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Gait and Balance Deficits in Chronic Alcoholics: No Improvement from 10 Weeks Through One Year Abstinence

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Abstract

Background—Disturbed gait and balance are common and important sequelae of chronic alcoholism. We present longitudinal data on recovery of gait and balance in alcoholics 6–15 weeks abstinent at baseline assessment through follow-up assessment 4–16 months after baseline.

Methods—We performed a follow-up assessment (4–16 months after baseline) of gait and balance functioning in 37 Short-Term (6–15 weeks) Abstinent Alcoholics (STAA), 25 of whom remained abstinent through the follow-up period. Fourteen Non-Substance-Abusing Controls (NSAC) were also brought back for a follow-up assessment to examine practice effects.

Results—Alcoholics showed gait and balance impairment vs. controls at both the initial and follow-up assessments, showing no improvement in gait and balance measures over the follow-up period. At follow-up, NSAC showed improvement on the Walk on Floor Eyes Closed measure, possibly representing a practice effect not present in STAA.

Conclusions—The present study finds no improvement from about 10 weeks to about 1 year of abstinence in chronic alcoholics. The study is silent with regard to gait and balance recovery that occurs prior to 10 weeks abstinence, and after the first year of abstinence. Other studies suggest some recovery of gait and balance prior to 10 weeks abstinence, and our recent cross-sectional study (Smith and Fein 2011) suggests that significant additional recovery occurs in the ensuing years.

Keywords

alcoholics; ataxia; gait and balance; recovery; abstinence; relapse

Introduction

Disturbed gait and balance is a well-documented sequelae of chronic alcoholism (Gilman et al., 1990; Rosenbloom et al., 2004; Rosenbloom et al., 2007; Sullivan et al., 2000b; Sullivan et al., 2000c), and may result from damage to one or more neural systems. Alcoholism associated cerebellar damage caused by excitotoxicity, thiamine depletion, glial abnormalities, oxidative stress, and impaired energy production (Alexander-Kaufman et al., 2007; Baker et al., 1999; Jaatinen and Rintala, 2008; Pentney, 1993; Phillips et al., 1987; Pierce et al., 1999), impairs balance and coordination (Gilman et al., 1990; Rosenbloom et al., 2004; Rosenbloom et al., 2007; Sullivan et al., 2000a; Sullivan et al., 2000b; Sullivan et al., 2006).

Studies have also shown that alcohol-induced degradation of white matter integrity, and fiber damage in the corpus callosum, are both associated with postural instability (Pfefferbaum et al., 2006). In addition, alcohol dependence is associated with reduced striatal volumes (Sullivan et al., 2005) and blunted dopamine transmission in the ventral striatum (Martinez et al., 2005). Positron emission tomography (PET) studies have found that dopaminergic denervation affects gait independent of age-related changes (Cham et al., 2008). Finally, ataxia has been associated with alcohol-related peripheral neuropathy (Melgaard and Ahlgren, 1986).

A number of investigations have assessed recovery of gait and balance function in abstinent alcoholics, but questions remain regarding the degree of recovery of gait and balance as a function of abstinence duration, and the degree to which full recovery is attainable. Gait and balance are typically assessed using the Walk-a-line Ataxia Battery (Fregly et al., 1972), which consists of three parts, each of which is performed first with eyes open (E/O) and then with eyes closed (E/C): standing heel-to-toe, standing on one foot (left then right), and walking heel-to-toe.

Longitudinal studies have typically employed relatively small samples with limited abstinence durations, restricting their power and generalizability, and results have been equivocal. For example, in a sample of 20 abstinent alcoholics two to twelve months after initial testing at one month of sobriety, Sullivan and colleagues (2000b) found improved performance on walking heel-to-toe with visual support and a trend toward better performance on an E/C standing heel-to-toe measure. Rosenbloom et al. (2004) found persistent disturbed gait and balance on E/C Stand On One (left or right) Leg in 14 alcoholic women, initially tested at 15 weeks abstinence, who had maintained sobriety for 30 to 53 months. Rosenbloom and colleagues (2007), also assessed 10 abstinent alcoholics (5 men, 5 women) at 4 months and 2 years abstinence and 26 controls (at a comparable test-retest interval). They found a weak Group $\times$ Time trend for abstinent alcoholics to improve relative to controls on Fregly E/C measures from test to retest. That result needs to be interpreted with caution because it is partially the result of poorer performance in controls at repeat vs. initial assessment.

