.24 Side effects of creatine maintenance in high level at post-maintenance period (Day 59)

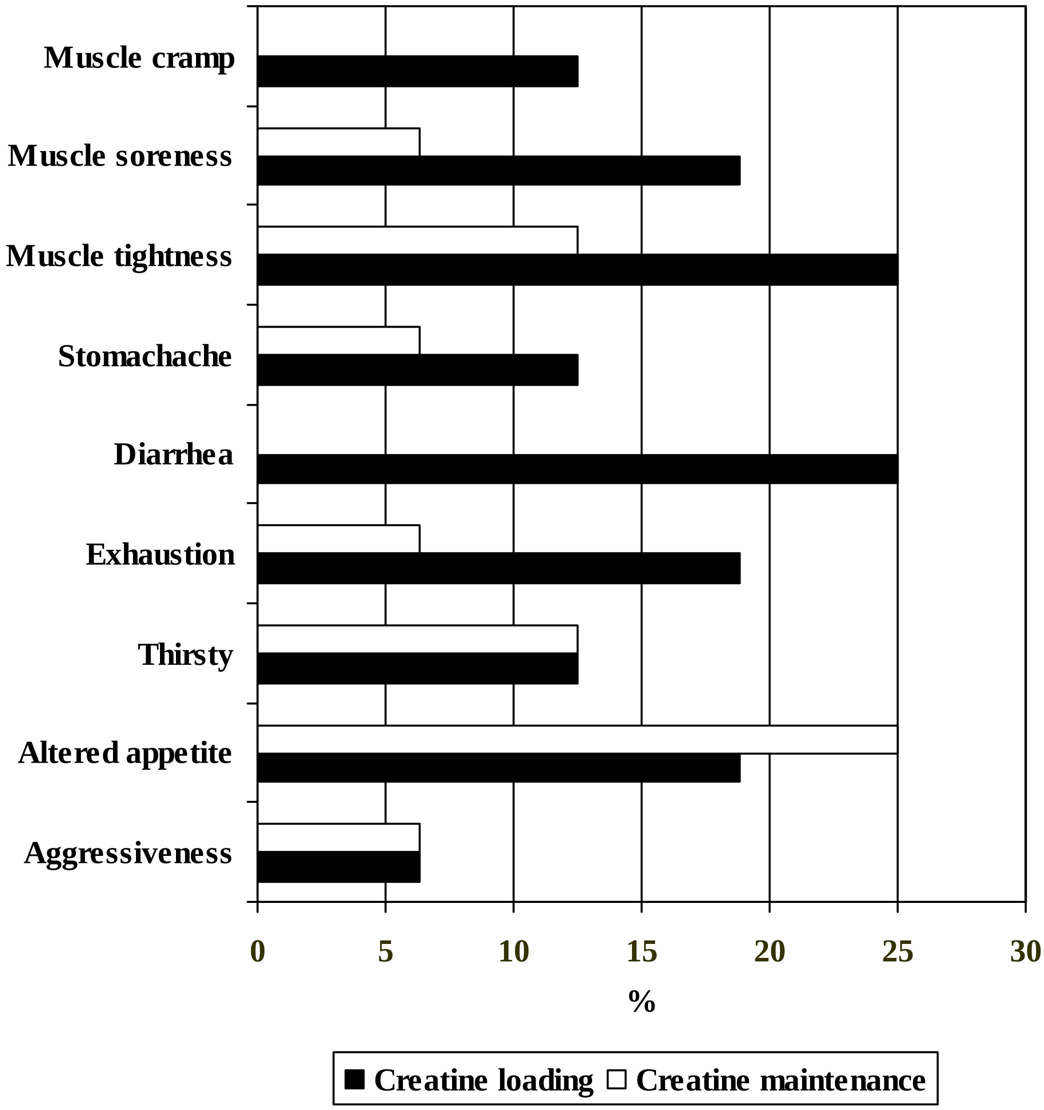


Figure 5.25 Side effects of creatine loading and creatine maintenance in high level of creatine group

CHAPTER VI
DISCUSSION

In general there was no difference in the means of subject characteristic in the study, indicating the perfect match regarding to VO_2max, body weight, height and age. However, there were no significant differences in most tests ranging from the amount of nutrients intake and the body composition between the two groups at baseline and after weight training. Higher energy intake during weight training in all subjects indicated the increased appetite after exercise in both groups (Table 5.2). Among the nutrients counted vitamin B2 intake was, exceptionally, lower than before training. Decrement of vitamin B2 intake of both groups might be due to the unfavor of some food items, such as pork liver, egg, and milk which are the major source of vitamin B2. These results indicated that both groups of players were physiologically response to weight training and post-exercise snack and this basic response was equal between the two groups.

There was significant difference in physical fitness test as shown in Table 5.4 after weight training and post-exercise snack period. It was found that there was significantly increased in VO_2max and significantly improved in time of shuttle run in creatine group. There was no significant change in placebo group

6.1 Effect of creatine supplementation on body water and protein synthesis

After 5 days of loading period, body weight was significantly increased in creatine group whereas there was no significant change in placebo group, 0.75 kg vs 0.47 kg, respectively. Total body weight increment after the entire period of creatine supplementation (26 days) was 1.08 kg and 0.64 kg in creatine group and placebo group, respectively. Previous research has indicated that subjects who took creatine supplements experienced a significant increase in weight gain (25,111-112). Several authors have also shown that the intervention is often accompanied by increase in body mass of approximately 0.4–2.1 kg (28,34,61,96-98,113-115). Typically, these increment were about 1–2 kg in 4–7 days (69, 115,118). This initial increase in body mass were attributed to the increase in total body water. Water retention in skeletal muscle cells was proved to be due to increase in cellular osmolarity (27,31,62,113,116).

In this study, total body water of the creatine supplemented group tended to increase after 5 days of loading. The increase was continued till post-maintenance (Day 59). Finally, the extracellular water, intracellular water and total body water were 0.19, 0.67 and 0.87 liters, respectively. The result of body water was the value calculating after the bioelectrical impedance analysis. This confirms the data of Ziegenfuss TN et al (118) who found that creatine ingestion produced significant trend in increasing intracellular fluid within 3 days, while there was no effect on extracellular fluid volumes. Higher increase in intracellular than extracellular water was due to the fact that 95 % of total creatine was stored intramuscularly (117). One of the reports also showed that urine volume was reduced within 3 days after creatine ingestion and turned to normal by the end of the supplementation (62).

The increment of body weight as shown in Table 5.5 should also come from protein anabolism since it had been postulated that cell swelling is a universal anabolic signal of stimulating protein synthesis and net protein deposition (63,119-120) and it attributed to positive nitrogen balance (1,28,113,123). Significant increase of body composition parameters e.g. protein, skeletal muscle mass, fat free mass and fat free mass index were found at post-loading (Day 37) and post-maintenance (Day 59). However, some other researches reported that the increased in body mass in as few as 5 to 7 days is unlikely to be explained by protein synthesis alone (12,113,115,120). In varifying the issue, the studies in skeletal muscle cells and isolated skeletal and cardiac tissue cultures demonstrated that creatine *per se* stimulated myofibrillar protein synthesis (121,122). Noticeably, creatine could act as an accelerator of protein synthesis (27,133). As was shown in Table 5.5. that total body protein was increased at post-loading.

In addition, at post-maintenance (Day 59), total body water, intracellular water and protein remained to increase but the increment was not significant difference from post-loading (Day 37). The result suggested that creatine can be maintained by the maintenance dose of creatine supplementation in this study.

The increment of protein may also come from weight training since weight training and post-exercise snack alone could increase the values of intracellular water and protein over the baseline (Day 0) were 0.28 liters and 0.13 kg, respectively. These anabolic changes during creatine supplementation periods should not come from appetite stimulation or increased intake since there were no significant differences of macronutrients and micronutrient intakes between creatine supplemented and placebo group. The results supported the study by Kutz et al. (80) who showed that creatine supplementation neither altered appetite nor calorie intake.

6.2 Effect of creatine supplementation on fat mass and catabolic rate

Fat mass and percent body fat in both groups after creatine loading (Day 37) declined from pre-supplementation (Day 31) because of the extensive aerobic and anaerobic exercise which is the nature of practice in baseball and softball. Decrement of fat mass might not relate to creatine supplementation since there was no significant difference in fat mass and percent body fat between both groups. The study supported those of Earnest et al. (111) and Mihic et al (67) who demonstrated no change in fat mass and that of Kutz et al. (80) who found no effect of creatine supplementation on body weight and percent body fat.

Could it be assumed, then, there was no effect of creatine on stimulation of neither energy catabolism as a whole nor the catabolism of any nutrient in particular? Stroud et al. (96) examined the effect of creatine supplementation (20 g/day for 5 days) on respiratory gas exchange during exercise and 15 min of recovery. The results indicated that creatine had no effect on respiratory gas exchange rate either during exercise or at recovery. The results were similar to those of van Loon LJ (27) who found that creatine loading (20 g/day for 6 days) and 6 week period of continued creatine supplementation with a 2 g/day maintenance dose did not affect substrate utilization rates during submaximal cycling exercise. On the contrary, Huso et al (124) found that respiratory exchange rate (RER) increased in creatine group, indicating that subjects utilized a greater percentage of carbohydrate than fat during creatine supplementation. The difference in carbohydrate oxidation before and after creatine supplementation was significant.

6.3 Effect of creatine supplementation on ergonomic stimulation

Earnest et al. (111) and Kelly VG et al (119) demonstrated that it is also possible that the subjects supplemented with creatine group experienced an ergogenic effect, allowing for greater training volume during the supplement period. However, the results of this study did not favor ergonomic stimulation with creatine supplementation.

6.4 Effect of creatine supplementation on muscle strength

There was no significant difference between both groups in most exercise tests except for better improvement of vertical jump (watt) in the creatine supplemented group. Strength test in this study consisted of leg strength and handgrip strength. These findings agree with Mihic S et al (67) who found no effect of 20 g creatine monohydrate/day for 5 days treatment upon grip strength during forearm ischemic test (FIT). However, Urbanski RL et al (126) found that creatine supplementation 20 g/day for 5 days significantly increased maximal isometric strength during knee extension but not during hand grip exercise. Ayoama R et al (29) studied in females softball players found that creatine supplementation did not increase maximal isometric strength and isokinetic peak torque.

6.5 Effect of creatine supplementation on agility

Failure to improve most tests after creatine supplementation especially the shuttle run test was at least due to the increment of body weight (0.75 kg) after creatine loading (Day 37) which may interfere with the movement during shuttle run test. Juhn et al (116) reviewed the current data concerning potential safety concerns of oral creatine supplementation. One of the conclusions was creatine supplementation results in weight gain due to water retention, which may impede performance in mass-dependent activities such as running and swimming. At post-loading (Day 37), 14 of 16 players in the creatine group had gained weight but 6 of these 14 weight gain players could improve in the runtime still. The average increasing of body weight in six players from pre-supplementation (Day 31) to post-loading (Day 37) was 1.02 kg and their average increment of runtime was 0.23 second.

More data suggested that creatine had no effect on ergogenic effect. Delecluse C et al (88) examined the impact of 0.35 g/kg/day for 7 days of creatine supplementation on single and intermittent sprint running performance in highly trained sprinters. It was concluded that no ergogenic effect on single or repeated 40 meters sprint times with varying rest periods was observed in highly trained athletes. Similarly, Glaister M et al (89) found no significant difference between groups in multiple sprints as measured by fastest time and mean time after supplementation with creatine 20 g/day and 1 g of maltodextrin for 5 days. Redondo et al. (87) also reported no creatine-induced improvements in field hockey and soccer players performing three 60 meters races with 2 minutes rest between runs. In a recent study, Smart et al. (125) found that 24 g of creatine monohydrate for 6 days in highly trained soccer players did not improve performance over thirty 20-meter sprints interspersed with 30 second rest periods.

