Effect on Behavior Problems of Teen Online Problem-Solving for Adolescent Traumatic Brain Injury

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KEY WORDS

adolescents, traumatic brain injury, telehealth, behavioral interventions

ABBREVIATIONS

TBI—traumatic brain injury
SES—socioeconomic status
TOPS—teen online problem-solving
IRC—Internet resource comparison
GCS—Glasgow Coma Scale
CBCL—Child Behavior Checklist
YSR—Youth Self-report
IBQ—Interaction Behavior Questionnaire

All of the authors made substantive intellectual contributions to the study, provided suggestions on previous drafts of the manuscript, and reviewed the final manuscript. Dr Wade was the principal investigator on the project, and she designed the study with input from others, oversaw all aspects of implementation, conducted the statistical analyses, and drafted the manuscript; Dr Walz was coinvestigator on the project, and she assisted in study conceptualization and design, development of the treatment modules, and preparation of the manuscript; Dr Carey assisted in development of the intervention content and treatment manual, served as a study therapist, and assisted in preparation of the manuscript; Ms McMullen assisted in the development of the intervention content and pretreatment and posttreatment assessments, oversaw data collection, entry, and management at participating sites, and assisted in preparation of the manuscript; Dr Cass oversaw intervention implementation and assisted in the conceptualization, analysis, and write-up of the findings in the manuscript; Ms Mark assisted in development of the treatment manual, served as a study therapist, and assisted in preparation and conceptualization of the manuscript; and Dr Yeates was the principal investigator in Columbus, oversaw all aspects of implementation at that site, and also assisted in the conceptualization, analysis, and write-up of the findings in the manuscript.

These results were presented in part at the annual meeting of the Ohio Brain Injury Association, October 1, 2009, Columbus, OH; and the annual conference of the American Psychological Association, August 15, 2010, San Diego, CA.

This trial has been registered at www.clinicaltrials.gov (identifier NCT00409058).

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WHAT'S KNOWN ON THIS SUBJECT: Traumatic brain injury in teenagers may lead to increased behavior problems and corresponding deterioration in family relationships. Family-centered training in problem-solving skills may facilitate improvements in behavior and self-management after traumatic brain injury, but this strategy has not been tested with teens.

WHAT THIS STUDY ADDS: A comparison of teen online problem-solving (TOPS) with access to Internet resources for treatment of teenagers after traumatic brain injury revealed lower family conflict after TOPS and improvements in behavior among teens with severe injury or lower socioeconomic status.

abstract

PURPOSE: To report the results of a randomized clinical trial of teen online problem-solving (TOPS) meant to improve behavioral outcomes of adolescents with traumatic brain injury (TBI).

METHODS: A randomized clinical trial was conducted to compare the efficacy of TOPS with access to Internet resources in teenagers with TBI in improving parent and self-reported behavior problems and parent-teen conflicts. Participants included 41 adolescents aged 11 to 18 years (range: 11.47–17.90 years) who had sustained a moderate-to-severe TBI between 3 and 19 months earlier. Teens in the TOPS group received 10 to 14 online sessions that provided training in problem-solving, communication skills, and self-regulation. Outcomes were assessed before treatment and at a follow-up assessment an average of 8 months later. Groups were compared on follow-up scores after we controlled for pretreatment levels. Injury severity and socioeconomic status were examined as potential moderators of treatment efficacy.

RESULTS: Forty-one participants provided consent and completed baseline assessments, and follow-up assessments were completed for 35 participants (16 TOPS, 19 Internet resource comparison). The TOPS group reported significantly less parent-teen conflict at follow-up than did the Internet-resource-comparison group. Improvements in teen behavior after TOPS were moderated by injury severity; there were greater improvements in the teens' internalizing symptoms after TOPS among adolescents with severe TBI. Family socioeconomic status also moderated the efficacy of TOPS in improving behavior problems reported by both parents and teens, although the nature of the moderation effects varied.

