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Hypothermia and acute alcohol intoxication in Dutch adolescents: The relationship between core and outdoor temperatures

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ABSTRACT

Purpose: To investigate hypothermia and its potential association with core and outdoor temperatures in adolescents suffering from acute alcohol intoxication. *Methods*: Data were derived from the Dutch Pediatric Surveillance System, which monitors alcohol intoxication among all Dutch adolescents. Adolescents < 18 years of age with a positive blood alcohol concentration (BAC > 0 g/l) were included. This resulted in an analysis of data from the years 2011 to 2015 that were obtained through a total of 967 questionnaires. *Results*: This study revealed small but significantly lower core temperatures in winter time (35.59°C [96.06°F]) versus summer time (35.83°C [96.49°F]). These differences could not be attributed to the genders and ages of the patients. In winter time, 26.6% of the adolescents experienced mild hypothermia, with body temperatures of 32.00–34.99°C (89.60–94.98°F), compared to 18.0% during the summer. Although not significant, amounts of time spent in reduced consciousness, hospitalized and receiving intensive care were prolonged in adolescents with lower core temperatures. *Conclusions*: This article is the first to describe this trend of hypothermia among alcohol-intoxicated Dutch adolescents admitted during winter time. These findings are important for awareness of this issue and can be used for prevention strategies in the future.

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Introduction

The use and abuse of alcohol seems to be institutionalized among the adolescent population of Europe. Despite the fact that many European countries have recently raised the legal age to buy, possess and/or consume alcohol to 18 years (Eurocare, 2014), the number of adolescents admitted to hospitals due to acute alcohol intoxication has not decreased (Van der Lely et al., 2016). Scientific knowledge of the potentially harmful effects of alcohol use in adolescence has accumulated (Hiller-Sturmhöfel & Swartzwelder, 2004), and as a result, more attention has been given to its impact on society by the general media and politicians (De Looze et al., 2014). Despite this, binge drinking and acute alcohol intoxication still occur on a regular basis in all parts of adolescent society (Van Zanten et al., 2013).

Excessive use of alcohol at young ages has serious effects both in the short and longer term. In young adolescents, the toxic effects of alcohol occur at lower blood alcohol concentrations compared to adults (Lamminpää, 1994). This may lead to long-term consequences such as negative effects on the brain, including effects on higher cognitive functions (Squeglia et al., 2015; Van Zanten et al., 2013). Additionally, acute effects such as reduced consciousness, metabolic acidosis, and hypoglycemia may occur. Another important acute effect of alcohol intoxication can be hypothermia (Stokbroekx et al., 2014), which is defined as a central core temperature below 35.00°C (95.00°F). Hypothermia is classified as mild (32.00–34.99°C [89.60–94.98°F]), moderate (28.00–31.99°C [82.40–89.58°F]), or severe (<28.00°C [<82.40°F]) (Brown et al., 2012; Kirkpatrick et al., 1999). Peripheral vasodilatation and depression of the central nervous system are the main contributors to hypothermia (Malpas et al., 1990 – Wilsterman et al., 2004).

These facts, together with risky behaviors, such as drinking outdoors, can cause adolescents to lose excessive amounts of body heat, resulting in significant and potentially dangerous drops in their central core temperatures (Stares & Kosatsky, 2015). Previous analyses have indicated that, in the Netherlands, approximately 25% of adolescents who require treatment for acute alcohol intoxication were drinking on the streets (Van Zanten et al., 2013). Thus, especially during winter time, some of those outdoor drinkers are exposed to a low environmental temperature, raising their risk of accidental hypothermia.

The aim of this study isLR to investigate hypothermia in relation to outside temperatures in adolescents with alcohol intoxication admitted to all Dutch hospitals from 2011 to 2015. We hypothesized that the number of adolescents with hypothermia is higher during winter time and that the hypothermia cases in this group are more severe. In this study, 967 patients were analyzed, all of whom were treated for acute alcohol intoxication with reduced consciousness.

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Method

Data collection

This study analyzed data collected by the Dutch Pediatric Surveillance System (NSCK) from 2011 to 2015. When an adolescent is admitted to a pediatric hospital department in the Netherlands with an alcohol-related problem, the pediatrician reports the admission to the NSCK. As part of this research, pediatricians interviewed the patients the morning after each was admitted. The information obtained was used to complete a questionnaire that was then returned to the research group. All adolescents (age <18 years) with positive blood alcohol levels (concentrations > 0 g/L) are included in the surveillance system. Data from the KNMI (the national data center for weather and climate) were used to calculate the average outdoor temperature during the month of admission (KNMI, 2016). This research was approved by the medical ethical commission with regard to the Helsinki Declaration on human subject testing.

