Effects of Low Blood Alcohol Level on Reaction Time

Pimprapai Seneewong Na Ayuthaya, M.D.*, Arnon Thasanasuwan, M.Sc., Siriwan Sasithonrojanachai, M.Sc.*, Chachawin Ra-ngabphai, M.D.*, Amnaj Kussalanan, M.D.***

**Department of Forensic Medicine, Faculty of Medicine Siriraj Hospital, ** 28 th Health Center, Metropolitan Administration, Bangkok 10700, Thailand*

ABSTRACT

Objective: To determine the effect of low-dose blood alcohol level on reaction time (RT), representing to the driving skill.
Methods: Three groups of 72 healthy volunteers (36 men and 36 women) divided by age, gender and drinking - practice characteristics (light, moderate and heavy drinker). They were monitored in an attempt to identify changes in reaction time after the administration of low doses of alcohol. They took part in a computer-based response reaction time system before and after administration of low doses of alcohol. The low doses of alcohol were identified to the blood alcohol concentration (BAC) values between 0 and 30-80 mg% by breathalyzer.
Results: In all categories, the means of reaction time (RT) at the BAC values between 0 and 30-80 mg% in all volunteers showed a statistically significant difference at $p < 0.05$, except in light drinkers and moderate drinkers, there was no statistically significant difference between BAC 0 and 30 mg% ($p > 0.05$) but a statistically significant difference at BAC between 0 and 40-80 mg% ($p < 0.001$).
Conclusions: The effect of low-dose blood alcohol level on reaction time in this study suggests that the BAC values lower than 50 mg% (legalistic limit) may impair driving skills which leads to a high risk of traffic accident.

Driving involves multiple tasks, the demands of which can change continually. To drive safely, one must maintain alertness make decisions based on ever-changing information present in the environment, and execute maneuvers based on these decisions. Drinking alcohol impairs a wide range of skills necessary for carrying out these tasks and associated with a wide range of accidents and injuries resulting from the impaired perfor mance of complex mental and motor functions.[1] Researchers have documented that the risk of a motor vehicle crash increases as BAC increases[2,3] and that the more demanding the driving task, the greater the impairment can be caused by even low doses of alcohol.[2] Compared with drivers who have not consumed alcohol, the risk of a single-vehicle fatal crash for drivers with BAC between 20 and 40 mg% is estimated to be 1.4 times higher; for those with BAC between 50 and 90 mg%, 11.1 times higher; for drivers with BAC between 100 and 140 mg%, 48 times higher; and for those with BAC at or above 150 mg%, the risk is estimated to be 380 times higher.[3]

Deterrence has been the principal approach for prevention of driving under the influence of alcohol. Legislatures have established blood alcohol concentration (BAC) limits for driving and law enforcement agencies have enforced those laws. Several western countries have set the legal limit of BAC at 80 mg%. The Netherlands and Norway have a 50 mg% limit; Australian states have adopted either 80 mg% or 50 mg% BAC levels and Sweden has lowered its BAC limit to 20 mg%.[4] The Thai Road Safety Act established a BAC limit in 1994.[5] The BAC limit for drivers age 18 and older is 50 mg%. The drivers with BAC above this would commit an offence. This legal limit has been questioned as appropriate for Thais. In this study we decided to look again at the effects of fairly low doses of alcohol on driving and attempt to assess the degree of impairment, if any.

MATERIALS AND METHODS

Seventy-two subjects were divided into three categories of age, two categories of gender and three categories of drinking practice. Thirty-six men and thirty-six women participated in the study. The three age groups contained thirty-six subjects in the youth (18-24 years) and eighteen subjects of both adult (25-50 years) and older (51-69 years). The subjects were classified as light, moderate and heavy drinkers, with twenty-four subjects in each category. The reaction time was examined using a computer-based system. They were administered alcohol about 600-900 ml of beer to produce mean test-time BAC from 0 mg% to 80 mg%. All subjects were tested by computer-based system prior to receiving alcohol and at the mean BAC of 80 mg%, 70 mg%, 60 mg%, 40 mg% and 30 mg%, respectively. They were repetitively monitored with a Breathalyzer (Alco-Sensor IV) and the testing actually began when BAC were about 80 mg% and were tested on the constant descending blood alcohol curve, because it is extremely difficult to pace alcohol consumption and track a rising alcohol curve for the purpose of reaction time testing at specified BAC.[6]