CONCLUSION: Our findings suggest that TOPS contributes to improvements in parent-teen conflict generally and parent and self-reported teen behavior problems for certain subsets of participants. *Pediatrics* 2011;128:e947–e953

Traumatic brain injury (TBI) is a leading cause of acquired disability in childhood, and incidence peaks during adolescence.¹ Consequences include persistent changes in cognitive abilities, executive functions, behavior, and social competence.²⁻⁴ Families are also adversely affected, particularly after severe TBI.^{5,6} Injuries during adolescence may contribute to difficulties negotiating normative developmental transitions such as dating, driving a car, and getting a job. Parental concerns coupled with deterioration in the teen's problem-solving skills and self-regulation can result in increased conflict and additional deterioration in teen behavior.

Few evidence-based treatments exist to facilitate adolescent and family adaptation after TBI.⁷ A trial of online family problem-solving for children aged 5 to 17 years with moderate-to-severe TBI provided preliminary evidence that a family problem-solving treatment may result in greater improvements in self-management and compliance among older children and adolescents.⁸ In this study, socioeconomic status (SES) and the child's age moderated treatment efficacy with greater effects in children 11 and older and those of lower SES.

Building on this previous study, we modified online family problem-solving to address the needs of adolescents by placing increased emphasis on metacognitive strategies, self-regulation, and emotion control.⁹ In the current investigation we examined the efficacy of teen online problem-solving (TOPS) relative to access to Internet resources regarding TBI (Internet resource comparison [IRC]). We hypothesized that teens and families who participated in TOPS would show greater reductions in adolescent behavior problems and parent-teen conflict than teens who participated in IRC. On the basis of previous research re-

sults,⁶ we also hypothesized that demographic characteristics and injury severity would moderate the efficacy of the TOPS treatment, and that adolescents with severe TBI and those of lower SES would show greater improvement than those with moderate TBI or those of higher SES.

PATIENTS AND METHODS

Participants

Participants were recruited from 2 urban children's hospitals. Eligible children were between 11 and 18 years old and had to have been hospitalized after a moderate-to-severe TBI in the previous 18 months. A severe TBI was defined as a lowest Glasgow Coma Scale (GCS)¹⁰ score of ≤ 8 ; a moderate TBI was defined as a GCS score between 9 to 12, or a GCS score of >12 accompanied by abnormal imaging or other evidence of neurologic impairment. Children were excluded if English was not the primary language spoken in the home; if there was a history of child abuse documented in the medical records; if the teen could not communicate sufficiently to participate in the sessions; if the teen had ever been hospitalized for psychiatric reasons; or if the primary caregiver had been hospitalized for psychiatric reasons in the previous 5 years.

Procedure

Random Assignment

After we obtained informed consent from the participating parents and assent from teens, families were randomly assigned to either the TOPS or IRC group by use of a randomization scheme that stratified participants on the basis of the adolescent's gender and race/ethnicity to ensure comparable diversity in each group. Given the nature of the study, we were unable to conceal group assignment from the participants and research staff; however, the primary outcome measures

were based on parent and teen report and therefore not dependent on judgments of research staff.

Therapist and Interviewer Training

Training of therapists and coordinators is detailed elsewhere.¹¹ Treatment fidelity was maintained through weekly supervision sessions among the 2 therapists and the supervising psychologists at each site. End-of-session checklists completed by the therapist and family indicated excellent correspondence between actual session content and intervention objectives.

Pretreatment and Posttreatment Assessments

During the initial visit, the research assistant administered baseline measures and instructed participants how to log onto the Web site. Families in both groups were given high-speed Internet access, when available, and families who did not have an existing home computer were given one to use during the course of the study. Follow-up assessments were completed 7.83 months (SD: 1.05 months) after baseline in the TOPS group and 7.92 months (SD: 2.88 months) after baseline in the IRC group ($t_{34} = 0.12$).

Description of the TOPS intervention

The TOPS intervention protocol and Web site are described more fully elsewhere.⁹ During the initial in-home session, the therapist identified goals that the teen and family wanted to address and trained the family on navigating the TOPS Web site and using the videoconferencing software. All subsequent sessions were conducted remotely by using online videoconferencing or, in rare instances when videoconferencing was not possible, over the telephone.

