The current study explored the relation between blood pressure and the Alcohol Use Disorders Identification Test (AUDIT) scores among cigarette smokers and their nonsmoking peers. When participants were assessed collectively, only a modest positive correlation between blood pressure and AUDIT score was observed. When assessed by smoking status, however, smokers demonstrated a significant relation between higher blood pressure and increased AUDIT scores. Findings from this study suggest that there is an additive increase in blood pressure when increasing levels of alcohol use and related problems is combined with cigarette smoking. Screening and treatment implications are also discussed.

**KEYWORDS** Tobacco, hypertension, alcohol use screening, cardiovascular risk

Address correspondence to Jared P. Dempsey, PhD, Department of Psychology, Oklahoma State University, 116 North Murray, Stillwater, OK 74078-3064. E-mail: jared.dempsey@okstate.edu
Hypertension doubles the risk of cardiovascular disease and is estimated to account for 30% of health problems seen among individuals with high blood pressure (HBP) (Wilson et al., 1998). Further, hypertension affects 50 million Americans and an estimated one billion people worldwide (Chobanian et al., 2003). Heavy alcohol consumption (Klatsky, 2004; Stamler, Caggiula, & Grandits, 1997) and cigarette smoking (Wen et al., 2008) are known to be contributing factors in HBP.

The link between alcohol and cardiovascular health is not a simple linear relation. It is clear that heavy alcohol consumption increases blood pressure and is a cardiovascular risk factor (Keil et al., 1993; Klatsky, 2004; MacMahon, 1987). However, there is substantial evidence that light-to-moderate drinking decreases cardiovascular risk (Abramson, Williams, Krumholz, & Vaccarino, 2001; Walsh et al., 2002), despite slightly increasing blood pressure (Burger, Bronstrup, & Pietrzik, 2004; Gordon & Doyle, 1986; Moreira, Fuchs, Moraes, Bredemeier, & Duncan, 1998). Indeed, light drinking is now widely considered to be a generic cardiovascular protective factor, alongside exercise and a healthy diet (Villegas, Kearney, & Perry, 2008). Smoking, on the other hand, has a more straightforward relation with blood pressure and cardiovascular health. Not only does smoking increase blood pressure (Shinozaki, Yuasa, & Takata, 2008), but smokers are at 2.95 times greater risk for acute myocardial infarction than nonsmokers (Teo et al., 2006). Additionally, smoking is directly attributed to 11% of all cardiovascular deaths (Ezzati, Henley, Thun, & Lopez, 2005).

There are several issues of concern when specifically examining blood pressure modulation from drinking alcohol and smoking cigarettes. First, use of these substances is typically investigated in isolation despite the fact that there is substantial comorbid use. In fact, 87% of individuals meeting the criteria for alcohol dependence also meet the criteria for nicotine dependence (John, Meyer, Hapke, & Rumpf, 2004). Relatedly, when the impact of heavy drinking on cardiovascular health is considered, it appears that at least part of what is actually being observed is likely due to cigarette smoking or the combined effects of these substances. For example, Wakabayashi (2008) examined non-, light, and heavy drinkers, while also considering their smoking status (e.g., non-, light, and heavy smoking). Consistent with previous research, heavy drinkers had higher blood pressure than light drinkers, across smoking status groups. However, among the heavy drinkers, smokers tended to have even higher blood pressure than nonsmokers. Interestingly, though research has shown that light alcohol consumption has cardiovascular benefits despite the associated increases in blood pressure (Burger et al., 2004; Gordon & Doyle, 1986; Keil et al., 1993; Klatsky, 2004; Moreira et al., 1998) light-drinking smokers were found to have significantly higher blood pressure in comparison to light-drinking nonsmokers (Wakabayashi, 2008). Thus, there appears to be an additive increase in blood pressure from moderate alcohol consumption and smoking.
Given past work suggesting an additive detrimental cardiovascular impact of alcohol, among smokers, it was hypothesized that risk level of an alcohol use disorder as defined by score on the Alcohol Use Disorders Identification Test (AUDIT; Saunders, Aasland, Babor, Fuente, & Grant, 1993) among smokers would be positively correlated with blood pressure. Given that the sample included individuals with low to moderate risk for an alcohol use disorder, it was expected that AUDIT scores would not be associated with blood pressure among nonsmokers. The general public and health care providers may benefit from determining that smokers may not receive the touted cardiovascular benefit from low levels of alcohol consumption and in fact may be doing more harm than good.