Reaction time was performed by using a computer-based system which uses three color circles (green, yellow and red) represent the traffic light. The subjects responded to the color signals which appear at the computer monitor and the change of the response time to the color was detected by the computer program. They have been well trained on using the computer-based system by instruction, demonstration and practice trial prior the experiment. All subjects were tested on computer-based system before and after being given alcohol, at the highest BAC for their drinking classification and at 0.02% BAC intervals as their alcohol levels decreased.

TABLE 1. The means of reaction time at different blood alcohol concentration (BAC) in 72 subjects.

BAC (mg%)	Mean of reaction time in total (msec) (SD)	Mean of reaction time in male (msec) (SD)	Mean of reaction time in female (msec) (SD)
Before drinking	266.6 (33.3)	262.9 (29.7)	270.2(36.6)
30 ±2	277.2 (25.7)*	275.4 (19.7)*	278.9 (30.6)
40 ±2	293.2 (35.0)*	293.5 (35.5)*	292.8 (34.5)*
50 ±2	296.9 (36.9)*	292.3 (24.6)*	301.4 (46.5)*
60 ±2	299.3 (31.5)*	295.9 (24.3)*	302.8 (37.7)*
70 ±2	303.6 (38.3)*	296.9 (29.6)*	310.3 (45.6)*
80 ±2	312.3 (34.5)*	306.8 (28.9)*	317.9 (39.6)*

* Significant difference from Baseline (Bonferroni Correction P-vaule) P< 0.001

The proportion of alcohol to blood in the body is expressed as the blood alcohol concentration (BAC). In the field of traffic safety, BAC is expressed as the percentage of alcohol in deciliters of blood. A 70-kg man will have a BAC of approximately 40 mg% one hour after consuming two 12 - ounce of beers or two other standard drinks on an empty stomach.[7]

At alcohol sessions, breath specimens were obtained with an Alco-Sensor IV for BAC measurement at 30 minutes after the drink. The breath sampling was repeated at 10 min intervals until the targets were reached or until the BAC began to decline.

The computer-base system was initiated within ±2 mg% of the target BAC and at 10 mg% intervals. Testing is initiated at alcohol sessions after obtaining the first breath specimens. Timing of subsequent test allowed sufficient time for a 10 mg% decrease with the interval calculated at 15 mg% per hour metabolism rate.

Statistical analysis: the different scores were assessed using a paired t-test with baseline at significant level p<0.05 (Bonferroni Correction p-value).

RESULTS

The means of reaction time at the BAC values between 0 mg% and 30, 40, 50, 60, 70, and 80 mg% in all 72 subjects, in both male and female, in Table 1 showed significant difference ($p < 0.001$). There are 11.36% difference in BAC between 0 and 50 mg%.

The means of the reaction time of the three age groups, youthful drivers (18-24 years), adult drivers (25-50 years) and older divers (51-69 years), at the BAC values between 0 and 30, 40, 50, 60, 70 and 80 mg% showed a significant difference ($p< 0.05$) (Table 2).

Table 3 shows the means of reaction time of 24 light drinkers and 24 moderate drinkers at different BAC levels: 0, 30, 40, 50, 60, 70, and 80 mg%. It shows significant difference between BAC 0 and 80, 70, 60, 50, and 40 mg% ($p< 0.001$) but no significant difference between BAC 0 and 30 mg% ($p> 0.05$).

In 24 cases of heavy drinkers, the means of reaction time showed a significant difference ($p <0.05$) at the BAC between 0 and 30, 40, 50, 60, 70 and 80 mg%.

