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Comparison of Riboflavin Status between Traditional Farming Women and Commercial Farming Women in Korea

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ABSTRACT

This study was undertaken to compare the riboflavin status of rural women with different physical activity intensity and to determine factors influencing biochemical riboflavin status. The study was carried out over three different farming seasons : planting(June), harvest(October) and interim(February) in two rural regions of Korea. One was a traditional farming region, the other a commercial farming region with heavier work intensity. Twenty women in the traditional region and eighteen women in the commercial region were involved. The intensity of physical activity was determined by a daily activity record. Body composition was assessed by bioelectrical impedence. Dietary riboflavin intake was measured by the food frequency method. Riboflavin biochemical status was assessed by erythrocyte glutathione reductase activity coefficient(EGR AC) and urinary riboflavin excretion. The results from the EGR AC and urinary riboflavin excretion during the period showed the overall riboflavin status of the commercial farming women was significantly worse than that of the traditional farming women(EGR AC $p<0.0001$, urinary riboflavin excretion $p<0.05$). The traditional farming group had about 40% with risk of riboflavin deficiency, whereas the commercial farming group had about 70%. Overall mean nutrient intake was not significantly different between the two groups, however, overall mean percent lean body mass representing long term physical activity was significantly higher in the commercial farming group($p<0.005$). It appears that the biochemical riboflavin status of traditional farming women was significantly influenced by riboflavin intake and crude nitrogen balance while the biochemical riboflavin status of the commercial farming women was significantly influenced by riboflavin intake and percent of lean body mass over the three seasons. (*Korean J Community Nutrition* 2(5) : 701~710, 1997)

KEY WORDS : nutrient intake · different physical activity intensity · EGR AC · urinary riboflavin excretion · riboflavin status · Korean rural women.

Introduction

Riboflavin is a cofactor for several enzymes involved in oxidation-reduction reaction and thus plays an important role in exercise-induced biochemical adaptations(Gollnick et al. 1972 ; Gollnick et al. 1973 ; Henriksson & Reitmann 1976 ; Mole et al. 1971). Previous studies demonstrated that healthy women have an increased requirement for riboflavin when they are engaged in moderate exercise(Belko et al.

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1983 ; Belko et al. 1984 ; Belko et al. 1985 ; Trebler et al. 1992).

However, it has not been closely examined yet whether the relationship between exercise and riboflavin requirement would be applied in the same manner to the population doing heavy work. Rural women have been more heavily involved in farming activity since the 1960s due to rapid urbanization and industrialization in Korea. As rural women are not only involved in farming activity but are also responsible for house work, their work intensity is getting heavier.

Intensity of physical activity in rural areas is dependent upon the type of farming as well as the farming season. In traditional farming, work intensity has been the lowest in the winter season and highest in June when rice transplanting is taking place. However, work intensity of traditional farming is generally less compared to that of commercial farming in which rice and other commercial crops are simultaneously cultivated. Therefore we are concerned about the riboflavin status of rural women as they are becoming more involved in commercial farming.

According to the Korean National Nutrition Survey, riboflavin is one of the most deficient nutrients in the nations diet, although recent studies have shown that due to rapid economic growth, urban adults suffer this deficiency less than those in rural areas. Most previous studies have examined riboflavin status of rural populations at particular times without any biochemical assessment. As the seasonal variation of food supplies greatly affect nutritional status of rural populations, we attempted to examine the riboflavin status of rural women throughout each farming season of the year.

Several factors may affect the riboflavin status and/or requirement in humans : such as nitrogen balance, energy expenditure and exercise level(Food and Nutrition board 1989). Negative nitrogen balance has been associated with increases in riboflavin excretion due to flavoprotein turnover and breakdown(Bro-Rasmussen 1958b ; Oldham et al. 1947 ; Pollock & Boo-kman 1951). The requirement for riboflavin has also been linked to protein requirement and to the total amount of lean body mass which may influence the formation and storage of flavoproteins(Horwitt 1966). Exercise would therefore be expected to increase riboflavin requirements due to increased energy expenditure and/or increased incorporation of ribofla-vin into new muscle tissue(Tucker et al. 1960). This report deals with those factors that are closely related to the assessment of nutritional riboflavin status. The main purpose of this study was to compare the riboflavin status of rural women with different intensities of physical activities and to determine factors influencing biochemical riboflavin status.

