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Sex Differences in Perceived Life Satisfaction and Functional Status One Year After Severe Traumatic Brain Injury

Karen L. Saban, Ph.D., R.N., APRN, CNRN,[1,2] Bridget M. Smith, Ph.D.,[1,3]
Eileen G. Collins, Ph.D., R.N., FAAN,[1,4] and Theresa Louise-Bender Pape, Dr.P.H., M.A., CCC-SLP/L[1,5]

Abstract

Aims: The primary aim of this study was to describe and compare perceived life satisfaction and perceived functional motor and cognitive status 1 year after severe traumatic brain injury (TBI) in males and females, adjusting for demographics and severity of injury.
Methods: Data of 297 participants were abstracted from the National Institute on Disability Rehabilitation and Research (NIDRR)-funded Traumatic Brain Injury Model Systems (TBIMS). Participants were aged 16–50, enrolled in the TBIMS study between the years 1998 and 2008, diagnosed with severe TBI (defined as having an initial Glasgow Coma Scale [GCS] score between 3 and 8), and with perceived life satisfaction and functional status data available at 1 year postinjury. Multiple linear regression models were used to estimate the association between sex, demographic variables, severity of injury, and the outcome variables.
Results: Our findings indicate that sex did not significantly influence perceived satisfaction with life or motor function 1 year after severe TBI. However, females had significantly better ($p = 0.031$) cognitive outcomes compared to males 1 year after severe TBI, after controlling for demographics and severity of injury.
Conclusions: Findings suggest that females may have better perceived cognitive functional outcomes than males 1 year after severe TBI. Further longitudinal research, including measurement of hormonal levels, is needed to determine if hormones influence outcomes of severe TBI as well as the trajectory of these outcomes. A better understanding of sex differences in outcomes after TBI will help clinicians improve strategies for rehabilitation.

Introduction

Traumatic brain injury (TBI) is the most common injury type in the United States, with over 1.1 million people treated in the emergency room for a TBI each year,[1] the majority of these patients being men.[2] Each year, over 50,000 individuals incurring TBI die, and 99,000 survive to live with permanent disability.[3] Furthermore, approximately 30% of people surviving a moderate or severe TBI will die within 30 days of the injury,[4] and only half of those surviving a severe TBI (i.e., initial Glasgow Coma Scale [GCS] score ≤ 8) for > 30 days will have a favorable neurological outcome 12 months postinjury.[5,6] Severe TBI causes significant cognitive, functional, and psychosocial impairments, including problems with memory, executive functioning, control of emotions, ability to perform activities of daily living (ADL), and return to work.[7]

The study of sex differences in TBI outcomes is an emerging area of research with the potential to improve quality of care. Evidence from animal studies suggests that estrogen and progesterone may offer protective effects in secondary brain injury. For example, after an ischemic insult, estrogen has been shown to stabilize the blood-brain barrier (BBB) to reduce cerebral edema,[8] improve blood flow by dilating cerebral arteries,[9,10] act as an antioxidant,[11] and suppress inflammation.[12] More recently, estrogen has been found to improve neurogenesis in mice after ischemic injury, potentially contributing to improved cognitive outcome.[13,14] Progesterone has also been found to have neuroprotective effects by protecting the BBB, decreasing cerebral edema, limiting cellular necrosis,[15] and inhibiting inflammation induced by cytokines.[15–17]

Clinical trials involving humans have begun to evaluate hormonal influences on ischemic brain injury outcomes. Wright et al.,[18] in the first human clinical trial of progesterone

[1]Center for Management of Complex Chronic Care, Edward Hines, Jr., Veterans Administration Hospital, Hines, Illinois.
[2]Department of Health Management and Risk Reduction, Marcella Niehoff School of Nursing, Loyola University Chicago, Maywood, Illinois.
[3]Health Services Research Program, Stritch School of Medicine, Loyola University Chicago, Maywood, Illinois.
[4]Department of Biobehavioral Health Sciences, College of Nursing, University of Illinois at Chicago, Chicago, Illinois.
[5]Department of Physical Medicine and Rehabilitation, Northwestern University Feinburg School of Medicine, Chicago, Illinois.

