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CAFFEINE INTAKE AND URINE CAFFEINE CONCENTRATIONS AMONG THAI VOLUNTEERS LIVING IN NAKHONNAYOK

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Abstract

Caffeine is a psychoactive substance that is not legally regulated. Moreover, it is found in various forms of foodstuff. This study aimed to investigate caffeine intake and knowledge concerning caffeine health effects in a community of Thailand, Nakhonnayok province. A questionnaire was used to survey how people consumed caffeine-containing foodstuff daily. Urine caffeine concentrations analyzed by GC/NPD method were used to estimate how much caffeine has been consumed in this community based. The study showed that there were a large number of people in this population who did not know if caffeine had health effects and some did not know if caffeine could be found in foods other than coffee and tea. Coffee was an important dietary source of caffeine for this population. No significant correlation of gender and age of the respondents on types of daily beverage intake were found. Urine caffeine concentrations were found up to 9,482 ng/mL. This maximum concentration was quite high which indicated that some had daily ingested large amount of caffeine containing food stuffs. Thus, the education program is needed for the studied community in order to prevent future excessive caffeine consumption unintentionally.

Key words: caffeine, community, consumption, health effects

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การบริโภคคาเฟอีนและปริมาณคาเฟอีนในปัสสาวะของผู้ที่อาศัยอยู่ที่จังหวัดนครนายก

*วีรวรรณ เล็กสกุลไชย**

บทคัดย่อ

คาเฟอีนเป็นสารที่มีผลต่อจิตประสาทที่ไม่ได้รับการขึ้นทะเบียนเป็นสารควบคุม นอกจากนี้ คาเฟอีนยังเป็นสารที่พบได้ในอาหารหลากหลายชนิดและยาที่มีขายทั่วไป การศึกษานี้ต้องการประเมินปริมาณคาเฟอีนที่บริโภคและความรู้เกี่ยวกับผลของคาเฟอีนต่อสุขภาพของคนในอำเภอองครักษ์ จังหวัดนครนายก โดยใช้แบบสอบถามสำรวจการบริโภคอาหารในชีวิตประจำวันที่มีคาเฟอีนเป็นส่วนประกอบ และวิเคราะห์ปริมาณคาเฟอีนในปัสสาวะโดยใช้ GC-NPD ผลการศึกษาพบว่า ในชุมชนนี้มีประชาชนจำนวนหนึ่งไม่ทราบว่าคาเฟอีนมีผลต่อสุขภาพ และมีคนจำนวนหนึ่งในชุมชนนี้ที่ไม่ทราบว่านอกจากกาแฟและชาแล้ว คาเฟอีนสามารถพบได้ในอาหารประเภทอื่น ๆ กาแฟคือแหล่งคาเฟอีนที่มีการบริโภคมากที่สุดในชุมชนนี้ เพศและอายุไม่มีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติต่อการบริโภคเครื่องดื่มในชุมชนนี้ ค่าคาเฟอีนในปัสสาวะที่ตรวจพบในชุมชนนี้มีค่าสูงสุดอยู่ที่ 9482 นาโนกรัมต่อมิลลิลิตร ซึ่งจัดว่าสูง บ่งชี้ว่ามีอาสาสมัครไทยจำนวนหนึ่งบริโภคคาเฟอีนปริมาณมากในแต่ละวัน ผลการศึกษาแสดงให้เห็นว่า การให้ความรู้เกี่ยวกับคาเฟอีนแก่ประชาชนในชุมชนนี้มีความจำเป็น เพื่อป้องกันการบริโภคคาเฟอีนมากเกินไปในอนาคต

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Introduction

Caffeine is a naturally occurring psychoactive substance found in coffee beans, tea leaves, and cocoa nuts. It presents in diet from a variety of sources primarily coffee, tea, and chocolate[1]. Caffeine is also an added ingredient in approximately 70% of soda drinks available in the markets[2]. Recreationally, caffeine is used to provide a "boost of energy" or a feeling of heightened alertness[1]. Furthermore, caffeine can be found in combination with other drugs due to its effects on wakefulness and analgesics[3]. Because of its wide consumption at different levels by most segments of the population, the public and the scientific community should express interest in the potential for caffeine to produce adverse effects on human health. From epidemiological data, caffeine is not as harmless as one might believe. Excessive amounts of coffee can cause very unpleasant side effects. An overdose of caffeine alone, intentional or not, might be deadly[4].

In Thailand, caffeine containing foods and beverages are produced and marketed in various forms. Caffeinated beverages especially coffee, soda drinks, energy drinks, and green tea are highly competing products nation wide. Though, food and drink dispensing machines are rarely found in Thailand, soft drinks and other caffeine containing items are easily bought at grocery stores, mini-marts, and shopping centers through out the country. On one hand, with motivation from advertisements and lack of public health information, Thai people may daily consume large amount of caffeine without awareness of its psychoactive effects and have its side effects unintentionally. On the other hand, based on the traditional Thai culture, coffee and tea are not Thai regular drinks unlike in some countries such as UK and China. Therefore, caffeine consumption in Thai community may not be as much as that found in other countries.

