Creatine supplementation and health variables: a retrospective study

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ABSTRACT

SCHILLING, B. K., M. H. STONE, A. UTTER, J. T. KEARNEY, M. JOHNSON, R. COGLIANESE, L. SMITH, H. S. O'BRYANT, A. C. FRY, M. STARKS, R. KEITH, and M. E. STONE. Creatine supplementation and health variables: a retrospective study. *Med. Sci. Sports Exerc.*, Vol. 33, No. 2, 2001, pp. 183–188. **Purpose:** Long-term safety of creatine supplementation has been questioned. This retrospective study was performed to examine markers related to health, the incidence of reported side effects and the perceived training benefits in athletes supplementing with creatine monohydrate. **Methods:** Twenty-six athletes (18 M and 8 *F*, 24.7 ± 9.2 y; 82.4 ± 20.0 kg; 176.5 ± 8.8 cm) from various sports were used as subjects. Blood was collected between 7:00 and 8:30 a.m. after a 12-h fast. Standard clinical examination was performed for CBC and 27 blood chemistries. Testosterone, cortisol, and growth hormone were analyzed using an ELISA. Subjects answered a questionnaire on dietary habits, creatine supplementation, medical history, training history, and perceived effects of supplementation. Body mass was measured using a medical scale, body composition was estimated using skinfolds, and resting heart rate and blood pressure were recorded. Subjects were grouped by supplementation length or no use: Gp1 (control) = no use (N = 7; 3 F, 4 M); Gp2 = 0.8–1.0 yr (N = 9; 2 F, 7 M); and Gp3 = 1^+ (N = 10; 3 F, 7 M). **Results:** Creatine supplementation ranged from 0.8–4 yr. Mean loading dose for Gp2 and Gp3 was 13.7 ± 10.0 and the maintenance dose was 9.7 ± 5.7 g·d^{-1}. Group differences were analyzed using one-way ANOVA. **Conclusions:** Expected gender differences were observed. Of the comparisons made among supplementation groups, only two differences for creatinine and total protein ($P < 0.05$) were noted. All group means fell within normal clinical ranges. There were no differences in the reported incidence of muscle injury, cramps, or other side effects. These data suggest that long-term creatine supplementation does not result in adverse health effects. **Key Words:** SUPPLEMENTATION, NUTRITION, SPORTS

Creatine supplementation is currently used as a nutritional ergogenic aid among various athletes, particularly strength/power athletes. A number of recent studies and reviews have examined the efficacy of creatine as an ergogenic aid (14,17,18,20–23). Generally, data indicate that creatine supplementation has its greatest effect on high-intensity performance lasting 30 s or less, especially if performance is repeated a number of times. Additionally, data (4,20,21) suggest that maximum isometric and dynamic strength can be markedly enhanced over short-term supplementation periods (5 d–10 wk), particularly in large muscle mass exercises (21).

Although the underlying mechanisms supporting the ergogenic effects of creatine supplementation are not completely understood, possibilities include (1,18,22): increased muscular concentrations of creatine phosphate (PCr), improved buffering effects, and possibly the enhancement of mitochondrial creatine kinase activity. These mechanisms would potentially affect the rate of ATP resynthesis and enhance recovery resulting in improved performance and training adaptations. Furthermore, some evidence indicates that creatine supplementation can either directly (11) or indirectly (7,8,21,22) stimulate protein synthesis, resulting in enhanced rates of muscle hypertrophy associated with training.

To date, the only documented side effect resulting from creatine supplementation has been weight gain, which may be partially associated with a gain in water (2,18,20,22). However, few controlled studies have directly examined side effects. Anecdotal evidence and hearsay have associated creatine supplementation with a variety of side effects including muscle cramps, tears, and gastrointestinal disturbances. As with any supplement, questions concerning long-term health effects have arisen (13,18). Presently, few long-term studies are available which address health and safety aspects of creatine supplementation. One method of addressing long-term health concerns is through retrospective studies of creatine users. The purpose of this study was to retrospectively examine markers of health, the incidence of side effects, and perceived benefits in athletes using creatine supplementation over a long term (up to 4 yr).

