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Characterizing computer-mediated communication, friendship, and social participation in adults with traumatic brain injury

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Abstract

Background: Adults with traumatic brain injury (TBI) report loss of friendship and reduced social participation after injury, but there is limited information regarding quantity of friends and methods of communication. Our objective was to characterize friendship networks, social participation, and methods of communication, including computer-mediated communication (CMC), used by adults with TBI compared to uninjured adults.

Methods: Participants were 25 adults with TBI and 26 uninjured healthy comparisons (HC) adults, who completed the Participation Assessment with Recombined Tools-Objective (PART-O) and the Social Network Questionnaire (SNQ).

Results: Adults with TBI had significantly fewer total friends and significantly lower levels of productivity and overall social participation. Face-to-face interaction was the preferred method of contact for both groups. Adults with TBI were significantly less likely to use texting as a primary method of communication than their uninjured peers, but used other methods of communication at similar rates.

Conclusion: Our study supports prior findings of reduced friendships and reduced social participation after TBI and adds new information about similarities and differences in communication methods between adults with and without TBI.

Keywords

Traumatic brain injury; friendship; social participation; computer-mediated communication; texting

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Disclosure of interest

The authors report no conflict of interest.

Introduction

Adults with moderate or severe traumatic brain injury (TBI) often report reduced social participation and community engagement in the chronic stage post-injury (1–9). In particular, they report difficulties maintaining existing friendships and establishing new ones, resulting in smaller social circles than those of uninjured adults (3,5,7). Most studies, however, have focused only on in-person friendships, and do not consider the role of communication technologies in building and maintaining social networks. Researchers also typically ask participants to extemporaneously recall names of friends, a significant problem for a clinical group with known memory problems. Thus, the true status of friendships and social networks after TBI has yet to be determined. It is critical to understand the social networks of adults with TBI because social connections provide mental and physical health benefits (10) and a mechanism to rebuild self-concept and identity (11). Friendships are especially important, as they provide psychological benefits beyond those associated with family, and are voluntary and usually established through shared interests and a desire for interaction (12–14). Maintaining friendships requires more communication and active participation than maintaining relationships with family (15), so they may be particularly vulnerable after TBI. The ability to maintain social networks is an important consideration in rehabilitation because adults with TBI who maintain social participation report better quality of life after their injury and higher levels of happiness than their socially isolated peers (16). Even brief interactions with peer mentors can offer an experience of companionship and can be associated with improvements in quality of life (10). Thus, any strategy that improves access to social networks could have major benefits to long-term outcome after TBI.

Mechanisms of human social interaction changed dramatically with the advent of computer-mediated communication (CMC). CMC encompasses every type of communication that occurs via computer technologies such as laptops, smart-phones, and personal computers. It has become a mainstay for keeping in touch with members of one's social circle and establishing new friendships (17), a phenomenon largely driven by the emergence of smartphones and social media (18). Only a few decades ago, CMC was confined to workplaces and was of limited availability, today its use is widespread (19). Given the ubiquity of CMC in social life (20), it is important to consider its application to rehabilitation in TBI as well as the challenges it may pose for persons with brain injury.

Prior research shows that CMC can play an important role for those with health challenges and disabilities, providing opportunities for maintaining social contact while avoiding the challenges of coordinating and traveling to face-to-face meetings (21). People who are socially isolated also might prefer CMC to face-to-face communication, because it allows them to communicate from private and relaxed environments and frees them from demands of monitoring their partners' and their own nonverbal behaviors (22–25). The asynchronicity of message exchange in some CMC formats (e.g., emailing and social media) can grant extra time for planning and composing messages, allowing for thoughtful and deliberate self-presentation (25,26). Communication impairments from TBI may be unnoticeable in these forms of CMC, reducing concerns around stigma (27). In individuals with TBI, CMC has

been found to facilitate expression of insight, reflection, and humor in conduct of qualitative interviews (28) and to provide a feasible method of delivering therapy, coaching, and education (29–31).

CMC can also pose challenges for those with TBI. These include costs of computer technology and internet service (32); demand for fine-motor skills and high-level cognitive functions (e.g., working memory, selective attention, and self-regulation) that can affect computer and smart-phone use (33–35); and barriers in learning how to use new technologies (33,35–37). CMC can also introduce social challenges for people with TBI including difficulties interpreting jargon, potential for social rejection, and risk of cyber bullying (27,37,38).