Subjects and Methods

1. Selection of subjects and experimental design

The study was conducted in two rural regions with different intensities of physical activities. One was a traditional farming region and the other was a commercial farming region. Twenty women in the traditional region and eighteen women in the commercial region aged between 31 and 67 years participated. Participation was by informed consent. Pre-study screening included health assessment by medical history and hematological and biochemical measurements. The study was carried out in the three different farming seasons : planting(June), harvest(October) and interim(February). June is the most active period with preparation and planting rice crops, October is harvesting time, while February is the dormant winter period when the least agricultural work is performed.

2. Dietary methodology

At each season the dietary intake was assessed by 24-hour recall. The riboflavin intake was also measured by food frequency method. The food frequency questionnaire consisted of commonly used food from prestudy lists.

3. Measurement of physical activity

The activity patterns of the women were measured by using a daily activity record. The time spent on each activity throughout the whole day was recorded minute by minute. The activities were divided into 4 key activities, eg physiological, basal, housework and farming. Physiological activity included sleeping or at rest ; basal activity included sitting, standing and walking ; housework included light domestic work such as preparing food, cooking meals, washing clothes, sweeping and tending children ; farming included agricultural work in the fields.

4. Anthropometry

Height was measured to the nearest 0.1cm and weight was measured to the nearest 0.1kg using a beam balance. Body composition was measured by bioelectrical impedence. All measurements were taken twice and the reported values are the mean of repeated measurements.

5. Urine and blood sampling

Each season, fasting venous blood samples were collected from all subjects at 6.00 AM and 24-hour urine collections were made. The activity of erythrocyte glutathione reductase(EGR) was determined by the method of Sauberlich et al.(1972). Urinary riboflavin excretion was measured by the method of Slater and Morell(1946). Urinary urea nitrogen was determined by using a modification of carbamidodiacetyl reaction in the presence of thiosemicarbazide (Marsh et al. 1965). Crude nitrogen balance was calculated from protein intake and urinary urea nitrogen measurements by using the method of Weinsier and Butterworth(1981).

6. Statistical analysis

Differences between groups were analysed by Student's t-test. Influence of variables such as nutrients, anthropometry and physical activity on EGR AC and urinary riboflavin excretion was examined by Pearson's correlation matrix as well as multiple regression analysis.

Results

1. General characteristics, body composition, physical activity and nutrient intake

Group overall means for general characteristics, body composition, physical activity, and nutrient intake over the three seasons are presented in Table 1. Differences between the traditional farming and commercial farming groups with regard to age($p<0.05$), height($p<0.05$), body weight($p<0.005$), lean body mass(kg)($p<0.005$), percent lean body mass($p<0.005$) and crude nitrogen balance($p<0.05$) were significant. The commercial farming women were significantly older than the traditional farming women. The height, body weight, and lean body mass(kg) of the commercial farming group were significantly lower than those of the traditional farming group.

However, among the variables relevant to physical activity the overall mean percent lean body mass representing long term physical activity was significantly higher in the commercial farming group than in the traditional farming group. Fig. 1 shows seasonal variation in percent lean body mass for the two groups. There was significant difference in percent lean body mass between the two groups in June when heavy agricultural work was done($p<0.05$) and percent lean body mass was lowest in February when agricultural work was minimal for both groups.

Although the difference was not statistically significant, the overall mean time spent on farming activity and total energy expenditure(as kg of body weight) of the commercial farming group seemed to be higher than that of the traditional farming group. The energy balances of both groups were negative and not significantly different. Although the crude nitrogen balance of the two groups were significantly different, the crude nitrogen balance of both groups were all positive.