0195-9131/01/3302-0183/$3.00/0
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Received for publication December 1999.
Accepted for publication May 2000.

METHODS

The subjects were 26 current or former competitive athletes (18 M and 8 F, 24.7 ± 9.2 yr; 82.4 ± 20.0 kg; 176.5 ± 8.8 cm). The subjects included national and international level sprinters, throwers, weightlifters, and football players. The subjects were recruited by contacting (with the consent of the coach) collegiate varsity sports teams and sports clubs. General guidelines, objectives, and procedures were provided orally to each group. All subjects volunteering for the study signed informed consents according to ACSM guidelines. Subjects answered a questionnaire dealing with dietary habits, creatine supplementation, medical history, training history, and perceived effects of supplementation. The test-retest reliability of the questionnaire was r = 0.88 (N = 13). The questionnaire is shown in Appendix 1.

Based on the questionnaire, subjects were grouped by supplementation length: Gp1 (control) = no use (N = 7; 3 F, 4 M); Gp2 = 0.8–1.0 yr (N = 9; 2 F, 7 M); and Gp3 = 1^{+} (N = 10; 3 F, 7 M). Creatine supplementation ranged from 0.8 to 4 yr. All subjects in groups 2 and 3 supplemented in a cyclical fashion, typically 4 wk on then 1–4 wk off. Mean loading doses for Gp2 and Gp3 were 13.7 ± 10.0, and the maintenance dose was 9.7 ± 5.7 $g \cdot d^{-1}$. All subjects in groups 2 and 3 were in a maintenance phase at the time of data collection and were actively training. None of the subjects reported being vegetarians.

Blood was collected after a 12-h fast between 7:00 and 8:30 a.m. Standard clinical analyses were performed for CBC and 27 blood chemistries (Labcorp, Charlotte, NC). Testosterone (T), cortisol (CORT), and growth hormone (hGH) were analyzed using an ELISA (Diagnostics Systems, Webster, TX) at Memphis University. Coefficient of variations for the hormone analyses were less than 4%. Body mass was measured using a medical scale; body composition was estimated using a seven-site skin-fold technique (17,20). Test-retest reliability for this skin-fold technique has been consistently r > 0.9 in our laboratory. After 10 min of quiet sitting, resting heart rate was measured using a Polar heart rate monitor (Polar Electro, Kempele, Finland) and blood pressure was measured by auscultation.

A total of 65 variables were analyzed (Appendix 2). Due to the large amount of data, only selected variables were reported here; complete data groupings and methodologies can be obtained by contacting the authors. Preliminary analyses using one-way ANOVA revealed no differences in physical characteristics between supplementation groups (Table 1). Preliminary analyses using one-way ANOVA on gender revealed no unexpected statistical differences; for example, height, weight, testosterone, etc. Due to the expected direction of the gender differences and small number of female subjects per group, the second step in analyses was to compute one-way ANOVAs to examine differences among supplementation groups. Although not statistically different, there were substantial differences in mean body mass among the three groups (Table 1). Where significant differences were found between groups ANCOVA using indices of body size (body mass, height or % fat) as a covariate was used. Dunnet's t-tests were used as follow-ups. The alpha level was $P < 0.05$. The authors recognize the shortcomings of a small sample size. However, due to the availability of high level current and former athletes and the nature of the study with the emphasis on health parameters, a less conservative approach was deemed appropriate.

TABLE 1. Measured variables.