Despite these challenges, research suggests that most individuals with TBI do make use of emerging technologies, especially social media (35,38,39). In a survey of 337 adults with moderate-severe TBI, Baker-Sparr and colleagues (38) reported that 74% regularly used the internet, although this percentage was somewhat lower than in the general population (84%). The study also found that about 79% of participants with TBI used social networking sites, and over 50% frequently used at least two social networking sites. Further, a study by Tsaousides and colleagues (39) found that most individuals with TBI used Facebook on a regular basis, and Wong and colleagues (35) found that 76% of adults with TBI used smartphones, compared to 86% of non-injured adults, with communication (e.g., calling and texting) being the primary function of smartphone use for both groups.

While we know that adults with TBI make use of the internet and social media, Brunner and colleagues (40) observed that, at the time their study was published, no research had examined to what extent this internet and social media use was devoted to social communication vs. solo activities like information browsing. Furthermore, it is unclear how often individuals with TBI use specific communication channels (e.g., social media, e-mail, texting, phone calls) for social connection. Knowing whether individuals with TBI tend to privilege one method over others, and whether their preferences differ from those of healthy individuals, could shed further light on the mechanisms leading to social isolation following a brain injury and inform clinicians working to support communication and social participation for adults with TBI, including through interventions involving communication technologies. If individuals with TBI tend to use CMC less than healthy individuals when communicating with their social network, this could suggest that CMC training and methods require redesign to better serve the needs of those with TBI. For example, a study by Egan and colleagues (41) found that providing training to individuals with TBI improved their ability to access the internet, and more recent research also suggests that adults with TBI may benefit from support and training to optimize the use of assistive technology and social media platforms (35,37). Alternatively, if individuals with TBI already disproportionately engage with certain CMC methods, this might offer opportunities to leverage these methods to enhance quality and quantity of social communication and improve community integration in the TBI population.

Communication technologies have a potential role to play in rehabilitation of those with TBI and lower the risk of social isolation after injury. To better use CMC as a tool for supporting

communication and social integration in adults with TBI, we must first understand how adults with TBI are already using CMC. To answer this question, we asked adults with TBI to report which method of communication they most frequently used to communicate with individuals in their friendship networks, and compared those results to data from uninjured adults of similar age and education, two factors that could influence CMC adoption. Our primary aim was to determine if there were differences between adults with TBI and healthy comparison peers in methods used to maintain contact with friends, expecting that individuals with TBI would use CMC less often than their uninjured peers. A secondary aim was to compare social participation and quantity of friendships in adults with TBI as compared to uninjured peers.

Methods

Participants

Participant characteristics are summarized in Table 1. Participants were adults with and without TBI, ages 24 to 59 years, who spoke English as a primary language. Inclusion criteria for both groups were: no history of medical or neurological disease affecting the brain, no history of a language and/or learning disability (pre-morbidly for those with TBI), and no history of mental health diagnosis. Additional criteria for participants with TBI were that they had sustained a moderate-severe injury as defined by nationally accepted criteria (42), were at least six months post injury, were out of post-traumatic amnesia, were free of aphasia as determined by the Western Aphasia Battery Bedside Tool (43), were understandable to a naïve listener, and were living in the community. All participants were a convenience sample recruited from participants in a larger study of social communication in adults with TBI at a Midwestern university in the US. Participants in the larger study were recruited from community contacts and brain injury organizations in Midwestern states. The inclusion criteria for this study reflect those of the larger study.

Twenty-eight adults with TBI and 27 uninjured healthy comparison (HC) peers consented to participate in the study. Four participants were later excluded from the sample because of mental health diagnoses that were identified as part of the review of medical history. The final sample included 25 adults with TBI and 26 HCs. The TBI and HC groups were matched group-wise for age ($T(49) = 1.18, p = .24$) and education ($T(49) = 0.139, p = .89$), but were significantly different for sex ($\chi^2(1, N = 51) = 4.46, p = .04$). The HC group included predominantly women (16 women and 10 men), while the TBI group included predominantly men (17 men and 8 women). Sex was added as a covariate in all analyses because of the group difference in sex and because prior research has found sex effects on outcome in some social domains (44,45). Cause of injury was predominantly motor vehicle accidents (17), with the remainder caused by assault (2), other causes (e.g., sports-related accidents) (5) and falls (1). Individuals in the TBI group were on average 12.53 years post injury.

