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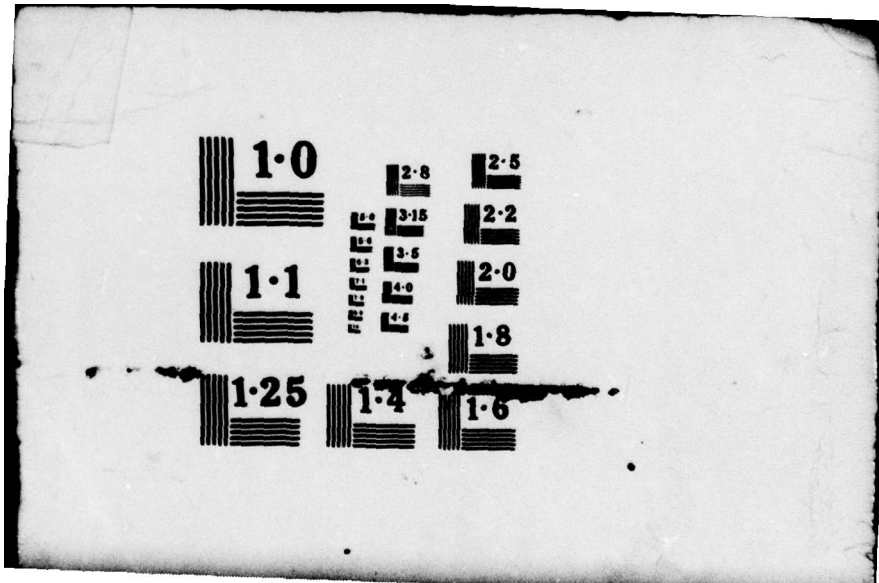
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INSTITUTE REPORT NO. 63

HUMAN BODY COMPOSITION DURING RIBOFLAVIN DEPLETION OF BRIEF BUT SUFFICIENT DURATION TO PRODUCE BIOCHEMICAL EVIDENCE OF DEFICIENCY

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H.J. KRZYWICKI, MS
J.A. TILLOTSON, MS
H.L. JOHNSON, PhD

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20. ABSTRACT.

of the study. The significant change in total body potassium and dry protein loss calculated from whole-body ⁴⁰K counting may have been an artifact.

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ABSTRACT

After 2 weeks on a control diet, 6 subjects were deprived of riboflavin for 9 weeks. Half of the subjects received 60g of protein in their 2,850 Kcal/day intake, while the remainder received 120g of protein daily. The protein increase was calorically at the expense of carbohydrate. Mean body weight decreased 0.95 kg. The densitometric data showed no significant changes to have occurred in body compartments. Potassium-40 counting approximated the densitometric loss in the dry protein mass after the third and sixth week of deprivation, but probably over-estimated the dry protein loss at the ninth week of the study. The significant change in total body potassium and dry protein loss calculated from whole-body ⁴⁰K counting may have been an artifact.

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FOREWORD

Special thanks are accorded to Specialist 5 Charles C. Scaief III for conducting all of the whole-body counts, and to Specialist 5 Sartor O. Williams III for carrying out all densitometric observations and calculations.

This manuscript was completed in the early 1970s and forwarded to the Scientific Publication Review Committee in March 1973 for clearance. Unfortunately due to the prolong illness of the division chief which began in May 1973; followed by the transfer of function in April 1974 and the retirement of the senior author shortly thereafter the manuscript was lost from processing. While the senior author was working as a special consultant at LAIR in December 1978 on another project this manuscript was found. This is a negative report. It was derived from a carefully conducted human deprivation study performed in normal young male adult volunteers. It is being published because of the difficulty in ever repeating the basic human experimentation on which this report is based.

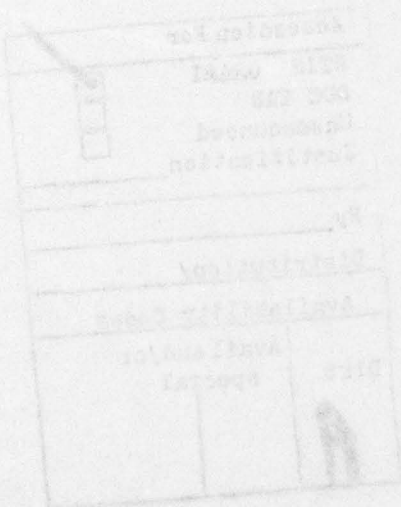


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INTRODUCTION

The effects of B-vitamin complex deprivation or low intake upon physical work performance is controversial. One group of investigators contended that no decrement in work performance was observed (1). Others have shown that rapid deterioration occurred (4 weeks) when B-vitamin deficient diets were consumed by humans (2,3). A direct relationship between B-vitamins deprivation and the capability to expend energy was suggested by Consolazio et al (4).