The overall means for nutrient intake did not differ significantly between the groups. The overall mean dietary energy, protein, and riboflavin intakes in both groups were below the recommended dietary allowances(RDA) for Koreans with moderate physical labor. The overall mean riboflavin intake was only 0.856mg/d(71% of RDA) in the traditional farming group and 0.788mg/d(66% of RDA) in the commercial farming group.

Fig. 2 shows seasonal variation in riboflavin intake for the two groups. There was no significant seasonal difference in riboflavin intake between the two

Table 1. Group overall means of three farming seasons for general characteristics, body composition, physical activity, and nutrient intake

	Traditional farming group Mean±SD	Commercial farming group Mean±SD
Age(yrs)	44.7 ± 8.2	52.6 ± 11.5*
Height(cm)	153.8 ± 5.2	151.6 ± 5.8*
Body weight(kg)	55.8 ± 8.2	50.3 ± 7.4**
Lean body mass(kg)	40.7 ± 4.0	38.4 ± 4.5**
Lean body mass(%)	73.1 ± 4.8	76.1 ± 5.6**
Farming activity(min)	301.8 ± 197.0	376.2 ± 264.4
Riboflavin intake		
(mg/d)	0.856± 0.226	0.788± 0.274
(mg/1,000kcal intake)	0.545± 0.166	0.514± 0.242
Protein intake(g/d)	57.1 ± 21.9	58.7 ± 30.4
Energy intake		
(kJ/d)	6902.8 ±2077.8	7094.8 ±2968.1
(kcal/d)	1649.8 ± 496.6	1695.7 ± 709.4
Energy expenditure		
(kJ/d)	10904.3 ±2285.7	9999.8 ±2679.9
(kcal/d)	2606.2 ± 546.3	2390.0 ± 640.5
(kJ/kg)	195.4 ± 30.1	198.7 ± 41.4
(kcal/kg)	46.7 ± 7.2	47.5 ± 9.9
Energy balance	0.650± 0.200	0.741± 0.320
Crude nitrogen balance(g/d)	0.633± 4.055	2.683± 4.921*

*significantly different at $p<0.05$ between two groups by t-test
**significantly different at $p<0.005$ between two groups by t-test

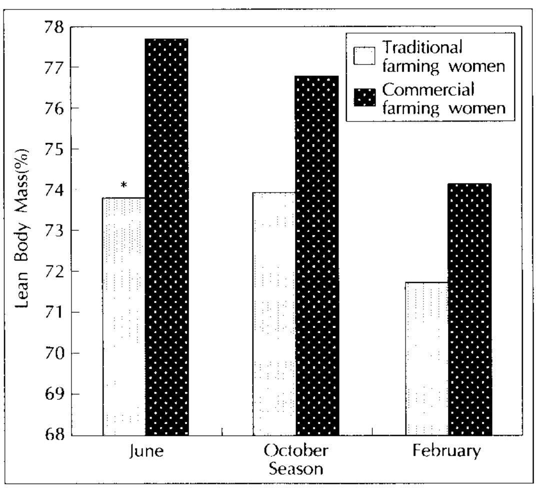

Fig. 1. Seasonal variation in percent lean body of rural women.
*Significant difference($p<0.05$) between the values in two groups.

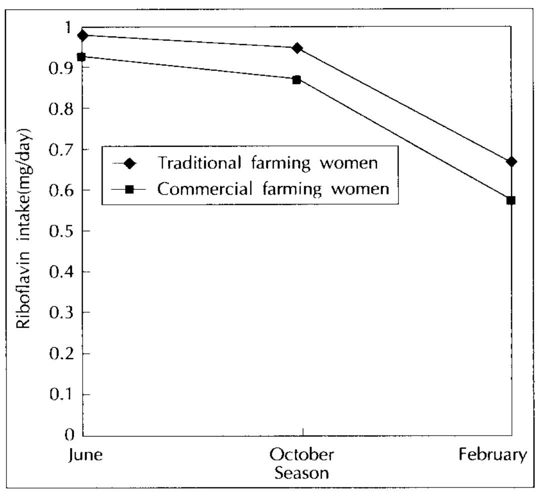

Fig. 2. Seasonal variation riboflavin intake of rural women.

groups. Riboflavin intake was below RDA at all seasons and was lowest in the dormant season for both groups.