6.6 Effect of creatine supplementation on cardiovascular fitness

Maximal oxygen uptake (VO_2max) determines endurance performance in this study. Although, findings in sedentary rats suggested that prolonged creatine supplementation increases muscle oxidative capacity (using citrate synthase activity as a marker for muscle mitochondrial content) (130). There was no significant improvement in VO_2max within group and between groups. Engelhardt M et al. (97) studied in athletes of triathelon found that high-intensity exercise performance, included the endurance exercise task was not affected by creatine intake. Balsom et al (98) studied the effect of 20 g/day for 6 days creatine supplementation. They found that subjects were able to perform a treadmill run till exhaustion, about 120% of VO_2max, in both before and after the supplementation period. Moreover, Barnett et al (99) measured the effect of 20 g/day for 4 days creatine loading on VO_2peak with cycle ergometer. They found that creatine supplementation did not increase VO_2peak. Juhn MS et al (131) reviewed and summarized the current data on oral creatine supplementation regarding its potential efficacy in athletic performance, mechanism of action and metabolism, they found no improvement on ergogenic effects of submaximal or endurance exercise. Moreover, Gianni Benzi (132) found that any beneficial effects seem to be unlikely in disciplines with continuous aerobic exercise of a longer duration, e.g. 10,000-m run, marathon and 800-m swim. Their result confirmed that of van Loon LJ (27) who found that creatine loading for 6 days and a total 6 weeks period of continued creatine supplementation with a 2 g/ day maintenance dose did not influence endurance performance as measured during the time trial on a cycle ergometer.

6.7 Effect of creatine supplementation on exercise using anaerobic energy metabolism

Anaerobic performance test consisted of vertical jump test and Wingate test. Vertical jump test was measured in 2 units consisting of the height in centimeter (cm) and the power in watt. Difference of vertical jump (cm) and power of vertical jump (watt) related with body weight which used to calculate for power of vertical jump. Vertical jump test tended to improve in creatine group although there was no significant difference between groups (Table 5.8). However, the power of vertical jump (watt) during prolonged creatine supplementation (Day 59) was significant difference from pre-supplementation (Day 31) whereas there was no significant difference in placebo group. After a similar short-term creatine ingestion procedure, Balsom et al. (61) and Miszko et al. (127) found that there was no improvement of vertical jump in physically active male and female softball players, respectively.

In this study, there was increment of body weight while distance of vertical jump (cm) was similar to the previous test of each individual. For example, at post-loading (Day 37), body weight of one subject was 62.20 kg and distance of vertical jump was 52 cm. The next test at post-maintenance (Day 59), body weight increased 1.4 kg from post-loading and distance of vertical jump was remained the same as the previous test. So, it can be concluded that increment of body weight in creatine group at post-maintenance did not interfere the efficacy of the jump. Although, the distance of the vertical jump (cm) in this subject was not change improve but the calculation for power of vertical jump (watt) was virtually improved.

Longer supplementation periods, on the other hand, have been reported to favor the effect on affect vertical jump in male football players and track athletes (128-

129). This difference could be related to the creatine induced changes in body mass. As discussed above, short-term increase in body mass seems to be due to an increase in body water content, which would be detrimental for performance in events those depend on overcoming the force of gravity, such as vertical jump. On the other hand, the improvement of vertical jump performance in this study, as was explained in the example case above, seems to be the result of long-term increasing lean muscle mass. In this study, there was no matched position of players because athlete's body weight, height and age in same position were not similar. Therefore, all of results did not represent any particular position of the players.

Subjects received creatine supplementation was expected to improve their performance in Wingate test. However, the creatine group in this study did not show any improvement neither in anaerobic power nor anaerobic capacity. Surprisingly, the anaerobic power in placebo group was significantly increased overtime (Day 31 vs day 59) whereas there was no change in creatine-supplemented group. The explanation is that the placebo group may compose of more subjects who are easily response to any kind of stimulation than the subjects in creatine-supplemented group.

When the performance in Wingate test of the creatine-supplemented group was individually varified, one should find the different response among the subjects. Some subjects, for example the one who had the highest weight gain (1.9 kg) showed the improvement of both anaerobic power and capacity. Whereas others whose weight gain were less than 1.9 kg showed no improvement of the performance as was expected. This hinted some kinds of heterogenity among individuals within the creatine-supplemented group, Those can mask the ergonomic effect of creatine in this study.

Odland LM et al (93) who determined the effect of 20 g/day for 3 days creatine supplementation in 9 males to whom on power output during a 30 seconds maximal cycling test. Results showed neither difference between conditions for peak, mean 10 seconds, and mean 30 seconds power output nor percent fatigue. McKenna et al (133) found no effects of 30 g of creatine monohydrate/ day for 4 weeks in 7 volunteers on peak power output, cumulative work production or the fatigue index during five bouts of 10-s maximal intermittent cycling sprints. Hoffman et al (92) examined the supplement of 6 g of creatine monohydrate/day in comparison to placebo for 6 days.

They found no significant differences (*P* > 0.05) between the groups on time observed in peak power, mean power, or total work of three 15 second Wingate anaerobic power tests.

The explanation for the negative result on Wingate test found in this study could be due to the fact that type II muscle fibers would gain more benefit by enhancing creatine availability during exercise (60) but there were more subjects whose less training on type II muscle fiber. Another explanation was because the test is depending on the quantity of each fiber type of an individual. Greenhaff (134) reported that 20% to 30% of individuals do not respond to creatine supplementation indicating by creatine content in muscle those less than 10 mmol/kg dry mass. Recently, Syrotuik DG (135) study the histochemistry of muscle biopsy of 11 normal and healthy males after 0.3 g creatine monohydrate per kg body weight per day for 5 days. He described the responders as those whose muscle total creatine increment were higher than 20 mmol/kg of dry muscle weight and the nonresponders as those who have less than 10 mmol total creatine/kg of dry muscle weight. The results indicated that there were 3 levels of response to the 5-day supplementation: responders (R), quasi responders (QR), and nonresponders (NR) with mean changes in resting creatine + phosphocreatine of 29.5 mmol/kg dw (n = 3), 14.9 mmol/kg dw (n = 5), and 5.1 mmol/kg dw (n = 3), respectively. The results clearly showed the individual variable in response to acute creatine supplementation. Those responders whose initial levels of total creatine were the lowest have the greatest percentage of type II fibers, greatest preload muscle fiber cross-sectional area and fat-free mass. Responders also showed improvement in one maximal repetition (1RM) leg press scores after the 5-day loading period. Nonresponders had higher preload levels of total creatine, less type II muscle fibers, small preload muscle cross-section, and lower fat-free mass. They displayed no improvements in 1RM strength scores after the 5-day loading period. The results suggested that a favorable preexisting biological profile may determine the final extent to which an individual responds to acute oral supplementation.

6.8 Side effects of creatine supplementation

Data on side effects of creatine supplementation were studied using questionnaire at post-loading (Day 37) and post-maintenance (Day 59) in this study.

Majority of subjects in creatine group had no side effect on muscle during the loading period. However, during high level of creatine supplementation, there were 12.5 %, 18.8 % and 25 % of muscle cramp, muscle soreness and muscle tightness, respectively. In the late maintenance phase, side effects of creatine supplementation on muscle were decreased from loading period and there was no muscle cramp. These results hints that side effect occur only at high dose (4,27).

As mentioned earlier that muscle cramps from creatine supplementation may be due to the increase in intramuscular water content. The diluted electrolytes within muscle cells promotes muscle cramping by interfering with the muscle's contraction-relaxation mechanism (31,73,136). Previous research of Juhn et al (137) reported that muscle cramping occurred in 25 % of 52 football and baseball players using 6-8 g/day for 3 or 5 months, respectively. Thus, the prevention should be done by consumption of adequate water and electrolytes (27). However, it must be born in mind that muscle dysfunctions (i.e. strains, cramping, stiffness) may be correlated with the increasing pressure in muscle compartment during water retention as well. Schroeder C et al (138) found that after the ingestion of 0.3 g/kg/day for 6 days and 0.03 g/kg/day for 28 days the anterior compartment pressure of the lower leg was increased at rest and following 20 minutes of running at 80 % of maximal aerobic power. He explained that an increase in water content or de novo protein synthesis in the muscle fiber gave rise to the compartment pressure at rest and after exercise. However, the same group of researcher further reported that the presence of this anterior compartment subsided at 7 and 21 days after cessation of creatine supplementation (139). Since creatine supplementation may promote rapid increases in body mass, the athlete may be more predisposed to additional weight pressing on their muscles, bones, joints, ligaments and connective tissues (74).

There were two subjects who said that they had stomachache and diarrhea in "high level" during loading period. Lower number of subjects who complained about the stomachache in "high level" during the maintenance period. There were no report of diarrhea was found in the later, as well. Juhn MS et al (137) reported diarrhea to be 31 % of 52 football and baseball players who were supplemented with 6-8 g/day of creatine monohydrated during 3 or 5 months of treatment. Their conclusion is that co-ingestion of other substances may account partially for the symptom, for example, co-ingested sugars in excessive amount increased gastric emptying and/or reduced the absorptive capacity of the gut (31). Graham A.S. et al (65) explained that undissolved creatine powder may cause gastroenteritis.

This study showed only 6.3 % of the subjects in creatine supplemented group those had behavior change to “high level” of aggressiveness during both loading and maintenance periods. T. McMorris et al (140) studied the effect of 20 g creatine loading per day for 7 days. They reported sleep deprivation with mild disturbance on cognitive and psychomotor performance and elevated mood state. Rising of plasma concentrations of catecholamine and cortisol are found following 24 hours sleep deprivation. The creatine effect on mood state was consisted of fatigue, anger, tension, depression and vigor.

Anger or aggressive behavior seems to be one of the most frequent reports about side effects among users, both male and female. A reason for this could be the increase of testosterone levels in the users. Testosterone is a male hormone. It is responsible for growth of muscle mass, increase bone density, development of sex organs and also increases aggressive behavior.

Op 't Eijnde B et al (141) examined effect of short-term creatine supplementation, 20 g/day for 5 days, on growth hormone, testosterone and cortisol in response to heavy resistance training. They found that the exercise-induced increase of serum growth hormone ($P < 0.05$) increment was not altered by acute creatine intake. The weight training session, either or not in conjunction with acute or chronic creatine intake, did not significantly have an impact on serum testosterone. It is concluded that short-term creatine supplementation does not alter the responses of growth hormone, testosterone, and cortisol to a single bout of heavy resistance training. On the contrary, Volek JS et al (82) who determined total testosterone (TT), sex hormone binding globulin (SHBG) and other hormones levels those were affected by 0.3 g/kg/day of creatine supplementation during short-term resistance training. They found that TT and the free androgen index (TT/SHBG) decreased in creatine monohydrate group and placebo group, reaching a nadir at week 3, whereas SHBG responded in an opposite direction. Cortisol significantly 29% increased after week 1 in creatine monohydrate supplementation, and returned to baseline at week 2. Growth hormone and IGF-I levels were not affected. These changes are not related to changes in circulating hormone concentrations obtained at rest or at post absorptive state.

The results of the studies mentioned above also explained that alteration of mood such as anger and aggressiveness were not affected by creatine supplementation since creatine did not increase testosterone level. However, when taking creatine, one should drink a lot of water. The body becomes dehydrated and this leads to mood swinging and increased anger bouts.

Moreover, 18.8 % and 25 % subjects in creatine-supplemented group in this study reported the "high level" of altered appetite during loading and maintenance period, respectively. The altered appetite was not the effect of any specific nutrients since there was no significant difference for macronutrient and micronutrient intakes between the two groups at overtime. Moreover, reports those expressed the effect of creatine supplementation on appetite were studies in subjects having a consistent caloric intakes (25,120,142). In contrary, some researches mentioned that creatine supplementation decreased appetite. Anecdotally, their subjects reported a decreased appetite during the supplementation period because they described a ‘‘full’’ feeling from ingesting the supplement and fluid on 5 occasions each day (31).