This study aimed to assess caffeine intake habits and knowledge concerning caffeine health effects of Thai subjects living in Nakhonnayok province, which is an urban area near Bangkok. The urine caffeine concentrations were also determined in order to estimate roughly how much caffeine had been consumed in this community.

Materials and Methods

The protocols were approved in advanced by the Srinakharinwirot University's human research ethics committee. The study population consisted of 400 Thai volunteers, ages between 18-83 years, who lived in Nakhonnayok province, Thailand. Each subject was fully informed about the experimental procedures before giving informed, written consent.

The survey was done during October 2004 to March 2005. It was conducted using a questionnaire developed by the investigator which included the following items: subject identifying code number (to protect individuals' privacy), individuals' sex and age, types of daily consumed beverages, knowledge about caffeine's health effects and sources of caffeine-containing items, and symptoms after drinking coffee. After answering the questionnaire, each subject provided 20-50 mL of urine in a clean and dry plastic container. Urine samples were tightly sealed and stored at 0°C for later analysis of caffeine.

Urine caffeine concentration was measured as followed. Two mL of urine was pipetted into a 16 x 100-mm screwed cap test tube. Diphenylamine and standard caffeine were purchased from Sigma Chemical Co. (St. Louis, MO). Diphenylamine was used as an internal standard. Dichloromethane was used as an organic solvent. The method consisted of a liquid-liquid extraction at alkaline pH with 2 N NaOH and analyzed by 6890 N gas chromatograph with nitrogen-phosphorus detector (Agilent Technologies. DE.) with a HP-5 column. Helium was used as a carrier gas. Temperature control program was used with 75°C initial temperature, 1 min holding time, 20°C/min ramping rate, and 240°C final temperature.

Data were analyzed through the SPSS 11.0 software. Values are expressed as mean ± SD. The correlation models included urine caffeine concentrations, sex and age of participants, types of caffeine containing items consumed daily, and symptoms found after drinking coffee. A result was considered statistically significant if $p < 0.05$.

Results

From 400 questionnaires, 316 were answered and the respondents' urine samples were analyzed for caffeine concentrations; 186 women with a mean age of 40.4 years (SD = 14.8) and 130 men with a mean age of 40.2 years (SD = 15.5). Only 277 respondents completed questionnaires for types of caffeine-containing items daily consumed. Some respondents daily consumed more than one type of caffeinated beverages. Coffee was an important dietary source of caffeine for this population. About 33% answered "no-caffeinated" beverages in their daily diet (Table 1 and 2). In this group, alcoholic beverages were the most popular one (68 answers). No significant correlation of gender and age of the respondents on types of daily beverage intake were found with $p = 0.073$ and $p = 0.543$, respectively.

Table 1 Numbers of respondents divided by types of daily beverage intake and age ranges

Age Range (years)	Numbers of respondents divided by type(s) of daily beverage intake (%)					
	Coffee only	Tea only	Other Caffeinated*	Coffee and Others	Non-caffeine	Total
18-20	3 (18.8)	1 (6.3)	2 (12.5)	3 (18.8)	7 (43.8)	16 (100.0)
21-40	28 (18.1)	3 (1.9)	15 (9.7)	57 (36.8)	52 (33.5)	155 (100.0)
41-60	16 (20.5)	3 (3.8)	8 (10.3)	30 (38.5)	21 (26.9)	78 (100.0)
61-83	2 (7.1)	0	2 (7.1)	12 (42.9)	12 (42.9)	28 (100.0)
Total	**49 (17.7)**	**7 (2.5)**	**27 (9.7)**	**102 (36.8)**	**92 (33.2)**	**277 (100.0)**

Table 2 Numbers of answers* classified by types of beverages consumed

Type of Beverage	Numer of Anawers	Percentage of Answers
Coffee	151	26.4
Carbonated drinks	98	17.1
Energy drinks	55	9.6
Tea	46	8.1
Gree tea	29	5.1
Cocoa	4	0.7
Non-caffeine**	188	33.0
Total	**571**	**100.0**

*Many respondents answered more than one type of beverages

** Non-caffeine include pure water, milk, fruit juices, and alcoholic beverages

Most of the participants knew that caffeine might have harm to their health. However, 23.4% of respondents reported they did not know if caffeine might have any impact on their health (Table 3).