More recently, in a larger-sample cross-sectional study (Smith and Fein, 2011), we used the Fregly battery to compare gait and balance in alcoholics who were Short-Term Abstinent (STAA) (6–15 weeks; $n = 70$) and Long-Term Abstinent (LTAA) (min. 18 months, mean = 7.38 years; $n = 82$). Overall, we found some lingering gait and balance impairment in LTAA, but less impaired performance in LTAA than STAA. Specifically, STAA were impaired, relative to Non Substance Abusing Controls (NSAC), on 6 of 8 measures (including both E/O and E/C measures), while LTAA were impaired on one measure (Stand on Right Leg E/C) compared to NSAC, with trends toward poorer performance on 4 others. Moreover, LTAA performed significantly better than STAA on 3 E/C measures. These results provide strong evidence that gait and balance are disturbed in alcohol dependent individuals following abstinence durations of 1.5 to 3.75 months, but also suggest that significant, albeit incomplete, recovery can occur with greatly extended abstinence, especially for gait and balance with visual support. However, while suggestive, these results cannot be conclusive regarding recovery with extended abstinence since differences between STAA and LTAA in gait and balance performance could be due to group differences not associated with abstinence duration. That is, although STAA and LTAA did not differ with respect to key factors (e.g., lifetime alcohol consumption, family drinking density), alcoholics who are likely to achieve long-term abstinence may represent a sub-population that is less susceptible than the overall STAA population to disturbances of gait and balance.

The data reported here on gait and balance is part of a more complete follow-up assessment of 48 STAA subjects. Eleven of these subjects (8 men and 3 women) were excluded from analysis because of a physical condition (e.g., hip, knee, ankle, foot, and/or back injuries) that would prevent meaningful interpretation of the gait and balance measures (see Fregly et al., 1972). This allowed longitudinal assessment of gait and balance in 25 STAA who maintained abstinence for almost a year, and 12 STAA who relapsed. To estimate the potential contribution of practice effects to the longitudinal assessment of STAA subjects, we retested 14 NSAC individuals after an interval comparable to that of the STAA subjects.

Methods

Participants

Participants were part of a cross-sectional study of short-term and long-term abstinent alcoholics and age and gender comparable non-substance abusing controls. About 18 months into the study, we received supplement funding for a longitudinal follow-up study of 50 short-term abstinent alcoholics. This study reports on the longitudinal assessment of 48 subjects, 11 of whom had to be excluded from the analysis because of physical conditions which prevented meaningful interpretation of the Fregly. Of the remaining 37 participants, 25 remained abstinent through follow-up period, with total abstinence durations ranging 188 to 581 days, with a mean of 338.24 days abstinent at the follow-up assessment. The remaining 12 participants had relapsed prior to follow-up and had a mean average abstinence at follow-up of 110.17 days.

Participants were recruited from the community through postings at university campuses, bulletin boards, Craigslist, community and health centers, and subject referrals. The NSAC group consisted of 35 men and 40 women (mean age at baseline = 48.46). A subset of 14 NSAC subjects (5 women, 9 men; mean age at baseline = 48.25) was retested 4–16 months later. NSAC inclusion criteria were: 1) a lifetime drinking average of less than 30 standard drinks per month with no periods of drinking more than 60 drinks per month, and 2) no history of alcohol or substance abuse or dependence (other than nicotine or caffeine). Alcohol-dependent participants consisted of 25 (10 women) non-relapsing and 12 (5 women) relapsing individuals who were initially studied at 6–15 weeks abstinence. Any consumption of alcohol, cocaine, methamphetamine, marijuana, and/or opiates after initial testing constituted a relapse. For alcohol-dependent subjects, inclusion criteria at recruitment were: 1) met lifetime DSM-IV-R (American Psychiatric Association, 2000) and current (within past 12 months) criteria for alcohol dependence, and 2) abstinence from alcohol and other drugs (other than nicotine or caffeine) for at least 6 weeks.

Exclusion criteria for all subjects were: 1) lifetime or current diagnosis of schizophrenia or schizophreniform disorder using the computerized Diagnostic Interview Schedule (C-DIS) (Leviton et al., 1991; Robins et al., 1998), 2) significant history of head trauma or cranial surgery, 3) history of significant neurological disease, 4) history of diabetes, stroke, or hypertension that required an emergent medical intervention, 5) history of hepatic disease, 6) clinical evidence of Wernicke-Korsakoff syndrome, or 7) clinical evidence of a physical condition (e.g., hip, knee, ankle, foot, and/or back injuries; (found in 8 men and 3 women) that would prevent meaningful interpretation of Fregly gait and balance measures (Fregly et al., 1972). All alcoholic subjects presented here were part of the larger STAA sample from which our earlier cross-sectional study was taken (Smith and Fein, 2011).

