EFFECTS OF ALCOHOL ON EXTRAOCULAR EYE MOVEMENTS.

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METHODS:

In this study, five men were randomly selected for the measurement of how alcohol effects extraocular eye movements. Specifically, end point nystagmus and the number of saccades per cycle were of points of interest. All participants were educated on the nature of this study and all signed responsibility clauses. Each subject was asked to sit for five separate sessions conducted on different days. Pursuit movements of the eyes were recorded using six different velocities. The duration of each session lasted approximately one hour per subject. Five minutes were used to take initial blood alcohol concentrations (BAC) to ensure that each subjects BAC was entering at zero before each test session. This reduced the chance of contaminating results from possible lingering BAC from outside influences (i.e. mouth washes and drinking before each session). One of five BAC was randomly selected at the beginning of each test session for each subject. After ingesting the alcohol dose, approximately fifteen to thirty minutes elapsed to allow blood alcohol levels to stabilize. The initial BAC was measured with a breath tester in order to allow any residual alcohol to subside from the mouth. This allows for a more accurate reading of BAC. Five minutes were used to measure each subjects horizontal gaze nystagmus with an arc perimeter. Lastly, the actual recording of saccades took approximately ten minutes. The subjects were then escorted home.

During the recording sessions, each BAC and pursuit target velocities were randomly selected as the session proceeded. Each subject was instructed not to drink twenty-four hours before each testing day, and was also asked not to use any products that may contain alcohol, such as mouth wash. All subjects were instructed to eat a light meal before reporting to each session.

All test conditions were determined to mimic those used by the State Police in their own controlled drinking exercises. The five BAC used in this study were those of:

a baseline of zero, .02, .04, .06, and .08mg %. The subjects randomly chose a piece of paper from a hat that specified the alcohol concentration to be used for that days recording session. Each subject was given the selected amount of 50% ethyl alcohol (vodka) mixed with 16 ozs. of orange juice. After the subject randomly chose a BAC, the following formula was used to reach the desired BAC for that subject:

$$\#ml = \frac{400 \times (BAC) \times \text{body weight in pounds}}{\text{percent alcohol}}$$

Each subject consumed the mixture and waited fifteen minutes before the first BAC measurement. The measurement was then taken every five minutes afterwords until the specific BAC was reached within .001% and stabilized. An Alco-Sensor portable breath tester was used. This is capable of measuring BAC to the nearest .001%. Testing of the endpoint nystagmus and horizontal pursuit eye movement then began.

Pursuit eye movements were recorded using an infra-red eye movement monitor. The pursuit stimulus was presented at six different velocities that were also randomly chosen as testing proceeded. These were; 10, 15, 20, 25, 30, and 45 degrees per second. Blood alcohol levels were sustained throughout the short testing time because alcohol is metabolized in the body at a rate of only .01% BAC per hour regardless of initial BAC. Each subject was asked to watch a spot on a TV screen. This spot was presented five degrees above the subject's eye level and moved horizontally across the screen. The spot moved a total of 110 degrees (55 degrees either side of center gaze). This ensured that the stimulus travelled beyond the normal limits of horizontal eye movements. The subject was instructed to follow the spot when it began to move at the randomly selected velocities. Two full cycles were then recorded using a strip chart recorder. The six different velocities were then recorded for each subject.

Once this portion of the testing was completed, each subject's horizontal gaze nystagmus was then measured monocularly and directly with an arc perimeter. All of the above procedures were conducted on each subject for each of the five different BAC.

DATA ANALYSIS

Endpoint nystagmus

The maximum extent of horizontal eye movements is approximately 50 degrees. About half the population will normally show a jerky response in their eye movements when they reach the horizontal extent. This nystagmoid motion is termed endpoint or gaze evoked nystagmus. When alcohol is introduced into the bloodstream, the angular limits of horizontal endpoint nystagmus is reduced, closer to the midline. This limitation, along with the amplitude and frequency of horizontal eye movements, is increased with increasing BAC.