Social participation

Social participation was measured using the Participation Assessment with Recombined Tools-Objective (PART-O) (46). The PART-O includes questions about the number of hours

a week spent working or in school, the type and frequency of social activities, and if the individual has any intimate relationships or meaningful friendships (46). The PART-O has 17 items divided into three domains: Productivity, Social Relations, and 'Out and About'. These included questions such as "In a typical week how many hours do you spend working for money, whether in a job or self-employed?", "In a typical week how many times do you socialize with friends in person or by phone?", and "In a typical month how many times do you engage in sports or exercise outside your home?". Each PART-O domain score and the PART-O averaged total score across the three domain scores were used as dependent variables for data analyses. In addition, the question regarding employment listed above was analyzed individually to characterize participant's employment status. The employment item is scored on a scale from zero to five where 0 = no hours, 1 = 1–4 hours, 2 = 5–9 hours, 3 = 10–19 hours, 4 = 20–34 hours, and 5 = 35 or more hours.

Friendship network and methods of communication

The Social Network Questionnaire (SNQ) (15) was used as a measure of friendship quantity, to compare the current sample to previous reports of friendship quantity in the literature. On the SNQ, we asked participants to list all non-family friends with whom they had interacted in the past twelve months, designating the friendship type for each (friends, neighbors, co-workers, or romantic partners except spouses). Spouses were excluded because they were considered family. Participants were instructed to include neighbors or co-workers only if they considered that person a friend. We will refer to the combination of friends, neighbors, co-workers, and romantic partners as a 'friendship network'. Participants identified members of their friendship network using initials to maintain friends' anonymity. For each person listed, the participant also identified the most common method used to communicate with that person (face-to-face, phone, e-mail, text, social media, or letter).

Participants were instructed in advance to bring their mobile phones, address books, and other resources to the testing session so they would be prepared for this task. They were encouraged to use all of these resources to prompt memory and promote completion of a near-exhaustive friendship network list. In addition, participants were encouraged to use these resources (e.g. reviewing texts, phone records, e-mails, or a calendar) to determine their primary method of communication with each person in the friendship network. The dependent variables for analysis were the total number of friends (in the friendship network) and percent of all friendship network members for which each communication method was identified as primary method of communication.

Tests to characterize the sample

Following the recommendations of the NINDS Common Data Elements project for TBI research (47), participants completed several neuropsychological tests to characterize the sample: the California Verbal Learning Test (CVLT-II) (48) was administered as a measure of learning and memory; the Wechsler Adult Intelligence Scales (WAIS-IV) Coding and Symbol Search subtests (49) was administered to obtain a measure of processing speed (Processing Speed Index (PSI)); and the Trail Making Test B (50) was administered as a measure of executive functioning. Tests were completed as part of the larger study from which participants were recruited.

Statistical analysis

For the PART-O, we compared group average scores on each of the subscales using one-tailed t-tests, based on previous evidence of lower scores in individuals with TBI (8). Similarly, one-tailed t-tests were used to examine group differences in neuropsychological data, with the hypothesis that individuals with TBI would perform worse than HCs. To compare groups independently of friendship network size, data on friendship type and method of communication were converted into proportions (i.e., to determine if individuals with TBI differed in the relative use of different communication methods, regardless of size of their friendship networks). Data were analyzed using Analyses of Covariance (ANCOVA), with groups as a between factor, sex as a covariate, and medium of communication and type of communication partner as within-groups factors (in two separate models). Bonferroni correction for multiple comparisons was applied as appropriate. As hours-of-work data were not normally distributed, we used Mann Whitney tests for analyses related to this PART-O variable.

Results

Tests to characterize the sample

Neuropsychological test scores are summarized in Table 2. With correction for multiple comparisons (significant p-value = 0.05/5, $p < .01$), TBI group scores were significantly lower than HC group scores for the CVLT-Immediate ($t(49) = 6.3$, $p < 0.001$, 95% CI [10.66, 20.61]), CVLT-Short ($t(49) = 6.6$, $p < 0.001$, 95% CI [1.1, 2.06]), CVLT-Long ($t(49) = 7.03$, $p < 0.001$, 95% CI [1.43, 2.57]), and WAIS PSI ($t(49) = 3.71$, $p < 0.001$, 95% CI [7.81, 26.31]); with a trend towards significant difference for Trails B ($t(48) = 2.28$, $p = .02$, 95% CI [.3, 4.77]).