DISCUSSION

Alcohol is water-soluble and readily absorbed in the blood. More blood is supplied to the brain than to other organs, with the result that alcohol impairs brain function within minutes. The effects of alcohol are first manifest in the brain centers involved in highly integrated functions, such as skilled performance.[8] The analysis of sensory information, the control of intricate movement patterns and short-term memory are especially sensitive to alcohol. The effects on human skills and performance commence at the lowest measurable blood alcohol concentrations.[9]

Historically, deterrence has been the principal approach for prevention of driving under the influence of alcohol. Legislatures have established blood alcohol concentration (BAC) limits for driving, and law enforcement agencies have enforced the laws. Scientists have also contributed to the establishment of BAC limits with data from experimental and epidemiological studies to identify the alcohol levels which produce driving-skill impairment and increased crash rates. In a report published by the National Highway Traffic Safety Administration (NHTSA), the experimental literature regarding the effects of alcohol on driving-related skills performance from the 1950's through 1985 was reviewed.[10] The report summarized 177 studies which met the following criteria for inclusion: placebo treatments, statistical significance, and the ability to determine the BAC at the time of testing. Overall, 21% of the studies reported perfor mance impairment by 0.04 g/dl, 34% by 0.05 g/dl, 66% by 0.08 g/dl and nearly all by 0.10 g/dl. The results of this study showed significant performance impairment by 30 mg% which is less than that in previous studies and Thailand legal limit. So it is the scientific evidence supported the legal limit for driving to 50 mg%.

Table 1 shows that the male has shorter reaction time than the female. The mean time to press a key in response to a light was 262.85 msec for the male and 270.29 msec for the female. In comparison, there are reports that the reaction time to sound is 227 msec (male) and 242 msec (female).[11] It was found that almost all of the male-female differences were accounted for by the lag between the presentation of the stimulus and the beginning of muscle contraction. Muscle contraction times were the same for the male and the female.[9] There are reports that the male uses a more complex strategy than the female and age-related deterioration in reaction time was the same in men and women.[12,13]

The means of reaction time for different age groups in table 2 show that the reaction time is shortened in adolescents and young adults and then increases slowly

TABLE 2. The means of reaction time at different blood alcohol concentration (BAC) in youth divers, adult divers and older divers.

BAC (mg%)	Mean of reaction time in youth (msec) (SD) N= 36	Mean of reaction time in adult (msec) (SD) N =18	Mean of reaction time in older (msec) (SD) N =18
	272.0		290.5
Before drinking	250.9 (20.7)	(43.8)	(27.3)
30 ±2	265.6 (22.8)*	274.0 (16.8)*	303.5 (23.2)*
40 ±2	279.6 (34.1)*	299.8 (31.1)*	313.6 (30.5)*
50 ±2	288.1 (44.4)*	298.1 (38.5)*	313.1 (32.5)*
60 ±2	283.6 (29.0)*	304.1 (32.7)*	326.1 (43.2)*
70 ±2	286.1 (31.7)*	308.5 (35.6)*	333.7 (59.6)*
80 ±2	295.1 (31.8)*	322.3 (36.7)*	336.9 (48.1)*

* Significant difference from Baseline (Bonferroni Correction P-vaule) P < 0.05

TABLE 3. The means of reaction time at different blood alcohol concentration (BAC) in light drinker, moderate drinker and heavy drinker

BAC (mg%)	Mean of reaction time in light drinker (msec) (SD) N=24	Mean of reaction time in moderate drinker (msec) (SD) N=24	Mean of reaction time in heavy drinker (msec) (SD) N=24
		271.2	
Before drinking	258.9 (39.6)	(23.7)	269.7 (34.7)
30 +2	268.1 (30.8)	281.4 (25.7)	281.9 (20.5)*
40 +2	298.5 (46.4)*	288.5 (31.0)*	292.4 (19.7)*
50 +2	301.4 (41.7)*	293.2 (38.8)*	296.0 (26.9)*
60 +2	296.7 (35.1)*	298.7 (30.5)*	302.7 (29.0)*
70 +2	301.2 (31.5)*	300.1 (30.9)*	309.5 (49.7)*
80 +2	312.6 (37.4)*	310.3 (26.5)*	314.1 (38.1)*

* Significant difference from Baseline (Bonferroni Correction P-vaule) P< 0.05

until 50, 60 and 70 years of age which is also consistent with previous reports.[14,15,16] There was a report that this age effect was more marked for complex reaction time tasks.[17] Reaction time also becomes more variable with age.[18] It is not just simple mechanical factors like the speed of nervous conduction; it may be the tendency of older people to be more careful and monitor their responses more thoroughly. When troubled by a distraction, older people also tend to devote their exclusive attention to one stimulus, and ignore other stimuli, more so than younger people.[19, 20]

