Blood Alcohol Concentrations after "One Standard Drink" in Thai Healthy Volunteers

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Objective: *The present study aimed to investigate if drinking one standard drink per hour could keep blood alcohol concentration below the legal limit of 0.05% in Thai men and women.*
Material and Method: *After overnight fast, 15 healthy Thai men and 15 healthy Thai women received 12 g of ethanol by drinking beer, rum, or carbonate mixed rum and their blood alcohol concentrations were monitored every 15 min for 1 hours.*
Results: *With one standard drink or 12 g of ethanol per hour, both Thai men and women had blood alcohol concentrations below 0.05%. At 45 min after drinking, women had significantly higher blood alcohol concentrations than men (p < 0.05). There was an inverse correlation between blood alcohol concentrations and the person's body weight. Blood alcohol concentrations were very low when alcoholic beverage was taken immediately after a meal. However, drinking alcohol along with a snack had no effect on blood alcohol concentrations. Drinking carbonate mixed rum led to the highest blood alcohol levels, followed by beer either rapidly drinking or sipping and pure rum, respectively.*
Conclusion: *For Thai people, one standard drink per hour should be considered in the definition of safe level of drinking for men and women driving motor vehicles. It will be safer if drinking immediately after a big meal. Due to rapid absorption of alcohol in the bloodstream, drinking a beverage with low alcohol content could inebriate more rapidly.*

Keyword: *Blood alcohol concentrations, One standard drink, Thai*

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Alcohol is widely used and abused worldwide. The relationship between alcohol consumption and motor vehicle crashes resulting from the impaired performance of complex mental and motor functions is well known[1-3]. Injuries and deaths from road traffic crashes have become a major public health and socioeconomic problem in Thailand[4]. To prevent such accidents, interventions directed at decreasing the use of alcohol including education programs and efforts to change drinking behavior are the main tools. Driver behavior controlled by law enforcement using the legal blood alcohol concentration limit is a very important factor. Due to the finding that impairment of driving-related skills by alcohol began at blood alcohol concentration of 50 mg/dL or 0.05 percent[5], the permissible level of blood alcohol concentration under the traffic law 1994 of Thailand was set at 0.05 percent or lower[6]. In 2000, the US department of health and human services recommended that to have blood alcohol concentration below the 0.05 limit, men should drink no more than 2 standard drinks in one hour, and women should drink no more than one standard drink in one hour[7]. The "standard drink" of alcohol may be defined as one-half ounce of absolute alcohol (100% v/v of alcohol)[8,9]; thus, a standard drink calculated from this definition will contain roughly 12-grams of ethanol. Since the pharmacokinetics of ethanol are affected by various factors including genetics and race[10,11], the present study aimed to find out if the above recommendation could also be used in Thai people. In addition, gender and body weights of drinkers were also studied for their association with blood alcohol concentrations.

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Material and Method

Subjects

Written informed consent was obtained from all subjects and the protocols were approved in advance by the human research ethics committee of Srinakharinwirot University. Fifteen Thai females (age 30.1 ± 5.2 years, body weight 55.1 ± 10.7 kg; mean ± SD) and 15 Thai males (age 30.5 ± 8.8 years, body weight 64.1 ± 10.9 kg) participated in this project after undergoing a medical physical examination and screening for HIV, viral hepatitis, liver diseases, and DM. All selected volunteers were healthy and had no signs of alcoholic, drug abuse, hypertension, pregnancy, and peptic ulcer. None had been receiving any medication 3 days before each experiment.

Experimental procedure

All volunteers were asked to arrive at the research lab after an overnight fast. In the first experiment, after cleaning with tincture iodine, an indwelling flexible catheter was placed in a peripheral vein of the volunteer's arm. Then, 2 mL of blood was taken into a Vacutainer^{TM} tube containing sodium fluoride/potassium oxalate to analyze the baseline alcohol concentration. Next, the subjects were asked to drink 12 g of pure rum (40 mL of 40% alcohol v/v) within 2 min. Then, 2 mL of blood samples were taken every 15-min for the first hour and every 30 min for the second hour. In the second experiment, the same protocols used in the first one were used, except 12 g of beer (275 mL of 5.5% alcohol v/v) was used instead of the pure rum. In the third experiment, the pattern of drinking was changed from drinking 12 g of beer within 2 min to drinking 12 g of beer by sipping for at least 10 min. In the fourth experiment, after collecting the fasting blood, the volunteers were asked to eat a big meal consisting of a 100 g of cooked rice, a 50 g of boiled chicken, 5-pieces of cucumber, 5-7 pieces of fruit (pineapple, melon, and cantaloupe), and a cup of chicken soup. After finishing their meal or no longer than 5 min after their meal, they were asked to drink 12 g of pure rum within 2 min and their blood samples were collected as done in the previous experiments. In the fifth experiment, the volunteers were asked to drink 12 g of pure rum along with a snack, which was a mixture of 20 g of roasted salty peanuts and 30 g of fried meat. They were allowed to finish their drink within 10 min and their blood samples were collected as done in the previous experiments. In the last experiment, the alcoholic beverage was 12 g of pure rum diluted by soda or carbonate in a ratio of 1:1 (v/v). The volunteers were asked to drink carbonate mixed rum within 2 min. Each experiment was done on different occasions placed at least 2 weeks apart.