Parameter	Variable	Supplementation History		
		No use	0–1 yr	1–4 yr
Anthropometry	Age (yr)	26.0 ± 10.4	19.8 ± 1.2	28.1 ± 11.1
	Height (cm)	171.6 ± 6.9	177.0 ± 8.6	179.6 ± 9.3
	Mass (kg)	72.8 ± 12.1	80.5 ± 20.5	90.8 ± 21.9
	% Fat	11.9 ± 6.8	11.0 ± 4.7	15.3 ± 6.3
Serum Enzymes	ALK PHOS	74 ± 13	83 ± 19	81 ± 19
	LDH	200 ± 66	165 ± 39	155 ± 20
	SGOT	25 ± 17	28 ± 9	32 ± 13
	SGPT	24 ± 13	21 ± 15	29 ± 15
	GGT	27 ± 14	25 ± 21	21 ± 9
Blood	CRTE	0.9 ± 0.3	1.0 ± 0.1	1.3 ± 0.3*
	TP	7.1 ± 0.3	7.4 ± 0.2*	7.2 ± 0.2
	UA	4.8 ± 1.5	5.8 ± 1.4	5.3 ± 1.9
	BUN	12.0 ± 1.8	13.6 ± 2.9	15.4 ± 3.4
	BUN/CRTE	13.7 ± 4.6	12.9 ± 2.4	12.1 ± 3.4
Hormones	T ($nmol \cdot L^{-1}$)	17 ± 15	19 ± 14	26 ± 28
	CORT ($nmol \cdot L^{-1}$)	610 ± 39	634 ± 34	608 ± 33
	T/C ($nmol \cdot L^{-1}$)	2.8 ± 2.4	3.0 ± 1.9	4.1 ± 4.2
	hGH ($g \cdot L^{-1}$)	1.7 ± 2.3	0.9 ± 1.9	1.9 ± 4.4
Lipids	TC (MG%)	175 ± 34	167 ± 52	158 ± 26
	HDL-C (MG%)	50 ± 8	53 ± 15	45 ± 13
	LDL-C (MG%)	97 ± 28	91 ± 45	91 ± 21
	RATIO	3.5 ± 0.8	3.3 ± 1.6	3.6 ± 1.0
	TRI (MG%)	136 ± 101	119 ± 78	107 ± 49

* $P \leq 0.05$ CRTE: GP3 > GP1; TP: GP2 > GP1.
ALK PHOS, alkaline phosphotase; LDH, lactate dehydrogenase; SGOT, serum glutamic oxalactic transaminase; SGPT, serum glutamic pyruvic transaminase; GGT, gamma glutamyl transpeptidase.
CRTE, creatinine; TP, total protein; UA, uric acid.
T, testosterone; CORT, cortisol; hGH, growth hormone; BUN, blood urea nitrogen.
TC, total cholesterol; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; RATIO:, HDL-C/TC; TRI:, triglycerides.

RESULTS

The results of the study are shown in Table 1. Physical characteristics of the groups were not statistically different; however, there are large absolute differences between the groups that may have biological significance. Expected gender differences occurred in a number of variables. For example males had greater values for height, body mass, lean body mass (LBM), HCT, Hb, T, hGH, etc. All group means for physiological/health related parameters were within normal clinical ranges. One-way ANOVA indicated two supplementation level differences: creatinine ($F(2,23) = 4.982$, $P = 0.016$; 95% confidence interval = 0.1–0.7)), and total serum protein ($F(2,23) = 3.689$, $P = 0.04$; 95% confidence interval = 0.0–0.6). These differences were obviated with ANCOVA. Several individuals showed variables slightly outside the normal range. However, there were no common trends for any variable. Selected individual variables are shown in Table 2.

Perceived side-effects were reported by questionnaire; subjects chose possible side-effects from a list and were free to comment on other possible side-effects and outcomes (Appendix 1). Based on the questionnaire, two subjects in GP3, one subject in GP2, and four subjects from group 1

TABLE 2. Examples: individual variables outside normal ranges.

Variable	Norm	Group	Value
Creatinine	(0.5–1.5 mg%)	Gp3	Male (1.6)
			Male (1.6)
LDH	(100–250 IU·L^{-1})	Gp2	Male (267)
		Gp1	2 Female (361, 381)
SGOT	(0–45 IU·L^{-1})	Gp3	Male (62)
		Gp1	Male (51)
SGPT	(0–50 IU·L^{-1})	Gp3	Male (59)
		Gp2	Male (52)

reported having experienced occasional muscle cramps. None of the subjects reported that they believed creatine supplementation was responsible for the cramps. The only reported side effects attributed to creatine ingestion were occasional gastrointestinal upset during the loading phase in two male subjects in GP3 and one male subject in GP2. Sixteen of 19 supplementing subjects (84%) believed that creatine supplementation provided noticeable ergogenic benefits.