Table 3 Numbers of answers when asking if caffeine has any harm to health

Answer	Male Respondents (%)	Female Respondents (%)	Total (%)
Caffeine has harm to health	78 (67.8)	130 (73.9)	208 (71.5)
Caffeine has no harm	8 (7.0)	7 (4.0)	15 (5.1)
Do not Know	29 (25.2)	39 (22.2)	68 (23.4)
Total	**115 (100.0)**	**176 (100.0)**	**291 (100.0)**

When asked if caffeine could be found in foods or drinks other than coffee and tea, 57.2% of the respondents answered "No" (Table 4).

Table 4 Numbers of answers when asking if there are any foods or drinks containing caffeine other than coffee and tea

Answer	Male Respondents (%)	Female Respondents (%)	Total (%)
Yes, there are	42 (41.2)	51 (34.5)	93 (37.2)
No, there are not	52 (51.0)	91 (61.5)	143 (57.2)
Do not Know	8 (7.8)	6 (4.1)	14 (5.6)
Total	**102 (100.0)**	**148 (100.0)**	**250 (100.0)**

In habitual coffee drinkers, about one fourth reported that they did not have any symptoms after consuming a cup of coffee, while 56.8% reported that they consumed coffee in order to get wakefulness and alertness. The negative effects of caffeine; i.e., increasing heart rate, insomnia, and headache, were also reported in the habitual coffee drinkers. In the group of non-habitual coffee drinkers, since their answers for this question might be a recalled experience, all answers of no sign were not counted. Half of this later group had increased heart rate (Table 5).

Table 5 Signs after drinking a cup of coffee

Sign	Habitual coffee drinkers (%)	Non-habitual coffee drinkers (%)
No any sign	44 (29.7)	Not counted
Wakefulness	46 (31.1)	14 (19.2)
Alertness/Active	38 (25.7)	14 (19.2)
Increasing heart rate	17 (11.5)	41 (56.2)
Insomnia	2 (1.3)	2 (2.7)
Headache	1 (0.7)	2 (2.7)
Total	**148 (100.0)**	**73 (100.0)**

Urine caffeine concentrations were determined by GC/NPD method. The calibration curve of this method was demonstrated to be linear in the working range of 300-8000 ng/mL (r^2 = 0.985). Within-run precisions were determined by using home-made control samples and were found to have %CV of 14.6% at the concentration of 1,000 ng/mL, 6.3% at the concentration of 2,000 ng/mL, and 2.8% at the concentration of 5,000 ng/mL. The GC chromatogram is shown in figure 1. The caffeine free urine from a volunteer was analyzed as a negative control in every run and it showed no caffeine peak.

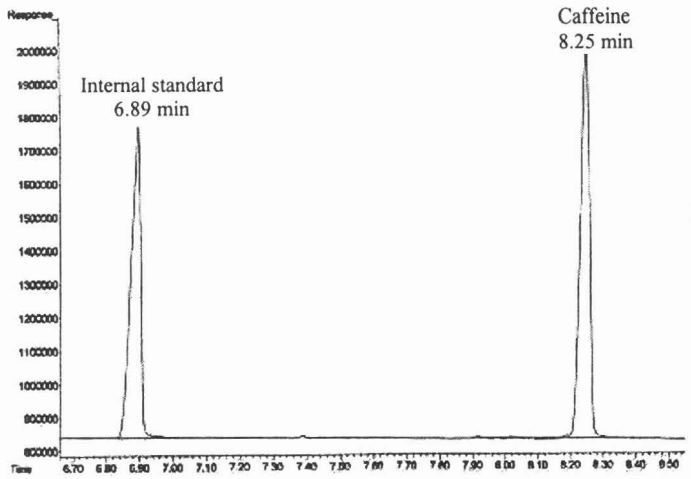


Figure 1 Gas chromatogram of caffeine

From 316 urine samples, caffeine concentrations were below the limit of quantitation (300 ng/mL) in 123 samples (38 men and 85 women). In 193 urine samples (92 men and 101 women), caffeine concentrations were found between 304 to 9482 ng/mL (mean = 2004.1 ng/mL, SD=1582.1) (Table 6). The group of habitual coffee drinkers had significantly higher urine caffeine concentrations compared to the group of non-habitual drinkers with p = 0.001. About 75.9% of the habitual coffee drinkers had urine caffeine concentrations over 300 ng/mL, while only 48.8% of non-habitual coffee drinkers had urine caffeine concentrations over 300 ng/mL. Soda drinks were the main dietary source of caffeine in the non-habitual coffee drinkers who had high urine caffeine concentrations. Ten respondents who reported "no-caffeinated" beverages in their daily diet had their urine caffeine concentration over 300 ng/mL. Five of them reported frequently using over-the-counter analgesic and anti-allergic drugs. No significant interaction and no significant main effect of gender and age on urine caffeine concentrations were found with p = 0.165 and p = 0.187, respectively.