Core Web-site modules provided training in problem-solving, plan-

ning/organization, self-regulation, anger management, verbal/nonverbal communication, and social problem-solving to all TOPS participants. For participants with issues not addressed by the core content, supplemental sessions provided information and skills training pertaining to pain management, sleep and memory issues, sibling concerns, transitioning after high school, parental guilt and grief, marital strains, and parent-teen communication. Families were encouraged to complete all 10 core sessions and could complete up to 4 supplemental sessions according to their individual needs.

The teen and his or her primary caregiver were required to complete the initial face-to-face session and subsequent videoconferences together with the therapist. They were also instructed to complete the self-guided Web modules together before each session with the therapist. Both parents, in 2-parent families, and siblings were also encouraged to participate, although this participation was not required. As part of the Web-site log in, participants indicated which family members were completing the module, and some of the interactive exercises required separate responses from each participating family member.

After completion of each Web module, the family met with the therapist via videoconference. The therapist reviewed the Web-site content and worked with the family to apply the problem-solving process with the goal of generating a plan to address a problem or goal identified by the family, giving the family experience in implementing the self-regulation skills taught through the self-guided Web pages.

Description of the IRC Intervention

Families in both the TOPS and IRC groups received access to a home Web page of brain injury resources and

links to online resources, but those in the IRC group did not have access to the specific session content offered in TOPS nor did they receive the synchronous videoconferences with the therapist. Resources included links to local, state, and national brain-injury associations and to sites specific to pediatric brain injury, such as the Center on Brain Injury Research and Training. Families were encouraged to spend at least 1 hour per week accessing the resources during the 6-month intervention; however, there was no requirement that parents and teens visit the Web sites together. Parents provided information about the Web sites visited and the time spent on each at the follow-up assessment. Contamination between the treatments as a function of contact among participants was unlikely given that neither of the participating medical centers had regularly scheduled TBI follow-up clinics or support groups.

Measures

Adolescent Adjustment

The Child Behavior Checklist (CBCL), a 113-item parent-report measure of child behavior problems, served as a measure of adolescent adjustment.¹² The Youth Self-report (YSR) is a self-report scale of behavior problems that parallels the CBCL.¹² The internalizing and externalizing behavior problem total scores from both the CBCL and YSR were treated as the primary outcomes in the current study. Both the CBCL and YSR generate standard (*T*) scores normalized for age and gender, with a mean of 50 and an SD of 10; higher scores reflect more problems. Results of previous studies of TBI indicate that the CBCL is sensitive to behavioral changes after pediatric TBI.

Family Conflict

Parent-adolescent communication and conflict behavior were assessed by using a 20-item short form of the

Interaction Behavior Questionnaire (IBQ).¹³ The IBQ was completed by both the parents and the adolescent. Respondents are asked to rate each statement as true or false. Items common to both the parent and adolescent versions include statements such as the following: "We almost never seem to agree" and "At least 3 times a week, we get angry at each other." Total scores can range from 0 to 20 on both the parent and adolescent versions. Normative data for the IBQ indicate that total scores for nonclinical samples ranged from 1.6 to 3.2, depending on the rater (parent versus child), and total scores for families in treatment ranged from 7.6 to 12.4.¹³

Analyses

We conducted *t* tests and χ^2 analyses or Fisher's exact tests to compare the TOPS and IRC groups on continuous and dichotomous background and injury characteristics, respectively. Similar analyses were conducted to examine baseline differences between those who completed the study and those who dropped out. Overall group differences were examined by using analysis of covariance, in which the baseline score on the measure of interest served as a covariate allowing us to assess change over time. Multiple regression analyses were used to examine the potential roles of family income and injury severity in moderating treatment response. In the model tested we controlled for the baseline score on the dependent variable of interest before analysis of the main effect for the moderator (ie, income), the effect for group, and the interaction of the group and the moderator. Given the small sample size and the difficulty of interaction detection, the 2 hypothesized moderators were considered in separate models. Partial η^2 provided a measure of effect size.