DISCUSSION

Sixty-five variables were investigated, including blood analyses and perceived side effects. The results of this retrospective study indicate that long-term creatine supplementation (up to 4 yr) does not result in any apparent untoward health effects or produce side effects such as muscle cramps or shin splints. The only reported side effect attributed to creatine was occasional gastrointestinal (GI) upset during the loading phase (N = 3). The reported GI disturbances ranged from "gas" to mild diarrhea.

The efflux of serum enzymes can be related to pathological conditions such as liver disease and muscle degeneration and can also be related to physical exercise (18). Kidney pathology can produce a number clinically observable effects including alterations in serum concentrations of BUN, total protein, creatine, and creatinine. Thus, the expectation was that adverse creatine effects would produce some type of clinical marker. In the present observation, no aberrant alterations in serum enzymes were noted.

Long-term effects of creatine supplementation on the liver, heart, and kidneys have been a concern (13,18). From a health standpoint, both abnormally high values for serum creatinine and total protein have been weakly correlated with the development of hypertension (12,16) and with kidney dysfunction. Although within normal values, creatinine was higher in GP3 compared to Gp1 (no use) and Gp2 was higher than Gp1 for total protein. A small increase in serum creatinine concentration may be related to the ingestion of supplementary creatine (10) and could also be related to an increased training volume or intensity, particularly if training promoted a net protein degradation (18). It should also be noted that measures of body mass/LBM are positively related to the total creatine content and can influence both urinary and serum creatinine concentrations (3,9,23,24). It is possible that differences in body mass/LBM among the groups were related to the differences in creatinine and total protein. Interestingly, adjusting these values according to indices of body size (as covariates) and using ANCOVA for analysis obviated the significant differences between groups for both creatinine and total protein.

Alterations in T, hGH, and CORT can alter the anabolic/catabolic environment of an organism. Creatine may have anabolic properties promoting protein synthesis (18,20). The enhanced protein synthesis may be a direct result of the action of creatine on the cell (11), an indirect effect resulting from water retention and cellular hydration (7,8) or an indirect effect from enhance training capabilities (i.e., using higher training intensities or volumes) (4,22). The interaction of anabolic and catabolic hormones could play an integral role in muscle hypertrophy, strength, and power adaptations to training. It is possible that part of the effect of creatine on protein synthesis could be mediated by alterations in these hormones (23). In the present study, resting concentrations of hormones were not different among the groups. This observation is in agreement with a previous longitudinal study indicating no changes in hormonal milieu resulting from creatine supplementation (23).

Previous longitudinal studies have indicated that creatine supplementation may effect positive alterations in blood lipids (5,15). In the present observation, although there were no statistically significant group effects, it is interesting to note that serum lipids tended to decrease with supplementation length.

Although all group means were within normal clinical ranges and there were no differences among groups, it is possible that an individual may be showing adverse effects. Although some values outside the normal ranges were noted (Table 2), there were no consistent aberrant observations.

Based on the questionnaire, other than occasional gastrointestinal complaints, no side effects including muscle cramps, tears, or shin splints were attributed to creatine. Although anecdotal claims of muscle cramps are likely the most common complaint, no study, including the present observation, has demonstrated an increased incidence in muscle cramps as a result of creatine ingestion (6,18). Interestingly, more subjects in the control group (Gp1) experienced muscle cramps; this represents an incidence of 57% in the controls, 11% in Gp2, and 20% in Gp3 (combined creatine Gps2 + 3 = 16%). It is possible that the muscle cramps experienced by the athletes in this study were associated with hydration or dietary problems (1); indeed, one subject reported considerable alcohol consumption the previous night before experiencing muscle cramps. Thus, there is little evidence from the present retrospective study to support claims of increased incidence of muscle cramps as a result of creatine supplementation.

