PRELIMINARY STUDY OF ENVIRONMENTAL AND CLIMATIC FACTORS ON URINARY EXCRETION IN THE TROPICAL REGION

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Abstract

A central estimate of daily urinary volume based on the data from the temperate environment has been reported by the International Commission on Radiological Protection (ICRP) Publication 89 as the worldwide reference value. However, in order to gain global acceptance, it is necessary to incorporate data from all parts of the world. Daily dietary habits and level of exercise are considered to contribute significantly to the daily urinary excretion in normal human subject. In addition, environmental factors such as air temperature, pressure and humidity seem to play a major contributing role in tropical environments. The tropical region seems to be neglected in the ICRP consideration apparently due to the dearth of data, and to the best of our knowledge, no data has been available from African countries for comparison. A preliminary result of a pioneering effort in this regard is presented. The results indicate mean value of urine volume (1306 ml d^{-1}) lower than the ICRP value for adult male. The mean daily creatinine excretion also shows value less than the ICRP reference value by about 44%. Though the low number of subjects makes statistically validated conclusion at this stage impossible, the results obtained in this work indicated a clear trend and required a more extensive and comprehensive data acquisition that is currently ongoing.

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Introduction

Bioassay measurements involve the determination of biological substances, such as radionuclides injected, ingested, or inhaled into the body. One of the commonest approaches is the daily collection of urine in order to determine the daily urinary excretion of the desired substance. The total daily urine volume excreted is very important for the accurate determination of the excretion rate of the substance. An adult take in between 2000 ml and 3000 ml of water per day but daily consumption of water in fluids and food varies from person to person. In addition to this, metabolism of foodstuffs also leads to production of water (Johnson, 1998; ICRP, 2002). Therefore, the total daily urinary volume will depend on individual habits such as diet and exercise, and on environmental factors like air temperature and humidity. In order to maintain constant body water, an amount of these ingested and metabolised water needed to be eliminated. The main route of clearance from the body under sedentary conditions is the urine production in the bladder. The urinary bladder is considered as a separate pool that receives all material destined for urinary excretion (ICRP, 1995). The rates at which materials enter the bladder depend on their clearance rate from the body tissues and the renal urine production. Hence, the concentration of this material in urine at any given time depends largely on the total urinary volume. This makes the latter very crucial in interpreting bioassay measurements. The urine production rate has also been noted to be dependent on age, gender, diet, exercise, and other factors (ICRP, 2002). These factors include among others the environmental condition of the subject. Apart from this notable water clearance route, water losses through the sweat pathway could be significant especially when environmental factor is taken into account. Large amounts of water may be lost in sweat production in a warm environment or during exercise, and as much as 3500 ml h^{-1} may be lost during vigorous exercise in a hot environment (Johnson, 1998). For a 70 kg male living in a temperate environment and engaged in light, indoor activities for 8 hours per day, an average sweat loss has been estimated as 500 ml d^{-1} (ICRP; 2002). Another form of water loss from the body is the invisible and insensible perspiration through the skin, even at room temperature. (Lamke et al, 1977). This kind of water loss increases with temperature and therefore, may be significant in warm, dry, windy conditions and at low pressure. Finally, loss through faeces is another form of water loss. Although a large volume of fluid is secreted into the gastrointestinal tract each day, most of it is re-absorbed before it reaches the end of the colon and rectum. A central estimate for water balance in human adult male is presented in Table 1. The estimate of urinary volume of 1600 ml d^{-1} as the worldwide reference value for adult male by the ICRP (2002) was estimated based on the above mentioned entry and clearance of water in the body.

However, in order to gain global acceptance, it is necessary to incorporate data from all parts of the world. The ICRP did not consider data from the tropical environment, and to the best of our knowledge, no data has been available from African countries for comparison. Nigeria falls on the tropical region of the world with considerable high temperature (> 45^{o}C in some places) with warm and dry air. In this paper, the result of the daily urinary volume conducted among four different groups of subjects namely, the mining workers, processing workers and member of public from Akure (altitude 300 m) and Jos (altitude 1300 m) in the southern and northern parts of Nigeria respectively, is presented and the probable influence of environmental and climatic factors on the result is discussed.