TABLE 1 Demographic and Injury Characteristics According to Treatment Group

	IRC	TOPS	<i>t/χ^{2a}</i>
Age at baseline, mean (SD), y	14.49 (2.13)	14.02 (2.45)	0.62
Age at injury, mean (SD), y	13.66 (2.22)	13.46 (2.82)	0.25
Time from injury to baseline, mean (SD), mo	10.32 (4.42)	8.75 (5.51)	0.93
Male, <i>n</i> (%)	11 (58)	6 (38)	1.45
White, <i>n</i> (%)	17 (89)	15 (94)	0.20
GCS score, mean (SD)	10.50 (4.63)	9.47 (4.61)	0.64
Income, mean (SD)	5.58 (3.39)	5.63 (3.24)	−0.04
WASI IQ, mean (SD)	98.68 (12.11)	105.19 (16.02)	−1.37
Premorbid LD/ADHD, <i>n</i> (%)	5 (26)	1 (6)	2.46

Family income was assessed by using a Likert scale. Income was coded in \$5000 to \$10 000 increments; 1 corresponds to incomes of less than \$20 000, and 9 corresponds to incomes of \$70 000 or higher. A rating of 5 corresponds to an income between \$35 000 and \$39 999, whereas a rating of 6 corresponds to an income between \$40 000 and \$49 999. WASI indicates the Wechsler Abbreviated Scale of Intelligence; LD, learning disability; ADHD, attention-deficit/hyperactivity disorder.

^a No significant group differences were found.

RESULTS

Participants

A total of 137 children were identified as potentially eligible for study participation on the basis of data from the trauma registry and subsequent review of medical records. The families of 87 of these children (63%) were successfully contacted regarding participation. Forty-two families (48%) consented to participate, and 41 completed the baseline assessment. Participants were representative of the broader sample with respect to age and race. Participants tended to have more severe injuries, although this difference was not statistically significant (mean GCS in participants: 9.58 [4.56] versus mean GCS in nonparticipants: 11.07 [4.09]; $t_{86} = 1.81$; $P = .07$). One TOPS family was subsequently dropped from the study because the primary caregiver lacked the cognitive capacity to complete the Web-based sessions. Of the 40 families who completed the baseline assessment and were retained in the study, 35 (88%) provided follow-up data. In the TOPS group, 4 of 20 families (20%) dropped out, compared with 1 of 20 (5%) in the IRC group. Although the difference was not statistically significant, TOPS participants may have been more likely to drop out than IRC participants because of the greater time commitment required. Comparison of completers and dropouts revealed no statistically significant differences in de-

mographic or injury characteristics or baseline behavior or family conflict.

As reported in Table 1, adolescents who completed both the baseline and follow-up assessment ranged in age from 11.47 to 17.90 years at baseline (mean: 14.27 years; SD: 2.26 years) and were between 3 and 19 months after injury (mean: 9.6 months; SD: 4.94 months). Fourteen (40%) had severe TBI and 21 (60%) had moderate TBI. Participants in the TOPS and IRC groups did not differ significantly with respect to demographic characteristics such as age or SES, nor did they differ in any of the parent or self-report measures of conflict and behavior before treatment (all $P > .28$). Three adolescents in TOPS and 2 in the IRC group were receiving other therapies concurrently with the study treatment.

Utilization and Satisfaction

Families in the TOPS intervention group completed an average of 10 sessions (range: 3–14), and all but 2 completed all 10 core sessions. Families in the IRC intervention reported spending an average of 0.5 to 1 hour per week at brain injury Web sites. Ratings of ease of logging on and navigating the Web did not differ across the 2 treatment conditions. Ninety-three percent of parents in the TOPS group and 68% of parents in the IRC group reported increased understanding of their child's

injury ($P > .05$). Significantly greater proportions of parents in the TOPS group (87% vs 50% in the IRC group; $P < .05$) reported that they reached the goals they had for the program, learned ways to improve their child's behavior, and understood their child better. Parents in the IRC group were more likely to report that the intervention content did not pertain to them (50% vs 13% in the TOPS group; $P < .05$).

Main Effects

Parents of adolescents in the TOPS group reported significantly lower levels of parent-teen conflict at follow-up than did those in the IRC group after we controlled for pretreatment levels of conflict (mean TOPS: 2.94 [3.99] versus mean IRC: 5.47 [4.98]; $F_{1,34} = 11.64$; $P = .002$). The corresponding effect size was large. However, adolescent ratings of parent-teen conflict did not differ between the groups (mean TOPS: 2.67 [3.75] versus mean IRC: 2.94 [4.22]; $F_{1,33} = 0.07$; $P = .9$). The groups also did not differ on either parent or teen reports of the adolescent's internalizing and externalizing symptoms at follow-up as assessed by use of the CBCL and YSR, respectively.