Roadside testing for BAC is an important test for the National Highway Safety Administration. In the 1983 article, Field Evaluation of a Behavioral Test Battery for DWI, the relation of BAC was determined by the formula; BAC = 50 - angle of nystagmus onset / 100. This suggests a linear relationship between BAC and endpoint nystagmus. Unfortunately, as discovered in the 1994 BAC testing, if this formula was applied to our results, the subjects would have been rated of having higher BAC then what we measured. For example: at a BAC of .06 our results suggest that endpoint nystagmus begins on an average of about 30.4 degrees. If we apply the NHTSA's formula; 50 - 30.4 / 100, the resulting suggested BAC would be .196. This is significantly higher than our findings.

If the NHTSA's formula is applied to each subjects results, we find that the NHTSA's linear relationship in which the onset of nystagmus begins closer to the midline with increasing blood alcohol concentrations exists, but with a threshold that varies in each subject. This is also confirmed by the testing of BAC on eye movements in the 1994 report. Graph #1 and #2 show the existence of this linearity but no common threshold of blood alcohol concentrations were noted in our results. Graph #3 and #4 show the resulting increase in the frequency of saccades with the increase in BAC.

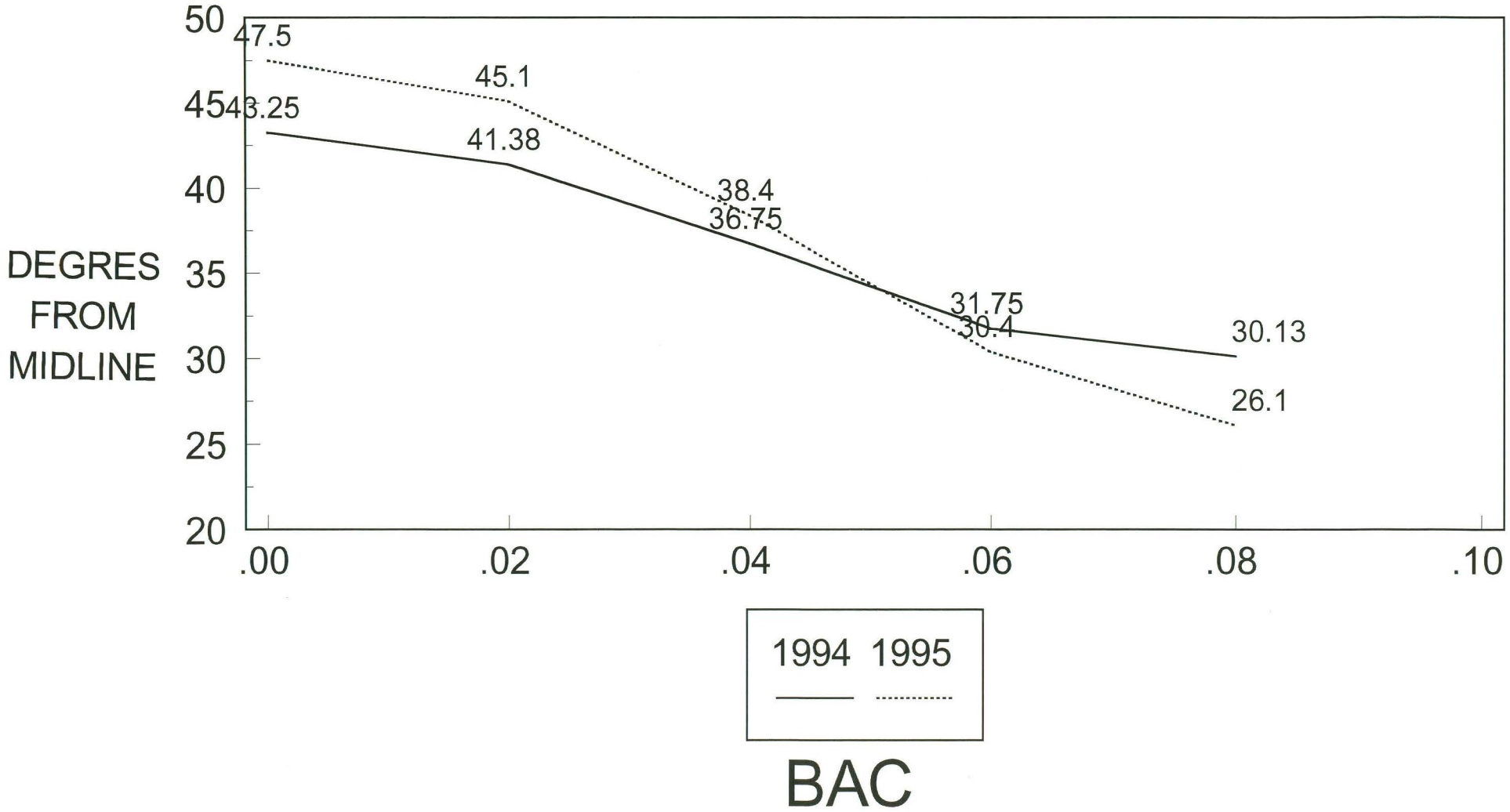
Pursuit Eye Movements

A pursuit eye movement is defined as a movement of an eye fixating a moving target. These eye movements are limited within certain angular velocities. Normal pursuit movements of the eyes are limited to a speed of approximately 30 degrees per second. The latency of this eye movement has been defined as 125msec. When alcohol is introduced into the bloodstream, pursuits are no longer smooth, but are broken down by the intrusion of eye movements called saccades. The average number of saccades per cycle where measured and plotted on graph #3. Saccadic eye movements increased with increasing velocities. On an average