in TBI patients, found that administration of progesterone after severe TBI was associated with lower mortality rate at 30 days postinjury. This study was limited by a small sample size ($n = 100$ in treatment group) and inclusion of a relatively small percentage of females (29%). Furthermore, differences in sex outcomes were not reported. However, results of this study were corroborated in another small prospective, randomized, double-blinded trial of 159 adults (115 men and 44 women) who sustained a severe TBI and received intravenous progesterone or a placebo for 5 days. Results of this study suggested that progesterone-treated patients had significantly more favorable outcomes as measured by the Glasgow Outcome Scale (GOS) and Functional Independence Measure (FIM) at 3 and 6 months postinjury.[19] In addition, the mortality rate at 6 months was significantly lower for the progesterone-treated patients.[19] Similar to the study of Wright et al.,[18] sex differences for outcomes were not reported.

Although recent clinical trials have demonstrated evidence of the benefits of administering progesterone to patients after TBI, epidemiological studies investigating sex differences in TBI outcomes have not yet reached a consensus. Farace and Alves,[20] found that outcomes were worse for women on 85% of the study variables, which included severity of somatic/postconcussive complaints, return to work, and new psychiatric symptoms. Several other studies have supported the findings of Farace and Alves,[20] reporting that women experience worse functional outcomes after incurring moderate or severe TBI.[21,22] Poorer functional outcomes could be attributed to women in general, however, because women tend to report more somatic symptoms and worse quality of life across multiple diseases.[23–25] Conversely, a study of outcomes for persons with moderate and severe TBI 3 months postinjury indicated that women, matched for initial injury severity and age at injury, had better GOS scores.[26] In another study examining sex differences in executive functioning after TBI of all severities, women were found to perform significantly better on neuropsychological tests of problem solving and abstract reasoning at the time of acute rehabilitation discharge.[27]

Perceived life satisfaction after severe TBI has rarely been addressed in the scientific literature,[28–30] and even fewer studies have examined sex differences in life satisfaction after severe TBI. One study of 275 people who sustained a moderate or severe TBI an average of 14 years earlier, however, found that women reported a significantly higher quality of life.[31] The inclusion of both moderate and severe TBI combined with the lengthy time interval between injury and study time point make interpretation of these findings difficult. However, perceived life satisfaction is an important outcome measure for patients incurring severe TBI because perceived life satisfaction can be significantly and permanently altered after TBI.[32,33] A better understanding of perceived life satisfaction and potential sex differences in life satisfaction after severe TBI will help clinicians identify patients at risk for diminished life satisfaction. Identification of at-risk patients will enable development and implementation of customized interventions addressing the needs of people recovering from TBI.

Study aims

Only a few epidemiological studies have examined sex differences in TBI outcomes, and no studies were found that specifically considered sex differences in outcomes 1 year after severe TBI. Additionally, few studies addressed sex differences in life satisfaction for people incurring severe TBI. Small sample sizes, inadequate control of such possible confounding variables as injury severity, hypotension, variation in outcome measures, and varying study follow-up time make interpretation of reported findings difficult.[19,31] Therefore, the primary aim of this study was to describe and compare perceived life satisfaction and perceived functional motor and cognitive status 1 year after severe TBI in males and females aged 16–50, adjusting for demographics and injury severity. Given evidence in the literature indicating a protective effect of female hormones for TBI outcomes, we hypothesized that females would have better perceived life satisfaction and more autonomy with cognitively mediated activities and activities mediated by motor functioning 1 year after severe TBI when controlling for demographics and injury severity.

