Original Article

User-centered preferences for a gait-informed alcohol intoxication app

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Background: mHealth technology can be used as a potential intervention for alcohol-related consequences. Applications designed to monitor alcohol use and relay information to the user may help to reduce risky behavior. Acceptability of such applications needs to be assessed.

Methods: Survey data from 139 participants (29.8 years on average, 58% female) completing a single-session study for developing an application to detect blood alcohol concentration (BAC) from gait was analyzed to examine user preferences. Participants reported on their interest in an application for monitoring BAC from gait. Participants also reported on their preference for controlling features of the application. Acceptability and feasibility data were collected. Data were examined for the entire sample as well as differences in preference by age and gender were examined.

Results: The majority of the sample indicated that they were interested in using an mHealth application to infer BAC from their gait. Users were interested in being able to control features of the application, such as monitoring BAC and reporting information to other individuals. Adults, as compared to emerging adults, preferred the ability to turn off the BAC-monitoring feature of the app. Females reported a preference for an app that does not allow the user to turn off notifications for BAC as well as safety features of the app.

Conclusions: Results of the survey data indicate general interest in mHealth technology that monitors BAC from passive input. These results suggest that such an app may be accepted and used as an intervention for monitoring alcohol levels, which could mediate drinking and alcohol-related consequences.

Keywords: mHealth; gait detection; blood alcohol concentration (BAC)

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Introduction

Alcohol is a commonly used substance in the United States with 69.5% of individuals over 18 reporting past year use and 54.9% reporting past month use (1). Binge drinking in the past month, that is consuming five or more drinks for men or four or more for women within a couple of hours, is reported by 25.8% of individuals over 18 and 33% of college students (1).

High levels of alcohol use, especially consuming multiple drinks during a single drinking event, leads to negative social and medical consequences, including blackouts and injuries from trauma or violence (2), unplanned or unprotected

sex (3), and visits to the emergency department (4). Of particular concern—and the frequent target of intervention—is alcohol-impaired driving. Motor vehicle collision and injury risk increases as alcohol consumption increases (2), and alcohol-impaired driving fatalities comprised of 28% of all traffic fatalities in 2019 (5).

mHealth, defined as "using information and communication technologies for health" by the World Health Organization, offers a promising avenue to influence impaired driving incidence. Monitoring health behavior, through wearable technology and mobile phone data collection and apps, has become increasingly common (6,7). Given the ubiquity of mobile phones and the uptake of health monitoring apps, there is a place for well-developed mHealth interventions in the prevention of impaired driving. To date, most apps aimed at reducing impaired driving are blood alcohol concentration (BAC) estimators or drink counters that require manual input by the user throughout a drinking episode. Emerging mHealth apps utilize mobile phone sensors, including the accelerometer and gyroscope to detect alcohol-related changes in gait passively during a drinking event (8,9). Changes in gait can be used by the app to estimate BAC, which can be relayed to the user.

Although promising, gait detection apps require engagement with end-users during app development and testing to ensure that the features and usability are consistent with the needs of the target audience (10-13). A better understanding of the acceptability of apps among the general population can help to inform development efforts of consumer-facing app. Recent qualitative research on the use, understanding, and acceptance of mHealth technology suggests that opinions on mHealth technology may not be consistent across participants, and interest may vary by demographic variables, such as age and gender (14-16). Adults between the ages of 18 and 25, or emerging adults, report the greatest willingness to share health data and endorse the belief that there are advantages to sharing data (16). In contrast to adults 25 years and older, emerging adults may be a suitable target population for gait detection apps as they engage in heavy episodic drinking and alcohol-impaired driving (17), while also reporting frequent use of mobile phones (15). Similarly, utilization of mHealth technology may vary by gender. For example, women report greater mHealth literacy as compared to males (16), which may be associated with greater interest in utilization of mHealth applications.