Procedures

Participant screening was initially conducted by a phone interview assessing alcohol use/dependence, use dependence of other drugs, medical history, and mental health history. All

participants were fully informed of the study's procedures and aims, and signed consent forms prior to participation. Participants completed four sessions of assessments to gather clinical, psychiatric, neuropsychological, electrophysiological, and neuroimaging data. Trained research associates administered the assessments to all participants. All participants completed all sessions. NSAC subjects were asked to abstain from consuming alcohol for at least 24 hours prior to any lab visit. A breathalyzer test (Intoximeters, Inc., St. Louis, MO) was administered to all participants. A blood alcohol concentration of 0.000 was required of all participants in all sessions. A rapid screen test (Oral Fluid Drug Screen, Innovacon, San Diego, CA), was administered to all participants, testing for the presence of cocaine, PCP, marijuana, opiates, and methamphetamine or other amphetamines. A negative result was required of all participants. Participants were compensated for their time and travel expenses upon completion of each session. Participants who completed the entire study were also given a completion bonus.

All participants completed the following general assessments: 1) Participants were interviewed on their lifetime drug and alcohol use using the timeline follow-back methodology (Skinner and Allen, 1982; Skinner and Sheu, 1982; Sobell and Sobell, 1990; Sobell et al., 1988), 2) medical histories were reviewed in an interview by a trained research associate, and 3) the Family Drinking Questionnaire was administered based on the methodology of Mann and colleagues (1985) and Stoltenberg et al. (1998). The Family Drinking Questionnaire asked participants to characterize their family members as either alcohol abstainers, alcohol users with no problem, or problem drinkers. Family Density of Problem Drinking (FDPD) was defined as the proportion of first-degree relatives who were problem drinkers. 4) The Family History Substance Use Questionnaire, based on the methodology of Mann et al. (Stoltenberg et al., 1998, 1985) was also administered to assess drug use problems, and the Family Density of Problem Drug Use (FDPDU) was computed. 5) Psychiatric diagnoses and symptom counts were gathered using the C-DIS. 6) Neuropsychological assessment was conducted using the CANTAB battery (Cambridge Cognition Ltd, 2006), supplemented by a number of individual tests with demonstrated sensitivity to damage in brain regions frequently compromised by chronic alcoholism.

Gait and Balance

Gait and standing balance were assessed with the Walk-a-line Ataxia Battery (Fregly et al., 1972) which consisted of three parts, each of which was performed first with eyes open (E/O) and then with eyes closed (E/C): 1) Sharpened Romberg, where participants stood with feet placed heel-to-toe with arms folded across the chest for a maximum of 60 seconds; 2) Stand on One Leg, wherein each leg was tested separately with a maximum score per trial per foot of 30 seconds standing; and 3) Walk Heel-to-Toe, wherein participants walked in a straight line heel-to-toe with arms folded across the chest for a maximum of 10 steps. Each condition was repeated twice unless a perfect score was obtained on the first trial, in which case the participant received a perfect score. For example, for Stand on Left Leg E/O, if the participant moved the standing foot, the clock was stopped immediately and the number of seconds stood prior to the violation constituted the trial score. When individuals received a perfect score on the first trial, perfect performance was assumed on the second trial, and a score of 60 (30×2) was assigned. If the subject required a second trial, the total number of seconds standing on the two trials became the assigned score.

Statistical Analyses

Because the Fregly scores were highly non-normally distributed, nonparametric statistics were used for all Fregly performance measures. Wilcoxon Mann-Whitney comparisons of independent samples were used to compare performance of alcoholics vs. NSAC on Fregly measures at baseline and at follow-up testing. The Wilcoxon Mann-Whitney odds ratio (OR)

(O'Brien and Casteloe, 2006) was computed as a non-parametric effect size measure. The related-samples Wilcoxon signed-ranks test was used to compare baseline assessment vs. follow-up assessment performance on Fregly measures.