Measurement

Plasma ethanol determination was done in fresh blood samples on the same day they were collected. Analysis was done on the TDx Abbott analyzer (Abbott Laboratories, Diagnostics Division, IL.) using TDx REA^{R} ethanol assay reagent.

Data analysis

Results are expressed as the means ± 1 SD. The significance of the differences was evaluated by one-way-analysis of variance (ANOVA) or the Student's paired t-test, with $p < 0.05$ considered statistically significant.

Results

Mean blood alcohol concentrations of 30 Thai healthy volunteers are shown in Table 1. By drinking one standard drink per hour, the blood alcohol concentrations of both Thai males and females were below the legal limit. Except drinking 12 g of rum after a big meal, there were statistically significant differences in blood alcohol concentrations between males and females (Table 2). The blood alcohol concentrations at 45 min after drinking in all studied patterns were inversely correlated with the subject's body weights with Pearson correlation < 0, $p < 0.05$, and r^2 of 0.683. This significant correlation was also found at 60, 90, and 120 min after drinking. In contrast, there was no correlation between the volunteer's ages and the blood alcohol concentrations in all studied patterns ($p > 0.05$). Blood alcohol concentrations after eating a meal and drinking 12 g of rum (the fourth experiment) were significantly lower than blood alcohol concentrations from the other patterns (Table 3). In males, drinking two standard drinks (24 g of ethanol) caused significantly higher blood alcohol concentrations than drinking one standard drink (Table 4). With 2 standard drinks, 57% of the male subjects had blood alcohol concentrations over 50 mg/dL within 45 min after drinking.

Discussion

As more and more people drive automobiles, the number of traffic accidents involving drunken drivers has soared. The Thai government has tried to reduce this number by establishing roadside sobriety checkpoints. To avoid drunk driving, people should know how to drink without getting drunk or getting caught at any sobriety check points. Under the traffic

Table 1. Mean blood alcohol concentrations

Time (min)	Mean ± SD of Blood alcohol concentrations (mg/dL) (n = 30)					
	Rapidly drinking rum	Rapidly drinking beer	Sipping beer	Rapidly drinking rum after a meal	Drinking rum along with a pack of snack	Drinking carbonate mixed rum
Baseline	<10	<10	<10	<10	<10	<10
15	22 ± 10	16 ± 10	28 ± 10	11 ± 9	21 ± 12	29 ± 16
30	26 ± 8	28 ± 8	28 ± 8	13 ± 9	22 ± 9	33 ± 7
45	23 ± 8	26 ± 8	23 ± 7	12 ± 7	27 ± 10	28 ± 6
60	20 ± 8	21 ± 7	19 ± 7	<10	19 ± 9	24 ± 6
90	15 ± 8	16 ± 7	13 ± 8	<10	12 ± 8	18 ± 7
120	<10	12 ± 7	<10	<10	<10	12 ± 6

Table 2. Mean of blood alcohol concentrations in males vs. in females

Drinking pattern	Time after drinking (min)	Blood alcohol concentrations in males (mean ± SD, mg/dL) (n = 15)	Blood alcohol concentrations in females (mean ± SD, mg/dL) (n = 15)	Unpaired t-test p-value*
Rapidly drinking rum	15	20.0 ± 11.9	23.7 ± 8.5	0.38
	30	23.3 ± 6.9	29.4 ± 7.9	0.04
	45	20.4 ± 8.0	26.3 ± 6.9	0.05
Rapidly drinking beer	15	15.2 ± 11.7	17.2 ± 8.7	0.61
	30	24.7 ± 7.9	31.1 ± 7.9	0.04
	45	21.5 ± 6.5	29.5 ± 6.3	0.04
Sipping beer	15	24.1 ± 8.5	32.7 ± 10.3	0.02
	30	23.3 ± 7.1	31.9 ± 6.9	0.002
	45	19.0 ± 6.0	26.8 ± 6.7	0.002
Rapidly drinking rum after a meal	15	10.9 ± 9.9	11.5 ± 9.1	0.88
	30	11.5 ± 5.6	14.0 ± 11.1	0.56
	45	9.8 ± 5.5	13.1 ± 10.4	0.41
Drinking rum along with snack	15	17.9 ± 10.6	22.0 ± 15.2	0.44
	30	23.4 ±9.3	28.5 ± 10.6	0.30
	45	16.7 ± 5.0	25.2 ± 9.8	0.03
Drinking carbonate mixed rum	15	26.1 ± 15.0	30.1 ± 16.1	0.57
	30	28.9 ± 6.3	35.3 ± 7.0	0.04
	45	23.4 ± 5.3	30.7 ± 5.4	0.005