The primary purpose of the current study was to assess the desired features of a gait app to estimate BAC by passively detecting alcohol-related changes during a drinking episode in a general sample and to report on these preferences. The study also sought to explore differences in app preferences by age and gender. We hypothesized that emerging adults and women would endorse greater acceptability and interest in using the app given the extant literature. We report the following article in accordance with the SURGE reporting checklist (available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-21-55/rc).

Methods

Procedures

The current study analyzed data from a larger study (18) that aimed to develop mHealth technology, the AlcoGait application, to monitor accelerometer and gyroscopic data and passively infer alcohol consumption based on change in subjects' gait. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional review board of Butler Hospital (No. 1612-001) and individual consent for this study was obtained. Participants were recruited from a Northeast community through local ads and online postings. Participants in the larger study were enrolled if they met the following inclusion criteria: (I) between 21–65 years of age; (II) drinking at least once in the past month; (III) drinking 5 drinks for men (4 for women) on one occasion at least once in the past month; (IV) willingness to consume beer for the study session; and (V) proficient in English. Exclusion criteria were: (I) past treatment for alcohol or substance use, or a comment by another person that they should seek treatment, (II) weight ≤85 or ≥ approximately 230 pounds to control volume of beverage; (III) current medication use contraindicating alcohol use; (IV) health condition that contraindicates alcohol use; (V) health condition that affects ability to walk; (VI) pregnant; (VII) use of recreational drugs or marijuana in the last week. Eligible participants provided consent and then completed a single laboratory visit within the hospital's research facility. Prior to the visit, participants refrained from alcohol or marijuana use for 24 hours as well as food intake for 4 hours before their appointment. Participants completed an initial interview administered by trained research staff followed by a monitored alcohol administration period of 60–90 minutes during which gait was assessed at approximate BACs of 0.02, 0.04, 0.06, 0.08 and 0.10 g% as determined by a

breathalyzer. For the purposes of the current data analyses, participants completed a survey of general interest in and potential use of a consumer-facing smartphone app for monitoring alcohol use and intoxication during the initial survey battery prior to alcohol administration. Participants were compensated $70 for their participation.

Participants

Analyses examined data from 139 participants who completed the study protocol. The sample consisted of participants that identified as 58% woman, 87% white, 2% Black or African American, 2% Asian, 9% other, and 94% Non-Hispanic or Latino, which was representative of the local population. Average age of the sample was 29.8 years (SD =10.7). Average age of the subsample of emerging adults—ages 21 to 25—was 22.85 (SD =1.31, n=71) and average age of the subsample of adults—ages 26 to 65—was 37.04 (SD =11.28, n=68). The sample reported an average of 15.8 years of education (SD =2.0), drinking an average of 8.7 (SD =6.0) days out of the last 30 days and drinking an average of 2.76 (SD =1.8) drinks on a typical drinking day. Participants also reported an average of 2.0 (SD =2.9) binge-drinking days in the last month.

Measures

Demographics

Participants self-reported gender, race, ethnicity, age, and alcohol use in the last 30 days.

Mobile phone usage

Participants provided self-report responses to questions about their smartphone use pattern. Specifically, participants reported where they normally carry their phone (i.e., pants/trousers, jacket/shirt pocket, handbag, backpack, hand, or on surface) when they are out in the world. Participants reported the percentage of time that their mobile phone is on their body when they are at home, outside of their home, or walking in order to determine the utility of an application that assesses gait. Participants also reported on whether they have ever used an app to monitor alcohol use and whether they would be interested in using an app to monitor drinking behavior.

Preferences for mobile application features

Participants completed a survey on their interest in features of a mobile app for alcohol use. Participants answered questions on how interested they would be in using the app using a Likert-type scale from 0 "not at all" to 3 "extremely interested." Participants then reported on what information they would like monitored (e.g., "Able to give you an estimate of your blood alcohol level?"), how they would like the information monitored (e.g., "Able to use a breathalyzer that connects to the app?"), whether they would like to receive feedback on their use or intoxication level (e.g., "Able to give you a signal that you are approximating the legal limit?"), method of notification (e.g., text message, push notification) and whether they would like the app to communicate this information to others (e.g., "Able to sync up/share your BAC with a friend/group of friends when going out for drinks?"). Participants reported on both their interest in the feature and whether they would like the option to turn the feature on or off.