Moderating Effects of SES

As reported in Table 2 and depicted in Fig 1, SES as assessed by an ordinal ranking of family income moderated the efficacy of TOPS in improving behavior problems according to reports by both parents and teens. SES moderated improvements in parent-reported adolescent externalizing symptoms on the CBCL ($F_{1,30} = 4.45$; $P = .04$). Table 2 shows the posttreatment scores for the TOPS and IRC groups at high and low levels of family income statistically adjusted for the baseline score on the respective measure. As depicted in Fig 1, TOPS was associated with greater improvements in parent-reported teen externalizing symptoms among chil-

TABLE 2 CBCL and YSR Internalizing and Externalizing Subscales at Follow-up According to High and Low Family Income and Treatment Group

Outcome	Low Income, Mean (SE)		High Income, Mean (SE)		$F_{1,30}$
	IRC ($n = 8$)	TOPS ($n = 8$)	IRC ($n = 11$)	TOPS ($n = 8$)	
CBCL Ext	57.92 (3.07)	49.83 (3.07)	48.87 (1.65)	49.43 (1.95)	4.45 ^a
CBCL Int	54.15 (2.82)	47.72 (2.82)	54.84 (2.30)	53.72 (2.71)	1.62
YSR Ext	51.87 (1.86)	54.26 (1.86)	51.21 (2.39)	40.58 (2.99)	7.38 ^a
YSR Int	53.50 (2.17)	56.13 (2.17)	50.09 (2.54)	44.63 (2.99)	4.70 ^a

Data are adjusted means and SEs controlled for baseline scores. F values reflect the significance of the R^2 for the interaction term of the group with injury severity. Ext indicates externalizing total; Int, internalizing total.

^a $P < .05$.

FIGURE 1

Means for the CBCL externalizing scale at baseline and follow-up according to group and SES. The influence of SES, as defined by family income, on improvement from baseline to follow-up according to group (TOPS and IRC) is shown. Group differences between the TOPS and IRC groups in externalizing symptoms at follow-up approached significance among families of lower SES ($F_{1,15} = 3.45$; $P = .09$).

dren with lower SES. The TOPS intervention had a large effect on parent-reported externalizing problems among adolescents of lower SES (partial $\eta^2 = 0.21$).

SES also moderated teen self-reported improvements in internalizing and externalizing totals of the YSR (internalizing: $F_{1,30} = 4.70$; $P = .04$; externalizing: $F_{1,30} = 7.38$; $P = .01$). As reported in Table 2, adolescents of higher income in the TOPS group reported significantly greater improvements in externalizing symptoms ($P = .01$) than those in the IRC group; whereas there were no differences between the groups among adolescents of lower in-

come (see Fig 2). The effects of TOPS on teen-reported externalizing symptoms were large (corresponding partial $\eta^2 = 0.34$). Adolescents of higher SES in the TOPS group also reported greater improvements in internalizing symptoms, although the group differences between the TOPS and IRC groups did not achieve significance among the teens from families with high incomes, and the effect sizes were moderate.

Moderating Effects of Injury Severity

Injury severity moderated the effects of TOPS on parent-reported teen internalizing symptoms on the CBCL ($F_{1,30} =$

6.97; $P = .01$). As reported in Table 3, separate analysis of covariance controlled for baseline levels of symptoms for participants with severe and moderate TBI revealed significant group differences at follow-up among those with severe TBI, but not those with moderate TBI. The corresponding effect sizes were large (partial $\eta^2 = 0.34$). Injury severity did not moderate improvements in self-reported internalizing or externalizing symptoms on the YSR, although there was a trend for teens with severe injuries to report lower levels of externalizing symptoms at follow-up.