Perceptions of the ergogenic efficacy of creatine supplementation were positive. Sixteen of 19 supplementing subjects believed that creatine supplementation provided noticeable ergogenic benefits. All 19 stated they would continue creatine supplementation. These data suggest that creatine supplementation does not result in adverse health effects or side effects and is in agreement with previous short-term (15) and retrospective studies (19). However, it

should be noted that the number of athletes participating (N = 26) was small and observations were limited to clinical measures and subject recollection; thus, further observation and longitudinal study is necessary.

The subjects in this study were all currently engaged in strength/power training and included several current and former national and international level athletes. The results of this study suggest that long term (up to 4 yr) creatine supplementation does not cause adverse effects. This is of particular importance considering the loading dose and the relatively high average maintenance dose used by these subjects. This does not mean that creatine supplementation should be used indiscriminately with no regard for dosage, etc. (18). Potentially, the same beneficial effects can be achieved by using lower doses of creatine, especially during the maintenance phase (1,18). Generally, a loading phase (5 or 6 d) should use a dose value of 0.3 $g \cdot kg^{-1} \cdot d^{-1}$ and during the maintenance phase a dose of 0.03 $g \cdot kg^{-1} \cdot d^{-1}$ is sufficient (20). Although a loading phase may accelerate the increased muscle PCr content, loading can be accomplished with lower doses (i.e., of 0.03 $g \cdot kg^{-1} \cdot d^{-1}$). It is likely that these lower doses reduce the potential of developing side effects. In this context, proper education on the part of the coaching/sports medicine staff is paramount in reducing the side effects of this or any other potential ergogenic aid. Educational information should include discussions of ergogenic properties, mechanisms potential side effects and proper dosages (1,18).

Although this retrospective study indicates few side effects occur as a result of creatine supplementation, to an extent it depends upon athlete recollection and perception. Long-term double-blind studies that actually monitor supplement adherence and carefully examine incidence of side effects are needed for this and all potential ergogenic aids.

Thanks is given to Twinlabs Inc., Hauppague, NY, for partially funding this study. A special thanks is given Dr. Andy Stewart for his statistical assistance.

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APPENDIX 1
Creatine Questionnaire

Name_____ _____Age _____ Grade Level_____ _____
Gender_____Weight_____Height_____
_____

Ethnic background:
☐ White, not of Hispanic origin ☐ American Indian/Alaskan Native ☐ Asian
☐ Black, not of Hispanic origin ☐ Pacific Islander ☐ Hispanic
☐Other (Please specify)_____

Diet

What are the average servings of fruit you eat per day? (One serving = 1 medium apple, banana, orange, etc., ½ cup chopped, canned, or cooked fruit, ¾ cup juice).
☐None ☐1 ☐2 ☐3 ☐4 or more

What are the average servings of vegetables you eat per day? (One serving = ½ cup cooked or chopped raw, 1 cup raw leafy, ¾ cup vegetable juice).
☐None ☐1 ☐2 ☐3 ☐4 or more

What are the average servings of bread, cereal, rice, or pasta you eat per day? (One serving = 1 slice of bread, 1 ounce of ready-to-eat cereal, ½ cup cooked cereal, rice or pasta).
☐None ☐1-3 ☐4-6 ☐7-9 ☐10 or more

When you eat grain and cereal products, do you emphasize:
☐Whole grain, high fiber ☐mixture of whole grain and refined ☐ refined, low fiber

What are the average servings of red meat (not lean) do you eat per day? (One serving = 2-3 ounces of steak, roast beef, lamb, pork chops, ham, burgers, etc.).
☐None ☐1 ☐2 ☐3 ☐4 or more

What are the average servings of fish, poultry, lean meat, cooked dry beans, peanut butter, or nuts do you eat per day? (One serving = 2-3 ounces of meat, ½ cup cooked dry beans, two tablespoons of peanut butter, or 1/3 cup of nuts).
☐None ☐1 ☐2 ☐3 ☐4 or more