Statistical analysis

We examined participant preference for the mobile application in three groups—full sample, by gender, and by age in SPSS. The sample was divided by age into emerging adults (ages 21 to 25) (15,19) and adults (ages 26 to 65). Participants were also categorized based on self-identification as man or woman. We first examined response frequencies to the mobile application survey questions. We then conducted chi-square analyses to determine whether there was an association between a specific mobile app preference and age or gender. All data from the sample was utilized for analyses.

Results

General interest in App

The majority of the sample (98%, n=136) reported that they had never used a mobile application to monitor their alcohol use. Twenty-nine percent of the sample (n=40) stated that they would be "extremely interested" in using a mobile application to monitor their use, 46% (n=64) stated that they would be "moderately interested," 23% (n=32) stated that they would be "somewhat interested," and 1% (n=2) stated that they would be "not at all interested."

Location of phone carriage

The full sample reported that their phone is on their body 76% (SD = 30.34) of the time when they are out somewhere

(58% indicated "pants" n=79; 20% "purse" n=28; 12% "shirt/jacket" n=16; and 10% "other place, such as backpack or in hand," n=10). There was a significant difference in percentage of time on body by gender [$t(136)=-7.38$, P<0.001, $M_{men}=94.71$ (7.66), $M_{women}=62.03$ (33.33)], but not by age. Location also differed by gender, with 100% of men reporting keeping their phone in their pants or shirt/jacket compared to 47% of women reporting keeping it in their pants or shirt/jacket (n=36) and 36% (n=28) keeping it in their purse.

The full sample reported that their phone is on their body 91.80% (SD =13.51) of the time when they are walking. This differed by gender [$t(136)=-3.77$, P<0.001, $M_{men}=96.59$ (8.37), $M_{women}=88.22$ (15.43)], but not by age. The full sample reported that their phone is on their body 35.72% (SD =29.92) of the time when they are at home. This differed by gender [$t(136)=-2.48$, P=0.02, $M_{men}=42.88$ (29.89), $M_{women}=30.37$ (29.00)] as well as age [$t(136)=2.46$, P=0.02, $M_{adults}=29.39$ (30.89), $M_{emergingadults}=41.69$ (27.90)].

Interest in mobile application features

Participants rated whether they would be interested in various features of the mobile application (*Table 1*). The majority of the sample (98%, n=136) indicated that they would be interested in entering the number of drinks consumed. The sample was split as to whether they wanted the ability to turn this feature on or off, with 54% (n=58) of the full sample interested in being able to turn it on/off. The majority of the sample (89%, n=124) was interested in being able to determine intoxication without any input from the user, with 62% (n=60) of the sample interested in being able to turn the feature on/off. There was a difference in this preference by age, with 72% (n=34) of adults wanting to be able to turn the feature on/off compared to 52% (n=26) of emerging adults wanting to be able to turn the feature on/off [$\chi^2(1, 139)=4.25$, P=0.04]. There was high interest in the ability to estimateBAC (99% of the full sample, n=137) and to signal that the user is approaching the legal limit (96% of the full sample, n=134). Sixty percent of the full sample (n=64) indicated that they would like to turn on or off the feature estimating BAC; however, only 39% (n=42) of the full sample wanted to be able to turn on or off the feature signaling that the user is approaching the legal limit. The majority of the sample (96%, n=134) indicated that they would be interested in receiving a notification from the app when their BAC reaches 0.08. Women were more interested in receiving a notification at a BAC of 0.06, with 87% (n=70) of women interested in a notification at this level compared to 69% (n=41) of males [χ^2 (1, 139)=6.85, P<0.01].