Results

Demographic, Alcohol Use and Smoking Variables

Table 1 presents demographic, alcohol use and smoking data for NSAC, the prior cross-sectional study STAA, the subset of STAA that was in the follow-up study, and within the follow-up study subset, those who remained abstinent through follow-up vs. those who relapsed prior to follow-up. The follow-up study subset of STAA was equivalent to the larger STAA sample with regards to age, sex, education, family history density of alcohol and/or drug use, alcohol use variables and smoking, as can be seen by the similar results when compared to NSAC and, when directly compared, no variable shows significant group effects as witnessed by Wilcoxon Mann Whitney odds ratios near 1:1 with the largest deviation reported as 1.41 for Average Alcohol Dose. These findings suggest that the follow-up STAA subset is a representative sample of the previous cross-sectional STAA sample.

Abstinent and Relapse groups also had no discernable differences in demographic and alcohol use variables as denoted by Wilcoxon Mann Whitney odds ratios near 1:1 with one exception; duration of abstinence at baseline assessment where STAA who remained abstinent through follow-up had longer periods of abstinence at the baseline assessment compared to those who relapsed prior to follow-up ($p = .002$, $OR = 4.04$). The Abstinent group did report a higher rate of smoking than those who relapsed. Abstainers were 3.56 times more likely to be lifetime smokers and 3.25 more likely to be current smokers than relapsers, but these differences were not significant (probably due to the small Relapse sample size), although higher rates of lifetime smoking for abstainers was a trend ($p = .08$).

Of the 12 individuals that relapsed prior to the follow-up assessment, 10 did so on alcohol (mean = 128 standard drinks), while 3 participants relapsed on methamphetamine (mean = 9 grams), and 1 person relapsed on both substances.

Gait and Balance Measures

Follow-up STAA subset is comparable to cross-sectional STAA group—Table 2 shows mean Baseline Fregly scores and odds ratios (OR) comparing NSAC, the original cross-sectional STAA, and the follow-up STAA subset. In general, there was a noticeable ceiling effect for E/O measures while E/C measures tended displayed more score variability across groups. STAA (cross-sectional) performed significantly worse than NSAC on Stand on Left Leg E/C ($p = .043$), Stand on Right Leg E/O ($p = .007$) and Stand on Right Leg E/C ($p = .002$). Similarly, STAA (follow-up subset) performed significantly worse than NSAC on Stand on Right Leg E/O ($p = .002$) and Stand on Right Leg E/C ($p = .003$), while also having a trend for impaired performance on Stand on Left Leg E/C ($p = .082$). When the cross-sectional and follow-up subset groups were directly compared, there were no significant differences for any of the Fregly measures as indicated by odds ratios for all measures between 0.86 and 1.14. Figure 1 displays this data and shows that NSAC performed better than both STAA groups on these measures and that the STAA who participated in the follow-up study were comparable to the STAA cross-sectional sample on these measures.

STAA abstainers and relapsers have impaired performance vs. NSAC at baseline—Table 3 displays the baseline assessment mean Fregly scores and odds ratios for

NSAC and within the follow-up study, for those who remained abstinent through follow-up, and for those who relapsed prior to follow-up. There were three significant NSAC vs. Abstinent effects for Stand on Right Leg E/O ($p = .004$), Stand on Right Leg E/C ($p = .003$), and Stand on Left Leg E/C ($p = .041$), all indicating impaired performance of abstinent individuals compared to NSAC. Comparing NSAC to relapsers yielded one significant Group effect for Stand on Left Leg E/C ($p = .034$), reflecting poorer performance for relapsers vs. NSAC, and 4 odds ratios greater than 1.5, all indicating worse gait and balance in relapsers vs. NSAC. We note that the relapser group is less than half the size of the abstainer group, with lower statistical power for comparisons to NSAC - thus, it is the comparability of effect size measures (odds ratios) of relapsers vs. NSAC and abstainers vs. NSAC that should be the primary comparison between abstainers and relapsers. When follow-up study abstainers and relapsers were compared, marginally significant poorer performance for the abstainers vs. relapsers was found in Stand on Left Leg E/C ($p = .049$). As illustrated in Figure 2, both abstinent and relapsing STAA had generally poorer Fregly performance than NSAC at baseline.