Friendship network size

SNQ total friends scores are summarized in Table 2. A one tailed t-test revealed that individuals with TBI had, on average, a smaller friendship network size than HCs ($t(49) = 2.43$, $p < .01$). Adults with TBI had an average of 12.92 (SD = 10.75) friends and HCs had an average of 22.77 (SD = 17.55) friends.

Social participation

PART-O scores are summarized in Table 2. With correction for multiple comparisons (significant p-value = 0.05/4, $p < .013$), TBI group scores were significantly lower for Productivity ($t(49) = 5.63$, $p < .001$, 95% CI [.63, 1.34]) and overall social participation ($t(49) = 4.43$, $p < .001$, 95% CI [.37, 1]). Groups did not differ significantly for “Out and About” scores ($t(49) = 0.06$, $p = .96$, 95% CI [−.01, .77]) or Social Relation scores, although for the latter there was a trend towards significantly lower scores in the TBI group ($t(49) = -2.56$, $p = .014$, 95% CI [−.15, 1.23]).

Role of communication partner and friendship networks

A mixed-effect ANCOVA revealed a significant effect of communication partner ($F(1.4, 67.13) = 422.29$, $p < .001$, $\eta^2 = 0.9$), with friends comprising a larger proportion of the

friendship network than romantic partners ($T(50) = 41.78$, $p < .001$, 95% CI [84.64, 93.19], $d = 6.01$), neighbors ($T(50) = 31$, $p < .001$, 95% CI [81.28, 92.54], $d = 2.71$) or co-workers ($T(50) = 23.06$, $p < .001$, 95% CI [75.27, 89.63], $d = .91$). This pattern was observed in both groups, with no significant effect of group ($F(1,48) = 0.01$, $p = .39$, $\eta^2 = 0.02$, 95% CI $[-4 \times 10^{-8}, 4 \times 10^{-8}]$) or group-by-partner interaction ($F(1.34, 67.13) = 1.05$, $p = .34$, $\eta^2 = 0.02$). There was no significant effect of sex ($F(1,48) < 0.001$, $p = 1$, $\eta^2 < 0.001$), and no sex by partner type interaction ($F(1.34, 67.13) = 2.74$, $p = .09$, $\eta^2 = 0.05$).

In our sample, 16% of participants in the TBI group worked 35 or more hours per week, 12% worked 20–34 hours, 24% worked 10–19 hours, 8% worked 5–9 hours, 4% worked 1–4 hours, and 36% were unemployed. In the HC group, 69.23% of individuals worked full time, 7.69% worked 20–34 hours, 7.69% worked 10–19 hours, 0% worked 5–9 hours, 3.85% worked 1–4 hours, and 11.54% were unemployed. A Mann Whitney test revealed that individuals with TBI worked significantly fewer hours per week than HCs ($U = 144$, $p < .001$). In the TBI group, there was no significant correlation between the number of hours worked per week and number of co-workers in their friendship network ($n = 25$, $Rho = 0.34$, $p = .1$), or the percent of people in their friendship network who were co-workers ($n = 25$, $Rho = 0.3$, $p = .15$). However, within the HC group there was a significant correlation between number of hours spent at work every week and number of co-workers within their friendship network ($n = 26$, $Rho = 0.48$, $p = .01$), and between number of hours spent at work every week and percent of co-workers within their friendship network ($n = 26$, $Rho = 0.49$, $p = .01$).

Communication method

Results for most common method of communication with friends are outlined in Table 3. Within groups, there was a significant main effect of communication method ($F(2.42, 116.05) = 23.45$, $p < .001$, $\eta^2 = 0.33$). For both groups, the most common method of contacting friendship network members was meeting them face-to-face (TBI = 62.02%, HC = 49.39%), followed by phone (TBI = 20.71%, HC = 12.82%), texts (TBI = 2.77%, HC = 22.40%), social media (TBI = 12.22%, HC = 11.04%), e-mails (TBI = 2.28%, HC = 4.15%), and letters (TBI = 0%, HC = 0.20%). There was a significant method-by-group interaction ($F(2.42, 116.05) = 4.75$, $p = .007$, $\eta^2 = 0.1$). Participants in both groups used most communication methods in similar proportions ($t(49) < -1.5$, $p > .05$ for all), except for texting: participants with TBI used texting significantly less than HCs ($T(49) < 3.9$, $p < .001$, 95% CI [9.52, 29.74]). Participants in the HC group used texting as primary method of contact for 22.4% of their friendship network members, vs. 2.77% for the TBI group. There was no significant effect of sex on communication method ($F(1,48) < 0.001$, $p = 1$, $\eta^2 < 0.001$), and no significant interaction of sex with communication method ($F(2.42, 116.05) = 1.44$, $p = .24$, $\eta^2 = 0.03$).