Participants also answered questions regarding whether they would like the app to send information to other supportive people (*Table 1*). Sixty-two percent (n=86) of the full sample reported that they would be interested in the app sending information to a friend or family member, with 71% (n=51) of the sample interested in being able to turn the feature on/off. Sixty-seven percent (n=77) of the full sample was interested in being able to share BAC with the group of other individuals they are going out with, with 88% (n=64) wanting to be able to turn the feature on/off. Ninety-three percent (n=106) of the full sample indicated that would use a breathalyzer connected to the app, with 80% (n=81) wanting to be able to turn the feature on/off. The full sample indicated that they were interested in the app tracking their drinking over a period of time (95% of the full sample, n=108), being locked out of social media at a certain BAC (77% of the full sample, n=88), activate ride share apps (97% of the full sample, n=110), and to be able to get help if their safety was being threatened (96%, n=111). Women indicated a stronger preference for not being able to turn on or off features that activate a ride sharing app [$\chi^2(1, 139)=4.50$, P=0.03], provide information on strategies for slowing rate of drinking [$\chi^2(1, 139)=9.52$, P<0.01], or signal for help [$\chi^2(1, 139)=8.60$, P<0.01].

The sample endorsed that they would most prefer a push notification as the primary method of notifications from the app (*Table 2*). This was followed by text message notification, connecting with a smartwatch, or an alarm. The order of notification preference did not differ by gender, but did differ by age with adults equally preferring a text message or push notification.

Discussion

The current study examined acceptability and user interest in an mHealth application for monitoring alcohol use and intoxication via gait analysis in community-based persons reporting last month binge alcohol use. The Alcogait application was developed to infer user blood alcohol concentration (BAC) and notify users of their level of intoxication in order to serve as an intervention for drinking and risky behavior, such as driving while over the legal limit. We determined interest in the consumer-facing mobile app, interest in specific features of the app, and ability to control features of the app. Generally, the sample endorsed interest in using the app, use of tracking features, estimating

Table 1 Mobile application features questionnaire

Questions	Total sample (n=139, %)		Gender						Age					
			Women (n=80, %)		Men (n=59, %)		χ^2	P	Emerging adults, 18–25 years (n=71, %)		Adults, 26–65 years (n=68, %)		χ^2	P
	No	Yes	No	Yes	No	Yes			No	Yes	No	Yes		
Able to enter the number of drinks consumed?	2	98	0	100	5	95		0.07	1	99	3	97		0.61
Able to turn this feature on/off?	46	54	48	52	42	58	0.45	0.50	45	55	47	53	0.06	0.80
Able to determine intoxication without any input from you?	11	89	13	87	9	91	0.57	0.45	11	89	10	90	0.03	0.85
Able to turn this feature on/off?	38	62	39	61	37	63	0.07	0.79	48	52	28	72	4.25	0.04
Able to give you an estimate of your blood alcohol level?	1	99	1	99	2	98		1.00	0	100	3	97		0.24
Able to turn this feature on/off?	40	60	44	56	36	64	0.69	0.41	47	53	32	68	2.62	0.11
Able to give you a signal that you are approximating the legal limit	4	96	3	97	5	95		0.65	4	96	3	97		1.00
Able to turn this feature on/off?	61	39	62	38	59	41	0.09	0.77	68	32	53	47	2.49	0.12
Able to give you strategies for avoiding/slowing down intoxication	14	86	13	87	17	83	0.55	0.46	17	83	12	88	0.74	0.39
Able to turn this feature on/off?	25	75	36	64	8	92	9.52	0.01	30	70	19	81	1.53	0.22
Able to communicate/send messages to your friends/family	38	62	38	62	39	61	0.03	0.86	35	65	41	59	0.52	0.47
Able to turn this feature on/off?	29	71	36	64	20	80	2.09	0.15	34	66	24	76	0.99	0.32
Able to sync up/share your BAL with a friend/group of friends when going out for drinks?	33	67	36	64	29	71	0.77	0.38	33	67	33	67	0.005	0.95
Able to turn this feature on/off?	12	88	13	87	12	88		1.00	18	81	6	94		0.16
Able to use a breathalyzer that connects to the app	7	93	9	91	4	96		0.46	5	95	9	91		0.47
Able to turn this feature on/off?	20	80	26	74	12	88	3.15	0.08	22	78	17	83	0.43	0.51
Able to track your drinking use over a period of time, maybe using charts/graphs	5	95	5	95	6	94		0.70	2	98	9	91		0.10
Able to turn this feature on/off?	41	59	47	53	33	67	1.81	0.18	46	54	36	64	0.90	0.34
Able to turn off or lock out of social media apps at a certain blood alcohol level	23	77	24	76	21	79	0.18	0.67	27	73	19	81	1.07	0.30
Able to turn this feature on/off?	17	83	22	78	9	91	2.83	0.09	12	88	21	79	1.37	0.24
Able to activate ride share apps (e.g., turn on app, send push notification about getting a ride, call for a ride)	4	97	2	98	6	94		0.31	2	98	6	94		0.34
Able to turn this feature on/off?	39	61	48	52	27	73	4.50	0.03*	41	59	38	63	0.14	0.71
Able to get help if your safety were being threatened	4	96	0	100	8	92		0.03*	2	98	6	94		0.35
Able to turn this feature on/off?	71	29	81	19	55	45	8.60	0.01**	71	29	70	30	0.03	0.87
Would you want the app to let you know when your BAL is 0.02?	81	19	78	22	86	14	1.79	0.18	79	21	84	16	0.56	0.45
Would you want the app to let you know when your BAL is 0.04 (halfway to legal limit)?	54	46	51	49	58	42	0.56	0.46	49	51	59	41	1.27	0.26
Would you want the app to let you know when your BAL is 0.06?	20	80	13	87	31	69	6.85	0.01**	21	79	19	81	0.09	0.77
Would you want the app to let you know when your BAL is 0.08 (legal limit to drive)?	4	96	1	99	7	93		0.16	3	97	5	95		0.67