CHAPTER VII
CONCLUSION

This study examined the effect of creatine supplementation combined with weight training and post-exercise snack supplementation on physical fitness performance and body composition in Thai National baseball and softball players. The result revealed that:

Phase I Weight training with post-exercise snack

1. There was no significant difference in body composition parameters when compared baseline. However, the means of protein and skeletal muscle mass tended to be slightly increased whereas fat mass and percent body fat tended to be slightly decreased after weight training with post-exercise snack supplementation.

2. Average daily macronutrient intake was found to be significantly increased in the energy (kcal), protein (g/day and g/kg/day) and carbohydrate (g/day and g/kg/day) intakes. Vitamin A and B2 intakes were significantly decreased as compared to baseline intake.

3. Physical fitness performance were found to be significantly improvement in the runtime for shuttle run test and in VO_2max when compared to baseline.

Phase II Creatine supplementation

1. There were no significant differences between groups in the body composition. However, in the creatine group, there were significant increases in body mass, total body water (TBW), intracellular water (ICW), body protein mass, skeletal muscle mass, fat free mass and fat free mass index after the loading and the maintenance periods when compared pre-supplementation (Day 31). Extracellular water (ECW) after creatine loading period showed a significant increase from pre-supplementation (Day 31) but tended to be decreased in the maintenance period.

Fat mass and percentage of body fat after loading and the maintenance period did not differ from pre-supplementation (Day 31).

2. There were no significant differences between groups in physical fitness performance. However, in the creatine group, there was a significant increase in power of vertical jump after maintenance period when compared to pre-supplementation (Day 31).

3. Side effects of creatine supplementation during high level of loading phase, revealed 18.8 % of exhaustion, 12.5 % of stomachache, 25 % of diarrhea, 6.3% of aggressiveness, 18.8 % of altered appetite and 12.5 % of increased thirsty. Moreover, creatine supplement group showed 12.5 % of muscle cramp, 18.8 % of muscle soreness and 25 % of muscle tightness which decreased or disappeared during high level of creatine maintenance period.

The results in this study demonstrated that creatine supplementation increased body water, body protein mass, skeletal muscle mass and power of vertical jump. Side effects occurred with high dose supplementation and tended to be decreased or disappeared with decreased dose. In conclusion, creatine supplementation does not accelerate improvement of physical fitness performance in baseball and softball players when compare with placebo group. Further research might need to focus on each position of baseball and softball players since each position needs some special skill and certain type of muscle fiber. Moreover, muscle biopsy and blood analysis are interesting methods to determine muscle type and muscle creatine content in Thai National baseball and softball players. These measurements should be good assistance for positioning the baseball and softball players in order that more specific results of creatine supplementation could be accomplished.

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APPENDIX

APPENDIX A
DIETARY RECORD

<u>ข้อแนะนำในการบันทึกรายการอาหาร</u>

- การบันทึกรายการอาหารให้เขียนอาหาร ขนม ผลไม้ และเครื่องดื่มทุกอย่างที่รับประทาน ตั้งแต่ตื่นนอนจนถึงก่อนเข้านอน ระบุมื้อและเวลาที่รับประทานด้วย

- บันทึกอาหารที่เป็นวันฝึกซ้อมของนักกีฬา 2 วัน และบันทึกอาหารที่เป็นวันหยุดของนักกีฬา 1 วัน

- อาหารประเภทแป้ง (คาร์โบไฮเดรต)

1. ข้าวสวย, ข้าวเหนียว ให้ระบุเป็นทัพพี (1 ทัพพี คือ ทัพพีตักข้าวมาตรฐานที่ตักแล้วพอดีกับทัพพี ไม่พูน)

2. ก๋วยเตี๋ยว ให้ระบุว่าประเภทของเส้นที่รับประทาน เช่น เส้นหมี่ เส้นเล็ก เส้นใหญ่ วุ้นเส้น บะหมี่เหลือง ให้ระบุเป็นทัพพี

- เนื้อสัตว์

1. เนื้อไก่ เนื้อหมู เนื้อปลา ปลาหมึก ให้ระบุปริมาณเป็นช้อนโต๊ะ (เนื้อสัตว์ 1 ช้อนโต๊ะ คือ เนื้อสัตว์ที่พอดีกับช้อนไม่พูน ส่วนกุ้งให้ระบุเป็นตัว) / เนื้อสัตว์ให้ระบุด้วยว่าเป็นเนื้อสัตว์ที่ติดมัน, ติดหนัง หรือ เนื้อล้วน เช่น ไก่ทอดกินหนังด้วย ขาหมูกินหนังด้วย

2. ลูกชิ้น ให้ระบุประเภทลูกชิ้นด้วย เช่น ลูกชิ้นเนื้อ ลูกชิ้นปลา ลูกชิ้นกุ้ง ลูกชิ้นหมู ลูกชิ้นเต้าหู้ และให้ระบุขนาดและจำนวนที่รับประทานเป็นลูก

3. เต้าหู้ ให้ระบุประเภท เช่น เต้าหู้ไข่ เต้าหู้ขาวหลอด เต้าหู้ขาวแผ่น และให้ระบุจำนวนที่รับประทานเป็นช้อนโต๊ะ

- ผัก

ให้ระบุประเภท ส่วนปริมาณระบุเป็นทัพพี หรือถ้าผักชนิดนั้นรับประทานน้อยจนระบุเป็นทัพพีไม่ได้สามารถระบุเป็นช้อนโต๊ะได้

- นม

1. นม ระบุรสชาดและดูข้างกล่องแล้วเขียนประเภทของนมด้วย เช่น นมพร่องมันเนย นมไขมัน 0 % นมสด เป็นต้น ระบุปริมาตรด้วย เช่น 200 มิลลิลิตร, 500 มิลลิลิตร เป็นต้น

2. ไอศกรีม ให้ระบุรสชาติและปริมาณเป็นลูกหรือแท่ง เช่น ไอศกรีม swensen 2 ลูก รสช็อคโกแลต, รสแคนตาลูป เป็นต้น หรือ ไอศครีมวอลล์ก็ระบุชื่อ เช่น คอนเนตโต้ แมคนัม เป็นต้น

- ผลไม้

1. ระบุเป็นลูก ส้ม แอปเปิ้ล กล้วย (ระบุประเภทด้วย เช่น กล้วยหอม กล้วยไข่ กล้วยน้ำว้า) ลำไย องุ่น ลิ้นจี่ เงาะ ชมพู่

2. ระบุเป็นกลีบ ส้มโอ

3. ระบุเป็นคำเคี้ยว มะม่วงดิบ มะม่วงสุก ฝรั่ง (แต่ถ้ามะม่วงดิบ มะม่วงสุก ฝรั่ง กินเป็นลูกก็ให้ระบุเป็นลูกได้) มะละกอ สับประรด แคนตาลูป แก้วมังกร แตงโม เป็นต้น

- น้ำมัน

1. น้ำสลัด ให้ระบุเป็นช้อนโต๊ะ

2. กะทิ เช่น แกงที่เป็นแกงกะทิ ขนมที่ใส่กะทิ ให้ระบุปริมาณน้ำแกงที่มีกะทิเป็นส่วนประกอบเป็นช้อนโต๊ะหรือทัพพีกรณีที่รับประทานปริมาณมาก

- การปรุงรส

1. ถ้าอาหารมีการปรุงรสโดยการเติมน้ำตาลให้ระบุเป็นช้อนชา เช่น การปรุงรสก๋วยเตี๋ยว

2. เครื่องดื่มที่มีการเติมน้ำตาล นมข้น คอฟฟี่เมต ให้ระบุเป็นช้อนชา

3. ขนมปังที่มีการทาเนย (ระบุประเภทเนย เช่น เนยหวาน เนยเค็ม) ทาแยมให้ระบุเป็นช้อนชา

- อาหารประเภท Fast food

1. Mcdonald ให้ระบุเป็นชื่อ เช่น แมคฟิช ซามูไรเบอร์เกอร์ ชีสเบอร์เกอร์ เบอร์เกอร์หมู 19 บาท เป็นต้น / เฟรนฟราย ได้แก่ ใหญ่ กลางและเล็ก / โค้ก ใหญ่ กลาง เล็ก

2. พิซซ่า ระบุเป็นชิ้นว่าขนาดใหญ่ กลาง เล็ก หน้าที่รับประทาน และอาหารอื่นๆ ที่รับประทานอีก เช่น สลัดผัก หอมทอด เป็นต้น

- เครื่องดื่ม

ให้ระบุยี่ห้อและปริมาตร เช่น โค้ก 1.25 ลิตร ขวด 7 บาท ขวด 8 บาท ขวด 11 บาท / เป็บซี่ max / ชาเขียวโออิชิ 500 มิลลิลิตร / อะมิโนโอเค รสมะนาว 470 มิลลิลิตร

<u>ใบบันทึกอาหาร</u>

ชื่อ-สกุล .... วันที่ ....

วันฝึกซ้อม ☐ วันหยุด ☐

มื้อ/เวลา	รายการอาหาร	ส่วนประกอบ	ปริมาณ

ตัวอย่างการบันทึกอาหาร

ชื่อ-สกุล ....วันที่ ....วันฝึกซ้อม ☐ วันหยุด ☑

มื้อ/เวลา	รายการอาหาร	ส่วนประกอบ	ปริมาณที่รับประทาน
- มื้อเช้า	- ข้าว		3 ทัพพี
(7.30 น.)	- ผัดเครื่องในไก่ใส่เม็ดมะม่วง	กึ๋น	1 ช้อนโต๊ะ
		ตับ	1 ช้อนโต๊ะ
		เนื้อไก่ล้วนไม่มีหนัง	1 ช้อนโต๊ะ
		เม็ดมะม่วง	10 เม็ด
	- ต้มจืดหมูสับผักกาดขาว	หมู	4 ช้อนโต๊ะ
		ผักกาดขาว	2 ทัพพี
	- กุนเชียงทอด		3 ช้อนโต๊ะ
	- น่องไก่ทอด		5 ช้อนโต๊ะ
	- ขนมมันฝรั่งเลย์ถุงใหญ่ (28 บาท)		ครึ่งถุง
	- โค้ก 1.25 ลิตร		1 ขวด
	- แคนตาลูป		8 คำเคี้ยว
-มื้อว่าง	- ขนมปังปิ้งทาเนย	ขนมปังฟาร์มเฮ้าส์	2 แผ่น
(10.00 น.)		เนยรสหวาน	2 ช้อนชา
	- นมจืดไขมัน 0 %		1 กล่อง (200 ml)
	- มะม่วงสุก		1 ลูก (12 x 6 ซม.)
- มื้อกลางวัน	- บะหมี่เกี๊ยวหมูแดง	บะหมี่เหลือง	2 ทัพพี
(12.30 น.)		เกี๊ยวหมู	5 อัน
		หมูแดง	2 ช้อนโต๊ะ
		ผักกวางตุ้ง	3 ช้อนโต๊ะ
		น้ำตาลที่เติมตอนปรุงรรส	2 ช้อนชา
	- ข้าวเหนียวหมูปิ้ง	ข้าวเหนียว	5 ช้อนโต๊ะ
		หมูปิ้ง	5 ช้อนโต๊ะ
	- ขนมเอแคร์ไส้ครีมวนิลา		3 ลูก
	- น้ำส้มซันควิก		1 แก้ว (240 ml)

<u>ตัวอย่างใบบันทึกอาหาร</u> (ต่อ)

มื้อ/เวลา	รายการอาหาร	ส่วนประกอบ	ปริมาณที่รับประทาน
- มื้อว่าง (15.00 น.)	- ซาลาเปาไส้หมูสับไข่เค็ม (ลูกใหญ่ 14 บาท ของ 7 eleven) - ขนมจีบไส้กุ้ง (7 eleven) - ไอศครีมวอลล์คอนเนตโต้ - น้ำเต้าหู้ (หวานมาก)	น้ำตาลทรายในน้ำเต้าหู้ ประมาณ 5 ช้อนชา	1 ลูก 4 ลูก 2 อัน 1 แก้ว (250 ml)
- มื้อเย็น (19.30 น.)	Mcdonald - แมคฟิช - เฟรนฟรายใหญ่ - โค้กใหญ่ - ไอศครีมสเวนเซ่น	ไอศครีม	1 ชิ้น 1 กล่อง 1 แก้ว 3 ลูก รสแคนตาลูป รสช็อคโกแลต รสมอคค่าอัลมอนด์ฟัดจ์ วิปครีม 2 ช้อนโต๊ะ

APPENDIX B
SIDE EFFECTS ASSESSMENT

<u>แบบสอบถามผลข้างเคียงจากการได้รับครีเอทีน</u>

ชื่อ-สกุล ....วันที่..