they also increased with increasing BAC between .00 and .04 for each subject. Above a BAC of .04 variations were noted. At target speeds greater than the limits of smooth pursuits, one would expect to see a variability in the number if saccades. As BAC increased the number of saccades increased even at speeds of 45. Because there is an increase in the number of saccades/cycle for almost every BAC, we can say that smooth pursuit eye movements are no longer smooth but rather saccadic as blood alcohol levels increase.

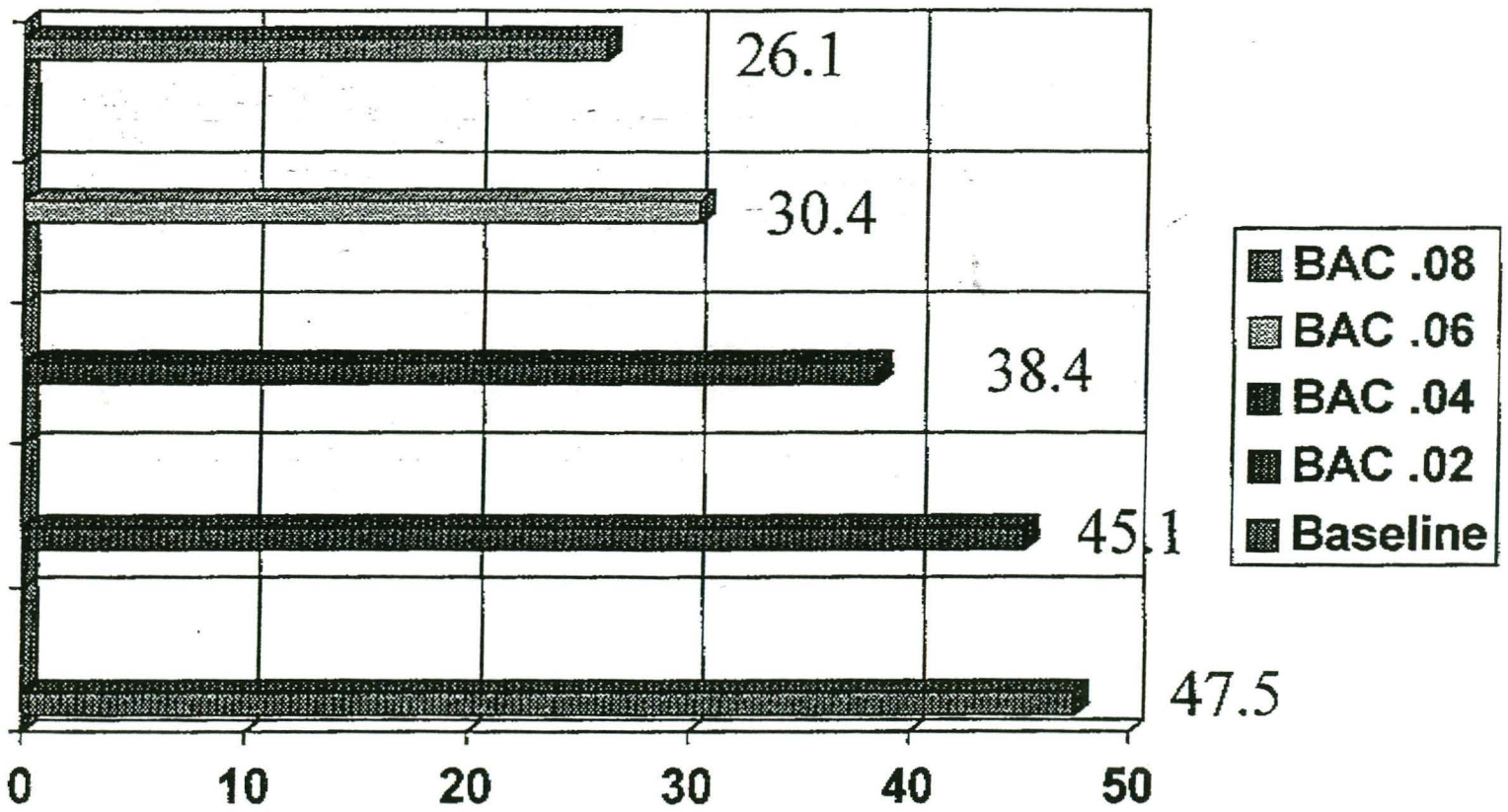
For ease and accuracy of identifying suspected BAC, it was noted in the 1994 study that the best velocity for road-side testing by police officers was at 10 degrees per second. If we were to look at the results obtained in this study, the suggested speed would be at 25 degrees per second. On graph #3 and #4 we can see that on an average the most consistent increased in saccades in relation to increase in BAC was found at the 25 degree per second velocity.