*, P<0.05; **, P<0.01. Frequency data for responses are provided in percentage of the sample or subsample listed. Fisher's Exact Test was utilized when the χ^2 value is not reported. BAL, blood alcohol level

Table 2 Method of notification

How much would you prefer the following methods of notification for your level of intoxication?[#]	Total sample (n=139)	Gender			Age		
		Women (n=80)	Men (n=59)	*t*-test, P	Emerging adults, 18–25 years (n=71)	Adults, 26–65 years (n=68)	*t*-test, P
Text message notification	7.51 (2.95)	7.89 (2.82)	7.00 (3.07)	0.08	7.18 (3.07)	7.85 (2.80)	0.18
Alarm	6.05 (2.98)	6.43 (2.81)	5.54 (3.15)	0.09	5.72 (2.83)	6.40 (3.11)	0.18
A friend of mine gets notified and tells me	3.43 (2.73)	3.15 (2.58)	3.81 (2.91)	0.16	3.42 (2.42)	3.44 (3.04)	0.97
Send an inspirational photo/image	3.64 (2.79)	4.26 (2.94)	2.80 (2.35)	<0.01**	3.04 (2.54)	4.26 (2.92)	<0.01**
Push notification	8.11 (2.25)	8.14 (2.43)	8.08 (2.00)	0.90	8.35 (1.85)	7.85 (2.61)	0.24
Connect with smart watch	7.37 (2.81)	7.68 (2.63)	6.94 (3.02)	0.16	7.57 (2.52)	7.15 (3.11)	0.43

**, P<0.01 is viewed as highly statistically significant; [#], 1 = would never prefer this; 10 = my most preferred method of notification. Mean and standard deviation are reported for each item within the sample and subsamples.

intoxication level, and notification of intoxication. The sample also endorsed interest in additional features that could sync with ridesharing applications or signal for help if an individual's safety was being threatened.

