尿中クレアチニン排泄量と背筋力との相互関係

戎 利 光 (福井大学)

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Relationships between urinary creatinine excretion and back strength

Toshimitsu Ebisu, Ed. D.¹

抄 録

本研究の目的は、筋肉量と比例関係にあるといわれる尿中クレアチニン排泄量(クレアチニン)が、体重、除脂肪体重(LBM)、握力、背筋力のどの変数と純粋に相関関係にあるかを明らかにすることである。32名の健康な男子大学生が被験者となり、クレアチニンと有意な相関関係が予測できる上記、体重、LBM、握力、背筋力とクレアチニンを測定した。クレアチニンについては、Moni-Trol I Chemistry Controlを用い、定量の妥当性、信頼性を確認した上で、Folin-Wu法により定量した。

本研究の結果、クレアチニンは、体重、LBM、握力、背筋力のどの変数とも有意な相関関係を示し、体重、LBM、握力、背筋力の間では、どの2変数間でも有意な相関が認められた。従って、体重、LBM、握力、背筋力の中で各々3変数の影響力を消去して、クレアチニンとの3次偏相関を求めた。その結果、体重、LBM、握力の影響力を消去した背筋力とクレアチニン間には、有意な偏相関が認められた。その後、実験結果を確認する目的で、21名の健康な男子大学生を被験者とし、再度同一の実験を行なったが、結果は酷似していた。従って、筋肉量と背筋力のかなり密接な相互関係が明らかになり、背筋力が全身の筋力を代表するという指摘¹⁾からも、この実験結果は理解できる。

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Abstract

The purpose of this study is to clarify what is purely correlative to urinary creatinine excretion (creatinine) widely indicated to be directly proportional to muscular mass. Thirty-two healthy male college students volunteered to be subjects. The variables determined in this study were as follows: creatinine, body weight, lean body mass (LBM), grip strength and back strength. All of the urine samples were collected over twenty-four hours. The Folin-Wu method and skinfold thickness measurement were applied to determine creatinine and body composition. The validity and the reliability of determining creatinine were confirmed by a Moni-Trol I Chemistry Control of DADE Division, American Hospital Supply Corporation.

This study found that creatinine was significantly correlated with all of the other variables. However, since body composition and strength values were mutually correlated, it is not clear what is purely correlative to creatinine. Furthermore, the study found that creatinine was purely correlative to back strength. A similar

¹ Faculty of Education, Fukui University, 3-9-1 Bunkyo, Fukui City, Fukui Pref. (code 910)

research study was done again to confirm the results, and similar results were found. It is, therefore, concluded that muscular mass is closely related to back strength.

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Introduction

Creatinine is directly proportional to muscular mass^{7),12),15),18)}. Although the creatinine is not easily determined without sophisticated experimental techniques and expensive equipments, creatinine is often analyzed in research studies concerning muscular mass and muscular activities.

Konishi¹⁴⁾ investigated creatinine as a possible index of muscular activity by estimating LBM and apparent physical activity. He indicated that creatinine levels may be useful in characterizing and assessing the physical activity profiles of individuals, and it may also be a useful index in estimating or predicting physical fitness and/or physical performance on a fat-free basis.

Singh et al.²⁵⁾ reported a significant correlation coefficient between creatinine and body weight while a correlation coefficient between creatinine and LBM was insignificant. The correlation between creatinine level and LBM, however, should be significant since creatinine is directly proportional to muscular mass, as previously mentioned, and LBM and muscular weight are considered to be correlated. Rasmussen²¹⁾, therefore, found a significant correlation between creatinine and LBM in male subjects. Singh et al.²⁵⁾ probably did not find a significant correlation between creatinine and LBM because they used adult male and female subjects together in their study, even though the amount of creatinine excretion in adult males is slightly higher than in adult females, as Satoyoshi²²⁾ indicated. The changes in creatinine and LBM were similar in Ebisu's study⁶⁾ and creatinine and LBM increased significantly due to two months of chronic exercise. Schutte et al.²³⁾ also showed significant correlation values between creatinine and body weight and LBM.

From these research studies, it seems that creatinine is correlative to body weight, LBM, and strength. However, it also seems that body weight, LBM, and strength are mutually interrelated. Although the three values may be correlated with each other, it is not clear what is purely correlative to creatinine in the three variables. On the other hand, strength is not so simply defined. Ono¹⁹⁾ (p. 37) has classified strength into active and static strength and, further, has subdivided each of these two classifications into powerful or isometric and enduring strength.