Although some epidemiological studies have suggested possible differences in the degree of alcohol impairment as a function of differences in age, gender and drinking practices, this laboratory study failed to detect such differential impairments. Within the limits of the population represented by the study sample, impairment differences between subjects were insignificant and solely determined by BAC. It should be noted that although the sample reflects the possible 80-90% of alcohol consumers who drive, it did not include drivers under age 18 or over 70. Furthermore, no very heavy drinker nor alcohol abuser was recruited, and the maximum BAC examined was 80 mg%. It is possible that the subjects being not representative of the sample population would be differently affected by alcohol. However, an examination of this would require separate studies on specific populations. It should be noted that epidemiological studies can produce correlations due to uncontrolled co-variants, a problem avoided by controlled laboratory studies. Finally, this laboratory study indicates that some important driving skills are impaired even with small amount of blood alcohol.

REFERENCES

1. Starmer GA. Effects of low to moderate doses of ethanol on human driving-related performance. In: Crow KE, Batt RD, eds. Human Metabolism of Alcohol: Vol I. Pharmacokinetics, Medicolegal Aspects, and General Inter ests. Boca Raton: CRC Press, 1989:101-30.
2. Howat P, Sleet D, Smith I. Alcohol and driving: Is the 0.05% blood alcohol concentration limit justified? Drug and Alcohol Review, 1991;10:151-66.
3. Zador PL. Alcohol-related relative risk of fatal driver injuries in relation to driver age and sex. J Stud Alcohol 1991;52:302-10.
4. Moskowitz H., Fiorentino D. A Review of the Scientific Literature Regar ding the Effects of Alcohol on Driving-Related Behavior at Blood Alcohol Concentrations of 80 mg/dl and Lower (Report HS-809-028). Washington DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 2000.
5. กฎกระทรวง ฉบับที่ 16 (พ.ศ.2537) ออกตามความในพระราชบัญญัติจราจรทางบก พ.ศ.2522 ลงวันที่ 15 พฤศจิกายน 2537
6. Moskowitz H, Daily J, Henderson R. Acute tolerance to behavioral impair ment by alcohol in moderate and heavy drinkers (Report HS-009-2-322). Washington DC: U.S. Department of transportation, National Highway Traffic Safety Administration, 1974.
7. Dubowski KM. Absorption, distribution and elimination of alcohol: High way safety aspects. Stud Alochol1985:98-108.
8. Ritchie JM. "The aliphatic alcohols" in the pharmacological basis of therapeutics.7th ed. In: Gillman AG, Goodman LS, Rall TV, Murad F, eds. Macmillan, New York, 1985:372.
9. Finnigan F, Hammersley R. The effects of alcohol on performance. In: Smith AP, Jones DM, eds. Handbook of Human Performance: Vol 2. Health and Performance. London, Academic Press, 1992:73-126.
10. Moskowitz H, Robinson CD. Effects of low doses of alcohol on Driving - related skills: A review of the evidence (Report No. DOT HS 807280) Washington DC: National Highway Traffic Safety Administration, SRA Technologies, Inc. 1988.
11. Adam J, Paas F, Buekers M, Wuyts I, Spijkers W, Wallmeyer P. Gender differences in choice reaction time: evidence for differential strategies. Ergonomics 1999;42: 327.
12. Botwinick J, Thompson LW. Components of reaction time in relation to age and sex. Genet Psychol 1966;108:175-83.
13. Engel BT, Thorne PR, Quilter RE. On the relationship among sex, age, response mode, cardiac cycle phase, breathing cycle phase, and simple reaction time. Gerontology 1972;27:456-60.
14. Bellis CJ. Reaction time and chronological age. Proceedings of the Society for Experimental Bi and Medicine 1933;30:801-6.
15. Jevas S, Yan JH. The effect of aging on cognitive function: a preliminary quantitative review. Res Q Exerc Sport 2001;72:A-49.
16. Rose SA, Feldman JF, Jankowski JJ, Caro DM. A longitudinal study of visual expectation and reaction time in the first year of life. Child Development 2002;73:47.
17. Luchies CW, Schiffman J, Richards LG, Thompson MR, Bazuin D, DeYoung AJ. Effects of age, step direction, and reaction step quickly. J Gerontol 2002;57:M246.
18. Welford AT. Motor performance. In: Birren JE, Schaie KW, eds. Hand book of the Psychology of Aging. Van Nostrand Reinhold, New York, 1977:450-96.
19. Redfern MS, Muller M, Jennings JR, Furman JM. Attentional dynamics in postural control during perturbations in young and older adults. J Gerontol 2002;57:B298.
20. Hultsch DF, MacDonald SW, Dixon RA. Variability in reaction time performance of younger and older adults. J Gerontol 2002;57:101.