* Statistically significant when p < 0.05

Table 3. Blood alcohol concentrations between drinking after meal and other studied patterns

Rapidly drinking rum after a meal compared with	Two-way ANOVA: p-value*	
	Males	Females
Rapidly drinking rum	0.009	0.000
Rapidly drinking beer	0.002	0.000
Sipping beer	0.007	0.000
Drinking rum along with snack	0.027	0.000
Drinking carbonate mixed rum	0.000	0.000

* Statistically significant when p < 0.05

Table 4. Mean blood alcohol concentrations in males drinking one drink vs. two drinks

Drinking pattern	Time (min)	Mean $\pm$ SD of Blood alcohol concentrations (mg/dL) in males drinki		
		1 Drink	2 Drinks	Unpaired t-test p-value*
Drinking rum after a meal	15	9.8 $\pm$ 5.5	16.9 $\pm$ 8.2	0.07
	30	11.5 $\pm$ 5.6	25.1 $\pm$ 13.5	0.02
	45	9.8 $\pm$ 5.5	25.9 $\pm$ 8.8	0.001
Drinking rum along with snack	15	17.9 $\pm$ 10.6	42.3 $\pm$ 25.0	0.12
	30	23.4 $\pm$ 9.3	48.0 $\pm$ 27.0	0.05
	45	16.7 $\pm$ 5.0	45.8 $\pm$ 19.2	0.006
Drinking carbonate mixed rum	15	26.1 $\pm$ 15	36.4 $\pm$ 20.8	0.42
	30	28.9 $\pm$ 6.3	45.3 $\pm$ 26.3	0.15
	45	28.9 $\pm$ 6.3	42.9 $\pm$ 15.1	0.01

* Statistically significant when $p < 0.05$

law 1994 of Thailand, drivers whose blood alcohol concentrations are over 0.05% or 50 mg/dL will be arrested. The US department of health and human services recommended their American people that to have blood alcohol concentration below the 0.05 limit, men should drink no more than 2 standard drinks in one hour, and women should drink no more than one standard drink in one hour[7]. In order to prove if this recommendation could be applied for Thai people, the present study has set six different dinking patterns using one standard drink in healthy Thai volunteers and monitored their blood alcohol concentrations. The results showed that mean blood alcohol concentrations of Thai healthy volunteers both males and females after drinking one standard drink 15, 30, 45, and 60 min were below the legal limit. However, based on raw data, there were some volunteers who had blood alcohol concentrations over 50 mg/dL (experiment 1:1 male at 15 min, experiment 5:1 female at 30 min, experiment 6: 1 male and 3 females at 15 min). Since no one in the present study had blood alcohol concentrations over 50 mg/dL at 60 min after drinking, one standard drink per hour recommended for US people should be applied for Thais as well. However, the present study showed that 2 standard drinks recommended for American men seemed to be too much for Thai males. Although mean blood alcohol concentrations after drinking 2 standard drinks were below 50 mg/dL, 40% of male volunteers had blood alcohol concentrations over 50 mg/dL at 15, 30, and 45 min in the fifth and sixth experiments. One of them had blood alcohol concentrations over 50 mg/dL at 90 min after drinking in experiment 5.

According to the results of the present study, Thai men and women should not drink more than one standard drink per hour, approximately one can of regular beer (330 mL) or 50 mL of a distilled spirit. The safest way is drinking after a big meal. Jones et al[12] reported that drinking alcohol after eating a meal, regardless of the nutritional composition, could decrease the systemic availability of ethanol. Thus, drinking alcoholic beverages after a meal could diminish the intensity and duration of ethanol induced impairment of performance compared with drinking the same dose on an empty stomach. However, the results from the fifth experiment indicated that drinking alcohol along with a small meal such as a snack had no effect on the blood alcohol concentrations.

Because the inverse correlation between body weight and blood alcohol concentrations was found, it is possible that two standard drinks will be too much for Thai males who have, on average, less body weight than Western males. Except drinking after a meal, the male subjects had lower blood alcohol concentrations than females after 30 min of drinking. As has been reported, women have a higher proportion of fat and a lower proportion of water in their bodies than men; therefore, a woman will have a higher blood alcohol content than a man who is of the same weight and who drinks the same amount[13,14].