กรุณาทำเครื่องหมาย √ ลงในช่อง

ในช่วงของการให้ Creatine loading ท่านมีอาการดังต่อไปนี้มากน้อยเพียงใด

	ไม่มี	เล็กน้อย	ปานกลาง	มาก
กล้ามเนื้อเป็นตะคริว				
ปวดกล้ามเนื้อ				
ตึงกล้ามเนื้อ				
ปวดท้อง				
ท้องเสีย				
อ่อนเพลีย				
กระหายน้ำ				
ความอยากอาหารมีความเปลี่ยนแปลงไป มากขึ้น / น้อยลง (โปรดวงกลมอาการที่เกิดขึ้น)				
อารมณ์หงุดหงิดฉุนเฉียวง่าย				
ปวดหัว				
วิงเวียนศีรษะ				
คลื่นไส้				
อาเจียน				
อาการอื่นๆ				

APPENDIX C
THE RAW DATA OF THE STUDY

Table i Body composition at baseline (Day 0)

Group	No	BW0 (kg)	TBW0 (l)	ICW0 (l)	ECW0 (l)	Prot0 (kg)	SMM0 (kg)	BMI0 (kg/m^2)
Cr	1	80.3	49.8	31.6	18.1	13.7	39.3	25.1
	2	70.3	42.8	27.6	15.2	11.9	34.0	24.3
	3	62.2	41.5	26.1	15.4	11.3	32.0	19.9
	4	80.0	47.7	30.8	16.9	13.3	38.1	25.5
	5	56.5	37.8	24.5	13.3	10.6	30.0	20.8
	6	73.9	46.5	30.1	16.4	13.0	37.3	24.4
	7	63.2	40.3	26.1	14.2	11.3	32.1	21.9
	8	70.0	41.0	26.0	15.0	11.2	31.8	23.4
	9	74.9	46.2	29.7	16.5	12.8	36.7	26.2
	10	55.7	37.7	23.9	13.8	10.3	29.1	20.5
	11	55.1	36.2	23.1	13.1	10.0	28.1	19.3
	12	58.3	38.4	24.4	14.0	10.5	29.8	19.9
	13	74.8	44.5	28.1	16.4	12.2	34.7	23.6
	14	66.0	40.8	25.6	15.2	11.1	31.4	21.6
	15	77.3	46.6	29.8	16.8	12.9	36.9	26.7
	16	82.3	45.9	29.0	16.9	12.5	35.8	25.4
P	1	96.9	52.0	33.3	18.7	14.4	41.4	30.8
	2	79.4	50.6	32.9	17.7	14.2	40.9	25.9
	3	67.1	44.4	28.8	15.6	12.5	35.6	23.5
	4	61.2	40.7	25.5	15.2	11.0	31.2	19.5
	5	66.6	41.1	26.5	14.6	11.5	32.6	23.0
	6	60.7	38.9	24.3	14.6	10.5	29.7	19.4
	7	55.5	35.7	23.0	12.7	9.9	28.0	22.0
	8	75.3	48.6	30.8	17.8	13.3	38.1	24.0
	9	69.0	41.8	26.4	15.4	11.4	32.4	24.4
	10	52.0	33.9	21.3	12.6	9.2	25.7	18.0

Cr = Creatine group, P = Placebo group

BW = Body weight, TBW = Total body water, ICW = Intracellular water

ECW = Extracellular water, Prot = Body protein mass, BMI = Body mass index

Table i Body composition at baseline (Day 0) (continued)

Group	No	BW0 (kg)	TBW0 (l)	ICW0 (l)	ECW0 (l)	Prot0 (kg)	SMM0 (kg)	BMI0 (kg/m^2)
	11	58.1	38.6	24.9	13.7	10.8	30.5	21.1
P	12	60.1	37.7	23.8	13.9	10.3	29	20.1
	13	68.5	42.4	27.3	15.1	11.8	33.6	22.4
	14	69.9	40.8	25.8	15	11.2	31.7	24.8
	15	80.6	46.5	29.6	16.9	12.8	36.6	26.2
	16	98.2	53.7	35.8	17.9	15.5	44.7	30.3

BW =Body weight, TBW = Total body water, ICW = Intracellular water

ECW = Extracellular water, Prot = Body protein mass, BMI = Body mass index

Table ii Body weight and body mass index

Group	No	BW 0	BW 31	BW 37	BW 59	BMI 0	BMI 31	BMI 37	BMI 59
		(kg)				(kg/m^2)			
Cr	1	80.3	80.2	81.1	81.1	25.10	25.00	25.30	25.30
	2	70.3	69.6	71.0	70.5	24.30	24.10	24.60	24.40
	3	62.2	62.9	63.7	65.9	19.90	20.10	20.30	21.00
	4	80.0	80.5	81.0	81.1	25.50	25.70	25.90	25.90
	5	56.5	56.2	57.4	57.0	20.80	20.60	21.10	20.90
	6	73.9	73.1	74.6	74.8	24.40	24.10	24.60	24.70
	7	63.2	64.0	64.3	64.9	21.90	22.10	22.20	22.50
	8	70.0	69.3	68.9	68.6	23.40	23.20	23.00	22.90
	9	74.9	74.2	74.5	74.3	26.20	26.00	26.10	26.00
	10	55.7	55.3	56.0	55.7	20.50	20.10	20.10	20.00
	11	55.1	56.2	58.1	57.7	19.30	19.70	20.30	20.20
	12	58.3	61.0	62.2	63.6	19.90	20.90	21.30	21.80
	13	74.8	74.5	75.4	75.9	23.60	23.50	23.80	24.00
	14	66.0	65.7	65.6	68.5	21.60	21.50	21.70	22.40
	15	77.3	76.3	77.1	76.4	26.70	26.40	26.70	26.40
	16	82.3	80.0	80.1	80.3	25.40	24.70	24.70	24.80
P	1	96.9	96.3	95.6	96.9	30.80	30.60	30.30	30.80
	2	79.4	79.9	79.5	79.6	25.90	26.10	26.00	25.70
	3	67.1	67.3	67.1	67.9	23.50	23.60	23.50	23.50
	4	61.2	62.7	61.7	62.3	19.50	19.80	19.50	19.70
	5	66.6	68.0	67.9	68.1	23.00	23.50	23.50	23.60
	6	60.7	61.4	61.8	61.5	19.40	19.60	19.70	19.90
	7	55.5	55.3	56.0	55.1	22.00	21.90	22.20	21.80
	8	75.3	73.3	76.6	74.8	24.00	23.40	24.50	23.90
	9	69.0	66.4	66.6	67.2	24.40	23.50	23.60	23.80
	10	52.0	51.3	52.2	52.6	18.00	17.50	17.90	18.00
	11	58.1	60.7	60.8	61.2	21.10	22.00	22.10	22.20
	12	60.1	60.1	59.9	60.0	20.10	20.10	20.00	20.00
	13	68.5	70.3	69.7	69.9	22.40	22.40	22.20	22.30
	14	69.9	69.6	70.9	70.4	24.80	24.70	25.10	24.90
	15	80.6	80.2	80.8	80.8	26.20	26.20	26.40	26.40
	16	98.2	94.8	98.0	99.5	30.30	29.30	30.20	30.70

Table iii Body water

Group	No	TBW 0	TBW 31	TBW 37	TBW 59	ICW 0	ICW 31	ICW 37	ICW 59
		(l)				(l)			
Cr	1	49.8	49.0	50.0	49.4	31.6	31.2	31.6	31.4
	2	42.8	42.1	43.3	42.5	27.6	27.3	27.7	27.6
	3	41.5	41.6	42.9	44.0	26.1	26.3	27.2	28.2
	4	47.7	47.5	47.8	47.4	30.8	30.8	30.9	30.7
	5	37.8	37.4	39.8	37.8	24.5	24.4	25.6	24.6
	6	46.5	45.9	47.0	46.5	30.1	29.8	30.4	30.5
	7	40.3	40.8	41.5	41.6	26.1	26.5	26.7	27.0
	8	41.0	41.5	41.3	40.7	26.0	26.7	26.4	26.3
	9	46.2	45.6	46.0	45.3	29.7	29.1	29.8	29.1
	10	37.7	38.0	38.4	38.5	23.9	24.2	24.4	24.8
	11	36.2	36.8	38.4	38.4	23.1	23.6	24.5	24.6
	12	38.4	40.9	41.2	43.0	24.4	26.1	26.4	27.3
	13	44.5	44.2	45.6	46.0	28.1	28.2	29.1	29.4
	14	40.8	41.1	40.8	44.0	25.6	26.2	26.0	28.1
	15	46.6	47.5	48.3	47.9	29.8	30.4	30.9	31.1
	16	45.9	47.6	47.3	48.4	29.0	30.2	30.4	30.9
P	1	52.0	52.2	50.5	52.4	33.3	33.6	32.4	33.5
	2	50.6	50.2	50.2	51.0	32.9	32.9	32.8	33.5
	3	44.4	44.0	44.5	44.4	28.8	28.5	28.8	28.7
	4	40.7	41.8	41.3	41.3	25.5	26.2	25.9	25.8
	5	41.1	42.0	41.9	41.3	26.5	27.2	27.1	26.8
	6	38.9	39.2	40.4	38.2	24.3	24.5	25.2	23.9
	7	35.7	35.4	36.2	35.3	23.0	22.9	23.6	22.8
	8	48.6	46.9	48.8	48.0	30.8	30.6	31.3	31.0
	9	41.8	39.9	40.3	41.0	26.4	25.6	25.8	26.3
	10	33.9	33.7	34.2	35.1	21.3	21.3	21.5	22.2
	11	38.6	40.0	40.0	40.4	24.9	26.0	26.1	26.0
	12	37.7	38.2	37.9	38.5	23.8	24.2	24.1	24.5
	13	42.4	45.0	44.2	44.3	27.3	28.9	28.4	28.6
	14	40.8	40.8	41.8	41.5	25.8	26.0	26.6	26.5
	15	46.5	47.2	47.9	48.2	29.6	30.0	30.4	30.6
	16	53.7	50.9	54.3	54.7	35.8	32.7	34.3	34.6

Table iii Body water (continued)

Group	No	ECW 0	ECW 31	ECW 37	ECW 59
		(l)			
Cr	1	18.10	17.90	18.40	18.00
	2	15.20	14.90	15.50	14.90
	3	15.40	15.30	15.70	15.80
	4	16.90	16.70	17.00	16.70
	5	13.30	13.10	14.20	13.20
	6	16.40	16.00	16.60	16.00
	7	14.20	14.30	14.80	14.60
	8	15.00	14.80	14.80	14.40
	9	16.50	16.50	16.20	16.20
	10	13.80	13.80	14.00	13.70
	11	13.10	13.20	13.90	13.80
	12	14.00	14.80	14.80	15.70
	13	16.40	16.00	16.50	16.60
	14	15.20	14.90	14.80	15.90
	15	16.80	17.10	17.40	16.80
	16	16.90	17.40	16.90	17.50
P	1	18.70	18.60	18.20	18.90
	2	17.70	17.30	17.40	17.50
	3	15.60	15.50	15.70	15.70
	4	15.20	15.60	15.40	15.50
	5	14.60	14.80	14.80	14.50
	6	14.60	14.70	15.20	14.30
	7	12.70	12.50	12.60	12.50
	8	17.80	16.30	17.50	17.00
	9	15.40	14.30	14.50	14.70
	10	12.60	12.40	12.70	12.90
	11	13.70	14.00	13.90	14.40
	12	13.90	14.00	13.80	14.00
	13	15.10	16.10	15.80	15.70
	14	15.00	14.80	15.20	15.00
	15	16.90	17.20	17.50	17.60
	16	17.90	18.20	20.00	20.10