Given that texting is a relatively recent communication method that older adults use less than younger adults (35% of those 65 or older, compared to 75% of those 50–64, 94% of those 30–49, and 97% of those 18–29) (51), we examined the relationship between age and texting. There was a significant negative correlation between number of friendship network members with whom the person primarily texted and age in the TBI group ($n = 25$, $r =$

−0.51, $p = .009$), but not the HC group ($n = 26$, $r = 0.003$, $p = .99$). A Fisher z transformation revealed that the two groups' correlations were not significantly different ($z = 1.47$, $p = .06$).

Discussion

The aims of this study were to characterize the methods of communications used by individuals with TBI when interacting with people within their friendship network and to extend existing research on social participation and friendship quantity. In particular, we were interested in investigating whether individuals with TBI used CMC more or less often than healthy individuals to communicate with people in their friendship network. Overall, results were consistent with earlier studies showing smaller social networks in adults with TBI, but some results were unexpected, including absolute size of friendship networks and use of CMC methods.

Friendship network size and social participation

Our study included a comparison group of adults without TBI who were matched group-wise for age and education, which allowed us to compare friendship network size and social participation between adults with TBI and their uninjured peers. Adults with TBI had significantly fewer friends than uninjured adults. This is consistent with prior research findings of reduced numbers of friends after TBI (3,4,6,52). However, those studies did not include a comparison group and thus our study adds valuable new information about how friendship networks of adults with TBI compare to those of uninjured adults.

The number of friends reported in this study ($m = 12.92$) is higher than previously reported by Hoofien and colleagues (3), who found that adults with severe TBI reported an average of 2.7 close friends. This may be attributed to difference in methods. Hoofien and colleagues (3) asked adults with TBI to estimate the number of their close friends via free recall, a problematic method in a group with memory impairments (adults with TBI in this study performed significantly worse on measures of memory including CLVT-Immediate, CLVT-Short, and CLVT-Long compared to the HC group). Participants in this study had access to paper and electronic resources when completing the form, which helped ensure that friendship network lists were as complete as possible and may have compensated for the memory deficits of adults with TBI. Further, participants were instructed to list anyone they considered a friend, not just “close friends” as in this study by Hoofien et al. (3).

A prior study of ours, Flynn et al. (8), found that adults with TBI reported an average of 15.67 friends. That study had a smaller sample size than the current study and also differed in methods. The prior study focused on reciprocal friendship relations, and thus excluded participants who did not have a friend who could also participate in the study. That created a selection bias potentially favoring individuals with more friends, thus the present study may more accurately represent friendship network size in adults with TBI. Our finding that adults with TBI had significantly lower levels of social participation was consistent with prior research on friendships in TBI in general (1,3–7,53), and with studies by Bogner and colleagues (54) and Flynn et al. (8) using the PART-O. When the three domains of the PART-O were analyzed individually, groups only significantly differed in the “Productivity” domain, which asks about the number of hours a week spent working or school and

completing household tasks. This is consistent with reports of reduced employment after TBI (6,9,55–57).

Communication method

Adults with TBI used face-to-face meetings, phone calls, e-mailing, social media, and letters in the same proportions as their uninjured peers, with face-to-face meeting being the preferred method for both groups. This suggests that face-to-face contact may play a particularly meaningful role in friendships, consistent with previous evidence that friendships typically require face-to-face interaction to support relationship maintenance over time (15,58). In addition, participation in in-person activities with others is associated with higher levels of happiness and quality of life in individuals with TBI (16), supporting the importance of this medium of interaction. Unlike the other methods of contact considered here, face-to-face interaction facilitates the exchange of a wide array of nonverbal social cues, including facial expressions, vocal intonations, postures, movements, and touch (59); such cues may play an important role in bonding, regardless of injury status.