Questionnaire

The questionnaire consisted of 40 questions divided into four categories. These categories included general and demographic information, information about alcohol use patterns, intoxication and treatment characteristics and hospital information. Relevant data that were used in this article were date of birth (ddmmyy), gender (male/female), date of admission (ddmmyy), reason for hospitalization (reduced consciousness, and if yes, duration of unconsciousness in hours; traffic accident; other accident [e.g., fracture]; aggression/violence; suicide attempt) core temperature at admission (°C), blood alcohol concentration (grams of alcohol/liter of blood), total length of hospitalization (days), and total time spent receiving intensive care (days).

Patients

A total of 3020 questionnaires regarding adolescents who were admitted to pediatric hospital departments due to alcohol intoxication were returned by pediatricians. Patients were included in this study if they were treated for acute alcohol intoxication with reduced consciousness and their core temperatures at admission were known. This resulted in a total of 1112 cases. One exclusion criteria (applied to 1 patient) was having a fever, defined as a body temperature ≥ 38.50°C (101.30°F). This is because fevers have no known relationship with alcohol intoxication and thus would probably be caused by a co-existing infection. In total, 967 adolescents were admitted due to acute alcohol intoxication with reduced consciousness. In 55 cases, the reason for admission was unknown. Other reasons for admission to the hospital included other accidents, e.g., fractures (n = 32); traffic accidents (n = 25); aggression/violence (n = 23); multiple reasons (n = 5); suicide attempts (n = 3); and vomiting (n = 1).

Data analysis

The data were analyzed using SPSS Statistical software for Mac, version 22. The normality of the variables was checked using the Kolmogorov–Smirnov test. Statistical analyses were performed based on the normality and whether variables were numerical or continuous. Baseline characteristics were compared using the chi-square test, Fisher's exact test, Mann–Whitney U test or independent samples t-test. The durations of reduced consciousness, blood alcohol concentrations, durations of hospitalization and admissions to intensive care units in different hypothermia groups were compared using the one-way ANOVA test. Pearson's correlation coefficient was used to examine the relationships between independent variables. P-values were considered significant if they were <.05.

Results

To assess the core temperatures of the adolescents in relation to the outdoor temperatures, we calculated the monthly average outdoor temperatures from 2011 to 2015 (Table 1) (KNMI, 2016). We decided to create categories based on the four months with the lowest and highest monthly average temperatures. December through March had the lowest temperatures, so this period was referred to as winter time. The months with the highest temperatures were June through September; this period was referred to as summer time. Only these months were included to amplify the differences between the mean outdoor temperatures.

During the winter time and summer time periods, a total of 603 adolescents were admitted and treated for alcohol intoxication. The questionnaires revealed no differences between the ratios of boys and girls in the winter time and summer time ($\chi^2[1, N = 601] = 0.06, p = .81$). The mean age was 15.43 years, and, again, no difference in this factor was found between the winter time and summer time periods ($t[599] = -0.53, p = .60$). The mean core temperatures were found to be significantly higher for patients treated in the summer time ($t[601] = -3.36, p = .001$) (Table 1).

The temperatures are divided into five categories based on the classifications used most often in the literature [9–10]. In winter time, a higher percentage of hypothermia cases is observed (Table 2). In summer time, more adolescents had temperatures

Table 1. Characteristics of the study population in winter time versus summer time.

	Winter (n = 308)	Summer (n = 295)	P-value
Gender			.81[a]
Male (%)	54.4%	53.4%	
Female (%)	45.6%	46.6%	
Mean age (years)	15.40	15.45	.60[b]
Core temperature °C (°F) (*SD*)	35.59°C (96.06°F) *(0.83)*	35.83°C (96.49°F) *(0.88)*	.001[b]
Mean outdoor temperature °C (°F) (*SD*)	5.02°C (41.04°F) *(1.52)*	16.50°C (61.70°F) *(1.62)*	.02[c]

[a]P-value calculated using the chi-square test.
[b]P-value calculated using the independent samples t-test.
[c]P-value calculated using the Mann–Whitney U test.

Table 2. Classifications of core temperatures in winter time versus summer time.

	28.00–31.99°C	32.00–34.99°C	35.00–36.49°C	36.50–37.49°C	37.50–38.49°C
Winter* n =	0	82	194	29	3
(Dec – March) %	*0.0%*	*26.6%*	*63.0%*	*9.4%*	*1.0%*
Summer* n =	1	53	184	49	8
(June – Sept) %	*0.3%*	*18.0%*	*62.4%*	*16.6%*	*2.7%*

P-value calculated using the chi-square test
$^*p < .01$.