Follow-up assessments of abstaining and relapsing STAA samples—Table 3 also shows the follow-up assessment for abstaining and relapsing STAA. When compared to NSAC, STAA with continued abstinence showed significant impairment vs. NSAC on three of the follow-up assessment measures: Stand on Left Leg E/C ($p = .003$), Stand on Right Leg E/O ($p = .003$), and Stand on Right Leg E/C ($p = .003$). Within the abstainers, there was no association evident between Fregly performance and abstinence duration at the follow-up assessment. STAA that relapsed showed a trend toward poorer performance than NSAC on Stand on Right Leg E/C ($p = .059$), an odds ratio consistent with poorer performance for Romberg, eyes closed, and otherwise showed performance comparable to NSAC. The better performance at baseline Stand on Left Leg E/C for follow-up relapsers vs. those who remained abstinent was still present at the follow-up assessment ($p = .035$). These results are illustrated in Figure 3.

NSAC baseline vs. follow-up—Table 4 and Figure 4 show baseline and follow-up Fregly scores and the associated Wilcoxon Sign Rank Effect Size (ES) for: a) the 14 NSAC that were retested, b) the STAA that remained abstinent through follow-up, and c) the STAA that relapsed prior to follow-up. Across all three sets of comparisons, there was only one significant effect, with no other effect even showing a trend. There was improvement at follow-up for NSAC on Walk Floor E/C ($p = .011$).

Discussion

The primary finding of the current study is that we saw no evidence of improvement in gait and balance in chronic alcoholics retested 4–16 months after an initial assessment at an average of 76 days abstinence. This observation was made in subjects who showed significant impairment in gait and balance when compared to age and gender comparable non-substance abusing controls. The subjects in this follow-up study were drawn from and comparable to the larger cross-sectional sample in which we previously reported significant gait and balance disturbance (Smith and Fein 2011), and thus are appropriate for determining whether there is recovery of gait and balance in the follow-up period. Our finding of no improvement in gait and balance in the follow-up period is consistent with the longitudinal study by Rosenbloom and colleagues (2004), where 13 alcoholic women were tested at 15 weeks of sobriety and then retested at 1 year and 4 years after the initial assessment. Even with continued abstinence these 13 women still showed persistent deficits in gait and balance. Sullivan et al. (2000) found marginally improved gait and balance in follow-up vs. baseline assessments for 20 abstinent men tested after one month of sobriety and again 2–12 months later on steps taken with eyes open. Sullivan's initial testing was

performed at a relatively short (1 month) abstinence duration, which means that her change measures included improvements in gait and balance that occur within the second and third month of abstinence, while our study and Rosenbloom and colleagues (2004) are both silent with respect to such changes. In our previous cross-sectional study (Smith and Fein, 2011), alcoholics with multi-year abstinence showed more normal gait and balance than the short-term abstinent alcoholics from whom the present follow-up sample was recruited, suggesting that further recovery of gait and balance does occur between 10.5 weeks and 7–8 years abstinence. The current study suggests that such recovery occurs slowly during the second and subsequent years of abstinence.

We do not know what to make of our observation that gait and balance is worse on Stand on Left Leg E/C in abstainers vs. relapsers. Other studies have found persistent abstainers and future relapsers to be indistinguishable in their gait and balance performance at baseline (Rosenbloom et al., 2007; Sullivan et al., 2000b). Given the relatively small sample size of the relapse group and the variability within the relapse group on the Stand on Left Leg E/C measure, it is possible that this result reflects a Type I error. We observed a trend for abstainers where they are more likely to be active smokers than relapsers. It is possible that abstainers have replaced their active addiction to alcohol with an active addiction to nicotine. This shift in addiction may help keep them from relapsing back to active alcohol use. This result suggests that it may be important to measure cigarette smoking in studies of recovery, and, if the finding is replicated, further investigation of its underpinnings would be warranted.

Finally, we found marginal improvement in NSAC (Baseline vs. Follow-up) on Walk on Floor E/C. This was the only condition for any group that showed consistent changes from baseline to follow-up. It is possible that the improvement in NSAC for Walk on Floor E/C demonstrates a practice effect which is not present in the STAA groups. If this is true, then the comparison between STAA and NSAC underestimates impairments in gait and balance function. We also note that the follow-up NSAC group was relatively small and underpowered for sensitively detecting improvement in gait and balance in NSAC over the follow-up interval. Given the persistent gait and balance deficits in the alcoholic samples, this is not a serious limitation to this study - a larger sample at most would have led to additional evidence that STAA vs. NSAC group comparisons underestimate STAA impairments.

In summary, the present study adds to the existing literature on the recovery of gait and balance in abstinent alcoholics, finding no improvement from about 10 weeks to about 1 year of abstinence in a longitudinal follow-up. The sample of 25 individuals who remain abstinent through follow-up is larger than most studies and includes both genders. The study is silent with regard to gait and balance recovery that occurs prior to 10 weeks abstinence, and after the first year of abstinence. Other literature (Sullivan et al., 2000b) suggests that recovery of gait and balance does occur during the first 10 weeks of abstinence, and our recent cross-sectional study (Smith and Fein, 2011) suggests that significant additional recovery occurs in the ensuing years.