The measurement of physical performance in humans is usually expressed in terms of oxygen uptake on a body weight basis. Because of the variability in human stature and build (mainly difference in body fat content), it appears that a more precise body compartment should be used to define ability to do physical work. Elimination of body fat provides a better base for comparison in the form of the fat free body. When water and minerals are removed from the fat free mass a residual dry protein mass remains which can be considered closest to the metabolizing mass of the body. Unfortunately, this compartment is composed of both muscle and non-muscle protein and only muscle protein should relate directly to work performance. In none of the aforementioned studies was body composition measured. Perhaps the differences reported could have been minimized had body compartments been studied and work performance expressed in terms of the dry protein mass.

During a recent study designed to develop a sensitive index of riboflavin nutritional status in man, an opportunity arose to study maximal work performance and body composition during riboflavin depletion and repletion (5-7). Only the impact of depletion upon body composition will be reported in this paper.

GENERAL METHODOLOGY

The six young adults, mean age 22.3 years, consumed a liquid diet of 2,850 Kcal/day complete in all nutrients excluding riboflavin during the study, however intakes were increased to 3,000 Kcal/day for 4 men to maintain body weights. Half the men consumed 60g of protein daily, and remainder consumed 120g daily. A 1.50 mg supplement of riboflavin was added to the diet during the 14-day control period. A depletion

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1. Keys, A., et al. *J Nutr* 26:399-415, 1943.
 2. Foltz, E.C., et al. *Gastroenterology* 2:323-344, 1944.
 3. Archdeacon, W.W., et al. *J Nutr* 23:241-254, 1944.
 4. Consolazio, C.F., et al. *Metabolism* 5:259-271, 1956.
 5. Tillotson, J.A., et al. *Am J Clin Nutr* 25:425, 1972.
 6. Sterner, R.T., et al. *Am J Clin Nutr* 26:150-160, 1973.
 7. Consolazio, C.F., et al. LAIR Report #47, January 1978.

period, which followed, ended when the activity coefficients of erythrocyte glutathione reductase (EGR) with and without flavinadenine denucleotide reached a peak. Repletion consisted of graded amounts of the vitamin being added to the diet till normal EGR activity coefficients were again noted. Details of the riboflavin status of the subjects were reported by Tillotson and Baker (5).

Details of the body composition methodology used in this study are contained in an earlier report from this laboratory (8). Briefly, total body fat, water, dry protein and mineral compartment estimates were derived from weekly body density measurements. Body potassium was measured in a whole body potassium⁴⁰ counter (9). Data were statistically analyzed using Edgington's technique (10). No attempt was made to differentiate the effects of the two levels of protein in the diet. It was recently reported (11) that densitometric methods lacked the sensitivity to determine the individual contribution of two such similar levels of protein intake to changes in the dry protein mass of the body.

RESULTS

Table 1 data shows body compartments as derived densitometrically, and total body potassium measured by whole body counting. Although measurements were conducted on a weekly basis, they are reported here as mean values at 3-week intervals for brevity. Body density exhibited the least of any changes having decreased by 0.0015 density units which represented a very slight but insignificant body fat gain. The subjects lost a mean of 0.95 kg of body weight during the deprivation phase of the study (week 9) which reflected a 1.2% body weight loss.

To further partition the body weight loss, Table 1 shows that body fat increased 0.31 kg which constitutes a 2.3% gain in the size of the fat compartment (from 12.85 to 13.16 kg). Body water was calculated as having been reduced by 0.92 kg after vitamin deprivation, and this represented a 2.0% loss in this compartment. Similar losses are to be noted in the dry protein mass (0.26 kg), and the mineral compartment (0.09 kg) which approximated 2.0% in each case.

Total body potassium was highest in the control period (152.2g), and showed a decline to 148.5g after three weeks, which persisted during the second 3-week period only to be further reduced to 141.6g at the end of the deprivation period. This amounted to a 10.6g loss of potassium or 6.9% of the potassium pool. When depicted on a body weight basis, a

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8. Krzywicki, H.J., et al. Am J Clin Nutr 21:87-97, 1968.
 9. Scaief, C.C. III, et al. US Army Med Research and Nutr Lab Rpt #330, November 1971.
 10. Edgington, E.S., Am Stat Assoc 56:156-159, 1961.
 11. Krzywicki, H.J., et al. Fed Proc 30:696, 1971 (Abstract).

similar trend is noted during the riboflavin deficient period, and the 0.11g potassium loss per kg of body weight amounted to a 5.5% reduction when viewed from this aspect.

