Trajectories of Life Satisfaction in the First 5 Years Following Traumatic Brain Injury

J. Aaron Resch, Victor Villarreal, Caitlin L. Johnson, Timothy R. Elliott, and Oi-Man Kwok
Texas A&M University

Objective: The trajectories of life satisfaction for 609 individuals who sustained a traumatic brain injury (TBI) were studied. Hierarchical linear modeling analysis examined individual level growth trends over the first 5 years following TBI using gender, functional independence, age, and time to estimate life satisfaction trajectories. Measures: Participants completed the Functional Independence Measure and the Life Satisfaction Inventory at years 1, 2, 4, and 5 after sustaining TBI. Results: Participants who reported higher functional independence at year 1 also had higher life satisfaction at year 1. Participants with lower functional independence across the 5-year period had life satisfaction trajectories that decreased at significantly greater rates than the individuals with more functional independence. The life satisfaction trajectory declined for the sample, but participants reporting lower cognitive and motor functional independence had significantly greater declines in life satisfaction trajectories. Age and gender were not significant factors in predicting life satisfaction trajectories following TBI. Implications: Individuals with greater cognitive and motor impairments following TBI are likely to experience significant declines in life satisfaction within 5 years of living with TBI.

Keywords: traumatic brain injury, life satisfaction, functional independence, hierarchical linear modeling, multilevel modeling

The prediction of adjustment and well-being following traumatic injury is essential to the development of meaningful psychological and medical interventions and informed health policy, especially when considering health-related life satisfaction as a relevant outcome measure (Mailhan, Azouvi, & Dazord, 2005). Patient-oriented outcomes should be a priority for researchers, clinicians, and policy makers in order to improve health care and to promote individual quality of life (Kaplan, 1994; Kaplan & Frosch, 2005). Ideally, studies of health-related quality of life inform treatment options, service provision, and the allocation of health-care resources (Kaplan, 2002). However, because outcome data are being used to inform so many important service and policy decisions, it is essential that steps are taken to ensure outcome data are analyzed and interpreted correctly (Brossart, Clay, & Willson, 2002). Understanding quality of life following acquired disability is particularly important yet challenging for many reasons. Many people who traumatically incur severely debilitating neurologic injuries can have life expectancies that approximate that of the general population (Lollar & Crews, 2003). Yet the sequelae of these injuries can vary tremendously and may include problems with cognitive disturbances, persistent pain, paralysis and other types of physical impairment, and affective and behavioral disruptions (e.g., depression, posttraumatic stress symptoms; Wilson, 2008). Ultimately, the scope and nature of the problems cannot be adequately addressed in the medical and rehabilitation services provided following the onset of the disability. Behavioral and social factors essentially have the greatest influence on the ongoing health and well-being of individuals who live with chronic disease and disability (Glass & McAtee, 2006; Israel, Schultz, Parker, & Becker, 1998).

Subjective well-being may be one of the most important aspects of long-term outcomes following neurologic injury (Fuhrer, 2000). The ability to measure and predict life satisfaction for individuals with traumatic brain injury (TBI) has become an important issue due to its high rate of occurrence and the negative impact it has on individuals, families, and communities. Annually, as many as 1.5 million Americans sustain a TBI (Sosin, Sniezek, & Thurman, 1996; Thurman, Alverson, Dunn, Guerrero, & Sniezek, 1999), and nearly 100,000 of individuals sustaining a TBI each year have permanent physical, cognitive, and behavioral disabilities (Thurman et al., 1999). The long-term consequences of TBI unfold over time, and they are borne by the individual, their families, and
public subsidy systems (Dikman, Machamer, Powell, & Temkin 2003), often imposing considerable physical and emotional burden to the persons injured and to their friends and families (Thurman et al., 1999).

Due to the long-term economic, physical, mental, and emotional burden placed on society, families, and individuals as a result of the high incident of TBI each year, it has become a major public health concern (Stalnacke, 2007). Adding to the incidence of TBI are the high number of veterans of the Iraq and Afghanistan wars who return home with TBI sustained due to blasts, motor vehicle accidents, shrapnel, and bullet wounds, etc. In a study of more than 2,500 soldiers, Hoge et al. (2008) found that 15% of returning veterans reported injuries that were consistent with at least a mild TBI. This suggests an incidence rate more than 10 times the civilian population and amplifies the growing problems caused by the already high incidence of TBI each year. Therefore, research initiatives that deepen our understanding of adjustment after sustaining a TBI are essential.