We first examined differences in these preferences based on age by comparing emerging adults (19) and adults ages 26 to 65 years. Interestingly, there were largely no differences in the percentages of individuals within each age group who were interested in using the app or interested in specific features of the app despite previous findings suggesting that younger adults report greater willingness to use mHealth (14) and share data (16). The current results may differ from previous findings in that the current sample was relatively younger on average (M_{age}=29.8, SD =10.7), and therefore, differences in interest, acceptability, and data sharing between the two age groups may not have been observed. The only preference that differed by age was the ability to turn on/off the feature that determines intoxication without any input from the user, with more adults over the age of 25 compared to emerging adults desiring the ability to turn this feature off. This may indicate willingness to use the app as an intervention among emerging adults, as the feature would remain active during a drinking episode without the ability to turn it on/off and would then signal increasing intoxication to the user. This finding is consistent with previous findings that older adults are less willing to share their information (16); and therefore, adults over the age of 25 may prefer the ability to control what information the app collects. Similarities in the patterns of preference for the use of the app, features of the app, and ability to control certain features suggests that the app might be widely used by individuals of all ages.

There were observed gender differences in preferences for certain features of the app and ability to control these features. Women preferred a version of the app where the user does not have the ability to turn on/off features that would provide strategies for slowing down drinking, sync with rideshare apps, or signal for help. Women may be more likely to want features that communicate information from the app to other people or services. This may increase the apps usability as an intervention for negative consequences from alcohol use, and particularly for women, the app may function to improve safety during drinking episodes. Women also endorsed interest in being notified when their BAC was approaching 0.06 at higher percentages then men, which may be representative of a motive to use the app to monitor and potentially moderate BAC as well as reduce negative consequences of drinking. These results are consistent with observed preliminary differences in mHealth literacy by gender (16) that indicate women endorse greater familiarity with mHealth topics and use of digital devices for health. The current findings suggest that women may interact differently with the app, using the app to increase safety and also monitor changes in BAC. Another notable difference by gender was the percentage of time that a user's phone is on their body when they are out somewhere, which may reduce effectiveness of the app to assess level of intoxication. Men indicated that they carried their phone on their bodies at a higher percentage than women, with approximately half of women reporting carrying their phone on their body compared to almost all men. While women seemed to rate a high interest in using the app as well as

using specific features of the app, one barrier to utilization might be the need to alter the placement of a user's phone on their body while out. Because our previous work (18) was heavily dependent on data derived from an individual's smartphone accelerometer and gyroscope, smartphone app locations other than a person's body may not be as useful. Future research is needed to determine the extent to which other phone locations (e.g., in a purse or coat pocket) would provide the same accuracy in predicting intoxication.

This study had several limitations. First, the sample consisted of primarily white individuals with a higher-than-average numbers of years of education. The final sample was also younger on average. It is possible that these factors could affect how willing individuals are to utilize an app that gathers and tracks information on intoxication. Similarly, acceptance of the app as a useful intervention to reduce negative consequences of alcohol use could differ by subsamples of the population dependent on factors such as education level. The sample was limited to individuals who reported past month binge alcohol use and to those with infrequent or no use of other intoxicating substances. Preferences might differ based on drinking history. Additional research is needed to examine user preferences among other populations as well as individuals who might endorse alcohol-related problems. The survey was completed prior to the participants interacting with the application, which may limit interpretations of the results. It is possible that the sample would have responded differently if they had first trialed the app and then responded to the survey questions. The survey did not assess the willingness of the participants to keep their phone on their bodies in order to be able to use the app, which would help determine acceptability of implementing an mHealth app for monitoring alcohol use. The study did not collect information from collaterals (i.e., friends and family members) as to whether they would want to receive estimates of another individuals' BAC from the app.

Overall, the survey data indicate a high interest in the mHealth app with a preference towards the user retaining the ability to turn features of the app on and off. Our findings suggest that mHealth used to monitor various aspects of health behaviors may be desired by the general public and could be used as a preventative intervention for alcohol misuse.

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Footnote

Reporting Checklist: The authors have completed the SURGE reporting checklist. Available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-21-55/rc

Data Sharing Statement: Available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-21-55/dss

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional review board of Butler Hospital (No. 1612-001) and individual consent for this study was obtained.

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