The one area in which TBI group members differed significantly from their uninjured peers was in use of texting to stay in touch with friends. This difference was not due to differences in types of relationships within friendship networks, as in both groups, friends comprised the largest part of friendship networks. Rather, we propose that the difference in texting is due to accessibility, i.e., aspects of texting that make it more challenging for adults with TBI. Texting usually is done via a mobile phone with a small screen and high demands for fine-motor control, which can pose significant barriers for individuals with sensorimotor impairments. In addition, texting requires not only phoneme-to-grapheme conversation but also knowledge of current abbreviation and slang conventions, which may be problematic for a group with cognitive challenges. Thus, the challenges could relate to the interfaces involved. In addition, since mobile phones are carried around throughout the day, texting may carry a greater expectation of synchronous communication (60) perhaps constraining time for composing and planning messages. Given that texting is associated with closer relationships (61) and is often used to keep in touch where more time and resource consuming methods are unavailable (62) it is possible that reduced texting among those with TBI contributes to the smaller size of their friendship network and to reduced overall social participation. Potentially consistent with this, Wong and colleagues (35) found that use of smartphone-based communication apps by individuals with TBI predicted better community integration. Future research should investigate how texting is related to maintenance of friendships and social participation.

We also asked if there was a relationship between texting and age because texting is more common communication method in younger generations than adults over age 50 (51). We found a significant negative correlation between age and use of texting, but only in the TBI group. Thus, reduced texting among those with TBI was driven in part by lower use among older participants. Similarly, Wong and colleagues (35) identified older age as a potential barrier to smartphone use in adults with TBI. Future research should further investigate the relationship between age and texting in adults with TBI with particular focus on barrier and supports to usage.

E-mailing and social media were used as a primary contact method at similar rates for those with TBI and healthy comparison participants. These findings are consistent with prior findings showing high interest and rates of use of social media among those with TBI (31,37,38). This appeal may reflect, in part, that social media allows those with TBI to choose among a wide range of communication behaviors (40). On Facebook, for instance, individuals may communicate privately via one-to-one messaging, with many network members at once through writing status updates, or may respond to others' status updates through comments or "lightweight" capacities such as "like" buttons (63). Social media platforms also vary in whether they center on image-based (e.g. Instagram) or text-based communication, and whether they facilitate anonymity/pseudonymity or implement policies that require users to reveal their true identities (e.g., Facebook's "real name" policy) (64). Future research may examine how specific design features and policies of social media platforms shape the use of CMC among those with TBI. Additional appeal of social media platforms may relate to their capacity to connect individuals with new people, including those who may share the experience with TBI (27,40). One prior study of social media users with TBI found that 30% used Facebook to "make new friends" (31).

An interesting peripheral finding of the current study is that while there was a significant correlation between the number of hours spent at work and the number of coworkers within one's friendship network in the HC group, this correlation was not significant within the TBI group which suggests that for adults with TBI the amount of time spent in a workplace does not necessarily translate into making friends. Future work should examine whether this is related to the type of employment, length of employment, and specific communication difficulties that adults with TBI encounter in the workplace.

Areas for future research

Individuals with TBI have fewer friends with whom they predominantly text than healthy comparison participants, but the reasons for this are unclear. Future research may clarify whether those with TBI use texting as a supplementary means of communicating with those they primarily interact with through other channels (e.g. face-to-face communication) or whether these patterns reflect their relationship with the technology supporting texting (e.g. difficulties with smartphones relative to personal computers). The latter would seem to contradict findings by Baker-Sparr (2018), who reported that most individuals with TBI used smartphones as their preferred method to access the internet, with over 90% using their smartphones for texting. However, other researchers have proposed that some individuals with TBI would benefit from support and training with the use of CMC, including texting (35,37). Future research should also investigate if targeting device training (e.g. training an individual with smartphone navigation, training use of speech-to-text features) could improve an adult with TBI's use of texting to communicate with others. Prior research has shown that training individuals to use CMC can be a successful method of supporting communication in individuals with communication disabilities (29,41).

Limitations

This study has several limitations. The main limitation lies in the fact that individuals with TBI and healthy comparison participants were not matched for sex. While we added sex as

covariate to control for this, the different sex composition between the two groups might represent a confounding factor. In addition, many relationships span multiple communication methods, particularly when those relationships are stronger and more central (65); our current study does not allow us to characterize friendship networks according to the number of communications methods used with each friend. We also cannot distinguish those relationships that involve contact only through the internet, such as may occur when using social media to connect with others who share TBI experience. We also did not ask participants if they had barriers to accessing technological supports for contacting friends, such as having access to smartphones. Although we found no empirical evidence that adults with TBI are less likely to have mobile technology, there is evidence of barriers to accessing digital social media in this population (37). These barriers may underlie group differences in friendship contacts.