Materials and Methods

Participants

Data were obtained from the National Institute on Disability Rehabilitation and Research (NIDRR) Traumatic Brain Injury Model Systems (TBIMS) national multicenter longitudinal TBI outcomes database.[34] Institutional Review Board approval was granted at each participating TBIMS site, and informed consent was obtained from the patient or patient's family or legal guardian as appropriate. For the current study, 297 adult participants were included. Participants were aged 16–50, enrolled in the TBIMS study between the years 1998 and 2008, diagnosed with severe TBI (i.e., initial GCS of 3–8), and with life satisfaction data available at 1 year postinjury. As a further control of injury severity, we also limited eligibility to only those persons who were unconscious (i.e., unable to follow commands) for at least 28 days consecutively but who regained consciousness within 1 year. This additional criterion was used to ensure that the abstracted sample included only people incurring severe TBI and who experienced a prolonged state of disordered consciousness.

A total of 9028 records were available from all TBIMS sites, and 5425 of these participants had a GCS between 3 and 8 or were intubated or chemically paralyzed at the time of emergency room admission. Of these 5425 participants, 647 followed commands between 28 and 365 days, and 584 of the 647 participants were between the ages of 16 and 50. Of the 584 participants, 297 had life satisfaction data 1 year postinjury (Fig. 1).

Outcomes: Instrumentation and measures

Satisfaction with Life Scale (SWLS). Life satisfaction is defined as the cognitive-judgmental component of global subjective well-being.[35,36] The SWLS comprises five statements, and the extent of agreement with each statement is rated on a scale of 1–7, ranging from strongly disagree (rating of 1) to strongly agree (rating of 7). The five statements are: (1) In most ways my life is close to my ideal; (2) The conditions of my life are excellent; (3) I am satisfied with my life; (4) So far, I have gotten the important things I want in life; and (5) If I could live my life over, I would change almost nothing. Total score for the instrument ranges from 7 to 35, with higher scores indicating higher levels of perceived life satisfaction. Total scores are categorized as follows: (1) 30–35, very satis-

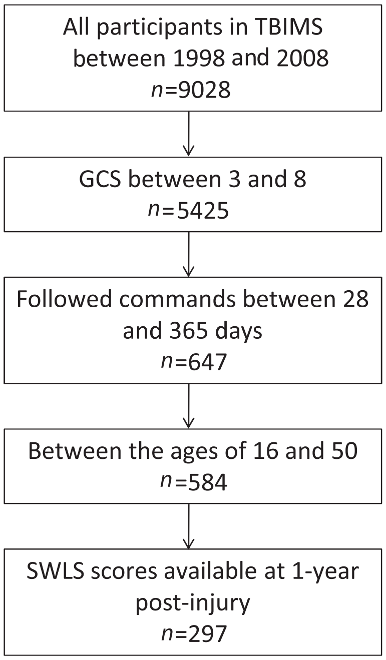

FIG. 1. Sample selection strategy. TBIMS, Traumatic Brain Injury Model Systems; GCS, Glasgow Coma Scale; SWLS, Satisfaction with Life Scale.

fied, (2) 25–29, highly satisfied, (3) 20–24, average, (4) 15–19, slightly below average, (5) 10–14, dissatisfied, and (6) 5–9, extremely dissatisfied. The SWLS has been found to be significantly positively correlated with other measures of subjective well-being, such as the Cantril and Fordyce.[36] In a factor analysis, based on a scree test of Eigen values, it was found that the SWLS represents one factor and accounts for 66% of the variance in the instrument.[36] Item to total score correlations ranged from 0.57 to 0.66.[36] Diener et al.[36] reported a Cronbach's alpha of 0.83 for the SWLS in a study of healthy undergraduate college students. Cronbach's alpha for the SWLS in this study was good at 0.79.