Table iv Body protein mass and skeletal muscle mass

Group	No	Prot 0	Prot 31	Prot 37	Prot 59	SMM 0	SMM 31	SMM 37	SMM 59
		(kg)				(kg)			
Cr	1	13.7	13.5	13.7	13.6	39.3	38.7	39.2	39.0
	2	11.9	11.8	12.0	11.9	34.0	33.6	34.1	34.0
	3	11.3	11.4	11.8	12.2	32.0	32.3	33.5	34.8
	4	13.3	13.3	13.3	13.3	38.1	38.2	38.3	38.0
	5	10.6	10.5	11.1	10.6	30.0	29.8	31.4	30.1
	6	13.0	12.9	13.1	13.2	37.3	36.9	37.6	37.8
	7	11.3	11.5	11.5	11.7	32.1	32.6	32.8	33.3
	8	11.2	11.5	11.4	11.4	31.8	32.8	32.5	32.2
	9	12.8	12.6	12.9	12.6	36.7	36.0	36.9	36.0
	10	10.3	10.5	10.5	10.7	29.1	29.5	29.8	30.4
	11	10.0	10.2	10.6	10.6	28.1	28.8	29.9	30.0
	12	10.5	11.3	11.4	11.8	29.8	32.0	32.4	33.6
	13	12.2	12.2	12.6	12.7	34.7	34.7	35.9	36.4
	14	11.1	11.3	11.2	12.1	31.4	32.2	31.9	34.6
	15	12.9	13.1	13.3	13.4	36.9	37.6	38.2	38.6
	16	12.5	13.1	13.1	13.4	35.8	37.4	37.6	38.3
P	1	14.4	14.5	14.0	14.5	41.4	41.8	40.2	41.7
	2	14.2	14.2	14.2	14.5	40.9	40.9	40.8	41.6
	3	12.5	12.3	12.4	12.4	35.6	35.2	35.5	35.4
	4	11.0	11.3	11.2	11.1	31.2	32.2	31.7	31.6
	5	11.5	11.7	11.7	11.6	32.6	33.4	33.3	32.9
	6	10.5	10.6	10.9	10.3	29.7	29.9	30.9	29.2
	7	9.9	9.9	10.2	9.9	28.0	27.9	28.7	27.7
	8	13.3	13.2	13.5	13.4	38.1	37.9	38.8	38.4
	9	11.4	11.0	11.1	11.4	32.4	31.3	31.6	32.3
	10	9.2	9.2	9.3	9.6	25.7	25.8	26.0	27.0
	11	10.8	11.2	11.3	11.3	30.5	31.9	32.1	32.0
	12	10.3	10.5	10.4	10.6	29.0	29.6	29.4	30.0
	13	11.8	12.5	12.3	12.4	33.6	35.7	35.0	35.3
	14	11.2	11.3	11.5	11.5	31.7	32.0	32.7	32.5
	15	12.8	13.0	13.2	13.2	36.6	37.2	37.7	37.9
	16	15.5	14.2	14.8	15.0	44.7	40.7	42.8	43.1

Prot = Body protein mass, SMM = Skeletal muscle mass

Table v Fat free mass and fat free mass index

Group	No	FFM 0	FFM 31	FFM 37	FFM 59	FFM index 0	FFM Index 31	FFM Index 37	FFM Index 59
		(kg)				(kg/m^2)			
Cr	1	67.9	66.9	68.1	67.4	21.19	20.88	21.25	21.04
	2	58.8	57.9	59.3	58.5	20.35	20.03	20.52	20.24
	3	56.6	56.8	58.5	60.2	18.07	18.13	18.67	19.22
	4	65.5	65.4	65.8	65.2	20.91	20.88	21.00	20.81
	5	51.9	51.4	54.5	51.9	19.06	18.88	20.02	19.06
	6	64.0	63.1	64.6	64.1	21.14	20.84	21.34	21.17
	7	55.3	56.0	56.7	57.0	19.13	19.38	19.62	19.72
	8	56.0	56.9	56.5	55.9	18.71	19.01	18.88	18.68
	9	63.3	62.3	63.1	62.0	22.16	21.81	22.09	21.71
	10	51.4	51.8	52.4	52.7	18.88	18.80	18.79	18.90
	11	49.5	50.4	52.5	52.5	17.33	17.65	18.38	18.38
	12	52.5	55.9	56.4	58.7	17.95	19.12	19.29	20.07
	13	60.9	60.6	62.5	63.1	19.22	19.13	19.73	19.92
	14	55.7	56.3	55.8	60.2	18.19	18.38	18.43	19.66
	15	63.6	64.8	65.9	65.7	22.01	22.42	22.80	22.73
	16	62.9	65.3	65.0	66.4	19.41	20.15	20.06	20.49
P	1	71.2	71.7	69.3	71.8	22.60	22.76	22.00	22.79
	2	69.5	69.1	68.9	70.2	22.69	22.56	22.50	22.66
	3	60.9	60.3	60.9	60.8	21.32	21.11	21.32	21.04
	4	55.3	56.9	56.2	56.1	17.65	17.96	17.74	17.71
	5	56.5	57.7	57.5	56.8	19.55	19.97	19.90	19.65
	6	53.0	53.4	54.9	52.0	16.92	17.04	17.52	16.79
	7	48.7	48.3	49.5	48.2	19.26	19.11	19.58	19.07
	8	66.2	64.4	66.7	65.7	21.13	20.56	21.29	20.97
	9	57.0	54.7	55.1	56.1	20.18	19.38	19.52	19.88
	10	46.1	46.0	46.5	47.9	15.95	15.73	15.90	16.38
	11	52.8	54.8	54.8	55.2	19.16	19.89	19.89	20.03
	12	51.5	52.2	51.7	52.6	17.21	17.44	17.27	17.57
	13	58.2	61.6	60.6	60.7	19.00	19.66	19.34	19.38
	14	55.8	55.9	57.1	56.7	19.77	19.81	20.23	20.09
	15	63.6	64.5	65.4	65.9	20.65	21.06	21.36	21.52
	16	74.3	69.9	74.2	74.7	22.93	21.57	22.90	23.06

FFM = Fat free mass, FFM index = Fat free mass index

Table vi Fat mass and percent body fat

Group	No	Fat mass 0	Fat mass 31	Fat mass 37	Fat mass 59	Body fat 0	Body fat 31	Body fat 37	Body fat 59
		(kg)				(%)			
Cr	1	12.4	13.3	13.0	13.7	15.5	16.6	16.0	16.9
	2	11.5	11.7	11.7	12.0	16.4	16.8	16.5	17.0
	3	5.6	6.1	5.2	5.7	9.1	9.8	8.1	8.6
	4	14.5	15.1	15.2	15.9	18.1	18.7	18.8	19.6
	5	4.6	4.8	2.9	5.1	8.2	8.6	5.1	9.0
	6	9.9	10.0	10.0	10.7	13.5	13.7	13.4	14.3
	7	7.9	8.0	7.6	7.9	12.5	12.5	11.8	12.1
	8	14.0	12.4	12.4	12.7	20.0	17.9	17.9	18.5
	9	11.6	11.9	11.4	12.3	15.5	16.0	15.3	16.6
	10	4.3	3.5	3.6	3.0	7.8	6.3	6.4	5.4
	11	5.6	5.8	5.6	5.2	10.1	10.3	9.7	9.1
	12	5.8	5.1	5.8	4.9	9.9	8.3	9.4	7.7
	13	13.9	13.9	12.9	12.8	18.5	18.6	17.1	16.8
	14	10.3	9.4	9.8	8.3	15.6	14.3	14.9	12.1
	15	13.7	11.5	11.2	10.7	17.7	15.1	14.5	14.1
	16	19.4	14.7	15.1	13.9	23.6	18.4	18.8	17.3
P	1	25.7	24.6	26.3	25.1	26.6	25.5	27.5	25.9
	2	9.9	10.8	10.6	9.4	12.5	13.5	13.3	11.8
	3	6.2	7.0	6.2	7.1	9.3	10.4	9.3	10.5
	4	5.9	5.8	5.5	6.2	9.6	9.2	8.9	9.9
	5	10.1	10.3	10.4	11.3	15.2	15.2	15.3	16.6
	6	7.7	8.0	6.9	9.5	12.7	13.1	11.2	15.4
	7	6.8	7.0	6.5	6.9	12.2	12.6	11.6	12.6
	8	9.1	8.9	9.9	9.1	12.1	12.2	12.9	12.2
	9	12.0	11.7	11.5	11.1	17.4	17.6	17.2	16.4
	10	5.9	5.3	5.7	4.7	11.3	10.4	10.8	9.0
	11	5.3	5.9	6.0	6.0	9.1	9.7	9.8	9.8
	12	8.6	7.9	8.2	7.4	14.4	13.1	13.6	12.4
	13	10.3	8.7	9.1	9.2	15.1	12.4	13.1	13.1
	14	14.1	13.7	13.8	13.7	20.2	19.7	19.4	19.5
	15	17.0	15.7	15.4	14.9	21.1	19.6	19.1	18.5
	16	23.9	24.9	23.8	24.8	24.3	26.2	24.3	24.9

Table vii Daily nutrient intake

Group	No	Energy 0	Energy 31	Energy 37	Energy 59
		(Kcal)			
Cr	1	1,817.89	2,677.39	2,608.00	1,774.41
	2	1,375.17	1,999.56	1,871.85	1,714.07
	3	2,092.17	2,069.92	1,880.22	2,435.73
	4	2,771.94	2,593.26	1,975.47	2,231.99
	5	1,337.67	2,069.08	2,156.47	1,475.28
	6	1,816.48	1,787.26	1,886.34	1,609.81
	7	1,563.64	1,817.11	2,446.57	3,316.59
	8	1,798.44	2,838.30	1,840.42	2,886.50
	9	1,244.03	1,694.00	1,970.80	2,103.00
	10	1,422.39	1,873.96	2,832.18	2,333.83
	11	2,549.76	2,055.04	2,534.72	2,274.65
	12	2,553.44	2,453.91	1,938.06	2,597.28
	13	2,146.22	1,808.37	2,075.46	1,844.99
	14	2,379.30	3,027.67	1,220.26	2,040.77
	15	1,619.18	1,939.37	1,705.94	2,114.92
	16	2,166.38	2,098.27	1,881.15	2,148.63
P	1	2,945.94	2,190.00	2,944.12	3,272.69
	2	1,884.31	2,008.22	1,723.29	2,260.17
	3	1,721.30	2,298.59	1,853.67	2,324.40
	4	1,397.11	1,839.00	1,773.59	1,823.63
	5	1,824.83	2,541.21	1,462.59	1,666.82
	6	1,441.29	2,355.94	2,286.14	3,613.95
	7	1,476.50	1,442.42	1,897.17	1,878.44
	8	1,779.57	2,112.78	1,928.36	2,244.36
	9	1,399.88	2,815.29	2,246.00	2,947.52
	10	1,412.52	2,143.39	1,934.20	2,277.65
	11	1,514.74	1,508.09	1,441.97	2,364.98
	12	2,470.42	2,418.84	2,012.50	2,018.77
	13	1,884.76	1,774.63	1,641.37	2,460.24
	14	2,295.63	2,357.17	2,246.93	1,836.18
	15	1,564.65	1,223.89	1,425.42	2,568.83
	16	1,606.14	1,538.06	1,753.74	3,757.83

Table vii Daily nutrient intake (continued)