CONCLUSIONS

Our results suggest that TOPS, a Web-based problem-solving treatment for teens with TBI and their families, may be effective in reducing parent-teen conflict and improving externalizing and internalizing behavior problems within certain subgroups. Parents in the TOPS group reported greater reductions in conflict with their adolescents than did parents in the IRC group. Improved parent-teen relationships may contribute to additional improvements in the teen's behavior over time.¹⁴

According to parent reports, teens of lower SES and those with severe TBI were more likely to demonstrate behavioral improvements after TOPS. Previous investigations have linked low SES and severe TBI to worse behavioral outcomes; the combined effects of low SES and severe TBI have resulted in significantly poorer long-term recovery.^{2,3,4} In a previous study of online family problem-solving for TBI, children from families of lower SES demonstrated greater improvements after the intervention relative to children of lower SES in the control group.⁸ In the current study, both family income and lowest GCS score had significant negative correlations with externalizing symptoms at baseline.

FIGURE 2

Means for the YSR externalizing scale at baseline and follow-up according to group and SES. The influence of SES, as defined by family income, on improvement from baseline to follow-up according to group (TOPS and IRC) on externalizing symptoms on the YSR is shown. Teens of higher SES in the TOPS group reported significant improvements in externalizing symptoms from baseline to follow-up ($t_7 = 10.05$; $P = .001$), whereas those of lower SES in the TOPS group and those in the IRC group reported minimal change.

TABLE 3 CBCL and YSR Internalizing and Externalizing Subscales at Follow-up According to TBI Severity and Treatment Group

Outcome	Severe TBI, Mean (SE)		Moderate TBI, Mean (SE)		$F_{1,29}$
	IRC ($n = 7$)	TOPS ($n = 7$)	IRC ($n = 12$)	TOPS ($n = 9$)	
CBCL Int	55.44 (2.99)	44.56 (2.99)	50.60 (1.89)	52.42 (2.17)	6.32 ^a
YSR Ext	59.01 (2.58)	50.85 (2.58)	46.49 (1.69)	45.56 (1.97)	3.91
YSR Int	54.57 (3.82)	53.86 (3.82)	49.14 (1.98)	48.48 (2.30)	0.12

Data are adjusted means and SEs controlled for baseline scores. F values reflect the significance of the R^2 for the interaction term of the group with injury severity. Int indicates internalizing total; Ext, externalizing total.

^a $P < .05$.

Thus, the adolescents who benefited most from the TOPS intervention were those who were likely to have the most significant behavioral consequences initially. In a related study, adolescents with severe TBI who received TOPS were found to report significantly greater improvements in executive function skills than adolescents with severe TBI in the IRC.¹¹

It was surprising that improvements on the YSR internalizing and externalizing scales were greater among teens of higher SES. Self-report means for externalizing behavior problems were in the average range for all 4 groups, and the TOPS high-SES group had the

lowest self-reported symptoms initially. Although all teens perceived themselves as doing well, the high-SES TOPS group perceived themselves as doing better, whereas the low-SES IRC group had significantly more behavior problems according to parents' reports. One possible explanation is that adolescents of higher SES had greater cognitive resources, which enabled them to make use of the training in self-regulation and problem-solving to a greater extent than teens in the TOPS group of lower SES. However, given the relatively small sample size and unexpected nature of these findings, replication is warranted.

The study was limited by a relatively small and heterogeneous sample. Study design also precluded distinguishing improvements attributable to specific elements of the treatment (ie, training in problem-solving) from supportive involvement with a skilled therapist. Because TOPS integrated therapist support with Web-based skill building, generalization and dissemination to remote locales without skilled therapists may prove more challenging. Assessment of both family conflict and behavior problems relied solely on parent report or self-report, and thus reported improvements may have been inflated by social desirability biases. Parents in both groups reported increased knowledge of TBI, which suggests that both groups perceived benefits from the treatment received. Future studies would benefit from extended follow-up and objective measures of adolescent functioning.

These findings add to the literature that supports the utility of Web-based, family problem-solving interventions to improve outcomes after TBI.^{8,9} Web-based interventions may be especially appropriate for adolescents who have high levels of computer sophistication coupled with an aversion to traditional, office-based psychotherapy. Large, randomized clinical trials with longer-term follow-up will be necessary to establish the efficacy of these interventions.

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