Functional Independence Measure (FIM). Functional status at 1 year postinjury was measured using the FIM. The FIM is a widely used 18-item scale covering the domains of self-care, sphincter control, transfers, locomotion, communication, and social cognition.[37] Each item is scored on a scale of 1–7, indicating complete dependence (1) to complete independence (7). The FIM motor subscale includes 13 items (with possible scores ranging from 13 to 91), and the FIM cognitive subscale consists of 5 items (with possible scores ranging from 5 to 35).[37] Higher scores represent higher levels of independence. Studies of the reliability and validity of the FIM indicate strong interrater reliability ($r = 0.95$),[38] and studies relevant to brain injury findings provide evidence of construct validity.[39] Reliability for the FIM motor and cognitive subscales at 1 year postinjury used in the current study had Cronbach's alphas of 0.88 and 0.91, respectively. Because the FIM cognitive and motor scores were not normally distributed, these scores were natural log transformed.[37]

Explanatory variables: Instrumentation and measures

Efficiency of rehabilitation. Rehabilitation efficiency was defined as the mean degree of functional improvement per day of acute rehabilitation.[40] Rehabilitation efficiency was calculated by subtracting the admission FIM total score from the discharge FIM total score and then dividing by the total number of days in acute rehabilitation.[40]

Injury severity. In addition to initial GCS scores, systolic blood pressure (SBP) at time of emergency room admission was entered as a continuous variable in regression models. SBP at the time of emergency room admission and the number of days to consistently following commands were used as indicators of injury severity.

Demographics. Demographics variables, such as age, sex, marital status at time of injury (married or not married), race (white or nonwhite), cause of injury (motor vehicle or non-motor vehicle), educational level (high school or no high school completion), and annual family income (≥$40,000 or <$40,000 per year), were self-reported measures by TBIMS participants.

Statistical analyses

Sex differences among demographics and injury characteristics were analyzed using independent *t* tests for continuous variables and chi-square tests for categorical variables. For each outcome variable, we estimated a separate multiple ordinary least squares regression model that included sex, demographic variables, and severity of injury as independent variables. The choice of variables to include in the models was guided by previous literature. The proportion of variation in the outcome measures that was explained by sex was measured using R-squared statistics for each regression model. All reported *p* values are two-sided. SPSS 16.0 (SPSS Inc, Chicago, IL) was used to analyze the data.

Results

Demographic and clinical characteristics of sample

Demographics and clinical characteristics are summarized in Table 1. Of the 297 participants, 84 (28.3%) were women and 213 (71.7%) were men. Age at time of injury ranged between 16 and 50 years (mean 26.85, median 24, standard deviation [SD] 9.11). Consistent with the mostly young age of participants, >78% were unmarried, and >50% had a high school education or less. The majority of participants were white (67.0%), and most (64.1%) had an annual family income of <$40,000. Mean SBP at time of ER admission was 129 mm Hg, and participants began consistently following commands an average of 44 days postinjury.

The mean FIM log-transformed motor score and cognitive scores at 1 year were 4.32 (equivalent to the nonlog-transformed mean score of 78.82) and 3.34 (equivalent to the nonlog-transformed mean score of 28.98), respectively, indicating that as a whole, this sample of participants was able to function independently if given additional time or equipment to facilitate autonomy. The mean SWLS score at 1 year postinjury (19.82, range 7–35) indicated a low to moderate level of life satisfaction (Table 2).

Univariate model: Sex differences

Independent *t* tests revealed no significant unadjusted differences between males and females in terms of age, marital

Table 1. Demographic and Clinical Characteristics of Males and Females 1 Year After Severe Traumatic Brain Injury and Sex Differences