Åstrand and Rodahl¹⁾ (p. 79) stated that the relative length of the muscle, speed of contraction, type of contraction (isometric, dynamic, excentric or concentric, proprioceptive afferent inflow, etc) can modify the motoneuron activity and the muscle's ability to develop strength when subjected to this neural activity. And, they (p. 77) suggested that since the correlation between dynamic and isometric strength was high, the maximal dynamic strength can be roughly predicted from simpler measurements of the maximal isometric strength of the same muscles, provided that the subject is not particularly well trained in one or another type of exercise. As it is widely known, in isolated muscles the maximal strength is proportional to the cross-sectional area of the muscle¹⁾ (p. 39). In this study, strength is defined as static, isometric, and active strength such as grip or back strength since Ono¹⁹⁾ (p. 39) indicated that static, isometric, and active strength is like grip or back strength.

The purpose of this study is, therefore, to clarify what is purely correlative to the creatinine which is directly proportional to muscular mass, in four variables; body weight, LBM, grip strength, and back strength.

Methods and Materials

Thirty-two healthy male college students volunteered to be subjects in Experiment 1. Two months later,

the same experiment was done as Experiment 2 by using 21 healthy male college students in order to confirm the results of Experiment 1.

The variables determined in this study were as follows: creatinine, body weight, LBM, grip strength, and back strength. All of the urine samples in this study were collected over 24 hours. The Folin-Wu method was used to determine creatinine by means of a reagent kit for the assay of creatinine in serum and urine called "Creatinine SET" by Iatron Laboratories, Inc.⁹⁾, following the instructions¹⁰⁾ from Iatron Laboratories, Inc. Although there are research studies indicating that chromatographic procedures are more precise than enzymic and conventional tests²⁶⁾, and that liquid chromatographic procedures give results that are lower than those obtained by the alkaline picrate method²⁰⁾, Ebisu et al.⁵⁾ found that urinary creatinine values were significantly ($p < 0.001$) correlated between an alkaline picrate method and high performance liquid chromatography. The procedure of the alkaline picrate method used in this study is as follows: 34 test tubes; 32 sample (A), a blank (B) and a standard (S) tubes in Experiment 1 and 23 test tubes; 21 A's, a B and an S, in Experiment 2 were used. An eliminating protein color reagent, 4.0ml, was added to each of the 0.5ml twenty-four hour urine sample in the A tubes. Each sample was diluted 20 times. The color reagent, 4.0ml, was also added to 0.5ml of distilled water in tube B and used as the blank solution. A standard solution, 4.5ml, of urinary creatinine, was put into tube S. Each solution in tubes A, B, and S was mixed separately and the 34 tubes in Experiment 1 and 23 tubes in Experiment 2 were put into a homeothermal container at 25 degrees centigrade and kept there for 20 minutes. After that, the 1.5ml of 0.4N-NaOH (a solution diluted 4N-NaOH ten times) was added to each of the 34 tubes in Experiment 1 and 23 tubes in Experiment 2, mixed separately, and put into the homeothermal container at 25 degrees centigrade and also kept for 20 minutes. After a spectrophotometer was warmed up, the wave-length was set at 520nm. The optical density adjustment of the spectrophotometer was set at zero with the blank solution previously mentioned. All of the optical density values in all tubes were determined and the creatinine was obtained by the equation: (creatinine excretion) = (optical density A) / (optical density S) $\times$ (concentration ratio of the standard solution) $\times$ (diluted ratio of the urine sample) $\times$ (urinary volume in twenty four hours)¹⁰⁾. The validity and the reliability of determining creatinine were confirmed by a Moni-Trol I Chemistry Control²⁾ of DADE Division, American Hospital Supply Corporation. Creatinine was determined by using the UV-120-02 Spectrophotometer and AFU-120 Auto Flowcell Unit of Shimadzu Corporation.

The amount of creatinine is not influenced by food or drink²⁴⁾ and nutrition or diuresis¹⁵⁾. Creatinine was reported to tend to be greater for middle-income girls²⁷⁾. For these reasons, all of the subjects were males who had their usual meals. Creatinine value in an individual is generally constant^{8), 18)}.

Skinfold thickness at two places, triceps and subscapula, were measured by using the procedure Nagamine¹⁷⁾ described. Briefly, the measurement areas were as follows: triceps, fold halfway between the armpit and the elbow joint with the arm relaxed and hanging in extension; and subscapula, fold the tip of the scapula on a diagonal plane. These measurements were done on the right side of the body by using Eiken Style Improved Skin Calipers with the subject standing in a relaxed condition. Concerning the reliability of determining skinfold thickness, Burkinshaw et al.³⁾, Ebisu⁴⁾ and Womersley and Durnin²⁸⁾ have conducted research studies. The reliability of determining skinfold thickness was confirmed to be significant.

All of the measurements in this study were mainly performed in the author's laboratory in the Faculty of Education, Fukui University.

Results and Discussion

The results of this study are shown on Tables 1 through 4. Table 1 illustrated the mean and standard deviation values in Experiments 1 and 2. As seen in the table, creatinine values are higher than the values

Table 1. Mean and standard deviation values in urinary creatinine excretion, body composition and strength in Experiments 1 and 2.