What are the average servings of dairy products do you eat per day? (One serving = 1 cup milk or yogurt, 1.5 ounces of natural cheese, 2 ounces of processed cheese).
☐None ☐1 ☐2 ☐3 ☐4 or more

When you eat dairy products, do you emphasize:
☐Regular ☐Low-fat ☐Fat-free

How would you characterize your intake of fats and oils (e.g., regular salad dressings, butter or margarine, mayonnaise, vegetable oils, etc.).
☐High ☐Moderate ☐Low

How many servings of alcoholic beverages do you consume? (1 serving = 1can/bottle beer, 1 glass wine, a shot glass of liquor, or 1 mixed drink).
☐None ☐less than 1 per week ☐1 to 6 per week
☐1 per day ☐2 to 3 per day ☐More than 3 per day

How many servings of caffeine do you consume per week? (1 serving = 12 oz. of soft drink, ½ cup coffee)
☐None ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 or more

Are you currently a smoker? If yes, how many cigarettes do you smoke per day?
☐< 1 pack per day ☐1-2 packs per day ☐2-3 packs per day ☐3+ packs per day

Medical Information

Please check any of the following medications you are currently taking. Give the name of the medication in the blank
☐Heart medicine
_____
☐Blood pressure medication
_____
☐Cholesterol medication
_____
☐Hormones
_____
☐Birth control pills
_____
☐Asthma medication
_____
☐Insulin
_____
☐Other diabetes medication
_____
☐Arthritis medication
_____
☐Antidepressants
_____
☐Sedatives
_____
☐Thyroid medication
_____
☐Pain medication
_____
☐Allergy medication
_____
☐Other (please specify)
_____

Please check any of the following conditions you have had or now have. Also check medical conditions in your family (father, mother, brother(s), or sister(s). Check all that apply.

Personal	Family	Condition
☐	☐	Coronary heart disease, heart attack, coronary artery surgery
☐	☐	Angina
☐	☐	High blood pressure
☐	☐	Peripheral vascular disease
☐	☐	Phlebitis or emboli
☐	☐	Other heart problems (specify_____)
☐	☐	Lung cancer
☐	☐	Breast cancer
☐	☐	Prostate cancer
☐	☐	Colorectal cancer (bowel cancer)
☐	☐	Skin cancer
☐	☐	Other cancer (specify_____)
☐	☐	Stroke
☐	☐	Chronic obstructive pulmonary disease (emphysema)
☐	☐	Pneumonia
☐	☐	Asthma
☐	☐	Bronchitis
☐	☐	Diabetes mellitus
☐	☐	Thyroid problems
☐	☐	Kidney disease
☐	☐	Liver disease (cirrhosis of the liver)
☐	☐	Hepatitis
☐	☐	Gallstones/gallbladder disease
☐	☐	Osteoporosis
☐	☐	Arthritis
☐	☐	Gout
☐	☐	Anemia (low iron)
☐	☐	Bone fracture
☐	☐	Major injury to foot, leg, knee, hip or shoulder
☐	☐	Major injury to back or neck
☐	☐	Stomach/duodenal ulcer
☐	☐	Rectal growth or bleeding
☐	☐	Cataracts
☐	☐	Glaucoma
☐	☐	Hearing loss
☐	☐	Depression
☐	☐	High anxiety
☐	☐	Substance abuse problems (alcohol, drugs, etc.)
☐	☐	Eating disorders (anorexia, bulimia)
☐	☐	Problems with menstruation
☐	☐	Hysterectomy
☐	☐	Sleeping problems
☐	☐	Allergies
☐	☐	Any other health problems (please specify, and include information on any recent illness, hospitalizations, or surgical procedures):

_____
_____
_____
_____
_____
_____
_____

How would you describe your training during the last year (or the period in which you have been taking creatine)?
☐General Fitness ☐Sport Specific
(Sport_____)

How frequent have these workouts been during this period?
☐ 1-2 times per week ☐3-4 times per week ☐5-6 times per week ☐7+ times per week

What types of exercises do your workouts consist of?
☐Weight training ☐Plyometrics ☐Running ☐Aerobic classes
☐Other_____
_____