บทคัดย่อ

ผลของแอลกอฮอล์ในเลือดระดับต่ำต่อระยะเวลาของปฏิกิริยาตอบสนองของร่างกาย

พิมพ์ประไพ เสนีวงศ์ ณ อยุธยา พ.บ.,* อานนท์ ทัศนสุวรรณ วท.บ., สิริวรรณ ศศิธรโรจนชัย วท.ม.,*ชัชวิน ระงับภัย พ.บ., *อำนาจ กุสลานันท์ พ.บ.***

**ภาควิชานิติเวชศาสตร์, คณะแพทยศาสตรศิริราชพยาบาล, มหาวิทยาลัยมหิดล, กทม. 10700 **ศูนย์บริการสาธารณสุข 28 สำนักอนามัย, กทม. ประเทศไทย*

การศึกษาผลของแอลกอฮอล์ในเลือดระดับต่ำต่อระยะเวลาของปฏิกิริยาตอบสนองของร่างกาย ซึ่งเป็นการทดสอบความสามารถในการขับรถในอาสาสมัครจำนวน 72 คน โดยแบ่งกลุ่มศึกษาเป็น 3 กลุ่ม แบ่งตามเพศ, อายุ และลักษณะนิสัยการดื่ม (ดื่มน้อย ดื่มครั้งคราวและดื่มประจำ) ทำการทดสอบระยะเวลาของปฏิกิริยาตอบสนองโดยใช้โปรแกรมคอมพิวเตอร์ก่อนและหลังการดื่มแอลกอฮอล์และวัดระดับแอลกอฮอล์ในเลือดโดยใช้เครื่องตรวจวัดแอลกอฮอล์จากลมหายใจ พบว่าทุกกลุ่มที่ระดับแอลกอฮอล์ในเลือดระหว่าง 0 และ 30-80 มิลลิกรัมเปอร์เซ็นต์ มีค่าระยะเวลาของปฏิกิริยาตอบสนองแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) โดยระดับแอลกอฮอล์ในเลือดเพิ่มขึ้นทำให้ระยะเวลาของปฏิกิริยาตอบสนองเพิ่มขึ้น ยกเว้นกลุ่มตามลักษณะนิสัยในการดื่ม กลุ่มดื่มเป็นครั้งคราว และปานกลาง ที่ระดับแอลกอฮอล์ในเลือดระหว่าง 0 และ 30 มิลลิกรัมเปอร์เซ็นต์ ค่าของระยะเวลาของปฏิกิริยาตอบสนองไม่มีความแตกต่างกันทางสถิติที่ $p> 0.05$ แต่มีค่าระยะเวลาของปฏิกิริยาตอบสนองแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p< 0.001$) ที่ระดับแอลกอฮอล์ในเลือดระหว่าง 0 และ 40-80 มิลลิกรัมเปอร์เซ็นต์

ผลของแอลกอฮอล์ในเลือดระดับต่ำต่อระยะเวลาของปฏิกิริยาตอบสนองของร่างกาย ในการศึกษาครั้งนี้ชี้ให้เห็นว่าระดับที่น้อยกว่า 50 มิลลิกรัมเปอร์เซ็นต์ (ระดับที่กฎหมายห้ามเกิน) อาจยังมีผลต่อการขับรถ ซึ่งนำไปสู่ความเสี่ยงในการเกิดอุบัติเหตุจราจรได้