Table 3. Degrees of hypothermia in relation to different patient outcomes.

	32.00–34.99°C (group 1)	35.00–36.49°C (group 2)	36.50–37.49°C (group 3)	*P*-value group 1 vs. 2	*P*-value group 1 vs. 3	*P*-value group 2 vs. 3
Duration of reduced consciousness (hours) *(SD)*	3.24 *(2.72)*	3.12 *(4.18)*	2.38 *(2.25)*	.79	.17	.17
Blood alcohol concentration (g/l) *(SD)*	2.07 *(0.46)*	1.99 *(0.51)*	1.71 *(0.56)*	.08	.00*	.00*
Duration of hospitalization (days) *(SD)*	1.04 *(0.18)*	1.02 *(0.21)*	0.99 *(0.25)*	.70	.24	.31
Time spent in intensive care unit (days) *(SD)*	0.50 *(0.58)*	0.14 *(0.36)*	0.00 *(0.00)*	.09	.14	.61

P-values calculated using a one-way ANOVA, Bonferroni post-hoc.
$* = p < .01$.

considered to be in the normal range (36.50–37.49°C [97.70-99.48°F]). These percentages constitute a significant difference ($\chi^2[4, N = 603] = 14.62, p = .006$). Two categories, 35.00–36.49°C (97.68°F) and 37.50–38.49°C (99.50–101.28°F), differ slightly from what are typically considered normal values, but are not considered to be abnormal.

We compared the three relevant temperature categories (regular, slightly low, and mild hypothermia) against the patient characteristics and found that adolescents with lower body temperatures had higher blood alcohol concentrations (Table 3). Although the differences for durations of reduced consciousness, hospitalizations and time spent in intensive care units are not statistically significant, they display the same trend in which lower core temperatures are associated with more severe consequences.

Additionally, a correlation analysis indicates that lower core temperatures negatively correlate with higher blood alcohol concentrations (Pearson's $r[926] = -.21$; $p = <.001$). This effect is presented in Figure 1.

Discussion and conclusions

This study shows that adolescents admitted during winter time had lower core temperatures and that hypothermia is

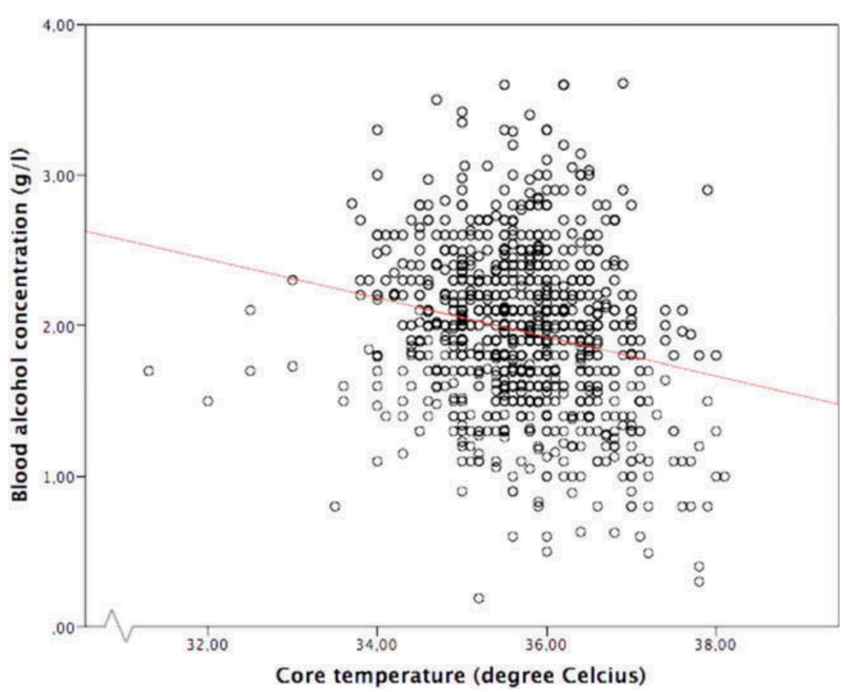

Figure 1. Correlation between BAC and core temperature.

associated with higher blood alcohol concentrations. Although this difference was small, it was caused by the higher percentage of adolescents who experienced mild hypothermia during winter time compared to summer time. Durations of reduced consciousness, durations of hospitalization and time spent in intensive care units appear to be prolonged among adolescents with lower core temperatures, though this finding was not statistically significant.