Table 2 indicates that >60% of dietary riboflavin intake by both groups was from cereals, pulse and vegetables, while eggs, meat, fishes, and milk & milk products combined contributed only <30% of daily riboflavin consumption over the test period. The results show cereals, pulse and vegetables are important dietary sources of riboflavin for both groups. Because the diet of both groups lack foods rich in riboflavin, such as meat and dairy products, particular attention has to be paid in selecting foods to meet the dietary requirements.

Table 3 presents the correlation of EGR AC and urinary riboflavin excretion with energy, protein, and riboflavin intakes as well as age over the three seasons. Although the overall means for age differed significantly between the groups, there was no correlation between age and EGR AC and urinary riboflavin excretion in either group. Riboflavin intake was significantly correlated with EGR AC in both traditional farming($p<0.005$) and commercial farming($p<0.05$) and urinary riboflavin excretion in the traditional farming group($p<0.05$). No correlation was observed in either group between the energy intake, protein intakes and EGR AC and urinary riboflavin excretion. The high prevalence of riboflavin deficiency seen in the present study indicates that both groups lack sufficient quantities of riboflavin in their diet.

Table 2. Dietary sources of riboflavin intake by food frequency method as percentage of daily riboflavin intake in two groups over the three farming seasons

	Traditional farming group Mean±SD	Commercial farming group Mean±SD
Cereals & Pulse	35.1±11.8	36.4±13.2
Vegetables	31.8±13.1	32.1±14.5
Fruits	2.2± 2.2	9.5±12.1***
Seaweeds	4.4± 3.7	2.8± 3.8*
Eggs & Meat	10.6± 6.2	7.3±11.7**
Fishes	8.1± 4.9	7.9± 5.0
Milk & Milk products	7.8± 7.3	6.3± 9.4

*significantly different at $p<0.01$ between two groups by t-test
**significantly different at $p<0.005$ between two groups by t-test
***significantly different at $p<0.0001$ between two groups by t-test

2. Riboflavin status

Table 4 shows the overall riboflavin status of subjects as assessed by the EGR AC and 24hr urinary excretion over the three seasons. It appears that the commercial group had a significantly worse biochemical riboflavin status(EGR AC $p<0.0001$, urinary riboflavin excretion $p<0.05$) than the traditional group. The overall mean EGR AC values of both groups showed biochemical riboflavin deficiency. The overall mean values for EGR AC and urinary riboflavin of the two groups show that urinary riboflavin excretion had a large coefficient of variation suggesting there was a large inter-subject variation compared to the EGR AC.

On the basis of the EGR AC and urinary riboflavin excretion criteria(McCormick 1985 ; Sauberlich et al. 1974), the frequency and percentage of subjects with deficient(high risk), low(medium risk), or acceptable(low risk) states over the three seasons were calculated for both groups(Table 5). The results were similar whether assessed by EGR AC or urinary riboflavin excretion criteria. The traditional farming group had about 40% of subjects with risk of riboflavin

Table 3. Relationship between EGR AC, urinary riboflavin excretion, and age, energy, protein, riboflavin intake in two groups over the three farming seasons

	Traditional farming group		Commercial farming group	
	EGR AC	urinary excretion	EGR AC	urinary excretion
Age	−0.073	−0.076	−0.102	0.063
Energy intake	−0.140	0.062	−0.167	−0.002
Protein intake	−0.176	0.058	−0.268	0.048
Riboflavin intake	−0.388**	0.296*	−0.297*	0.156

*$p<0.05$ **$p<0.005$

Table 4. Group overall means of three farming seasons for EGR AC and urinary riboflavin excretion

	Traditional farming group Mean±SD(CV)	Commercial farming group Mean±SD(CV)
EGR AC	1.208±0.137(11.3)	1.306±0.150****(11.5)
Urinary riboflavin excretion(ug/d)	253.4±492.3(194.3)	108.8±185.6* (170.6)