Variable	All (n = 297)	Males (n = 213)	Females (n = 84)	p
Age, years				
Mean	26.85	27.06	26.30	0.516
Range	16–50	16–50	16–50	
(SD)	(9.11)	(8.97)	(9.49)	
Marital status, *n* (%)				0.875
Married	63 (21.2)	46 (21.6)	17 (20.2)	
Not married	234 (78.8)	167 (71.4)	67 (79.8)	
Race, *n* (%)				0.683
White	199 (67.0)	141 (66.2)	58 (69.0)	
Black, Hispanic, and other	98 (33.0)	72 (33.8)	26 (31.0)	
Education, *n* (%)				0.022*
High school or less	158 (53.6)	124 (58.5)	34 (41.0)	
More than high school	86 (29.2)	54 (25.5)	32 (38.6)	
Family annual income, *n* (%)				0.869
<$40,000	125 (64.1)	89 (63.6)	36 (65.5)	
≤$40,000	70 (35.9)	51 (36.4)	19 (34.5)	
Cause of injury, *n* (%)				0.032*
MVA	189 (64.1)	127 (60.2)	62 (73.8)	
Non-MVA	106 (35.9)	84 (39.8)	22 (26.2)	
SBP at ER admission (mm Hg) (SD)	129.33 (30.76)	132.35 (31.79)	121.8 (26.74)	0.008*
Days of unconsciousness (SD)	44.41 (18.4)	43.29 (15.47)	47.24 (25.35)	0.104
Rehabilitation efficiency (SD)	1.27 (0.93)	1.29 (0.95)	1.20 (0.87)	0.462

*Significant at ≤0.05 level.
ER, emergency room; MVA, motor vehicle accident; SBP, systolic blood pressure; SD, standard deviation.

status, race, family income, number of days until consistently following commands, and rehabilitation efficiency (Table 1). However, females were significantly more likely than males to have completed high school ($p = 0.022$). In addition, males were more likely than females to have had their injury caused by something other than a motor vehicle accident (such as motorcycle accident, sporting accident, or assault) ($p = 0.032$). SBP at emergency room admission was significantly lower for females than for males ($p = 0.008$); however, this is not a clinically significant difference. On further analysis, there was no significant difference between males and females in the number of participants who had an emergency room SBP of ≤of 90 mm Hg ($p = 0.207$).

In terms of 1 year postinjury outcomes, there were no unadjusted significant differences in motor and cognitive functional status between males and females (Table 2). However, quality of life was significantly lower in females than in males ($p = 0.020$) before adjusting for demographics and severity of injury indicators.

Adjusted models

The results of the multiple regression models are shown in Table 3.

Satisfaction with life 1 year postinjury. After controlling for age, number of days to command following, race, family income, educational level, marital status, cause of injury, emergency room SBP, rehabilitation efficiency, and motor and cognitive FIM scores 1 year postinjury, sex was not significantly associated with SWLS at 1 year postinjury. Only age was a significant predictor ($p = 0.020$) of SWLS at 1 year postinjury. The age coefficient (1.81) suggested that increased age is associated with higher levels of life satisfaction 1 year after injury. Overall, the demographic and clinical characteristics explained only a small portion of the variance in SWLS ($R^2 = 0.054$, $p = 0.047$).

Autonomy of motor functioning 1 year postinjury. After controlling for age, number of days to following command,

Table 2. Results of Key Variables and Sex Differences (Unadjusted)

Variable	All (n = 297)	Male (n = 232)	Female (n = 91)	p
Total SWLS (SD)	19.82 (7.65)	20.67 (7.62)	18.49 (7.71)	0.020*
FIM (motor) (SD)[a]	4.32 (0.344)	4.33 (0.315)	4.29 (0.407)	0.259
FIM (cognitive) (SD)[a]	3.34 (0.232)	3.34 (0.237)	3.36 (0.223)	0.473
FIM (total) (SD)	4.65 (0.263)	4.66 (0.251)	4.63 (0.295)	0.461

*Significant at ≤.05 level.
[a]FIM motor and FIM cognitive scores have been log transformed.
FIM, Functional Independence Measure; SWLS, Satisfaction with Life Scale.