Materials and Methods

Sample collection and Measurement

Twenty-four hour urine samples were collected from four different groups of subjects working under different conditions. Six mine workers in one of the mining sites in the Jos Plateau were considered as the heavy exercise group (D), five processing workers from tin processing company in Jos were considered as the sedentary group (A), four members of the public group (B) living in Jos area and four members of the public group (C) in Akure about 900 km away from the Jos Plateau as control were considered as the moderate exercise groups but at different altitude. The 24 hr urine was collected starting early in the morning. After wake-up, the subjects emptied their bladder in the toilet noting the time, and all urine thereafter was collected in a graduated 3000 ml container until the following morning, and for the last time at the exact time the bladder was emptied the previous morning. The first void collected at the start of the sampling was acidified with 0.5 ml HCL to prevent decomposition. The weight (using analytical balance) and the total volume of the 24 hr urine collected from each subject were noted and recorded. Personal effort was made to limit occurrence of all systematic errors in the determination of the urine volume. Prior to the collection, each subject was asked to complete a questionnaire, which was designed specially to retrieve information about their eating, drinking and working habits. Additionally, urine creatinine was measured using an alkaline picrate procedure.

Result and Discussion

The daily urinary volume for the heavy exercise group ranged from 700 – 2030 ml d^{-1} with arithmetic mean ± SD value of 1230 ± 490 ml d^{-1}. Moderate exercise group in Jos and Akure and sedentary workers values ranged from 990 – 1450 ml d^{-1}, 780 – 2200 ml d^{-1} and 780 – 1950 ml d^{-1} with arithmetic mean values of 1273 ± 198 ml d^{-1}, 1318 ± 662 ml d^{-1} and 1416 ± 596 ml d^{-1}, respectively as shown in Figure 1. Figure 2 shows the relative frequency distribution of the measured urine volume. The result suggested that the heavy workers group has the lowest daily urine volume. In addition to this, it can be observed from Figure 1 that the influence of exercise seems less pronounced among the separate groups. However, the seemingly low urine volume observed in the heavy exercise group, when compared with the others, could be expected since they will obviously produce more sweat. The sedentary group will produce least sweat and could be the reason for the high urine volume observed among the subjects. The results for the two moderate exercise groups (Jos and Akure) seem to indicate data from the same population, even though their environmental weather conditions are different. Jos weather throughout the whole year is colder than all other parts of Nigeria and the air is dry and the atmospheric pressure is low due to the high altitude. It has been reported that insensible and invisible water loss from the body could range between 300 and 1000 ml per day especially in a warm and dry weather condition and at low barometric pressure (Lamke et al, 1977).

Creatinine is the by-product of creatine, which is a nitrogenous organic acid synthesised in the liver and helps to carry energy to the muscle cells. Measurement of creatinine levels a common indicator for the determination of renal function impairment. Figures 3 show the variation of daily urinary creatinine value among the subjects. Figures 4 show the variation of urinary creatinine value per body weight among the subjects. Both results seem to indicate lower creatinine value by 44% and 41%, respectively when compared with the ICRP reference values (ICRP, 2002). The reason for this trend is not clear especially when it has been reported that black subjects has higher urine creatinine value per body mass than their white counterpart by 5%. This was attributed to higher relative muscle mass in blacks (James et al., 1988; ICRP, 2002). However, in a case discussion on impaired renal function and tolerance to high altitude (Mary Ann Liebert, 2002), a loss of about 50% renal function based on glomerular filtration studies and renal biopsy was reported. The present study seems to follow this trend especially when the average daily creatinine value (0.8 g d^{-1}) pooled together among the subjects from Jos plateau (altitude: 1300 m) is about 50% lower than the average value (1.6 g d^{-1}) for the subjects from Akure (altitude: <300 m). Figure 5 shows the variation of daily creatinine per urine volume (g ml^{-1}) and seems to indicate a trend similar to the daily urine excretion among the subjects.

Implication on the ICRP model

ICRP (2002) set the daily urinary volume for adult male between 1200 and 2000 ml d^{-1} with a central estimate of 1600 ml d^{-1}. In this present study, all the averages of the daily urine volume from the different groups of male subjects were lower than the ICRP reference value (but within the variation interval). It has been mentioned earlier that within the limit of the error, the data from the groups seem to originate from the same population. Hence, the overall arithmetic mean value of the daily urine volume of 1306 ml d^{-1} is a true representation of the population, and is about 80 % of the ICRP reference value. The lower daily urine volume reported here for Nigeria in comparison with the ICRP value seem to suggest the influence of environmental and climatic factors (as earlier discussed) in Nigeria, degree of exercise, which depend on the working conditions, eating and drinking habit and racial differences. However, this hypothesis could not be validated due to the statistically low number of data presented. This was due to some economic and logistic constraints, which we hope to overcome in the ongoing broad based data collection in Nigeria.