*significantly different at $p<0.05$ between two groups by t-test
****significantly different at $p<0.0001$ between two groups by t-test
CV : Coefficient variance EGR AC : Erythrocyte glutathione reductase activity coefficient
Cut off value of EGR AC : 1.20 Cut off value of urinary riboflavin excretion : 120ug/d

Table 5. Frequency distribution of riboflavin status of traditional and commercial farming women group by EGR AC and urinary riboflavin excretion over the three farming seasons

		Traditional farming group		Commercial farming group	
		Frequency	Percentage	Frequency	Percentage
EGR AC					
Deficient	(>1.4)	4	6.7	10	18.5
Low	(1.2 - 1.4)	21	35.0	30	55.6
Acceptable	(<1.2)	35	58.3	14	25.9
Total		60	100	54	100
Urinary riboflavin excretion(μg/24hr)					
Deficient	(< 40)	8	13.3	12	22.6
Low	(40 - 119)	19	31.7	27	50.9
Acceptable	(≥120)	33	55.0	14	26.4
Total		60	100	53	99.9

EGR AC : Erythrocyte glutathione reductase activity coefficient

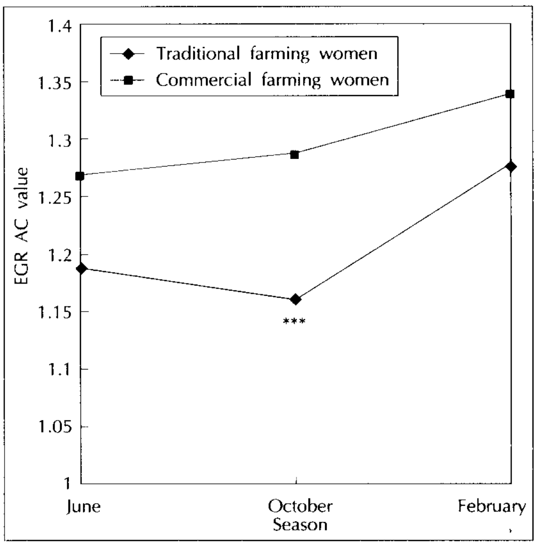

Fig. 3. Seasonal variation in EGR AC of rural women.
***Significant difference($p<0.005$) between the values in two groups.

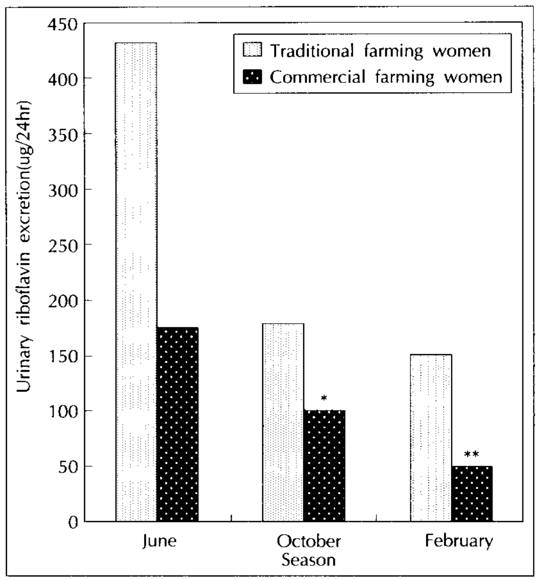

Fig. 4. Seasonal variation in urinary riboflavin excretion of rural women.
*Significant difference($p<0.05$) between the values in two groups.
**Significant difference($p<0.005$) between the values in two groups.

deficiency, while the commercial farming group had about 70% with risk of a deficiency.

Figs. 3 and 4 show the seasonal variations of EGR AC and urinary riboflavin excretion for the two groups. The commercial farming women showed biochemical riboflavin deficiency at all seasons, while the traditional farming women showed biochemical riboflavin deficiency only in February as assessed by EGR AC. The EGR AC value of the commercial farming group was significantly higher than that of the traditional farming group in October($p<0.005$) and although the difference was not statistically significant, the EGR AC value of the commercial group was also higher than that of the traditional group in June and February. The urinary riboflavin excretion of the commercial group was significantly lower than that of the traditional group in October($p<0.05$) and February($p<0.005$). In February EGR AC value was highest and urinary riboflavin excretion was lowest for both groups. Therefore the riboflavin status for both groups was worse in February.