Group	No	CHO 0	CHO 31	CHO 37	CHO 59	CHO 0	CHO 31	CHO 37	CHO 59
		(g/day)				(g/kg/day)			
Cr	1	242.58	309.60	393.80	205.23	3.02	3.86	4.86	2.53
	2	145.03	272.93	199.54	202.72	2.06	3.92	2.81	2.88
	3	257.17	320.03	269.99	341.23	4.13	5.09	4.24	5.18
	4	368.63	377.73	237.95	336.59	4.61	4.69	2.94	4.15
	5	150.01	273.86	265.99	216.41	2.66	4.87	4.63	3.80
	6	213.09	217.50	236.57	196.56	2.88	2.98	3.17	2.63
	7	244.61	268.18	261.57	490.15	3.87	4.19	4.07	7.55
	8	224.55	326.20	248.75	337.83	3.21	4.71	3.61	4.92
	9	184.32	231.41	296.18	361.90	2.46	3.12	3.98	4.87
	10	175.71	286.07	356.54	303.47	3.15	5.17	6.37	5.45
	11	373.27	292.93	344.99	252.12	6.77	5.21	5.94	4.37
	12	326.32	377.91	279.12	381.84	5.60	6.20	4.49	6.00
	13	295.86	259.96	297.58	299.48	3.96	3.49	3.95	3.95
	14	302.62	440.48	168.66	271.28	4.59	6.70	2.57	3.96
	15	198.76	214.15	213.66	183.39	2.57	2.81	2.77	2.40
	16	283.41	307.74	261.30	277.51	3.44	3.85	3.26	3.46
P	1	363.83	286.54	316.77	390.24	3.75	2.98	3.31	4.03
	2	276.44	292.82	282.92	365.67	3.48	3.66	3.56	4.59
	3	258.27	302.28	279.81	317.13	3.85	4.49	4.17	4.67
	4	233.20	296.12	280.84	243.12	3.81	4.72	4.55	3.90
	5	237.28	319.07	203.35	206.34	3.56	4.69	2.99	3.03
	6	185.91	326.33	272.25	336.34	3.06	5.31	4.41	5.47
	7	223.78	183.07	225.56	299.75	4.03	3.31	4.03	5.44
	8	224.63	311.10	233.20	352.67	2.98	4.24	3.04	4.71
	9	154.15	492.95	321.95	503.67	2.23	7.40	4.83	7.50
	10	173.74	328.85	249.87	353.62	3.34	6.40	4.79	6.72
	11	224.10	196.27	200.13	343.36	3.86	3.23	3.29	5.61
	12	288.39	282.68	206.86	265.88	4.80	4.70	3.45	4.43
	13	239.64	235.59	244.13	232.07	3.50	3.35	3.50	3.32
	14	308.59	339.30	285.99	286.45	4.41	4.88	4.03	4.07
	15	174.10	141.79	187.91	206.40	2.16	1.77	2.33	2.55
	16	230.30	164.89	203.18	432.86	2.35	1.74	2.07	4.35

CHO = Carbohydrate

Table vii Daily nutrient intake (continued)

Group	No	Prot 0	Prot 31	Prot 37	Prot 59	Prot 0	Prot 31	Prot 37	Prot 59
		(g/day)				(g/kg/day)			
Cr	1	61.03	77.07	106.23	63.52	0.76	0.96	1.31	0.78
	2	67.40	60.30	68.75	71.88	0.96	0.87	0.97	1.02
	3	84.60	76.83	75.88	82.37	1.36	1.22	1.19	1.25
	4	87.12	84.43	76.05	73.80	1.09	1.05	0.94	0.91
	5	64.34	85.75	118.25	67.70	1.14	1.53	2.06	1.19
	6	106.51	79.56	71.55	72.54	1.44	1.09	0.96	0.97
	7	54.60	70.92	145.11	98.81	0.86	1.11	2.26	1.52
	8	88.44	101.85	75.28	72.76	1.26	1.47	1.09	1.06
	9	49.53	72.92	73.33	63.44	0.66	0.98	0.98	0.85
	10	67.81	72.55	120.29	106.85	1.22	1.31	2.15	1.92
	11	108.44	85.12	92.63	110.93	1.97	1.51	1.59	1.92
	12	105.97	78.93	67.54	84.70	1.82	1.29	1.09	1.33
	13	64.87	79.19	81.71	62.78	0.87	1.06	1.08	0.83
	14	103.40	109.04	61.77	81.31	1.57	1.66	0.94	1.19
	15	75.23	110.08	104.03	121.30	0.97	1.44	1.35	1.59
	16	70.16	91.98	86.64	89.94	0.85	1.15	1.08	1.12
P	1	129.62	96.29	153.93	169.28	1.34	1.00	1.61	1.75
	2	72.84	73.17	63.49	72.34	0.92	0.92	0.80	0.91
	3	74.82	107.02	75.71	85.58	1.12	1.59	1.13	1.26
	4	42.92	65.72	67.33	67.95	0.70	1.05	1.09	1.09
	5	77.74	102.08	51.96	66.68	1.17	1.50	0.77	0.98
	6	56.03	92.10	105.81	168.83	0.92	1.50	1.71	2.75
	7	53.16	77.17	77.70	47.36	0.96	1.40	1.39	0.86
	8	83.46	84.56	86.49	84.92	1.11	1.15	1.13	1.14
	9	64.89	81.94	93.02	90.73	0.94	1.23	1.40	1.35
	10	59.72	85.15	81.16	79.35	1.15	1.66	1.55	1.51
	11	58.00	75.58	76.56	94.46	1.00	1.25	1.26	1.54
	12	112.15	106.57	111.83	110.57	1.87	1.77	1.87	1.84
	13	77.16	86.18	83.86	144.69	1.13	1.23	1.20	2.07
	14	98.06	91.73	103.27	63.74	1.40	1.32	1.46	0.91
	15	84.92	67.34	67.33	109.98	1.05	0.84	0.83	1.36
	16	58.14	71.10	80.26	163.65	0.59	0.75	0.82	1.64

Prot = Protein

Table vii Daily nutrient intake (continued)

Group	No	Fat 0	Fat 31	Fat 37	Fat 59	Fat 0	Fat 31	Fat 37	Fat 59
		(g/day)				(g/kg/day)			
Cr	1	68.29	129.80	71.81	79.86	0.85	1.62	0.89	0.98
	2	58.19	78.39	90.76	70.98	0.83	1.13	1.28	1.01
	3	81.15	56.10	56.97	86.29	1.30	0.89	0.89	1.31
	4	107.39	87.24	82.11	67.87	1.34	1.08	1.01	0.84
	5	53.50	72.34	70.75	40.01	0.95	1.29	1.23	0.70
	6	59.30	69.45	76.27	61.87	0.80	0.95	1.02	0.83
	7	42.61	53.29	94.70	109.72	0.67	0.83	1.47	1.69
	8	61.52	132.58	65.29	142.72	0.88	1.91	0.95	2.08
	9	34.33	55.63	56.40	47.61	0.46	0.75	0.76	0.64
	10	49.77	52.48	105.25	80.20	0.89	0.95	1.88	1.44
	11	69.24	62.67	90.44	93.37	1.26	1.12	1.56	1.62
	12	91.26	72.74	64.44	84.31	1.57	1.19	1.04	1.33
	13	81.23	52.97	64.92	46.71	1.09	0.71	0.86	0.62
	14	84.33	94.30	35.08	72.10	1.28	1.44	0.53	1.05
	15	58.22	72.67	50.47	100.00	0.75	0.95	0.65	1.31
	16	85.41	58.17	56.86	77.30	1.04	0.73	0.71	0.96
P	1	108.78	75.52	119.41	118.09	1.12	0.78	1.25	1.22
	2	53.91	63.09	39.67	59.42	0.68	0.79	0.50	0.75
	3	42.99	75.55	50.09	82.02	0.64	1.12	0.75	1.21
	4	32.77	45.49	45.01	67.12	0.54	0.73	0.73	1.08
	5	62.88	98.43	51.85	66.18	0.94	1.45	0.76	0.97
	6	53.23	79.60	88.78	96.51	0.88	1.30	1.44	1.57
	7	42.61	47.90	80.72	57.72	0.77	0.87	1.44	1.05
	8	60.89	61.97	74.16	54.08	0.81	0.85	0.97	0.72
	9	58.33	59.65	68.02	68.86	0.85	0.90	1.02	1.02
	10	53.16	57.06	70.56	63.67	1.02	1.11	1.35	1.21
	11	43.88	48.21	39.47	70.88	0.76	0.79	0.65	1.16
	12	96.98	98.17	83.94	59.14	1.61	1.63	1.40	0.99
	13	68.86	56.71	38.86	107.99	1.01	0.81	0.56	1.54
	14	74.36	72.70	79.39	50.93	1.06	1.04	1.12	0.72
	15	57.94	44.83	46.58	123.17	0.72	0.56	0.58	1.52
	16	50.60	68.03	70.09	114.70	0.52	0.72	0.72	1.15

Table vii Daily nutrient intake (continued)

Group	No	CHO distribution 0	CHO distribution 31	CHO distribution 37	CHO distribution 59
		(%)			
Cr	1	53.05	45.61	59.52	45.77
	2	42.24	53.56	42.23	46.68
	3	49.05	61.18	56.95	55.24
	4	52.86	57.37	47.71	59.78
	5	44.82	52.43	48.95	57.84
	6	47.04	47.98	49.31	48.14
	7	61.91	58.43	42.21	58.64
	8	49.74	44.91	52.82	46.17
	9	59.25	53.88	59.66	67.97
	10	49.43	60.01	49.96	51.37
	11	58.55	56.44	53.81	43.99
	12	51.18	60.90	56.77	58.19
	13	54.44	56.72	56.64	64.08
	14	50.80	57.83	54.52	52.70
	15	49.08	43.91	49.54	34.62
	16	51.93	58.00	54.91	51.26
P	1	49.29	51.84	42.84	47.29
	2	58.74	57.65	64.94	63.96
	3	60.09	52.18	59.76	54.00
	4	66.66	63.79	62.49	52.61
	5	51.98	49.65	54.67	48.90
	6	51.40	54.61	47.12	46.56
	7	60.02	49.74	46.52	62.84
	8	50.47	58.14	47.93	63.06
	9	44.01	69.52	56.68	67.22
	10	49.21	60.63	51.02	61.37
	11	58.85	51.60	54.76	57.49
	12	46.61	46.33	40.75	52.18
	13	50.80	52.43	58.77	37.45
	14	53.76	57.06	50.36	61.63
	15	44.71	45.74	52.19	34.78
	16	57.25	42.38	46.06	50.65

Table vii Daily nutrient intake (continued)

Group	No	Prot distribution 0	Prot distribution 31	Prot distribution 37	Prot distribution 59
		(%)			
Cr	1	13.35	11.36	16.06	14.17
	2	19.63	11.83	14.55	16.55
	3	16.14	14.69	16.01	13.33
	4	12.49	12.82	15.25	13.11
	5	19.22	16.42	21.76	18.10
	6	23.51	17.55	14.92	17.77
	7	13.82	15.45	23.41	11.82
	8	19.59	14.02	15.98	9.94
	9	15.92	16.98	14.77	11.91
	10	19.08	15.22	16.86	18.09
	11	17.01	16.40	14.45	19.35
	12	16.62	12.72	13.74	12.91
	13	11.94	17.28	15.55	13.43
	14	17.36	14.32	19.97	15.79
	15	18.58	22.57	24.12	22.90
	16	12.86	17.33	18.21	16.61
P	1	17.56	17.42	20.82	20.51
	2	15.48	14.40	14.57	12.65
	3	17.41	18.47	16.17	14.57
	4	12.27	14.16	14.98	14.70
	5	17.03	15.89	13.97	15.80
	6	15.49	15.41	18.31	23.37
	7	14.26	20.97	16.02	9.93
	8	18.75	15.80	17.78	15.18
	9	18.53	11.56	16.38	20.68
	10	16.91	15.70	16.57	13.77
	11	15.23	19.87	20.95	15.81
	12	18.13	17.47	22.03	21.70
	13	16.36	19.18	20.19	23.35
	14	17.09	15.43	18.19	13.71
	15	21.81	21.72	18.70	18.53
	16	14.45	18.27	18.19	19.15