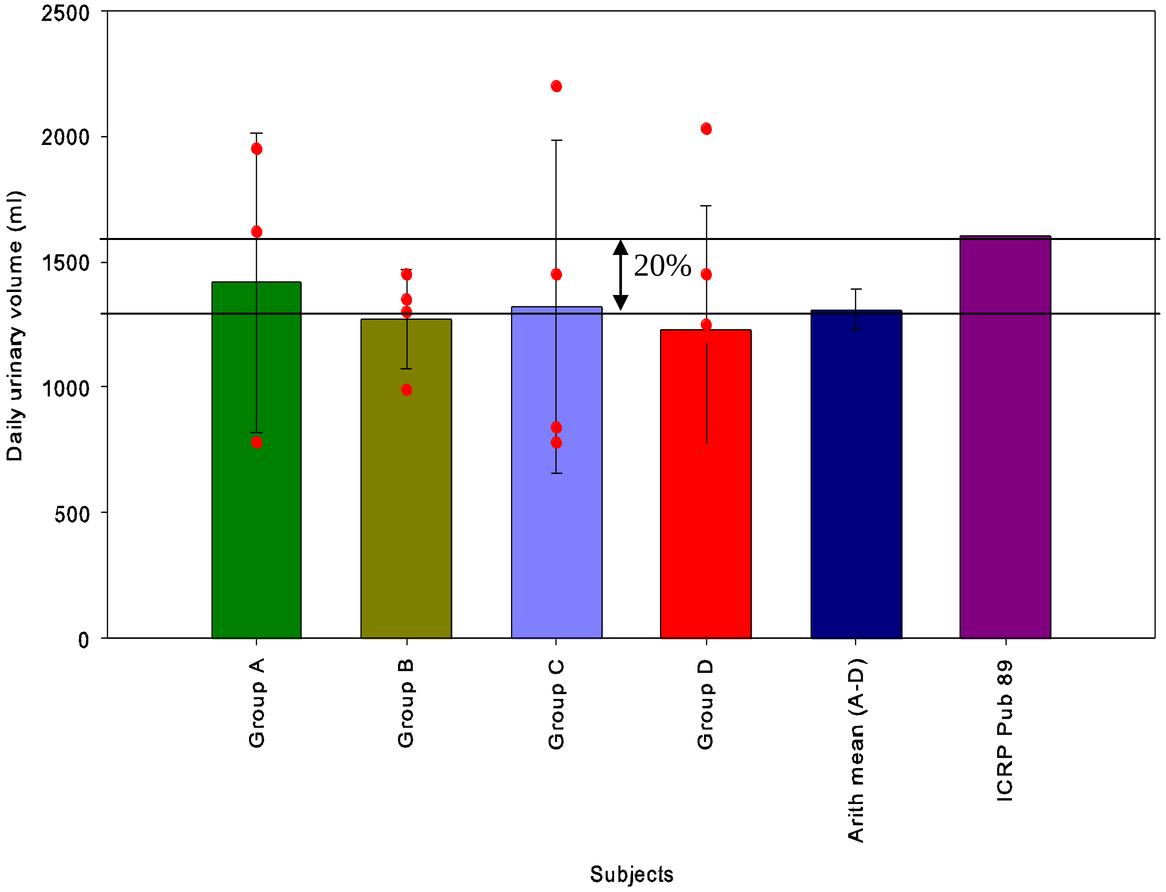
Conclusion

Daily urinary volume and urinary creatinine of male subjects in Nigeria has been reported and the possible implication on the ICRP model has been enumerated. Both values seem to be lower than the ICRP Publication 89 model and might suggest the influence of environmental and climatic factors such as the prevailing weather conditions and altitude in Nigeria, dietary habit and to a lesser extent, the degree of exercise. The need for a concerted effort to collect data from the tropical environment in order to contribute to the ICRP anatomical reference value has been unveiled. This form the basis of a more extensive and comprehensive data acquisition that is currently ongoing.

Table1: Central estimate for water balance in human adult male (ICRP, 2002)

Water intake in food and fluids (ml/day)	2600
Oxidation of food (ml/day)	300
Losses (ml/day)	
Urine	1600
Insensible loss[a]	690
Sweat	500
Faeces	110

[a] Assumed to be divided equally between the lung and skin.



The two solid lines inside represent the difference between the ICRP value and the present value, column is the mean value ± SD and dots are the measured values. Groups (A-D) represent the sedentary, public Jos, public Akure and heavy, respectively.