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Figure 1. Scatterplots representing the Fregly measures that show impairment in STAA relative to NSAC. The figure shows that the follow-up study STAA sample is similar to the larger STAA cross-sectional sample with respect to these deficits.

Figure 2.

Fregly scatterplots showing impairment vs. NSAC at baseline of subsequent abstainers and relapsers on Stand on Right Leg measures. Relapsers perform significantly better than abstainers on the Stand on Left Leg E/C measure but this may be due to a few outliers.

Figure 3.

Fregly scatterplots showing impairment vs. NSAC (baseline assessment) at follow-up assessments of abstainers and relapsers on Stand on Right Leg measures. Relapsers perform significantly better than abstainers on the Stand on Left Leg E/C measure but this may be due to a few outliers. This figure, in comparison to Figure 2, shows essentially no improvement in Fregly scores in abstainers or relapsers.

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Table 1

Demographics, Alcohol Use, and Smoking Measures

	Data				Comparisons			
	NSAC (n = 75)	STAA (Cross-Sectional) (n = 70)	STAA (Follow-up Study) (n = 37)	Abstinent through Follow-up (n = 25)	Relapse prior to Follow-up (n = 12)	STAA (Cross-Sectional) vs. NSAC	STAA (Follow-up Study) vs. NSAC	STAA (Follow-up Study): Abstinent through Follow-up vs. Relapse prior to Follow-up
Demographics								
Age (years)	48.5 ± 7.3	45.1 ± 6.9	45.9 ± 6.2	45.7 ± 6.3	46.4 ± 6.3	0.58**	0.64	0.86
Sex (# Females/% Females) ^a	40/53.3%	21/30%	15/40.5%	10/40%	5/41.7%	0.38**	0.60	0.63
Years of Education	15.8 ± 2.4	13.4 ± 1.9	13.3 ± 1.9	13.4 ± 2.1	13.2 ± 1.6	0.27***	0.26***	1.03
Proportion 1 st Degree Relative Problem Drinkers ^b	.16 ± .20	.27 ± .29	.22 ± .26	.23 ± .28	.19 ± .23	1.44*	1.18	1.22
Proportion 1 st Degree Relative Problem Drug Users ^c	.05 ± .13	.14 ± .21	.14 ± .22	.14 ± .26	.14 ± .14	1.77**	1.68*	1.06
Alcohol Use Variables								
Duration of Abstinence at Baseline (days)	N/A	72.3 ± 19.1	76.0 ± 17.6	81.9 ± 15.3 ^d	63.8 ± 16.2	N/A	N/A	0.79
Duration of Alcohol Use (months)	225.2 ± 152.1	315.4 ± 91.3	309.9 ± 85.0	304.5 ± 86.6	321.3 ± 84.1	2.05 ^e	1.90 ^e	1.12
Alcohol Lifetime Use (standard drinks)	1985.2 ± 2200.7	67138.7 ± 62412.0	58816.8 ± 69141.4	54031.9 ± 55964.4	69032.8 ± 92875.4	327.13 ^e	307.33 ^e	1.35
Average Alcohol Dose (standard drinks/month)	8.5 ± 8.2	211.1 ± 189.3	186.2 ± 217.1	168.1 ± 150.4	224.8 ± 319.8	115.67 ^e	114.63 ^e	1.41
Duration of Maximum Use (months)	77.3 ± 68.9	102.3 ± 96.6	75.7 ± 74.7	72.3 ± 84.2	83.2 ± 51.6	1.25 ^e	0.92 ^e	1.30
Total Dose during Maximum Use (standard drinks)	1174.1 ± 1234.8	39981.8 ± 47791.0	31817.1 ± 48702.6	28661.4 ± 44528.6	38639.0 ± 57868.6	33.09 ^e	30.90 ^e	1.33