The available research concerning life satisfaction following TBI has yielded inconsistent results. For example, Dijkers (2004) concluded in a review of the extant research that following TBI people generally report somewhat lower life satisfaction than do comparison groups. One of the few long-term studies found that life satisfaction for survivors of severe TBI was relatively high 10 years after injury (Koskinen, 1998). Other studies, however, have found life satisfaction to be fairly stable over time for individuals sustaining a TBI. For example, Corrigan, Bogner, Mysiw, Clinchot, and Fugate (2001) found life satisfaction was relatively stable in a 2-year longitudinal study of over 200 individuals with TBI. Other cross-sectional research has indicated that TBI, life satisfaction, and disability are not linearly related (Mailhan et al., 2005). Similarly, Corrigan, Smith-Knapp, and Granger (1998) found that life satisfaction was only minimally predictable among 95 persons with TBI.

Further complicating the prediction of TBI outcomes is that researchers often attempt to evaluate individual variables “. . . when recovery is a dynamic and multifactorial process” (Bush et al., 2003, p. 1803). Moreover, the multiple factors believed to be predictive of TBI outcome have been shown to be contradictory at times. Bush et al. (2003) found that injury severity was predictive of 1-year outcomes following a TBI. However, injury severity has been only mildly predictive of adjustment in some research (Testa, Malec, Moessner, & Brown, 2005) and not at all in others (Dijkers, 2004). Many researchers have attempted to predict outcomes following TBI based on premorbid characteristics of the individual with mixed results. For example, Corrigan et al. (2001) found that premorbid characteristics, such as substance abuse and employment, were modestly predictive of lower life satisfaction, accounting for 14% and 30% of the variance at the first and second years after TBI. Premorbid factors were not directly predictive of psychological outcomes in the Bush et al. (2003) study. Other individual variables have also demonstrated different results when predicting outcomes following TBI. Depression has been thought to play a significant role in life satisfaction following a TBI and several studies have supported this assertion. Underhill et al. (2003) found that decreased life satisfaction was significantly associated with a diagnosis of depression among individuals who sustained a TBI at 24, 48, and 60 months after injury. Mailhan et al. (2005), however, found that depression itself was not sufficient to directly explain all aspects of life satisfaction.

Much of the existing relevant literature about outcomes following TBI has been confined to cross-sectional and prospective designs. These methods are restricted to predictive models from a single point in time and do not take into account trends that occur over time, as longitudinal designs can. However, longitudinal studies, in turn, are compromised by attrition rates, and these may be potentially problematic in the wake of social and personal sequelae of trauma. One TBI outcome study had an attrition rate of over 40% at the 1-year follow-up and 60% over 2 years of follow-up (Corrigan et al., 2003).

To date, the study of adjustment following TBI has been permeated by methodological designs that imply a rather linear perspective of adjustment. Contemporary models of adjustment following disability conceptualize adjustment as a dynamic and evolving process that can be influenced by an array of psychological, disability-specific, and social characteristics at any time (Elliott & Mullins, 2004; Elliott & Warren, 2007). From this perspective, then, adjustment is not a linear process toward a specific outcome but a trajectory that may be facilitated or impeded by an array of personal and environmental factors over the lifespan. This type of model is well suited for understanding positive growth following disability (Elliott, Kurylo, & Rivera, 2002), and it is best studied with techniques that examine developmental trajectories of adjustment that may be affected by enduring and time-varying characteristics.

Multilevel modeling (MLM) techniques are used to study dynamic changes over time. Although these tools have considerable promise in evaluating long-term outcomes following rehabilitation, very few studies of this nature have appeared in the rehabilitation literature, implying that the field has yet to realize the potential of these approaches (Kwok et al., 2008). One of the more appropriate strategies—hierarchical linear modeling (HLM)—is a robust statistical method that solves many of the shortcomings associated with longitudinal designs that use traditional linear regression models and ANOVAs. As opposed to traditional univariate analysis of variance, HLM can yield accurate and reliable results despite the presence of missing data caused by attrition or loss to follow-up (Kwok et al., 2008). Furthermore, the standard errors of the fixed effects are usually underestimated in traditional regression approaches because they do not account for dependency within clusters. HLM, however, does account for this dependency; consequently, HLM can provide more precise results compared to more commonly used regression approaches (Hox, 2002; Snijders & Bosker; 1999). HLM is especially useful when multiple observations are collected over a period of time and these observations are nested within each individual. HLM then permits a tracking of each individual’s growth trajectories by analyzing the information contained in the repeated measures (Raudenbush & Bryk, 2002). Hence, as opposed to ANOVAs, which only estimate an average growth model for all the participants combined, HLM can also estimate individual growth models for each distinct participant (Kwok et al., 2008). Additionally, the treatment of the time predictor in HLM is distinct from other statistical methods because time can be treated as a continuous rather than a discrete variable. Thus, HLM can flexibly accommodate unequal spacing between time intervals as long as the time predictor is appropriately specified (Kwok et al., 2008). Because of the flexibility and precision of HLM, it is a valuable tool...
for predicting long-term adjustment following the onset of any disabling condition.