Fig 1: Variation of 24-hr urine volume in the four groups

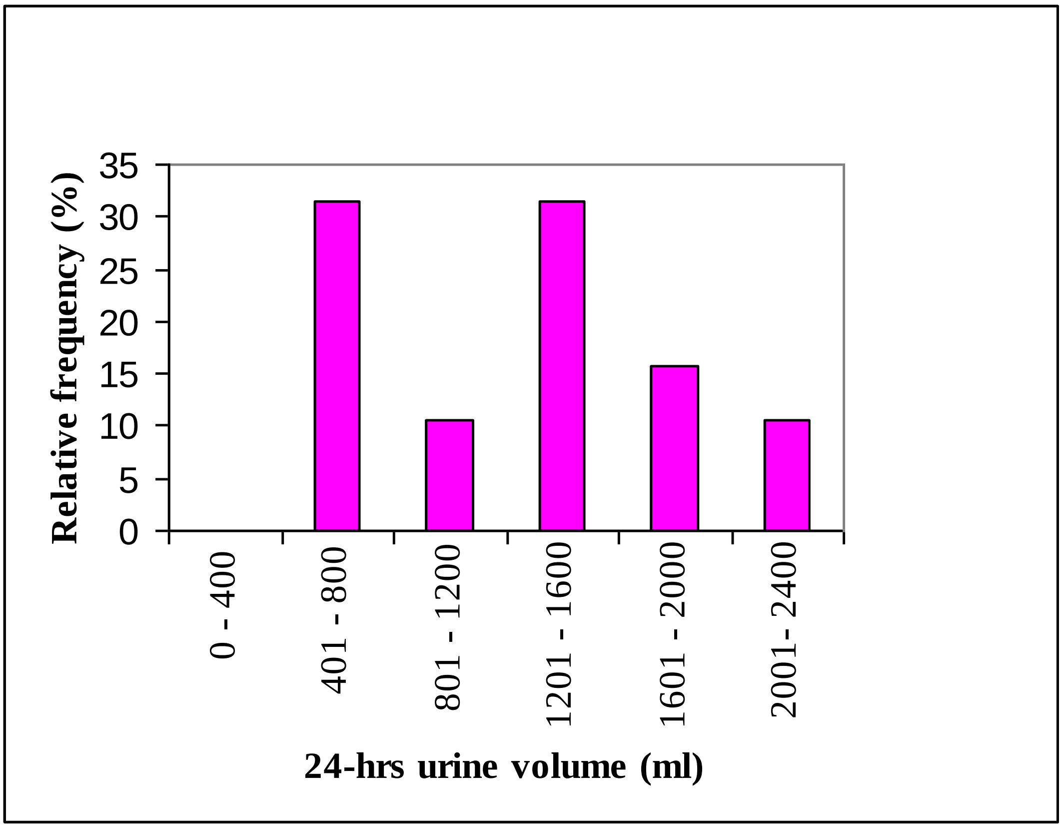