**METHOD**

**Participants**

Participants included 26 male smokers and 25 male nonsmokers. Smoking status was biologically verified, with a required carbon monoxide (CO) expired breath reading of ≥10 ppm and nicotine dependence was verified by self-report, with a required score of ≥4 on the Fagerström Test of Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). Nonsmokers were also verified using CO measurements (<6 ppm) in addition to self-report of nonsmoking status. Smokers were somewhat older, had higher levels of CO (as expected), and higher AUDIT scores than their nonsmoking peers (see Table 1). All participants were provided with an informed consent approved by the Institutional Review Board at Texas Tech University.

**Measures**

*Alcohol Use Disorders Identification Test (AUDIT; Saunders et al., 1993).* The AUDIT was developed to identify individuals whose alcohol use has become potentially hazardous and/or harmful to their health. Responses on the AUDIT report the frequency of negative drinking behaviors via 10

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Participant Characteristics and Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age**</td>
</tr>
<tr>
<td>Smokers</td>
<td>23.27 (4.32)</td>
</tr>
<tr>
<td>Nonsmokers</td>
<td>19.84 (1.75)</td>
</tr>
</tbody>
</table>

CO = carbon monoxide; AUDIT = Alcohol Use Disorders Identification Test; SBP = systolic blood pressure; DPB = diastolic blood pressure; MAP = mean arterial pressure.
Values in parentheses are standard deviations.
*p < 0.05, **p < 0.01, ***p < 0.001.
questions. Specifically, the AUDIT consists of three questions assessing the amount or frequency of drinking, three questions assessing alcohol dependence, and four questions assessing the problems caused by their alcohol use. The AUDIT has been shown to have an overall sensitivity of 80% and a specificity of 98% for detecting problem drinking. It has also shown strong internal consistency with undergraduates (.80) along with strong test–retest reliability (.84) (O’Hare, 1998).

Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991). The FTND was used to assess level of nicotine dependence and is a brief self-report instrument designed to correlate with physiological measures of nicotine tolerance. The FTND consists of six items rated either from 0 to 1 or from 0 to 3 (depending on the question) that can yield a total score of 10, with higher scores indicating greater nicotine dependence. The FTND has demonstrated adequate internal consistency (Cronbach’s alpha = .64; Pomerleau, Carton, Lutzke, & Flessland, 1994) and strong test–retest reliability over time (r = .88; Pomerleau et al., 1994).

Procedures

Participants completed a demographic/health questionnaire developed for the current protocol, had their blood pressure taken from a standard cuff (Dinamap Pro, GE Healthcare), and completed the AUDIT and FTND. Exclusionary criteria included any known current or past cardiovascular disorder, present use of psychotropic medications, or drug use other than alcohol or nicotine. The current investigation was a secondary analysis from a larger investigation of drug-cue physiological reactivity. Detailed information on methodology can be found in this parent investigation (Dempsey, Cohen, Hobson, & Randall, 2007).

Data Analysis

One-way ANOVA were conducted to determine if participants differed by smoking status on test variables. Bivariate correlation analyses were conducted, for all participants, on the three measures of blood pressure (systolic, diastolic, and mean arterial pressure) and risk of alcohol use disorder (i.e., AUDIT). Family-wise error variance was utilized for all analyses. No alpha corrections were used for tests of a priori hypotheses.

RESULTS

Between Group Analysis

One-way ANOVA were conducted to determine if participants differed by smoking status on test variables (see Table 1). Smokers and nonsmokers did
Blood Pressure and Risk of Alcohol Use Disorders

not differ in systolic blood pressure (SBP), $F(1, 50) = .01, p > 0.05$; diastolic blood pressure (DBP), $F(1, 50) = 0.01, p > 0.05$; or mean arterial pressure (MAP), $F(1, 50) = 1.20, p > 0.05$. In other words, smoking status alone did not affect blood pressure. However, smokers did have significantly higher AUDIT scores in comparison to nonsmokers, $F(1, 50) = 5.97, p < 0.05$.

Blood Pressure and Alcohol Use Disorder Risk

Bivariate correlation analyses were conducted, for all participants, on the three measures of blood pressure and risk of alcohol use disorder (i.e., AUDIT). Results indicated significant positive correlations between AUDIT scores and SBP, $r(51) = .33, p < 0.05$; DBP, $r(51) = .29, p < 0.05$; and MAP, $r(51) = .31, p < 0.05$. To test the primary study hypothesis, the same analyses were conducted, separated by smoking status. In doing so, the strength of the relation between AUDIT scores and blood pressure increased for smokers but was not significant among nonsmokers. Specifically, for smokers AUDIT scores significantly correlated with SBP, $r(26) = .61, p < 0.001$; DBP, $r(26) = .48, p < 0.05$; and MAP, $r(26) = .63, p < 0.001$. Among nonsmokers, analyses were all not significant. Correlations and additional statistical information at total and group level are presented in Table 2. See Figure 1 for a scatterplot of this relationship.