In the present study, we examine the trajectories of life satisfaction in the first 5 years following the traumatic onset of TBI. In this study, we used growth modeling techniques to prospectively examine the long-term and co-occurring relationship of functional impairment subsequent to TBI to rates of change in life satisfaction over the first 5 years of TBI. We took gender into account in these analyses in light of evidence that women may have more complicated long-term adjustment than men following TBI (Farace & Alves, 2000). Current research indicates that this pattern of gender differences is apparent in survival rates after TBI (Ponsford et al., 2008). Unfortunately, women are often underrepresented in the study of long-term adjustment following TBI, and this in turn limits statistical sensitivity to detect meaningful differences in a consistent fashion (Corrigan et al., 2007). Although women have reported more symptoms of depression than men after TBI (e.g., Schopp, Shigaki, Johnstone, & Kirkpatrick, 2001), we do not know if this is due to differences in grief reactions (Niemeier, 2008), neuropsychological functions (and impairments; Niemeier, Marwitz, Leslie, Walker, & Bushnick, 2007), or other psychological, social, or health-related mechanisms (Nosek, Hughes, & Robinson-Whelen, 2008). Essentially, prospective study of gender differences in TBI outcomes with sufficient sample sizes and designs that improve upon the existing cross-sectional research is required to systematically resolve these issues.

In the present study, then, we examined potential differences between men and women in our modeling of functional impairment and trajectories of life satisfaction after TBI.

Methods

Participants

Participants were part of a larger longitudinal study conducted by the Injury Control Research Center of the University of Alabama at Birmingham, which includes data from a retrospective acute-care medical record review and telephone interviews with persons that had at least one of four potentially disabling injuries (i.e., spinal cord injury, TBI, severe burns, or intra-articular fractures of the lower extremity) who were discharged from a sample of hospitals representing a cross-section of patients in north-central Alabama. Participants were included in the study if they met the following criteria: (a) had an acute-care length of stay of 3 or more days; (b) resided in Alabama; (c) were discharged alive from an acute-care hospital between October 1, 1989, and September 30, 1992; (d) were more than 17 years old when injured; and (e) could be contacted at specified intervals after discharge. Study participants were identified from acute-care medical records and were contacted at 12 months after discharge. Letters were sent to all persons eligible for follow-up, inviting them to participate. Those who agreed to participate were interviewed. Participants with TBI were selected for analysis. A total of 1,026 individuals with TBI were identified from acute-care medical records, and a total of 609 individuals (435 men, 174 women) consented to participate in the study. The mean age of participants was 38.31 years (SD = 18.00 years), but there was a significant difference in the mean ages of men and women at time of injury (men = 35 years, women = 44 years; p < .001). A majority of the participants were White (n = 436; 71.6%); 27.6% of the sample were identified as African American (n = 168). Acute-care medical records were gathered from the participants’ respective hospitals. Data were collected on the etiology and severity of the injury, clinical characteristics, acute-care treatment, source of payment, demographic characteristics, and discharge disposition.

Reasons for not participating were not recorded; however, 10% (n = 102) of eligible individuals died before the first data collection period at 1 year after discharge. Although information about socioeconomic status was not collected on participants, there was a significant difference between the participants and nonparticipants in terms of their payment for acute care, χ²(4) = 25; p < .005. Specifically, participants were more likely to have private medical insurance and less likely to have no insurance compared to nonparticipants. There was no difference between these groups in terms of Medicare coverage.