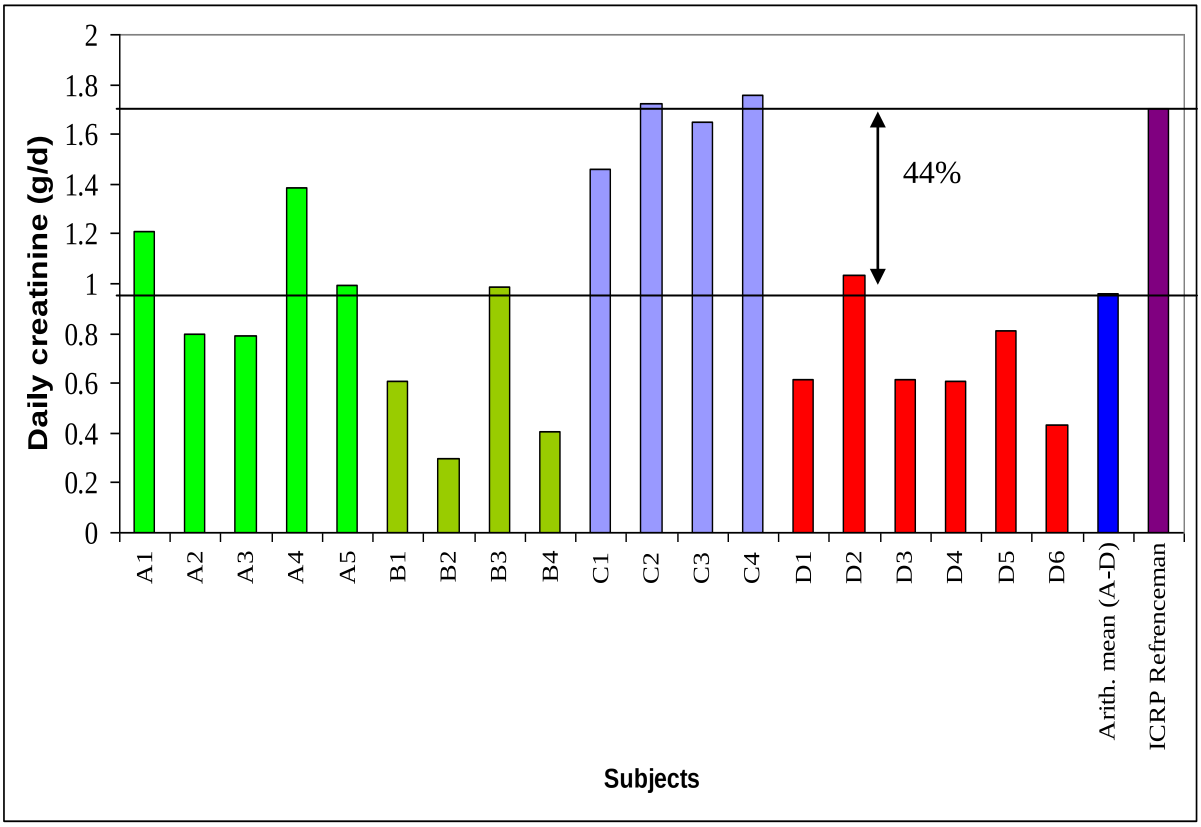
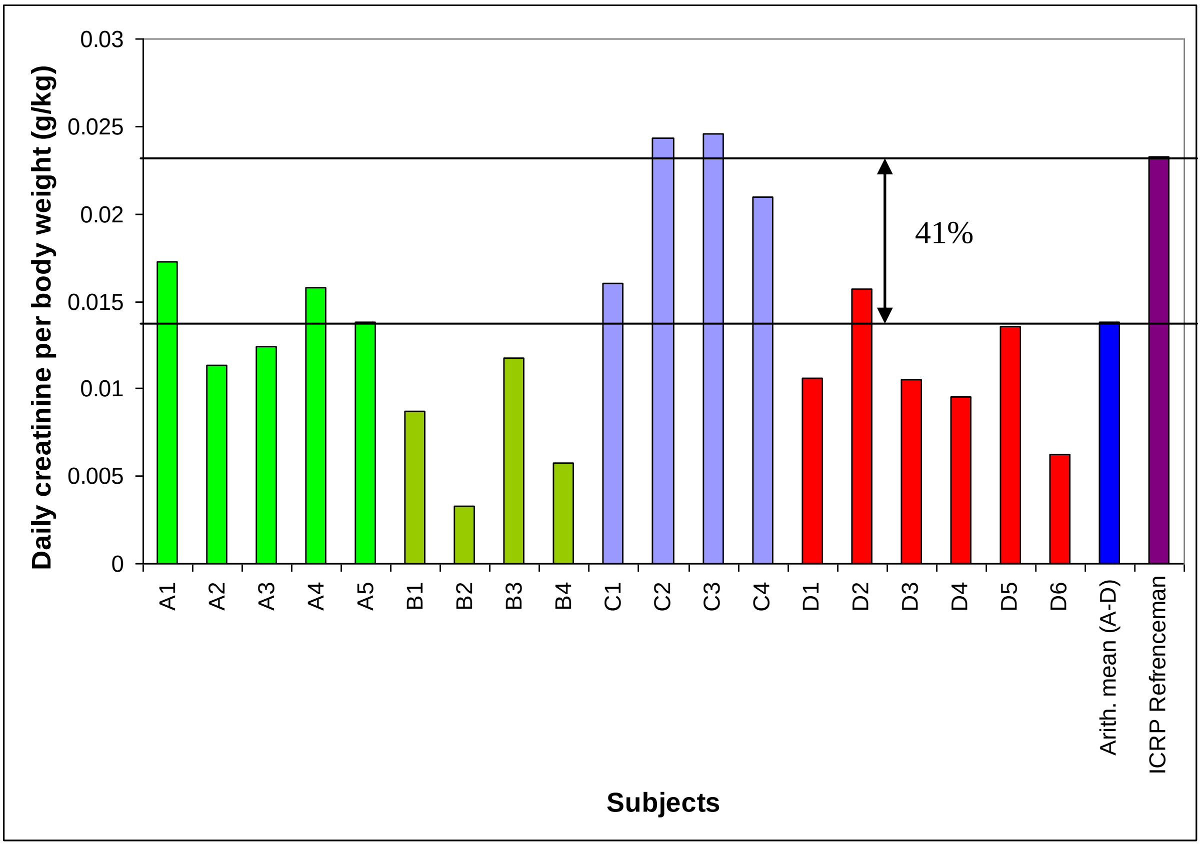