Table 3. Predictors of 1 Year Satisfaction with Life Scale, 1-Year Functional Independence Measure Motor, and 1 Year Functional Independence Measure Cognitive After Severe Traumatic Brain Injury Using Multiple Regression

	1 Year SWLS			*1 Year FIM motor*			*1 Year FIM cognitive*		
	b (SE)	*β*	p	*b (SE)*	*β*	p	*b (SE)*	*β*	p
Sex	1.15 (1.35)	0.069	0.396	0.053 (0.056)	0.068	0.345	−0.079 (0.037)	−0.165	0.031*
Age	0.181 (0.077)	0.214	0.020*	−0.002 (0.003)	−0.060	0.465	0.002 (0.002)	0.087	0.323
Days of unconsciousness	−0.007 (0.041)	−0.015	0.866	−0.004 (0.002)	−0.166	0.034*	−0.002 (0.0001)	−0.126	0.129
Race	0.699 (1.30)	0.044	0.593	−0.111 (0.054)	−0.151	0.042*	0.022 (0.036)	0.050	0.529
Family income	2.00 (1.29)	0.130	0.124	0.073 (0.055)	0.101	0.185	0.020 (0.036)	0.045	0.574
Education	−2.28 (1.26)	−0.150	0.072	−0.001 (0.053)	−0.002	0.980	0.030 (0.035)	0.069	0.387
Marital status	1.09 (1.62)	0.061	0.499	0.032 (0.068)	0.038	0.639	0.044 (0.045)	0.085	0.327
Cause of injury	−0.302 (1.26)	−0.019	0.811	−0.021 (0.053)	−0.030	0.685	0.062 (0.035)	0.138	0.077
ER SBP	−0.017 (0.018)	−0.074	0.334	0.000 (0.0001)	−0.012	0.867	0.001 (0.000)	0.099	0.182
Rehabilitation efficiency	−1.35 (0.791)	−0.157	0.089	0.158 (0.031)	0.392	0.000*	0.055 (0.020)	0.223	0.008*
1 year FIM motor	3.39 (2.03)	0.159	0.096	–	–	–	–	–	–
1 year FIM cognitive	−1.18 (3.08)	−0.034	0.703	–	–	–	–	–	–
Adjusted R^2 (significance)	5% (0.047)			22% (0.000)			11% (0.001)		

*Significant at <0.05.
b, unstandardized coefficient; SE, standard error; β, standardized beta value.

race, family income, educational level, marital status, cause of injury, emergency room SBP, and rehabilitation efficiency, sex was not significantly related to FIM motor score 1 year after injury. However, number of days to consistently following commands ($p = 0.034$), race ($p = 0.42$), and rehabilitation efficiency ($p < 0.0001$) were related to FIM motor scores 1 year postinjury when controlling for demographic and clinical characteristics. As number of days to consistently following commands increased, the 1 year FIM motor score decreased (b = −0.004, $p = 0.034$). White participants had better FIM motor scores than nonwhite participants (b = −0.111, $p = 0.042$), controlling for demographic and clinical characteristics. Furthermore, better rehabilitation efficiency was associated with better 1 year FIM motor scores (where b is the unstandardized coefficient; b = 0.158, $p < 0.001$). The demographic and clinical characteristic variables predicted 22% of the variance in the 1 year FIM motor score ($p < 0.001$).

Autonomy with cognitively mediated activities 1 year postinjury. While controlling for age, number of days until consistently following commands, race, family income, educational level, marital status, cause of injury, emergency room SBP, and rehabilitation efficiency, sex was significantly ($p = 0.031$) related to the 1 year FIM cognitive scores. Females had better FIM cognitive scores while controlling for demographic and clinical characteristics (b = −0.079). Additionally, rehabilitation efficiency was significantly ($p = 0.008$) related to the 1 year FIM cognitive scores, indicating that better rehabilitation efficiency predicted higher levels of autonomy with cognitively mediated activities at 1 year. This model predicted 11% ($p = 0.001$) of the variance in the 1 year FIM cognitive score.