Table vii Daily nutrient intake (continued)

Group	No	Fat distribution 0	Fat distribution 31	Fat distribution 37	Fat distribution 59
		(%)			
Cr	1	33.60	43.03	24.42	40.07
	2	38.13	34.61	43.22	36.77
	3	34.82	24.13	27.04	31.43
	4	34.65	29.81	37.04	27.12
	5	35.96	31.16	29.29	24.06
	6	29.45	34.47	35.77	34.09
	7	24.27	26.12	34.38	29.54
	8	30.66	41.07	31.20	43.89
	9	24.83	29.14	25.56	20.12
	10	31.50	24.77	33.18	30.54
	11	24.44	27.17	31.74	36.65
	12	32.20	26.38	29.49	28.91
	13	33.63	26.00	27.80	22.49
	14	31.85	27.86	25.51	31.51
	15	32.35	33.52	26.33	42.48
	16	35.21	24.67	26.88	32.13
P	1	33.16	30.74	36.34	32.20
	2	25.78	27.95	20.49	23.39
	3	22.51	29.34	24.07	31.42
	4	21.08	22.05	22.53	32.68
	5	30.99	34.46	31.36	35.29
	6	33.11	29.97	34.57	30.06
	7	25.72	29.29	37.46	27.23
	8	30.78	26.06	34.30	21.76
	9	37.47	18.93	26.94	12.11
	10	33.88	23.67	32.41	24.86
	11	25.92	28.52	24.30	26.70
	12	35.26	36.20	37.21	26.12
	13	32.84	28.39	21.05	39.21
	14	29.15	27.51	31.46	24.65
	15	33.48	32.54	29.11	46.69
	16	28.30	39.34	35.75	30.20

Table viii Vitamin and mineral intake

Group	No	Vit A 0	Vit A 31	Vit A 37	Vit A 59
		(mg/day)			
Cr	1	448.90	293.49	232.26	278.01
	2	2,501.05	117.27	786.68	4,545.18
	3	1,230.02	118.35	335.00	1,960.84
	4	317.60	290.51	472.14	223.39
	5	1,029.72	267.39	203.92	2,003.28
	6	2,466.45	1,427.16	3,459.69	313.59
	7	218.52	2,557.72	86.84	252.97
	8	318.31	203.32	1,893.12	2,370.29
	9	915.38	125.03	1,661.47	55.48
	10	3,144.83	83.29	1,995.22	283.04
	11	115.02	338.45	309.35	658.55
	12	1,436.24	333.23	308.35	272.47
	13	2,036.50	68.69	231.05	2,357.09
	14	1,853.32	1,897.19	798.76	338.58
	15	376.31	956.27	257.68	409.75
	16	1,349.23	1,068.38	4,836.85	2,573.63
P	1	197.67	169.08	187.18	162.95
	2	4,225.01	167.51	92.51	981.54
	3	15,452.95	258.19	132.42	3,298.25
	4	356.72	191.81	165.51	2,515.91
	5	1,649.48	178.66	93.48	122.90
	6	127.41	132.62	145.66	484.42
	7	2,069.30	142.55	296.97	128.89
	8	2,562.68	425.89	529.08	1,797.79
	9	2,450.35	429.49	160.39	421.51
	10	1,711.30	364.51	280.24	299.66
	11	286.63	33.40	41.75	120.00
	12	290.14	241.66	99.28	3,364.66
	13	4,193.44	1,549.27	4,606.40	3,186.84
	14	164.06	1,354.81	777.32	2,466.37
	15	397.76	120.31	209.48	471.27
	16	1,402.38	1,110.24	1,834.58	717.72

Vit A = Vitamin A

Table viii Vitamin and mineral intake (continued)

Group	No	Vit B1 0	Vit B1 31	Vit B1 37	Vit B1 59	Vit B2 0	Vit B2 31	Vit B2 37	Vit B2 59
		(mg/day)				(mg/day)			
Cr	1	2.04	1.79	2.12	0.76	1.24	1.16	1.34	0.98
	2	2.21	1.81	1.42	1.35	0.95	0.71	1.54	1.06
	3	2.52	1.26	0.97	1.12	1.42	0.97	1.25	1.60
	4	1.28	1.43	1.83	2.00	1.15	0.88	2.84	0.84
	5	1.81	1.84	4.29	1.48	1.39	1.61	1.88	1.10
	6	2.09	0.96	0.63	1.72	1.79	1.93	1.59	1.46
	7	1.19	1.28	7.33	5.65	1.10	0.96	1.13	2.40
	8	3.29	2.73	1.89	2.17	1.01	0.88	0.64	0.91
	9	1.34	1.46	1.38	1.22	0.62	0.74	0.93	0.51
	10	1.89	2.65	2.84	2.49	0.68	0.87	1.03	1.03
	11	2.30	0.86	1.79	1.71	1.35	1.38	1.66	2.26
	12	2.51	1.00	1.36	1.72	2.21	1.51	1.11	1.69
	13	1.60	1.89	1.02	1.92	1.43	0.66	1.46	0.58
	14	4.14	2.02	1.95	2.96	2.02	1.57	0.56	0.99
	15	1.17	1.73	3.77	1.27	1.04	1.34	0.80	2.07
	16	0.97	1.80	1.64	1.12	1.36	1.37	1.40	1.46
P	1	4.19	1.93	4.07	7.74	1.59	1.43	1.94	1.38
	2	1.65	1.23	1.19	1.34	1.65	0.97	0.97	1.49
	3	1.35	1.82	3.07	1.27	2.54	1.43	1.25	1.66
	4	1.13	3.96	1.58	0.81	0.92	1.55	1.08	1.26
	5	1.37	2.37	1.12	1.94	1.34	1.21	0.44	0.77
	6	1.20	1.90	1.08	3.89	0.83	0.98	0.85	2.12
	7	1.79	1.28	1.72	1.14	0.89	0.80	1.05	0.48
	8	1.99	1.62	1.43	2.29	1.65	1.41	1.59	1.39
	9	1.56	1.82	2.08	1.06	1.12	1.38	0.81	1.98
	10	1.90	1.69	1.76	1.74	1.17	1.74	0.99	1.95
	11	0.95	2.24	2.37	3.08	0.78	0.57	0.41	1.07
	12	1.95	2.41	0.44	3.48	1.33	1.17	1.10	1.48
	13	1.67	1.14	0.98	3.28	1.35	0.73	1.08	1.83
	14	0.63	3.10	3.99	0.99	1.23	1.20	1.15	0.80
	15	2.00	0.43	0.68	1.42	1.18	0.77	0.90	1.68
	16	1.00	0.90	1.00	2.44	1.60	1.50	1.18	3.04

Vit B1 = Vitamin B1, Vit B2 = Vitamin B2

Table viii Vitamin and mineral intake (continued)

Group	No	Vit C 0	Vit C 31	Vit C 37	Vit C 59	Niacin 0	Niacin 31	Niacin 37	Niacin 59
		(mg/day)				(mg/day)			
Cr	1	79.57	96.92	28.32	10.76	19.03	15.21	17.20	8.81
	2	71.55	68.49	41.01	65.54	16.82	13.54	11.90	18.30
	3	179.21	253.65	99.67	223.29	19.28	14.05	11.75	15.36
	4	74.58	159.83	46.22	65.93	19.50	17.61	10.57	19.17
	5	13.42	20.44	69.42	10.61	13.87	16.07	24.14	13.26
	6	15.07	27.26	21.35	9.47	20.24	11.56	14.63	8.99
	7	95.51	71.63	115.91	32.77	13.14	16.40	37.53	19.11
	8	268.20	112.96	18.57	231.82	20.41	20.88	16.40	15.71
	9	116.14	69.79	67.44	64.39	14.76	15.12	17.65	14.99
	10	25.05	27.56	128.87	49.52	15.79	13.76	25.40	22.01
	11	87.64	12.43	25.20	36.95	28.74	12.33	12.36	14.53
	12	195.72	38.03	50.17	23.64	27.57	12.81	12.12	16.79
	13	314.53	13.10	20.19	6.32	17.93	16.99	19.55	16.70
	14	397.15	77.93	15.67	39.59	30.06	30.62	15.29	19.33
	15	36.59	27.64	25.69	53.86	17.35	19.69	18.76	23.46
	16	46.54	102.26	77.30	62.15	18.98	20.03	16.23	16.21
P	1	381.52	209.59	59.31	118.49	25.04	15.20	38.16	37.20
	2	183.52	247.15	6.70	140.69	18.09	12.46	14.40	14.53
	3	123.80	106.52	56.57	88.39	19.15	19.09	15.86	20.35
	4	289.79	121.69	83.72	19.88	9.18	13.29	12.24	13.72
	5	257.87	245.91	11.40	59.51	16.30	20.41	7.02	12.22
	6	74.97	46.59	3.68	20.46	11.45	19.10	19.31	40.93
	7	20.11	18.39	22.18	74.61	11.86	13.40	15.69	11.13
	8	19.23	64.98	29.43	114.94	17.34	16.33	16.13	15.36
	9	6.46	218.42	85.62	158.93	13.15	14.74	19.78	11.52
	10	30.83	107.32	23.79	59.32	12.98	14.41	16.47	14.18
	11	91.75	8.74	6.98	113.18	11.58	16.45	13.39	21.23
	12	68.52	42.92	17.01	16.81	24.18	23.72	26.62	18.75
	13	83.49	7.35	3.35	13.60	18.52	16.36	14.45	28.34
	14	79.82	9.48	43.49	68.92	24.64	20.56	22.50	12.50
	15	51.62	22.50	17.62	48.30	21.34	10.96	9.98	23.96
	16	99.13	111.13	41.76	338.78	17.78	18.45	17.97	38.09

Vit C = Vitamin C

Table viii Vitamin and mineral intake (continued)

Group	No	Ca 0	Ca 31	Ca 37	Ca 59	Iron 0	Iron 31	Iron 37	Iron 59
		(mg/day)				(mg/day)			
Cr	1	262.2	351.0	493.1	382.5	9.17	12.30	12.29	10.78
	2	228.9	270.1	298.0	250.9	10.18	9.56	12.54	12.86
	3	261.1	286.5	337.9	382.1	12.44	9.85	10.70	15.66
	4	276.9	450.1	1332	296.1	12.97	14.94	8.90	13.01
	5	489.5	573.6	437.4	295.3	7.32	9.94	11.11	10.74
	6	494.9	595.1	453.8	594.1	8.80	9.88	11.88	14.08
	7	399.4	258.0	346.7	652.2	7.09	11.68	14.80	13.88
	8	265.1	353.9	189.1	356.1	11.62	16.71	12.60	15.23
	9	162.7	207.2	301.0	424.7	7.26	8.74	11.18	11.16
	10	274.2	207.3	383.7	300.2	9.38	8.19	15.77	14.88
	11	215.5	410.0	513.9	583.1	13.57	17.76	22.13	16.00
	12	266.4	636.3	387.0	757.7	15.30	12.06	10.81	9.86
	13	287.3	268.1	384.6	145.6	14.43	9.01	10.27	12.82
	14	338.2	450.3	113.0	194.0	41.10	17.89	7.08	11.63
	15	181.5	399.7	208.0	306.2	9.52	12.39	11.69	16.42
	16	215.4	334.4	301.9	303.0	13.29	15.07	17.90	17.34
P	1	410.0	361.9	752.2	562.4	15.42	12.14	21.04	16.17
	2	431.1	314.8	221.9	697.4	15.02	10.97	7.66	18.26
	3	752.7	680.0	382.5	461.0	22.32	12.10	9.32	14.33
	4	205.8	355.6	372.4	347.1	9.41	10.94	8.20	11.88
	5	393.4	467.5	173.1	296.8	77.52	13.74	7.97	9.26
	6	362.6	295.0	328.0	502.2	7.08	11.18	8.60	23.64
	7	159.1	180.9	195.2	257.4	8.52	10.11	16.54	14.87
	8	493.9	376.0	447.9	274.0	12.38	22.09	14.85	15.67
	9	302.4	449.4	270.9	394.1	8.97	13.36	11.39	21.78
	10	518.3	609.3	340.9	449.4	7.47	11.35	10.75	11.78
	11	238.0	126.9	129.3	241.0	7.54	7.22	8.00	12.59
	12	208.4	314.7	279.6	319.6	13.34	11.70	11.49	15.69
	13	165.7	124.5	134.1	226.0	17.77	14.10	26.82	20.74
	14	198.4	202.0	269.3	265.9	9.73	11.08	12.25	12.36
	15	421.4	157.6	241.8	394.0	17.89	11.09	9.24	17.94
	16	343.6	270.4	368.6	876.8	13.31	9.92	12.81	26.09