Which of the following effects have you experienced during the last year (or the period in which you were taking creatine)?
☐Muscle cramping ☐Muscle tears ☐Irregular heart beat
☐GI distress ☐Insomnia ☐Dehydration
☐Decreased performance ☐Increased recovery ability ☐Muscle gain

☐Increased strength ☐Other responses (please specify)_____

If you have been taking creatine, which of those effects do you contribute to supplementation?_____

What supplements besides creatine have you used during this period? (Please specify which supplements and for how long you have used them.)_____

Creatine Information

How long have you been using creatine monohydrate?
☐<6 months ☐6-12 months ☐12-18 months
☐18-24 months ☐24+ months

During this period, what is the longest that you have stopped taking creatine?
☐0-2 weeks ☐2-4 weeks ☐4-6 weeks ☐6+ weeks

What loading dosage have you used?
☐5 g/day ☐10 g/day ☐15 g/day ☐20 g/day ☐25 g/day ☐30+ g/day

How long was the loading period?
☐2-3 days ☐3-4 days ☐4-5 days ☐5-6 days ☐6+ days

What maintenance dosage have you used?
☐5 g/day ☐10 g/day ☐15 g/day ☐20 g/day ☐25 g/day ☐30+ g/day

Have you used a specific cycling pattern during your supplementation period? Please specify your pattern including time on/off and dosages_____

Overall, would you say that creatine supplementation has been beneficial for you?
☐No ☐Yes ☐Not sure

Will you continue to take creatine?
☐No ☐Yes ☐Not sure

APPENDIX 2: Variables.

- Gender: 18 male, 8 female
- Creatine supplementation
  - Dose
  - Dosing period
  - Loading dose
  - Maintenance dose
  - Cycling pattern
  - Time off supplementation
  - Positive and negative effects
- Anthropometry
  - Age
  - Body mass
  - Height
  - Body fat
  - Heart rate
  - Systolic blood pressure
  - Diastolic blood pressure
- BLOOD CHEMISTRY/CBC[a]
  - Glucose
  - Uric acid
  - Blood urea nitrogen (BUN)
  - Creatinine
  - BUN/creatinine
  - Sodium
  - Potassium
  - Chloride
  - Calcium
  - Phosphorus
  - Protein
  - Albumin
  - Globulin
  - Albumin/globulin (A/G) ratio
  - Bilirubin
  - Alkaline phosphatase
  - Lactate dehydrogenase (LDH)
  - Serum glutamic oxalactic transaminase (SGOT)
  - Serum glutamic pyruvic transaminase (SGPT)
  - Gamma glutamyl transpeptidase (GGT)
  - Total iron
  - Total cholesterol (TC)
  - Triglycerides (TRI)
  - High density lipoprotein cholesterol (HDL-C)
  - Low density lipoprotein cholesterol (LDL-C)
  - Very low density lipoprotein cholesterol (VLDL-C)
  - TC/HDL ratio
- Blood chemistry/CBC[a]
  - WBC
  - RBC
  - Hemoglobin
  - Hematocrit
  - MCV
  - MCH
  - MCHC
  - Platelets
  - Polys
  - Lymphocytes
  - Monocytes
  - Eosinophils
  - Basophils
  - Polys (Absolute)
  - Monocytes (Absolute)
  - Eosinophils (Absolute)
  - Basophils (Absolute)
- HORMONES[a]
  - Testosterone (T)
  - Corticol (CORT)
  - T/CORT ratio
  - Human growth hormone (hGH)

[a] All blood chemistry/CBC profiles were carried out by Labcorp, Charlotte, NC. Blood for the CBC was collected by venepuncture in 5-mL EDTA treated vacutainers. Blood for serum hormones and blood chemistries were collected in two 10-mL serum separator vacutainers allow to stand for 10 min and then centrifuged at 22°C (2000 rpms). for 20 min. Serum was frozen at −80°C before transfer to Memphis University. Serum samples (3, 1-mL microcentrifuge tubes) were packed in dry ice and shipped to Memphis University by 24-h express delivery 1 wk after collection.