Effect Size in Wilcoxon Mann Whitney Odds Ratios

	Data				Comparisons			
	STAA (Follow-up Study)				STAA (Cross-Sectional) vs. NSAC	STAA (Follow-up Study) vs. NSAC	STAA: Cross-Sectional vs. Follow-up Study	STAA (Follow-up Study): Abstinent through Follow-up vs. Relapse prior to Follow-up
	NSAC (n = 75)	STAA (Cross-Sectional) (n = 70)	STAA (Follow-up Study) (n = 37)	Abstinent through Follow-up (n = 25)	Relapse prior to Follow-up (n = 12)			
Maximum Dose (Standard drinks/month)	16.3 ± 15.0		417.8 ± 408.7	414.6 ± 367.4	424.5 ± 502.1	∞ ^e	∞ ^e	1.17
Smoking Status								
Lifetime Smokers # (%) ^a	12 (16%)	35 (50%)	20 (54.1%)	16 (64%)	4 (33.3%)	5.25 ^{***}	6.18 ^{***}	3.56
Current Smokers # (%) ^a	3 (4%)	34 (48.6%)	16 (43.2%)	13 (52%)	3 (25%)	22.67 ^{***}	18.29 ^{***}	3.25
Odds Ratios								

Effect is significant:

* p .05,

** p .01,

*** p .001

^aEffect Size Reported in Chi-Square Odds Ratios.

^bNSAC (ALL) (n=73), STAA (Cross-Sectional) (n=68), STAA(Follow-up Study) (n=35), STAA Abstinent through Follow-up (n=23), STAA Relapse prior to Follow-up (n=12), Due to adopted participants.

^cNSAC (ALL) (n=72), STAA (Cross-Sectional) (n=68), STAA(Follow-up Study) (n=35), STAA Abstinent through Follow-up (n=23), STAA Relapse prior to Follow-up (n=12), Due to adopted participants.

^d Average Duration of Abstinence at Follow-up 338.2 ± 91.7 (days).

^eComparison significance inappropriate - Due to grouping variable.

Table 2

Fregly Gait and Balance Measures at Baseline Assessment

	Comparisons Effect Size in Wilcoxon Mann Whitney Odds Ratios)					
	Data					
Fregly Gait and Balance Measures	NSAC (n=75)	STAA (Cross-Sectional) (n=70)	STAA (Follow-up Study) (n=37)	NSAC vs. STAA (Cross-Sectional)	NSAC vs. STAA (Follow-up Study)	STAA: Cross-Sectional vs. Follow-up Study
Romberg, Eyes Open	117.16 ± 12.09	114.37 ± 18.73	112.57 ± 23.24	1.10	1.12	1.02
Romberg, Eyes Closed	85.31 ± 43.68	72.31 ± 48.20	68.95 ± 46.81	1.35	1.47	1.05
Stand Left Leg, Eyes Open	55.67 ± 11.42	51.87 ± 16.00	52.46 ± 15.09	1.22	1.21	0.99
Stand Left Leg, Eyes Closed	21.04 ± 18.34	15.37 ± 15.64	16.59 ± 16.17	1.48 [*]	1.30	0.86
Stand Right Leg, Eyes Open	56.55 ± 11.01	50.47 ± 17.56	48.41 ± 19.57	1.44 ^{**}	1.65 ^{**}	1.14
Stand Right Leg, Eyes Closed	22.12 ± 17.55	13.43 ± 11.45	12.59 ± 11.78	1.87 ^{**}	2.05 ^{**}	1.08
Walk Floor, Eyes Open	19.40 ± 2.37	19.53 ± 2.05	19.57 ± 1.97	0.96	0.95	0.99
Walk Floor, Eyes Closed	13.41 ± 6.45	11.97 ± 6.57	12.43 ± 6.58	1.28	1.17	0.92

Effect is significant:

* p 0.05,

** p 0.01.

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Table 3

Follow-up Study Gait and Balance Measures; Cross-Sectional Comparisons

Fregly Gait and Balance Measures	Comparisons (Effect Size in Wilcoxon Mann Whitney Odds Ratios)									
	STAA (Follow-up Study)									
	Data		Relapse prior to Follow-up (n=12)		NSAC (n=75)		NSAC vs. STAA Abstinent through Follow-up		NSAC vs. STAA Relapse prior to Follow-up	
	Abstinent through Follow-up (n=25)	Baseline Assessment	Follow-up Assessment	Follow-up Assessment	Baseline Assessment	Follow-up Assessment	Baseline Assessment	Follow-up Assessment	Baseline Assessment	Follow-up Assessment
Romberg, Eyes Open	109.00 ± 27.7	117.48 ± 8.75	118.17 ± 6.35	118.17 ± 6.35	120.00 ± 0.00	118.17 ± 6.35	1.24	0.90	1.05	0.99
Romberg, Eyes Closed	70.36 ± 49.04	85.60 ± 44.39	64.75 ± 51.55	64.75 ± 51.55	66.00 ± 43.72	64.75 ± 51.55	1.42	1.58	1.00	1.49
Stand Left Leg, Eyes Open	51.84 ± 16.55	53.24 ± 16.52	57.00 ± 7.21	57.00 ± 7.21	53.75 ± 12.03	57.00 ± 7.21	1.23	1.16	0.98	0.97
Stand Left Leg, Eyes Closed	11.08 ± 7.26	11.64 ± 15.14	19.00 ± 17.45	19.00 ± 17.45	28.08 ± 22.96	19.00 ± 17.45	1.76 *	0.72	2.35 **	0.40 *
Stand Right Leg, Eyes Open	48.32 ± 19.83	46.72 ± 21.75	57.33 ± 9.24	57.33 ± 9.24	48.58 ± 19.88	57.33 ± 9.24	1.68 **	1.59 *	1.72 **	0.55
Stand Right Leg, Eyes Closed	10.40 ± 5.99	11.96 ± 12.51	14.25 ± 16.66	14.25 ± 16.66	17.17 ± 18.48	14.25 ± 16.66	2.31 **	1.62	2.33 **	0.90
Walk Floor, Eyes Open	19.56 ± 2.20	19.48 ± 1.50	20.00 ± 0.00	20.00 ± 0.00	19.58 ± 1.44	20.00 ± 0.00	0.93	1.00	1.07	0.79
Walk Floor, Eyes Closed	13.36 ± 6.72	11.20 ± 6.75	13.58 ± 7.31	13.58 ± 7.31	10.50 ± 6.08	13.58 ± 7.31	1.00	1.67	1.46	0.74

Effect is significant:

* p 0.05,

** p 0.01.

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Table 4

Follow-up Study Gait and Balance Measures; Repeated Measures Comparisons (FU - BL)

Fregly Gait and Balance Measures	Data		Comparison		Data		Comparison		Data		Comparison	
	NSAC (Follow-up Study) (n = 14)		Wilcoxon Mann Whitney Odds Ratios		STAA Abstinent through Follow-up (n = 25)		Wilcoxon Mann Whitney Odds Ratios		STAA Relapse prior to Follow-up (n = 12)		Wilcoxon Mann Whitney Odds Ratios	
	Baseline Assessment	Follow-up Assessment			Baseline Assessment	Follow-up Assessment			Baseline Assessment	Follow-up Assessment		
Romberg, Eyes Open	112.57 ± 18.92	120.00 ± 0.00	1.33		109.00 ± 27.7	117.48 ± 8.75	1.20		120.00 ± 0.00	118.17 ± 6.35	0.85	
Romberg, Eyes Closed	86.21 ± 47.74	84.86 ± 49.24	0.99		70.36 ± 49.04	85.60 ± 44.39	1.36		66.00 ± 43.72	64.75 ± 51.55	0.85	
Stand Left Leg, Eyes Open	54.5 ± 11.79	58.57 ± 4.80	1.20		51.84 ± 16.55	53.24 ± 16.52	1.22		53.75 ± 12.03	57.00 ± 7.21	1.23	
Stand Left Leg, Eyes Closed	21.21 ± 19.21	18.14 ± 18.69	0.74		11.08 ± 7.26	11.64 ± 15.14	0.65		28.08 ± 22.96	19.00 ± 17.45	0.68	
Stand Right Leg, Eyes Open	55.21 ± 12.52	59.07 ± 3.47	1.18		48.32 ± 19.83	46.72 ± 21.75	0.97		48.58 ± 19.88	57.33 ± 9.24	1.72	
Stand Right Leg, Eyes Closed	22.86 ± 18.49	21.86 ± 19.43	0.80		10.40 ± 5.99	11.96 ± 12.51	0.89		17.17 ± 18.48	14.25 ± 16.66	0.79	
Walk Floor, Eyes Open	18.86 ± 2.93	20.00 ± 0.00	1.33		19.56 ± 2.20	19.48 ± 1.50	0.86		19.58 ± 1.44	20.00 ± 0.00	1.18	
Walk Floor, Eyes Closed	12.14 ± 6.47	18.00 ± 4.44	2.77*		13.36 ± 6.72	11.20 ± 6.75	0.68		10.50 ± 6.08	13.58 ± 7.31	1.44	

Effect is significant:

*
p .05