Ca = Calcium

Table ix Muscle strength

Group	No	Hand grip 0	Hand grip 31	Hand grip 37	Hand grip 59	Leg strength 0	Leg strength 31	Leg strength 37	Leg strength 59
		(kg/BW)				(kg/BW)			
Cr	1	64.0	59.0	57.0	55.0	298.0	280.0	300.0	360.0
	2	50.0	46.0	48.0	52.0	266.0	257.5	280.0	279.5
	3	53.0	51.0	58.0	59.0	271.0	252.0	251.0	286.0
	4	41.0	45.0	44.0	48.0	313.0	357.0	359.0	362.5
	5	45.0	45.0	44.0	44.5	246.5	285.0	316.0	285.0
	6	55.0	58.0	56.0	52.0	358.0	353.0	359.0	-
	7	47.0	40.0	45.0	46.0	354.0	297.0	264.0	316.0
	8	44.5	43.0	45.0	45.0	268.5	278.0	300.0	292.0
	9	57.0	54.0	58.0	60.0	302.5	268.0	295.0	284.5
	10	38.0	41.0	39.0	42.0	227.0	246.0	251.0	239.0
	11	43.0	38.0	46.0	42.0	187.5	180.0	200.5	246.5
	12	34.0	43.0	46.0	41.0	207.5	200.0	214.0	226.0
	13	45.0	45.0	51.0	44.0	159.5	197.0	207.0	204.0
	14	43.5	40.0	44.0	47.0	173.0	161.5	173.5	167.5
	15	52.0	50.0	54.0	55.0	227.5	218.0	193.0	182.0
	16	41.0	45.0	49.0	47.0	204.5	171.5	219.0	193.0
P	1	50.0	51.0	47.0	47.0	220.0	274.0	252.0	209.0
	2	53.5	50.0	53.0	54.0	361.0	351.0	356.0	362.0
	3	50.0	43.0	58.0	52.0	265.0	275.0	282.0	273.0
	4	41.0	49.0	47.0	50.0	229.0	218.0	243.0	270.5
	5	45.0	42.0	45.0	46.0	212.5	242.0	265.0	277.0
	6	45.0	47.0	49.0	47.0	286.0	271.0	272.5	267.0
	7	44.0	42.0	43.0	43.0	195.0	200.0	222.0	240.0
	8	47.0	50.0	54.0	52.0	242.5	230.5	208.5	274.0
	9	41.0	43.0	45.0	42.0	207.5	241.5	223.0	226.5
	10	44.0	44.0	45.0	44.0	223.0	228.0	183.0	208.0
	11	46.0	48.0	50.0	54.0	237.5	232.5	229.0	244.5
	12	36.5	38.0	49.0	46.0	210.0	219.0	202.0	253.5
	13	43.0	50.0	53.0	46.5	259.0	204.0	252.5	327.5
	14	46.0	49.0	58.0	46.0	185.5	187.5	192.5	165.0
	15	51.0	53.0	57.0	53.0	301.0	235.5	317.5	264.0
	16	51.0	50.0	57.0	63.0	286.0	221.0	258.0	273.5

Table x Agility and cardiovascular fitness

Group	No	Shuttle run 0	Shuttle run 31	Shuttle run 37	Shuttle run 59	VO_2 max 0	VO_2 max 31	VO_2 max 37	VO_2 max 59
		(sec)				(ml/kg/min)			
Cr	1	9.99	9.80	10.14	10.07	30.67	36.19	36.14	33.06
	2	10.20	9.79	9.91	9.87	43.94	40.69	45.84	52.81
	3	10.17	9.90	9.89	9.91	37.89	39.94	36.81	40.91
	4	10.01	9.87	9.68	9.60	51.88	51.42	49.59	48.31
	5	9.54	8.98	9.02	9.14	39.82	41.20	37.42	34.95
	6	10.06	9.35	9.71	9.36	40.91	34.88	35.84	37.40
	7	9.66	9.18	9.44	9.27	47.12	44.69	48.00	39.70
	8	10.10	9.57	9.55	9.58	33.65	40.15	40.50	43.75
	9	9.78	9.35	9.66	9.54	37.68	43.56	39.51	37.68
	10	9.64	9.67	10.17	9.55	56.48	62.12	49.26	56.84
	11	9.82	10.10	9.59	9.45	48.95	57.14	56.26	54.64
	12	10.18	10.25	9.98	9.83	48.90	58.21	55.61	52.92
	13	10.22	10.27	10.09	9.91	41.77	44.35	44.96	39.08
	14	10.32	10.35	9.76	10.69	34.25	44.53	39.68	40.91
	15	10.16	10.13	9.98	9.63	33.33	38.81	33.85	30.13
	16	10.40	10.38	10.41	10.12	40.59	41.29	37.41	33.96
P	1	10.69	10.27	10.14	10.91	27.86	25.66	28.94	30.07
	2	10.00	9.64	9.81	9.81	42.42	43.86	38.35	36.09
	3	10.14	9.75	9.74	9.74	44.51	43.27	42.77	43.12
	4	10.41	10.06	9.88	10.18	54.59	47.47	42.06	48.09
	5	9.65	9.46	9.18	9.26	39.87	41.17	40.69	37.67
	6	10.22	9.87	9.96	9.75	38.60	41.42	41.09	36.70
	7	10.86	10.27	9.80	9.47	50.84	52.87	48.31	51.12
	8	10.00	9.99	10.19	9.82	35.36	32.77	35.90	33.55
	9	10.44	10.25	10.38	10.16	37.69	37.19	36.97	36.66
	10	10.38	10.08	10.39	9.92	42.32	54.49	48.01	47.29
	11	9.75	9.82	9.50	9.36	46.37	43.68	50.08	43.05
	12	10.41	10.38	10.06	9.79	41.46	45.38	45.53	40.00
	13	10.32	10.83	9.99	9.78	45.76	42.40	48.60	41.70
	14	10.25	10.22	9.89	9.87	36.41	43.09	37.54	47.86
	15	10.36	10.09	9.89	9.82	28.27	33.85	35.06	32.24
	16	11.19	11.09	10.78	10.49	27.19	29.72	33.23	31.58

Table xi Vertical jump and power of vertical jump

Group	No	Jump 0	Jump 31	Jump 37	Jump 59	Power jump 0	Power jump 31	Power jump 37	Power jump 59
		(cm)				(Watt)			
Cr	1	60	61	59	59	1340	1356	1353	1353
	2	53	60	57	59	1112	1161	1154	1176
	3	48	51	49	54	930	968	966	1042
	4	53	55	57	61	1266	1291	1316	1371
	5	60	61	66	67	943	950	1008	1013
	6	62	62	66	68	1265	1251	1309	1329
	7	67	69	74	74	1123	1151	1198	1209
	8	45	62	52	53	1016	1186	1075	1085
	9	47	51	56	60	1120	1142	1211	1240
	10	60	52	56	58	929	863	910	917
	11	54	53	57	60	872	889	944	963
	12	49	52	52	52	884	952	970	992
	13	53	52	52	51	1183	1162	1176	1168
	14	56	50	50	46	1073	1011	1009	1009
	15	46	44	47	47	1139	1091	1153	1142
	16	53	55	57	53	1302	1283	1302	1270
P	1	45	45	49	46	1407	1398	1450	1428
	2	59	60	62	65	1325	1333	1361	1397
	3	53	59	61	60	1061	1123	1134	1133
	4	48	53	56	47	915	992	1003	932
	5	59	58	58	60	1111	1120	1118	1136
	6	52	63	59	56	947	1051	1031	1000
	7	58	60	58	60	914	923	922	919
	8	55	55	60	58	1207	1175	1278	1232
	9	48	46	51	52	1032	978	1025	1048
	10	48	46	49	48	778	756	792	786
	11	60	53	54	54	969	960	962	968
	12	46	49	46	44	886	912	883	858
	13	57	63	60	61	1113	1203	1163	1181
	14	46	44	48	47	1030	995	1060	1053
	15	56	58	57	58	1310	1321	1313	1331
	16	53	49	51	50	1553	1438	1508	1531

Table xii Anaerobic power and anaerobic capacity of Wingate test

Group	No	An power 0	An power 31	An power 37	An power 59	An capa 0	An capa 31	An capa 37	An capa 59
		(Watt/kg)				(Watt/kg)			
Cr	1	10.45	12.86	12.86	12.06	8.31	8.31	8.31	7.91
	2	11.26	12.06	12.06	11.26	7.91	8.58	8.44	8.71
	3	11.26	12.06	12.06	12.06	8.17	8.71	8.44	8.71
	4	12.06	11.26	11.26	12.06	8.17	8.04	8.17	8.31
	5	12.86	12.86	12.06	12.86	10.18	10.59	9.78	10.03
	6	13.67	12.06	12.86	12.86	8.98	9.11	8.98	9.25
	7	12.86	12.86	12.86	13.67	9.51	9.11	9.25	8.98
	8	10.45	12.06	12.06	12.06	8.58	9.38	9.38	8.98
	9	12.06	12.06	12.06	12.86	8.71	8.84	8.89	9.11
	10	12.06	12.06	11.26	12.06	8.71	8.98	8.71	8.71
	11	12.86	12.06	12.86	12.86	9.38	8.44	9.25	9.11
	12	11.26	11.26	12.06	11.26	8.84	8.71	9.11	8.84
	13	11.26	12.06	12.06	12.06	8.71	8.04	9.11	8.98
	14	10.45	10.45	12.86	10.45	8.98	8.31	9.11	7.91
	15	13.67	12.06	12.86	12.06	8.17	7.91	8.31	8.04
	16	11.26	11.26	12.06	12.06	7.91	7.77	7.91	7.91
P	1	10.45	10.45	9.65	10.46	6.70	6.57	6.70	6.70
	2	12.06	12.06	12.06	12.86	8.58	8.84	8.71	8.71
	3	12.06	12.06	12.06	12.06	8.98	9.11	8.58	9.25
	4	11.26	10.45	11.26	11.26	8.84	8.58	8.71	8.84
	5	12.86	12.06	12.86	12.86	8.98	9.25	8.84	9.25
	6	11.26	11.26	12.06	12.06	8.84	8.71	8.31	8.98
	7	11.26	-	-	11.26	9.11	-	-	9.25
	8	11.26	11.26	11.26	12.06	8.17	8.17	8.31	7.91
	9	10.45	11.26	11.26	10.45	7.91	8.31	8.17	7.77
	10	10.45	10.45	10.45	10.45	9.25	9.25	9.38	8.98
	11	13.67	12.06	12.86	13.67	8.98	8.71	9.25	9.11
	12	10.45	10.45	12.06	11.26	8.44	7.64	8.58	8.31
	13	12.86	11.26	12.86	13.67	9.11	8.98	9.25	9.51
	14	12.06	11.26	12.06	12.86	7.91	8.04	8.44	8.58
	15	12.86	12.86	12.86	12.86	8.58	8.44	9.38	8.71
	16	10.45	11.26	11.26	11.26	7.10	6.70	7.10	7.37

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