In summery, alcohol affects the onset of end-point nystagmus and smooth pursuit eye movements at the lowest levels tested. As BAC increases, the effect of alcohol on these characteristics also increases. This could be used as an estimate, not conclusive, in determining BAC in a road-side setting. As further testing is conducted with larger group studies, smaller standards of deviations may become more conclusive.

GRAPH #1
AVERAGE ONSET OF END-POINT NYSTAGMUS
1994 AND 1995 REPORTS.

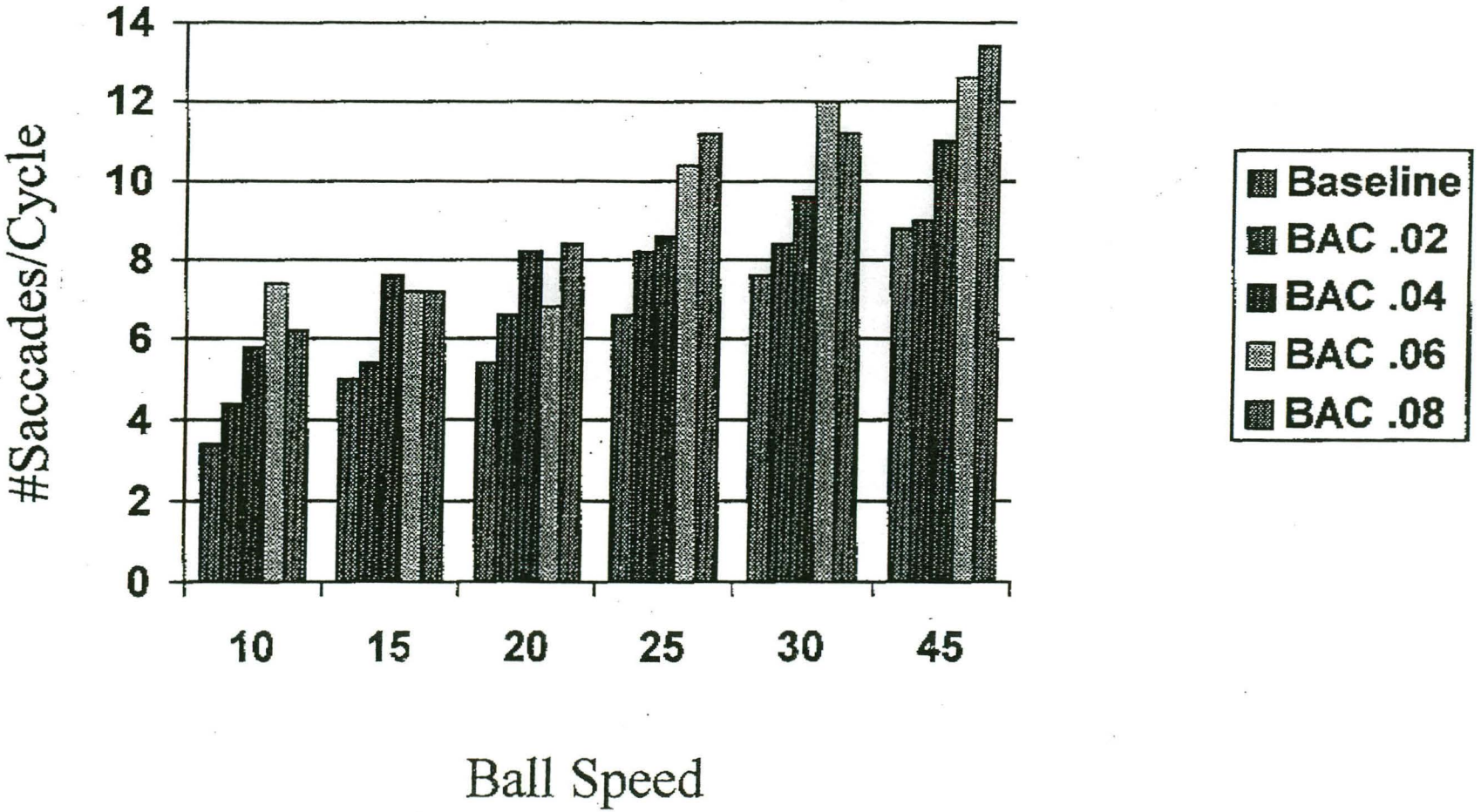


Effect of Alcohol on Eye Movements (Avg. Nystagmus)



#7

Effect of Alcohol on Eye Movements (Avg. # Saccades/Cycle)