Tables 6 & 7 show factors influencing the overall EGR AC and urinary riboflavin excretion of the two groups over the three seasons. Multiple regression analysis revealed that riboflavin intake and crude nitrogen balance significantly influenced the biochemical riboflavin status of the traditional farming group

Table 6. Variable selection influencing EGR AC & urinary riboflavin excretion of traditional farming women by mutiple regression analysis over the three farming seasons

EGR AC					
		R-square=0.15078267		C(p)= − 7.97543319	
	DF	SS	MS	F	Prob>F
Regression	1	0.167	0.167	10.30	0.0022
Error	58	0.942	0.016		
Total	59	1.109			
Variable	Parameter Estimate	SE	C(p)	F	Prob>F
Intercept	1.410	0.065		470.78	0.0001
Riboflavin intake	− 0.235	0.073	− 7.975	10.30	0.0022
Urinary riboflavin excretion					
		R-square=0.15078267		C(p)= − 7.97543319	
	DF	SS	MS	F	Prob>F
Regression	2	1791871.042	895935.52	4.08	0.0220
Error	57	12508554.462	219448.324		
Total	59	14300425.505			
Variable	Parameter Estimate	SE	C(p)	F	Prob>F
Intercept	− 406.640	248.495		2.68	0.1073
Riboflavin intake	789.018	285.001	− 3.104	7.66	0.0076
Crude nitrogen balance	− 24.832	15.890	− 3.277	2.44	0.1236

EGR AC : Erythrocyte glutathione reductase activity coefficient

Table 7. Variable selection influencing EGR AC & urinary riboflavin excretion of commercial farming women by mutiple regression analysis over the three farming seasons

EGR AC					
		R-square=0.08816756		C(p)= − 4.05568283	
	DF	SS	MS	F	Prob>F
Regression	1	0.105	0.105	5.03	0.02
Error	52	1.090	0.021		
Total	53	1.196			
Variable	Parameter Estimate	SE	C(p)	F	Prob>F
Intercept	1.435	0.060		563.15	0.00
Riboflavin intake	− 0.163	0.072	− 4.056	5.03	0.029
Urinary riboflavin excretion					
		R-square=0.05422872		C(p)= − 5.12001804	
	DF	SS	MS	F	Prob>F
Regression	1	99021.438	99021.438	2.98	.090
Error	52	1726974.951	33211.057		
Total	53	1825996.389			
Variable	Parameter Estimate	SE	C(p)	F	Prob
Intercept	− 481.930	342.989		1.97	0.165
Lean body mass(%)	7.765	4.497	− 5.120	2.98	0.090

EGR AC : Erythrocyte glutathione reductase activity coefficient and riboflavin intake and percent lean body mass significantly influenced the biochemical riboflavin status of the commercial group.

Discussion

Comparing riboflavin status between traditional farming women and commercial farming women in Korea, it is significant to note that in general the commercial farming women had a worse biochemical riboflavin status than the traditional farming women with a higher EGR AC and a lower urinary riboflavin excretion over one year. The commercial farming women showed biochemical riboflavin deficiency throughout, whereas the traditional farming women showed biochemical riboflavin deficiency only in February as assessed by EGR AC. Results on the overall means for EGR AC and urinary riboflavin excretion of the two groups over the three seasons indicate that the biochemical riboflavin status of the commercial farming women was significantly worse than that of the traditional farming women(EGR AC $p<0.005$, urinary riboflavin excretion $p<0.05$). The traditional group had about 40% of subjects with risk of riboflavin deficiency, whereas the commercial group had about 70% at risk of riboflavin deficiency. The overall mean dietary riboflavin, protein, and energy intakes known to influence biochemical riboflavin status were below RDA for Koreans in both groups and the overall dietary intake showed no significant difference between them. However, among the variables relevant to physical activity overall mean percent lean body mass was significantly higher in the commercial farming group than in the traditional farming group. Lean body mass represents long term physical activity(Layman & Boileau 1986).