Discussion

Because previous epidemiological studies comparing sex differences in functional outcomes after TBI have been difficult to interpret, we examined functional outcomes and perceived life satisfaction in males and females between the ages of 16 and 50 one year after severe TBI. Given previous findings that hormones have a neuroprotective role in TBI outcomes, we expected to find that females would report better perceived life satisfaction and have higher levels of autonomy with cognitively mediated activities and activities mediated by motor functioning 1 year after severe TBI. Sex, however, was found to be a significant predictor only for autonomy with cognitively mediated activities and not for perceived life satisfaction or autonomy with activities mediated by motor functioning 1 year after severe TBI.

Given that life satisfaction has seldom been reported for patients with severe TBI, it is important to note that we found a slightly below average to average life satisfaction for both men and women. These findings are consistent with findings of Mailhan et al.,[29] who reported life satisfaction scores of patients 2 years after severe TBI to be flat, suggesting that participants were neither satisfied nor dissatisfied with their lives. In contrast, Lippert-Gruner et al.[30] found that patients with severe TBI reported poor quality of life 12 months after injury, although scores had improved from 6 months. Andelic al.[28] found that quality of life 10 years after moderate to severe TBI was significantly lower than that of the general population. Different measures of life satisfaction and duration of time since injury make comparison of our findings with previously reported findings difficult.

Only a few studies have specifically considered functional outcomes after severe TBI. A total mean FIM score of 107.8 (mean log-transformed FIM score of 4.65) at 1 year postinjury in our study indicated that the majority of the sample functioned with modified independence, requiring additional time or equipment to facilitate autonomy with cognitively mediated activities and activities mediated by motor functioning. These levels of functional autonomy are better than levels reported in other studies. For example, Whitlock and Hamilton[41] reported an average total FIM score of 79.0 in a retrospective study of 328 patients about 1 year after severe TBI (drawn from the Uniform Data System for Medical Rehabilitation dataset between 1989 and 1991). Likewise, in a small study of 24 patients with severe TBI , the mean total FIM was 88.0 1 year after injury.[42] Conversely, in a study of 101 patients (mean age 41) with severe TBI, the mean total FIM at 6 months postinjury was 125.0.[43] Inclusion of different age ranges may have influenced the findings of these studies, although, findings may also be attributed to the inclusion of patients who received rehabilitation who may have had a better prognosis than those patients who did not qualify for rehabilitation.

Our finding of significant sex differences in autonomy with cognitively mediated activities 1 year after severe TBI is different from previously published findings. For example, Graham et al.[40] examined 18,413 participants from the Uniform Data Systems for Medical Rehabilitation database and found that gender was not significantly correlated with FIM motor ($p = 0.223$) or FIM cognitive ($p = 0.740$) scores at acute rehabilitation discharge, when controlling for demographic differences, case complexity, admission functional status, and length of rehabilitation stay. Their study, however, limited the sample to participants aged $\geq$65 and included all levels of injury severity.[40]

Our findings indicate that females incurring severe TBI who are admitted to acute rehabilitation have significantly higher levels of perceived autonomy with cognitively mediated activities 1 year after injury compared to male patients with similar injury severity. This finding is consistent with those of Niemeier et al.,[27] in which women outperformed men on various neuropsychological tests of executive functioning during acute rehabilitation for TBI. It must be noted, however, that we measured perceived autonomy with cognitively mediated activities and that formal neuropsychological testing of cognitive performance may have yielded different results.

Our findings are also consistent with animal model studies that have demonstrated better cognitive outcomes, such as memory, after ischemic brain injury, suggesting a hormonal influence on TBI outcomes. Our results suggest that females, when compared to males, have significantly higher levels of perceived autonomy with cognitively mediated activities 1 year after severe TBI, after controlling for demographics, severity of injury, and clinical characteristics.