#2

Sheet2 #14

Effect of Alcohol on Eye Movements

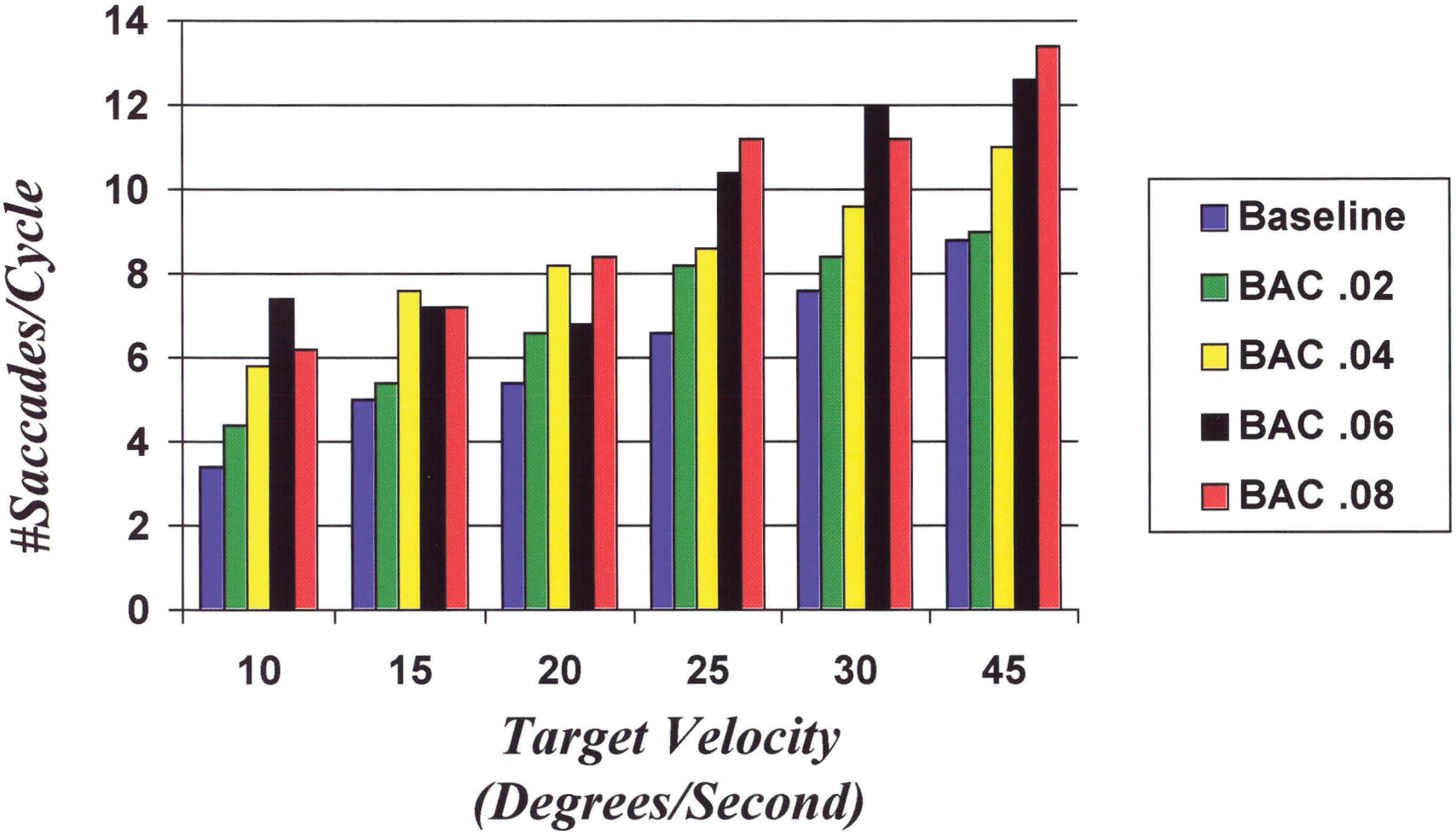
(End Point Nystagmus)

	OD	OS
BASELINE		
M. Gahan	46	48
D. Carlson	40	45
M. Gelfius	45	50
J. Depinto	49	46
A. Baldus	51	55
BAC .02		
M. Gahan	41	45
D. Carlson	41	46
M. Gelfius	48	46
J. Depinto	50	45
A. Baldus	42	47
BAC .04		
M. Gahan	42	39
D. Carlson	35	38
M. Gelfius	40	38
J. Depinto	41	39
A. Baldus	36	36
BAC .06		
M. Gahan	30	32
D. Carlson	28	29
M. Gelfius	34	28
J. Depinto	29	33
A. Baldus	31	30
BAC .08		
M. Gahan	25	27
D. Carlson	20	24
M. Gelfius	26	26
J. Depinto	25	27
A. Baldus	34	27