A statistical analysis of the data was based on a 'null' hypothesis wherein the relative magnitude of a data point is independent of its position in the series (10). The data revealed no significant differences between treatments from week to week despite the minor body weight loss. The various body compartments of fat, water, protein and mineral also failed to demonstrate significant change. The potassium⁴⁰ counting showed only the K loss at the ninth week of deprivation (10.6g), or that noted between the sixth and ninth week (7.1g) to be statistically significant. Based on the ⁴⁰K measurement at the ninth week, it was estimated that 0.786 kg of dry protein was lost as compared to the 0.260 kg loss calculated from densitometry. Calculations show that losses of 3.7 and 3.5g of K from whole-body counting after the third and sixth weeks reflect losses of approximately 0.285 kg of dry protein at these times.

DISCUSSION

In a study designed to maintain body weight by adjusting energy expenditure to caloric intake, it appears that body weight changes would be minimal. In this study, a 0.95 kg body weight loss reflected a slight gain in body fat and a loss of body protein. However, the fact that the changes were insignificant shows that deprivation of riboflavin did not inflict any stress on body composition as could be observed by such macro techniques of body volume and ⁴⁰K counting.

With exercise and a good protein intake in the presence of adequate calories, it should be expected that body protein stores would increase. This was observed when either 103 or 204g of protein was included in a 3,766 Kcal/day diet for a 6-week period (11), where a 1.97 kg gain of body weight was noted with a 0.47 kg gain of dry protein, increased body water and a 0.34 kg loss of body fat. Extended exercise and an increased caloric intake may have affected better protein utilization as compared to this study on riboflavin depletion when the subjects continued their normal activity and had not exercised.

No credence is attached to the fact that the ⁴⁰K counting served to approximate the protein loss observed densitometrically during the third and sixth week of the study and over estimated the loss at the ninth week. The counter data are expected to be improved as calibration data on more subjects is added. Calibration to the beginning of this study had been limited to but five subjects.

In the laboratory rat and in other animals who have been intensively studied a dietary deficiency of riboflavin as severe as that utilized in this study would have rapidly led to severe incapacity of the animals and death. Pure riboflavin deficiency in man has never

been reported to produce death or severe incapacity (12). Please note that while biochemical⁵ and psychological⁶ changes compatible with riboflavin deficiency occurred, no clinical signs of the deficiency were observed. In the classical riboflavin deficiency studies conducted by Horwitt et al (13), several months of feeding a riboflavin depleted diet were required before signs or symptoms of the riboflavin deficiency were observed. While it is proper to state that under the conditions of this study that a nine week period of riboflavin depletion did not significantly alter the parameters of body composition that were studied, it cannot be assumed that a condition of ariboflavinosis of sufficient duration to produce clinical signs of marked deficiency would not affect body composition. Based on animal studies such would be assumed to be the case however man does not respond the same as the rat. While it is suspected that signs of severe pure riboflavin deficiency in man would not be associated with body composition changes this study cannot rule that possibility out.

CONCLUSIONS

Riboflavin deprivation over a nine week period did not produce any significant changes in body composition in six young adult males maintained on moderate activity and a caloric intake to preserve body weight.

12. Pearson, W.N. Personal Communication.
13. Horwitt, M.K., et al. J Nutr 41:247, 1950.

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APPENDIX A

TABLE 1. Body composition change before and after 9 weeks of riboflavin deprivation in man.

Body	End of Control Period	Experimental after			change	percent
		3 weeks	6 weeks	9 weeks		
Density, g/ml	1.0665	1.0650	1.0650	1.0650	-0.0015	-0.14
Weight, kg	76.67	76.06	75.76	75.72	-0.95	-1.2
Fat, kg	12.85	13.09	13.03	13.16	+0.31	+2.3
Water, kg	46.59	45.97	45.79	45.67	-0.92	-2.0
Dry protein, kg	12.89	12.72	12.67	12.63	-0.26	-2.0
Minerals, kg	4.34	4.28	4.26	4.25	-0.09	-2.1
Total potassium, g	152.2	148.5	148.7	141.6*	-10.6g*	-6.9
Potassium g/kg body wt	1.98	1.95	1.96	1.87	-0.11g	-5.5

*Significantly lower than sixth week.

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