Another limitation of the current study was the sample size. TBI is a highly heterogeneous disorder, and thus large sample sizes are crucial to be able to generalize findings to the larger population. We excluded individuals with aphasia and a history of language, learning, or mental health disorders because these diagnoses can be associated with changes in social networks, confounding our attribution of group differences to TBI. Further study of individuals in these groups is warranted. Finally, we recognize that the concept of friendship can vary across cultures, so cultural differences also merit future study.

Conclusion

Our study supported previous findings of reduced social participation and reduced numbers of friends in adults with TBI. We learned that adults with TBI were less likely than their peers to use texting as a primary method of contact with friends, but that they used other methods of communication at similar levels as their uninjured peers. Our findings show the importance of including CMC when considering social participation in adults with TBI, both in research and also in rehabilitation. Communication is an essential tool for maintaining relationships. To best support adults with TBI, we need to understand how they use CMC and potential areas for improvement, with the goal of improving long-term relationship maintenance and social participation after TBI.

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Table 1.
Demographics of healthy comparison participants and individuals with traumatic brain injury.

	HC	TBI	Group comparison (<i>p</i>)
<i>n</i>	26	25	N/A
Age (<i>Mean</i> ± <i>SD</i>)	35.85 ± 12.29	39.87 ± 12.03	0.24
Sex (Females)	16	8	0.04
Education (<i>Mean</i> ± <i>SD</i>)	15.21 ± 1.72	15.14 ± 1.96	0.89
Chronicity (<i>Months, Mean</i> ± <i>SD</i>)	N/A	150.36(± 114.71)	N/A

Notes: HC = Healthy comparison participants, TBI = Traumatic brain injury, SD = Standard Deviation, N/A = Not Applicable.

Table 2.

Mean scores and group comparison for the neuropsychological assessments, SNQ, and PART-O.

	HC (Mean±SD)	TBI (Mean±SD)	Group comparison (<i>p</i>)
WAIS PSI	100.58 ± 18.64	83.52 ± 13.76	<0.001 ***
Trail's B (z score)	0.55 ± 1.5	-2.00 ± 5.45	= 0.02
CVLT-Immediate (t score)	56.04 ± 9.08	40.40 ± 8.58	<0.001 ***
CVLT-Short delay (z score)	0.5 ± .77	-1.08 ± .93	<0.001 ***
CVLT-Long delay (z score)	0.54 ± 0.79	-1.46 ± 1.21	<0.001 ***
SNQ Total friends	22.77 ± 17.55	12.92 ± 10.75	<0.01 *
PART-O Averaged total	2.69 ± 0.53	2.00 ± 0.58	<0.001 ***
PART-O Productivity	2.71 ± 0.58	1.72 ± 0.66	<0.001 ***
PART-O Social Relations	3.22 ± 0.90	2.53 ± 1.03	0.014
PART-O Out and About	2.14 ± 0.67	1.76 ± 0.73	<0.05

Notes: HC = Healthy comparison participants, TBI = Traumatic brain injury, *p* = *p*-value, SD = Standard deviation, WAIS PSI = Wechsler adult intelligence scale processing speed index, CVLT = California verbal learning test, SNQ = Social network questionnaire, PART-O = Participation assessment with recombined tools-objective.

* denotes statistically significant value when *p* < 0.05.

** denotes statistically significant values after correction for multiple comparisons (significant *p*-value = 0.05/4, *p* < 0.013).

*** denotes statistically significant values after correction for multiple comparisons (significant *p*-value = 0.05/5, *p* < 0.01).

Table 3.

Most common method of communication with friendship network members.

Method of Communication	HC	TBI	Group Comparison (<i>p</i>)
Face-to-Face	49.39%	62.02%	>0.05
Phone	12.82%	20.71%	>0.05
Texting	22.4%	2.77%	<0.001 *
Social Media	11.04%	12.22%	>0.05
E-Mail	4.15%	2.28%	>0.05
Letter	0.20%	0.00%	>0.05

Notes: TBI = Traumatic Brain Injury. HC = Health Comparison participant.

* denotes statistically significant value when $p < 0.05$.