	Cr. (mg/day)	Weight (kg)	LBM (kg)	Grip (kg)	Back (kg)
Exp. 1 (n=32)	1734.03 ± 311.42	64.72 ± 6.27	57.11 ± 4.90	52.43 ± 7.24	172.8 ± 33.5
Exp. 2 (n=21)	1752.11 ± 339.27	64.07 ± 6.61	56.97 ± 5.28	50.20 ± 7.60	165.8 ± 29.1

where : Cr.=urinary creatinine excretion

LBM=lean body mass

Grip=grip strength

Back=back strength

Table 2. Correlation matrix on urinary creatinine excretion, body composition and strength in Experiment 1. (×1000)

	(1)	(2)	(3)	(4)	(5)
Creatinine (1)	1000	398*	456**	375*	557**
Weight (2)		1000	968**	570**	463**
LBM (3)		Exp. 1 (n=32)	1000	604**	530**
Grip st. (4)				1000	792**
Back st. (5)					1000

(*p<0.05) (**p<0.01)

where : Creatinine=urinary creatinine excretion

LBM=lean body mass

Grip st.=grip strength

Back st.=back strength

Table 3. Correlation matrix on urinary creatinine excretion, body composition and strength in Experiment 2. (×1000)

	(1)	(2)	(3)	(4)	(5)
Creatinine (1)	1000				
Weight (2)	675**	1000			Exp. 2 (n=21)
LBM (3)	686**	989**	1000		
Grip st. (4)	637**	687**	752**	1000	
Back st. (5)	757**	605**	662**	816**	1000

(**p<0.01)

where : Creatinine=urinary creatinine excretion

LBM=lean body mass

Grip st.=grip strength

Back st.=back strength

ishii¹²⁾ and Okishio and Omori¹⁸⁾ indicated. They indicated that creatinine is usually 900 through 1700mg/day¹²⁾ or 700 through 1800mg/day¹⁸⁾, respectively. The high values in this study are, however, reasonable since body weight, LBM, and strength are high in all subjects. Schutte et al.²³⁾ showed significant correlation values between creatinine and body weight and LBM. Singh et al.²³⁾ also discovered a significant correlation between creatinine and body weight. From these significant correlations, it is understandable why their creatinine values were relatively high in this study. All of the subjects have often experienced giving urine samples over a 24 hour period even before this study. Therefore, the accuracy of collecting 24 hour urine samples cannot be doubted.

Tables 2 and 3 show correlation matrixes on creatinine, body composition, and strength in Experiments 1 and 2. As seen in the tables, all of the correlation coefficient values are significant in the two experiments. Since body weight, LBM, grip strength and back strength were found to be correlated in the tables, it is not clear what is purely correlative to creatinine which is widely known to be directly proportional to muscular mass, in the four variables.

Percentage values, 31.0% and 57.3%, of square of the correlation coefficients, 0.557 and 0.757, between creatinine and back strength in tables 2 and 3 are known to explain ranges of variation of either one to another variables. However, in order to clarify what is purely correlative to creatinine, calculation of partial correlation was applied. Table 4 illustrates the third order values of partial correlation between creatinine and body composition and strength. As shown in the table, the partial correlation coefficient between creatinine and back strength without influences of body weight, LBM and grip strength is significant.

Table 4. The third order of partial correlation between urinary creatinine excretion and body composition and strength in Experiments 1 and 2.

	Exp. 1 (n=32)	Exp. 2 (n=21)
$\gamma(\text{Cr} \cdot \text{Wt} \cdot \text{LBM} \cdot \text{Grip} \cdot \text{Back})$	0.018	0.248
$\gamma(\text{Cr} \cdot \text{LBM} \cdot \text{Wt} \cdot \text{Grip} \cdot \text{Back})$	0.167	0.174
$\gamma(\text{Cr} \cdot \text{Grip} \cdot \text{Wt} \cdot \text{LBM} \cdot \text{Back})$	0.222	0.046
$\gamma(\text{Cr} \cdot \text{Back} \cdot \text{Wt} \cdot \text{LBM} \cdot \text{Grip})$	0.425*	0.558*

(*p<0.05)

where : $\gamma(\text{A} \cdot \text{B} \cdot \text{C} \cdot \text{D} \cdot \text{E})$ = the third order of partial correlation between A and B without influences of C, D and E

Cr=urinary creatinine excretion

Wt=body weight

LBM=lean body mass

Grip=grip strength

Back=back strength

This study found that back strength is directly correlative to creatinine which is proportional to muscular mass in the four variables ; body weight, LBM, grip strength, and back strength. Muscular mass is, therefore, closely related to back strength. The back muscles consist of dorsi superficial muscles such as trapezius, latissimus dorsi, levator scapulae and rhomboideus and deep back muscles in the neck, back and waist¹⁶⁾. According to the results, it seems that back strength can be produced by many muscles which create whole strength. Since back strength represents muscular strength in the entire body¹¹⁾, the results of this study are also understandable.

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