Ethanol is absorbed slowly from the stomach and rapidly from the small intestine, and the rate of its absorption depends on the rate of gastric emptying. When gastric emptying is slow, the absorption of alcohol is delayed and peak blood alcohol concentrations are reduced. In addition, there is a gastric enzyme that breaks down alcohol before it reaches the blood steam. This gastric enzyme activity has been found to be significantly low in women compared to men[15-17]. This difference could be another reason to explain why women had higher blood alcohol concentrations than men.

The liver can metabolize only a certain amount of alcohol per hour; approximately 2/3 of a standard drink per hour, regardless of the amount has been consumed. Therefore, consumption needs to be controlled to prevent accumulation in the body and intoxication. If the amount of ethanol consumed is not great, the oxidation of the alcohol can keep up with the rate that the ethanol is entering the blood stream and the alcohol concentration will not increase[10,18,19].

As shown in Table 1, drinking carbonate mixed rum led to the highest absorption rate followed by rapidly drinking beer (5.5% v/v alcohol) and rapidly drinking rum (40% v/v alcohol), respectively. Thus, type and alcohol content of the beverage consumed influence the alcohol absorption rate. It has been reported that alcohol contents higher than 30% v/v could delay absorption due to an irritant effect and reaction on the membranes. Such high concentrations, pylorospasm may occur leading to the closing the gastric outlet and consequently delaying the gastric emptying and alcohol absorption. Furthermore, it was found that mixing carbonate in soda to distilled spirit or rum could accelerate alcohol absorption[20,21]. According to the results, anyone drinking a beverage with low alcohol content may get drunk due possibly to rapid alcohol absorption.

Alcohol preference and consumption are regulated by a complex interaction of social, psychological, and biologic variables. However, some variables are easier to alter than others, and it is clear that the absorption rate is easier to change than many other variables. For Thai people, alcohol absorption rate is based on the person's weight, the amount and rate of alcohol consumption and the amount of food in the stomach while the alcoholic beverage is consumed.

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ปริมาณแอลกอฮอล์ในเลือดของอาสาสมัครไทยหลังจากดื่มเครื่องดื่มมีแอลกอฮอล์ “หนึ่งปริมาณมาตรฐาน”

วีรวรรณ เล็กสกุลไชย, สมดี รัตนาวิบูลย์

การศึกษานี้ให้อาสาสมัครชาวไทยจำนวน 30 คน เป็นชาย 15 คนและหญิง 15 คน อดอาหารข้ามคืน แล้วทำการดื่มเครื่องดื่มมีแอลกอฮอล์ “หนึ่งปริมาณมาตรฐาน” ในลักษณะต่าง ๆ จากนั้นจะได้รับการตรวจวัดปริมาณแอลกอฮอล์ ในเลือดทุก 15 นาที เป็นเวลา 1 ชั่วโมง ผลการศึกษาพบว่า การดื่มในปริมาณนี้เป็นเวลา 1 ชั่วโมง จะให้ปริมาณแอลกอฮอล์ในเลือดต่ำกว่าเกณฑ์ที่กฎหมายกำหนดคือต่ำกว่า 50 mg/dL หรือ 0.05% หลังดื่ม 45 นาที พบว่าโดยเฉลี่ยหญิงจะมีปริมาณแอลกอฮอล์ในเลือดสูงกว่าชายอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) ปริมาณแอลกอฮอล์ในเลือดมีความสัมพันธ์แบบผกผันกับน้ำหนักตัว การดื่มหลังจากการกินอาหารมื้อหนักทันทีให้ค่าปริมาณแอลกอฮอล์ในเลือดต่ำอย่างมากในอาสาสมัครทุกรายแต่การดื่มพร้อมกับกับแกล้มหรือการเจือจางเหล้าด้วยโซดา ยังคงให้ค่าปริมาณแอลกอฮอล์ในเลือดสูง ดังนั้นปริมาณ “หนึ่งปริมาณมาตรฐาน” ภายใน 1 ชั่วโมง ที่แนะนำในชาวตะวันตกน่าจะเหมาะกับคนไทยด้วย การดื่มที่ปลอดภัยที่สุด คือ ดื่มหลังการกินอาหารมื้อหนัก การดื่มที่ต้องระวังคือ การดื่มเครื่องดื่มเจือจาง การดื่มกับอาหารมื้อเบา เพราะเป็นภาวะที่การดูดซึมแอลกอฮอล์เข้าสู่กระแสเลือดเกิดขึ้นได้ดี