Study limitations

Several study limitations should be considered. We abstracted the study sample from a national acute rehabilitation database to examine the relationship between gender and life satisfaction, cognitive function, and motor function 1 year after a severe TBI. The abstracted sample represents persons incurring severe TBI who meet criteria for admission to acute rehabilitation. As this criterion requires rehabilitation candidates to demonstrate an ability to actively engage in rehabilitation, the sample includes persons with better prognoses. People in a vegetative state are not able to actively engage in rehabilitation and are, therefore, not likely to be admitted to acute rehabilitation; therefore, the sample abstracted from this national acute rehabilitation database included people with higher levels of responsiveness at time of rehabilitation admission, thus having better prognoses relative to persons not admitted to rehabilitation.[44,45] Considering this sample bias, we employed three mechanisms to control for injury severity. We limited the sample to participants with an emergency room GCS score between 3 and 8 but who also experienced a loss of consciousness for at least 28 days consecutively and regained consciousness within 365 days. We further controlled for injury severity by including emergency room SBP and rehabilitation efficiency as potential confounding variables. Regardless, our findings cannot be generalized to patients who do not qualify for acute rehabilitation after severe TBI.

Although we attempted to include only premenopausal women in our study by limiting the age range from 16 to 50, we cannot be confident that the women in this study were premenopausal; this datum was not available in the database. Furthermore, without hormone levels, we can only speculate that our results are related to sex differences in hormones. Alternatively, sex differences found in this study may have been influenced by factors other than sex-related hormones. In addition, although data were available in the TBIMS database related to depression, large amounts of missing data precluded us from including depression as a confounding variable in our models. Depression has been widely shown to influence perceived life satisfaction and should be included in future research. Also, our measure of cognition was a measure of perceived autonomy with cognitively mediated activities and did not include formal neuropsychological testing.

Important to note, the SWLS is a global measure of life satisfaction. Assessing global life satisfaction 1 year after severe TBI may be too early in the recovery trajectory. Future research is needed to further assess perceived life satisfaction over time as the person recovers from severe TBI. Given the global nature of the SWLS, it may not have been sensitive enough to detect satisfaction with life specific to the changes that result from severe TBI. Studies have demonstrated that self-efficacy[46,47] and perceived independence[48] highly correlate with quality of life after TBI. Given that our model explained only a small amount (5%) of the variance in the SWLS, it is possible that other factors not measured in this study, such as family support, job satisfaction, and community integration, may influence life satisfaction to a greater degree than biological sex. Inclusion of these additional variables in future studies may help further explain possible mediators or moderators of quality of life in people with severe TBI.

Although the SWLS is one of the more commonly used tools to measure global life satisfaction in patients with TBI, there is no consensus in the literature about the best instrument to use to measure quality of life in this population. Multidimensional measures may better capture the complexities of quality of life in the TBI patient. Recently, the Quality of Life Inventory (QOLI)[49,50] has been suggested as a multidimensional quality of life instrument for patients with TBI. Others have combined quality of life questions from multiple instruments in an attempt to reflect quality of life domains unique to the TBI population.[51] Clearly, the development and evaluation of quality of life measures for persons with TBI is an important area of future research.

Conclusions

Our findings suggest that females admitted to acute rehabilitation after severe TBI, relative to males, have higher levels of autonomy with cognitively mediated activities 1 year after severe TBI. Further longitudinal research, including measurement of hormonal levels, is needed to determine if hormones influence outcomes of severe TBI as well as the trajectory of these outcomes. A better understanding of sex differences in outcomes after TBI will help clinicians develop and customize rehabilitation treatments and interventions. Finally, our study contributes to a more comprehensive understanding of sex influences on TBI outcomes, specifically after severe TBI, which may help advance future research into the administration of hormones in patients with TBI.

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Address correspondence to:
Karen L. Saban, Ph.D., R.N.
Loyola University Chicago
Marcella Niehoff School of Nursing
Maguire Building, Room 2840
2160 S. First Avenue
Maywood, IL 60153

E-mail: ksaban@luc.edu