Table 6 Urine Caffeine Concentrations in Male and Female Respondents

Urine caffeine concentration (ng/mL)	Male respondents (%)	Female respondents (%)	Total (%)
< 300*	38 (30.9)	85 (39.1)	123 (100.0)
≥ 300	92 (47.7)	101 (52.3)	193 (100.0)
300-1000	*31 (33.7)*	*29 (28.7)*	*60 (31.1)*
1001-2000	*31 (33.7)*	*23 (22.8)*	*54 (28.0)*
2001-3000	*16 (17.4)*	*20 (19.8)*	*36 (18.6)*
3001-4000	*2 (2.2)*	*19 (18.8)*	*21 (10.9)*
4001-5000	*9 (9.8)*	*5 (4.9)*	*14 (7.2)*
5001-6000	*1 (1.1)*	*2 (2.0)*	*3 (1.6)*
> 6000	*2 (2.2)*	*3 (3.0)*	*5 (2.6)*
Total	***92 (100.0)***	***101 (100.0)***	***193 (100.0)***

*Limit of caffeine quantitation

Discussion

From the self-reporting survey, sub-population of Thais who live in the urban area, Nakhonnayok province, received caffeine mostly from coffee, regardless of their sex, age and occupation. The second source of dietary caffeine in this community was the soda drinks, followed by the energy drinks. Pichainarong and colleagues[5] had reported that the construction workers living in Chonburi province, Thailand consumed caffeine mainly from the energy drinks. People living in Nakhonnayok mostly work in farms and in government offices. Thus, the respondents' occupation may have impact on the types of daily caffeine diet. Morgan and colleagues[6] reported that caffeine was consumed mostly in carbonated beverages in adolescents. However, as shown in Table 1, most adolescent Thai; ages between 18-20 years, preferred to drink non-caffeinated beverages. Because the number of respondents in this age group was so little and adolescents under the age of 18 were excluded in this study, further study has to be done before making a conclusion in this circumstance.

Most of the non-habitual coffee drinkers had experience of adverse effects of caffeine. In the group of habitual coffee drinkers, half of them reported no symptoms after consuming coffee. This might be the result of tolerance. Routine caffeine consumption may cause tolerance or dependence, and abrupt discontinuation can produce irritability, mood shifts, headache, drowsiness, or fatigue[7, 8]. Unfortunately, the questionnaire did not ask if these respondents had any withdrawal symptoms after cessation of daily coffee intake. In the habitual coffee drinkers, however, some still had the psychoactive effects of caffeine including increased heart rate, increased alertness, decreased fatigue, and increased wake time. It was found that there were potential individual differences in caffeine-tolerance formation among the population. Some regular caffeine consumption may have only partial tolerance effect[9]. Based on this evidence, in the studied community, some habitual coffee drinkers might develop full tolerance and some had only partial tolerance. From the reported symptoms, the consumption of coffee and other caffeinated foodstuffs in the studied community more likely reflected the mood-altering and physical dependence-producing effects of caffeine than its subtle effects as a flavoring agent. This relationship has been previously reported[10, 11].

In this urban community, there were high percentages of people who did not know the health related effects of caffeine and types of caffeine containing foodstuffs. Thus, education programs are needed to inform the community on health issues related to excessive intake of caffeine-containing foodstuffs. Limitation of the availability of caffeine should also be considered in order to prevent consumers from unwittingly consuming excessive amounts of caffeine that may lead to adverse physiological side effects.

Based on the finding that there was a significant correlation between the dose of caffeine intake and urinary caffeine concentration[12], this study used urine caffeine concentration

as an indicator to assess how much caffeine had been taken by the studied population. The results indicated that this studied urban community consumed in average high amount of caffeine compared to that reported in the western countries[13]. Maximum caffeine concentration found in this study was 9,482 ng/mL (mean = 2004.1 ng/mL) while the normal range of urine caffeine concentrations had been reported as high as 2.5 microgram per milliliter or 2,500 ng/mL[13]. Even in the dehydration state, peak urine caffeine concentration had been reported only at 7,600 ng/mL[14]. Surprisingly, ten respondents, who reported no caffeine intake in their daily life, had high concentrations of urine caffeine. Five of them were found to frequently use over-the counter analgesic and anti-allergic drugs. Therefore, they might receive some amounts of caffeine unwittingly from their medicines.

With its psychological, physiological, and metabolic effects, caffeine may be considered as a drug and should be used carefully. But caffeine is found in various foods and beverages and is consumed unlimitedly by most segments of the population. People may unintentionally consume excess amount of caffeine and get its unpleasant side effects. The side effects may be deadly especially in some patient groups such as epileptic patients[15, 16], hypertensive patients[17], and diabetic patients[18-20]. Since caffeine is not classified as a controlled drug, a way to limit caffeine intake in each community is an education program to inform the community on health issues related to excessive intake of caffeine-containing foodstuffs.

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