In the current sample, smokers had a significantly higher AUDIT score, in comparison to nonsmokers. As it is possible that higher AUDIT scores per se may account for the relation between smoking status and blood pressure, additional analyses were conducted. A median-split was conducted on the AUDIT scores for the entire sample. Participants scoring below the sample median were split by smoking status and correlational analyses were run between AUDIT scores and blood pressure variables. Results were consistent, with no significant correlations observed among nonsmokers ($p$'s > 0.30). However, smokers' AUDIT scores were significantly correlated with DBP, $r(10) = .88, p < 0.001$, and MAP, $r(10) = .81, p < 0.01$. Thus, it

<table>
<thead>
<tr>
<th>TABLE 2 Correlations between AUDIT Score and Blood Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>All participants</td>
</tr>
<tr>
<td>Smokers</td>
</tr>
<tr>
<td>Nonsmokers</td>
</tr>
</tbody>
</table>

AUDIT = Alcohol Use Disorders Identification Test; SBP = systolic blood pressure; DBP = diastolic blood pressure; MAP = mean arterial pressure.

$p$ values below and above significance level are presented in actual value. $p$ values less than 0.001 are noted as such, for parsimony sake.
FIGURE 1 Risk of an alcohol use disorder and blood pressure

does not appear that lower scores on the AUDIT per se accounted for the hypothesized difference between smokers and nonsmokers.

DISCUSSION

Despite a minor increase in blood pressure, it has been well established that moderate consumption of alcohol decreases cardiovascular risk factors (Burger et al., 2004; Gordon & Doyle, 1986; Moreira et al., 1998). However, it is unclear if this decrease in cardiovascular risk holds true for cigarette smokers, as smoking is also known to increase blood pressure. Further complicating this relation are studies which have found that higher levels of alcohol consumption increase cardiovascular risk (Wakabayashi, 2008). The current study examined whether the risk of an alcohol use disorder as measured by the AUDIT is differentially associated with blood pressure depending upon smoking status. Significant positive correlations were found between risk of an alcohol use disorder and SBP, DBP, and MAP. The current results suggest that, in addition to simple alcohol consumption, the risk of an alcohol use disorder is associated with increased blood pressure. A closer
examination of the data indicates these relations were only significant among those individuals who smoked cigarettes.

Certainly there are several potential explanations for the noted relation between blood pressure and AUDIT score among smokers only. Perhaps the young age of the sample buffers the relation between nonsmoker AUDIT scores and blood pressure. If this is the case, this association could be documented by testing older-aged, nonsmoking individuals for a correlation between AUDIT score and blood pressure. Alternatively, another possible explanation for the current findings could be a synergistic interaction between alcohol use disorder risk potential and consumption of cigarettes as it relates to blood pressure.

These findings suggest that lower levels of alcohol consumption and related alcohol problems still may put young smokers at an increased level of cardiovascular risk. As a result, alcohol treatment programs should take into consideration the individual’s smoking status given the potential synergistic effects of the comorbid use of these substances. These findings may also have clinical and research implications. Perhaps it is warranted that health care professionals inform their patients who smoke that the documented cardiovascular benefit of light-to-moderate drinking may not apply to them. Indeed, it is possible that light-to-moderate drinking among individuals who smoke may actually be a cardiovascular risk factor. Additionally, these findings underscore the importance of health care providers regularly assessing for alcohol and tobacco use (Beulens et al., 2007; Wen et al., 2008). Research has indicated that physicians do not assess alcohol intake as often as smoking, and there may be several reasons that account for this including (1) the assessment can be time-consuming and (2) the risk of inaccurate information due to biased self-reporting by patients (Babor et al., 1987; Maisto et al., 1990; Sobell & Sobell, 1990). Therefore, it is important that physicians and clinicians assess for alcohol use disorders as well as smoking status as comorbid use may have significant health implications for their patients.

In considering the limitations of these findings, it is important to note that the results could be influenced by factors other than alcohol and nicotine consumption (e.g., lifestyle associated with smoking status, weight, age, college attendance). Further, the study’s sample included only men, and therefore the findings may not generalize to women. Although these findings are an important first step, further research is needed to better delineate the relation between risk of an alcohol use disorder, smoking status, and blood pressure.

In summary, the current study found that the risk of an alcohol use disorder is associated with increased blood pressure. Importantly, this phenomenon was identified only for smokers. The findings suggest that smokers who consume alcohol, even at light-to-moderate levels, may have increased cardiovascular risk factors, independent of those associated with smoking or alcohol use alone.
REFERENCES