Fig 2: Relative frequency distribution of the measured volume



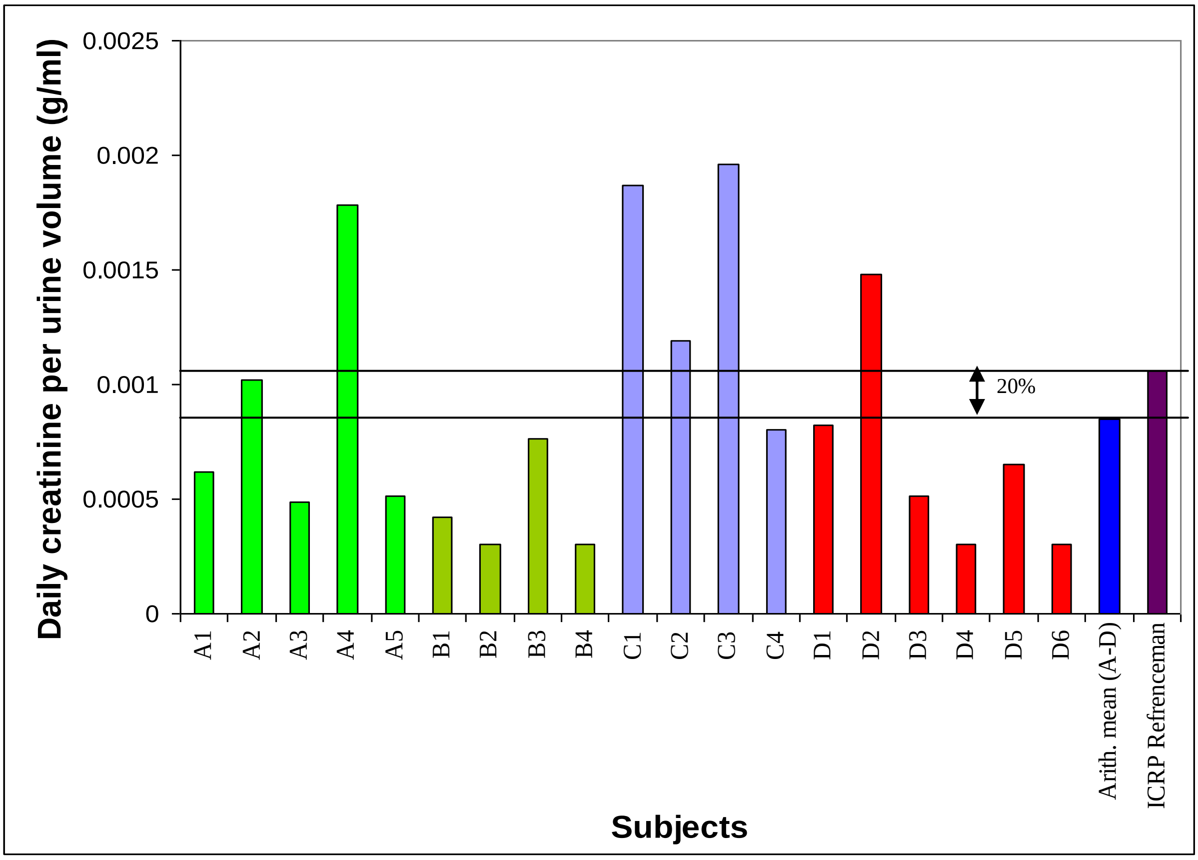
The two solid lines inside represent the difference between the ICRP value and the present value and column is the mean value ± SD.

Fig 3: Variation of daily creatinine among subjects



The two solid lines inside represent the difference between the ICRP value and the present value and column is the mean value ± SD.

Fig 4: Variation of daily creatinine per body weight among subjects



The two solid lines inside represent the difference between the ICRP value and the present value and column is the mean value ± SD.

Fig 5: Variation of daily creatinine per urine volume among subjects

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