To our knowledge, this is the first study to evaluate hypothermia in alcohol-intoxicated adolescents with a comparison of cases occurring in the winter time and summer time. Hypothermia is described as a complication of alcohol intoxication in adolescents (Bouthoorn et al., 2011), and it has also been described as a manifestation of acute alcohol toxicity in adults (Wilson & Waring, 2007). In most of the literature, hypothermia is discussed in relation to traumas. In these studies, the use of alcohol is described as a predictor for hypothermia (Brown et al., 2012; Kirkpatrick et al., 1999; Kosinski et al., 2015).

There are a few limitations in this study. Between 2011 and 2015, the questionnaires were not all filled in completely, which may lead to information bias. We used average outdoor temperatures, but there is no information regarding whether the adolescents were outside while drinking, or if they were hospitalized on extremely or just mildly cold days. Also, in our data only the date of admission was recorded (not the time). In future research it would be interesting to connect the outdoor temperature to the body temperature more precisely (e.g. outdoor temperature the hours before admission). The times when core temperatures were measured were not noted; however, because this is a regular measurement taken during the course of acute care in hospitals, this should be comparable among the adolescents. Only adolescents who were treated by pediatricians were included in this study, and there is no information about alcohol-intoxicated adolescents who did not end up at hospitals. At last, it would be of very much value to add a control group in this kind of studies. In this project, given the dynamics of a real life hospital setting, the practical drawbacks, costs, time investment (and subsequently, this involved ethical issues, since doctors spend their valuable time on a control group), we were not able to include a control group in the research design. In the future, for each new study, the added value of a control group (taking possible drawbacks into account) should be investigated. However, we were able to include a large group of adolescents, and the results are relevant to both the scientific and medical communities.

The use of alcohol is widespread among adolescents (Bitunjac & Saraga, 2009; De Looze et al., 2014; Weinberg & Wyatt, 2006), a group known to participate in risky and reckless behaviors, especially among peers (Steinberg, 2008). Alcohol induces vasodilatation and depresses the central nervous system (Malpas et al., 1990; Wilsterman et al., 2004). In combination with risky behaviors, such as drinking outside in the cold, this increases the risk of developing hypothermia (Johnston et al., 1996). Paradoxical undressing may also be a contributor. Due to reperfusion of the skin, a loss of vasoconstriction occurs during continuous exposure to low temperatures, resulting in an influx of "cold" blood. The ΔT (central temperature versus peripheral temperature) drops, which causes a warm sensation after a prolonged period of shivers (Albiin and Eriksson, 1984; Brändström et al., 2012). A larger number of binge drinking adolescents experienced hypothermia in winter time. However, severe hypothermia did not occur in any of the adolescents in our study. No hypothermia-related deaths due to alcohol intoxication have been reported in the Netherlands. However, we experience mild winters here, with an average temperature of 5°C (41°F). The risks of hypothermia and its possible consequences would therefore be greater if we experienced more severe winters. Hypothermia may eventually lead to changes in metabolic and hematopoietic features, and it can also induce cardiac arrhythmias (Kirkpatrick et al., 1999). We can expect that the number of alcohol-intoxicated adolescents would be comparable to the current numbers. Therefore, more adolescents would experience hypothermia, which may result in cases of severe hypothermia.

Higher blood alcohol concentrations were recorded among hypothermic adolescents. The influence of lower body temperatures on the pathways responsible for the metabolism of alcohol has not been described (Ammon et al., 1996; Cederbaum, 2012; Eckardt et al., 1998; Paton, 2005). Thus, the higher blood alcohol concentrations cannot be explained by a reduction in the clearance of alcohol. We may carefully conclude that adolescents with more severe intoxication are at greater risk of developing hypothermia.

The knowledge derived from this study can be used in multiple contexts. Because we have established this trend, pediatricians and health workers in the field (e.g., ambulance personnel) can be better informed. This information could be especially important in countries in which low temperatures are a regular occurrence. Prevention strategies could be adjusted, and adolescents, their parents, and drinkers in general could be made aware of this problem. Because hypothermia seems to increase the risk of being admitted to an intensive care unit, it is a serious issue.

In conclusion, this study demonstrates the increased risk of hypothermia among alcohol-intoxicated adolescents during a mild winter. It is important that more attention is given to the risk of hypothermia, especially when outdoor temperatures are low. Further research is necessary to investigate the consequences of hypothermia. This research should include larger study groups and include settings with less mild winters.

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