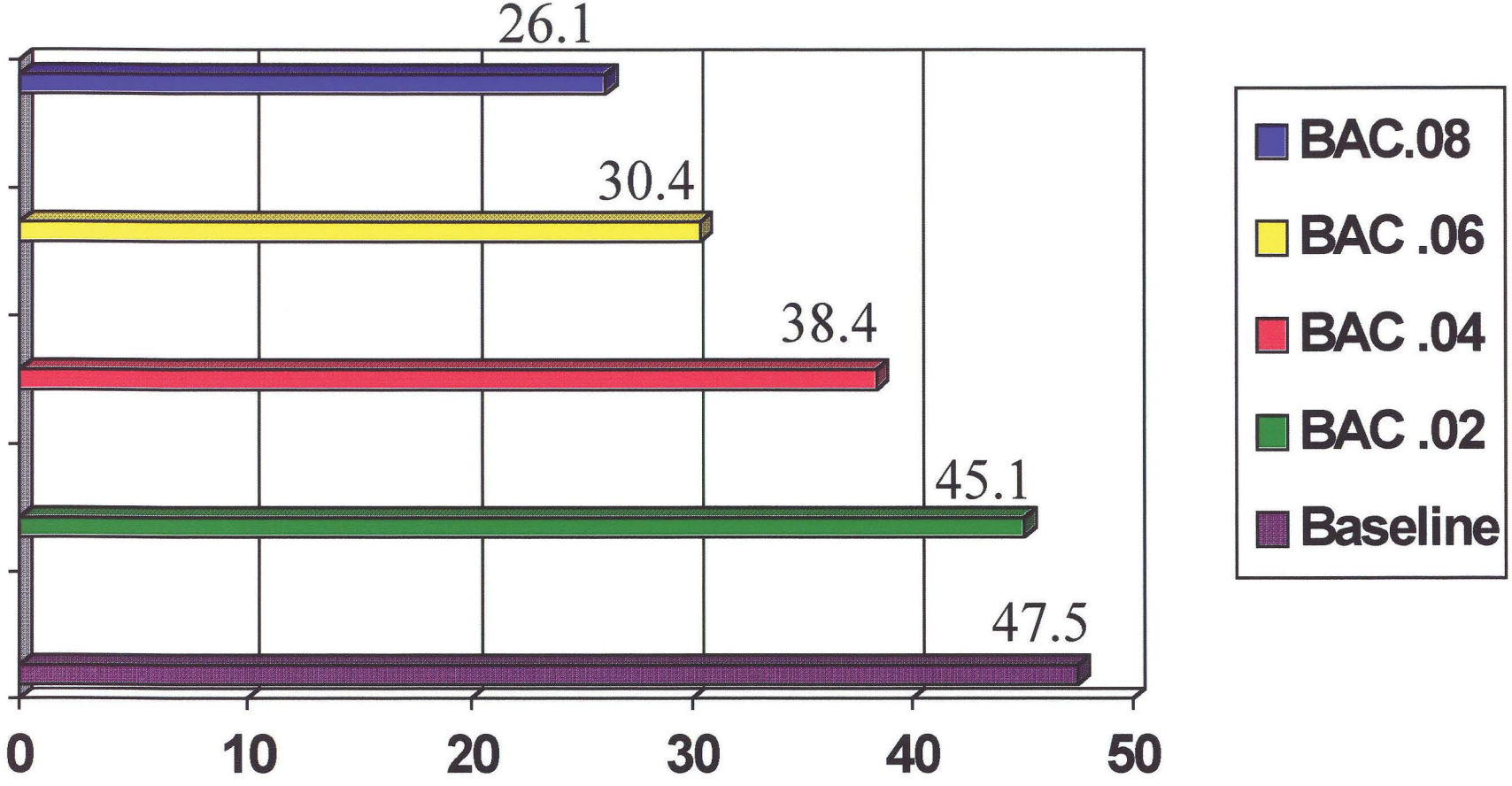
Sheet1 #4

	Effect of Alcohol on Eye Movements					
	(Measured by # of Saccades/Cycle)					
Ball Speed	10	15	20	25	30	45
BASELINE						
M. Gahan	2	3	3	6	6	8
D. Carlson	2	3	2	3	4	5
M. Gelfius	3	5	6	7	7	10
J. Depinto	5	7	8	6	10	13
A. Baldus	5	7	8	11	11	8
BAC .02						
M. Gahan	4	4	6	12	9	9
D. Carlson	1	4	3	5	4	7
M. Gelfius	2	3	5	6	7	16
J. Depinto	6	6	9	8	11	12
A. Baldus	9	10	10	10	11	11
BAC .04						
M. Gahan	4	3	5	7	7	9
D. Carlson	3	7	8	7	9	8
M. Gelfius	5	4	5	4	4	8
J. Depinto	5	11	8	8	12	10
A. Baldus	12	13	15	17	16	20
BAC .06						
M. Gahan	4	6	7	8	9	8
D. Carlson	4	6	5	7	9	10
M. Gelfius	3	4	1	5	7	12
J. Depinto	11	5	8	13	17	13
A. Baldus	15	15	13	19	18	20
BAC .08						
M. Gahan	3	5	5	7	11	12
D. Carlson	4	7	8	10	9	11
M. Gelfius	6	6	8	9	11	10
J. Depinto	7	7	13	12	14	20
A. Baldus	11	11	8	18	11	14

Average Number of Saccades per Cycle



Average Onset of Nystagmus



Horizontal Extent
(Degrees from Midline)