The results on factors that affected the overall EGR AC and urinary riboflavin excretion of the two groups over the three seasons show that riboflavin intake and crude nitrogen balance significantly influenced the biochemical riboflavin status of the traditional group and riboflavin intake and percent lean body mass significantly influenced the biochemical riboflavin status of the commercial group. It appears that EGR AC was influenced by riboflavin intake in both groups and urinary riboflavin excretion was influenced by riboflavin intake and crude nitrogen balance in the traditional group and percent lean body mass in the commercial group. Crude nitrogen balance in the traditional farming group was not negative but near to zero.

Considering the seasonal variation of riboflavin status in both farming groups, in February(dormant season) the biochemical riboflavin status of subjects was worst(Fig. 3 or 4) and showed riboflavin deficiency as assessed by EGR AC(Fig. 3) in both groups. In February when agricultural work was done least of all seasons, the percent lean body mass was lowest (Fig. 1) and so also was the riboflavin intake being below RDA(Fig. 2). It appears that in February the riboflavin status of both groups was worst due to lowest intake of riboflavin.

It seems that riboflavin intake had the largest influence on the biochemical riboflavin status of both groups. Like several other studies(Garry et al. 1982 ; Tillotson & Baker 1972), EGR AC was found to be significantly correlated with riboflavin intake in both the traditional farming($p<0.005$) and the commercial farming($p<0.05$) groups. Garry et al.(1982) mentioned that, even at low intake of riboflavin, the correlation between riboflavin intake and EGR AC would be significant if dietary information were more reliable. In the present study food frequency method was used to estimate the riboflavin intake. We found $>60\%$ of dietary riboflavin intake in both farming groups was from cereals, pulse & vegetables, whereas eggs, meat, fish, milk & milk products combined to contribute $<30\%$ of daily riboflavin consumption. Riboflavin intake was mostly of plant origin. The high prevalence of riboflavin deficiency was seen in both groups. Riboflavin deficiency is a widespread micronutrient problem in many developing countries where diets lack foods rich in riboflavin, such as animal products and dairy products(Boisvert et al. 1993 ; Brun et al. 1990)

Although the mean ages were significantly different between the groups, we found no correlation of age with EGR AC and urinary riboflavin excretion in either group. This finding is similar to the report by Glatzle et al.(1970) who failed to find a correlation between age and EGR AC in 185 healthy male and female blood donors between the ages of 19 and 69 yr. Another recent study(Boisvert et al. 1993) showed that despite the fact that there was a wide range of age between the subjects(50 - 90 yrs), there were no significant differences in the riboflavin status among them.

The observed effects of physical activity on riboflavin status in the present study were likely to have been associated with the dietary intake. The major finding to emerge from this study was that heavy work performance has a potential to produce significant deterioration of riboflavin status unless optimum dietary intake is maintained. The commercial farming group had a worse biochemical riboflavin status than the traditional group because of insufficient dietary intake and a higher percent lean body mass.

Our findings agree with those of earlier studies showing that maintenance of daily exercise needs require more riboflavin intake. Tucker et al.(1960) proposed that riboflavin requirements are probably increased with exercise in relation to change in lean body mass. In Trebler Winters et al. study(1992) the difference in lean body mass between non-exercise and exercise periods was nearly significant($p<0.07$) and exercise significantly affected riboflavin status as EGR AC increased and riboflavin excretion decreased. Bro-Rasmussen(1958a) on the other hand, favored an association between riboflavin requirements and energy requirements. Belko et al.(1984) proposed that riboflavin requirements may be increased during periods of negative energy balance. Our study shows that the energy balances of both traditional and commercial farming groups were negative but not significantly different.

In conclusion, while optimum intake of riboflavin is the primary factor in maintaining desirable riboflavin status, physical activity is one of the other important determinants of riboflavin status in rural populations who routinely participate in heavy work activity.

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