Procedure

Participants were interviewed by telephone. These interviews began as close as possible to the 12-month time period after the individual was discharged from the acute-care setting. Interviewers received training on administering the follow-up instruments, and they were in daily communication with the project coordinator on matters related to the interview process. As part of the interviews, data were collected on social and demographic characteristics, rehabilitation services, other medical services, secondary complications due to the injury, overall health status, physical and psychological adjustment to disability, and rehabilitation outcomes. Of particular interest in the present study were the Functional Independence Measure (FIM) and the Life Satisfaction Index (LSI). Interview data were subsequently collected at 24, 48, and 60 months after acute discharge. Interviews were not conducted at 36 months; but as previously mentioned, analyses with HLM accommodate the unequal spacing of time intervals.

Measures

Severity of TBI. TBI severity was measured using the Abbreviated Injury Scale (AIS; Committee on Injury Scaling, 1985). AIS scores for each of the six body regions, including the head, were calculated through the use of ICDMAP, a computerized table that converts ICD-9-CM coded discharge diagnoses to AIS scores (MacKenzie, Steinwachs, & Shankar, 1989). The AIS is a measure of injury severity based on anatomic descriptors of the injury with ordinal values ranging from 1 (minor injury) to 6 (maximum injury, virtually unsurvivable; Committee on Injury Scaling, 1985). The distribution of injury severity ratings for the sample is contained in Table 1.

Life satisfaction. The Life Satisfaction Index-A (LSI; Neugarten, Havighurt, & Tobin, 1961) is a 20-item instrument designed to measure psychological well-being. The LSI assesses enthusiasm for life, mood, and congruence between desired and achieved goals. Scores range from 0 to 20, with higher scores indicating greater perceived life satisfaction.
Table 1

Distribution of Injury Severity Codes for the Sample

<table>
<thead>
<tr>
<th>Injury severity code</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>.20</td>
</tr>
<tr>
<td>2</td>
<td>198</td>
<td>32.70</td>
</tr>
<tr>
<td>3</td>
<td>237</td>
<td>39.10</td>
</tr>
<tr>
<td>4</td>
<td>138</td>
<td>22.80</td>
</tr>
<tr>
<td>5</td>
<td>32</td>
<td>5.30</td>
</tr>
<tr>
<td>Total</td>
<td>606</td>
<td>100.00</td>
</tr>
</tbody>
</table>

*The injury severity for 3 of the participants was unknown.

Previous studies have found LSI item discriminative values that range from 16 to 75.4%, with means of 42% and 58.7% (Adams, 1969; Rao & Rao, 1981). The LSI total score has been positively correlated with other measures of life satisfaction, adjustment, and morale, and over 150 other studies of LSI validity have yielded an average internal consistency coefficient of .79 (Wallace & Wheeler, 2002).

Functional impairment. The telephone version of Functional Independence Measure (FIM; Keith, Granger, Hamilton, & Sherwin, 1987) is self-reported assessment for assistance across various functional domains. The FIM contains 18 items that are rated on a Likert-type scale. The FIM is composed of two domain subscales: motor (13 items) and cognitive (5 items). These 18 items combine to form a total FIM score. Lower scores indicate greater impairment, and higher scores indicate greater independence. The scale ranges from 1 (total assistance) to 7 (complete independence). Scores 1 through 5 range from need for total assistance or inability to complete the activity despite assistance to need for supervision of a second person. A score of 6 is used to indicate activities that require the use of an assistive device, take more than a reasonable amount of time, or require safety considerations. A score of 7 is used to indicate complete independence. To obtain a score of 7, the individual would need to perform the activity safely, without modification, assistive devices or aids, within a reasonable time. Internal consistency of the FIM in the present study was high (Cronbach’s alpha = .97 to .98).

In the present sample, the distribution of FIM scores showed strong ceiling effects, which can be especially problematic in the study of change over time (Fischer, 1976). To overcome this limitation, we linearized FIM scores using Rasch scaling procedures (Bond & Fox, 2001). Data for the FIM total scale and the cognitive and motor subscales were fit to the Rasch partial credit model for polytomous items. Items for all item periods were corrected in a single analysis, which places measures over time in a common framework of reference (Wright, 2003). For the FIM total and subscales, item reliabilities were greater than .98. Pearson separation reliabilities (analogous to Cronbach’s alpha but corrected for measurement error) were .82 for FIM total, .83 for FIM motor, and .78 for FIM cognitive. We used information-weighted mean square fit statistics to assess individual item quality. Items with fit statistics less than 1.50 contribute successfully to the construction of a measurement continuum; items with fit values between 1.50 and 2.00 indicate “noisy” items but do not necessarily degrade the measurement system; items with fit values greater than 2.00 are degrading to measurement (Linacre, 2003). For the FIM total, all but one item (fit = 1.78) had fit statistics less than 1.40. For the motor subscale, all but one item (fit = 1.79) had fit values less than 1.50. For the FIM cognitive subscale, all fit values were less than 1.30.

Chang and Chan (1995) recommend evaluating the consistency of item estimates across time periods to determine whether it is reasonable to pool items in a combined analysis. To assess item stability over time, we examined uniform differential item functioning (DIF) across the time samples (Bond & Fox, 2001). In Rasch DIF analysis, scaling is first conducted on item responses from subjects in all time samples combined, which provides anchor values for subject measures and the rating scale structure. Next, scaling is conducted for each time sample separately, using anchor values from the combined analysis to equate the measures to a common scale (Bond & Fox, 2001). We evaluated DIF by subtracting difficulty estimates of each item at each time from the average estimate of the item across all other time periods. Differences of less than half a logit are considered evidence of stability (Linacre, 2003). These results suggest that the individual items of the TRIM are stable in measurement structure across time. We also examined DIF by gender. Logit differences by sex, for FIM total and subscales, ranged from −.48 to .45, suggesting no appreciable gender bias in FIM items.

Statistical Analysis

Hierarchical linear modeling (HLM) was used to examine the influences of functional independence, gender, and injury severity over a period of 5 years on life satisfaction. Multiple observations of the same measures were collected over a period of several years, and these observations were nested within individuals. As previously mentioned, HLM allows the examination of individual growth trajectories by analyzing the information contained in the repeated measures (Raudenbush & Bryk, 2002). We conducted these analyses with the multilevel linear growth-modeling program in SPSS (for details regarding the program, see Kwok et al., 2008). We also conducted a quadratic growth model (which would capture the potential curvature/acceleration of growth trajectories; Raudenbush & Bryk, 2002). We compared the variance components of the quadratic growth model and the linear growth model using the Maximum Likelihood Estimation Method; based on Schwartz’s Bayesian Criterion (BIC) model selection guidelines (Raftery, 1996), the linear growth model was the better-fitting model (reflecting a linear growth trend) and will therefore be reported here.

Repeated data of the outcome, life satisfaction, and of functional independence represent Level 1 data units. In this one-level model, the outcome could be defined by a unique set of intercept and slope parameters and was expressed as

\[ LSI_i = \pi_{i0} + \pi_{i1} \text{Time}_i + \pi_{i2} \text{FIM}_i + \epsilon_i. \]

Here LSI\(_i\) is an outcome measure of life satisfaction for participant \(i\) at time \(t\); \(\pi_{i0}\) is an intercept or initial status parameter; and \(\pi_{i1}\) and \(\pi_{i2}\) are slope parameters that represent linear rates of change over time for their respective variables.

However, the data are nested for each participant by gender and this served as the Level 2 unit in the model. We tested the possibility that variation between participants could be modeled at Level 2 as a function of gender. In this case, the intercepts and slopes of the individual participants’ models became the outcomes
that we attempted to explain at the second stage of the HLM analysis. The combined model for participants in the study was expressed as

\[ LSI_{it} = \beta_{00i} + \beta_{10i}Time_{pi} + \beta_{20i}FIM_{it} + \beta_{30i}Gender_{t} + \beta_{11i}Gender_{t}Time_{pi} + \beta_{12i}Gender_{t}FIM_{it}. \]

Here \( LSI_{it} \) is an outcome measure of life satisfaction for participant \( i \) at time \( t \); \( \beta_{00i} \) is a Level 2 estimate of the mean population value for initial status; and \( \beta_{10i}, \beta_{20i}, \beta_{30i}, \beta_{11i}, \) and \( \beta_{12i} \) represent Level 2 rate-of-change parameters for each respective predictor. Although not presented, random effects representing unexplained variability were also a part of the HLM model.

A significant advantage of an HLM approach over other repeated measures designs is its ability to examine relationships that occur within and across hierarchically arranged data simultaneously. HLM can be used to identify systematic patterns of change and correlations of change that would be difficult to examine when different levels of data are not modeled explicitly. Statistically efficient solutions can be obtained by using HLM to analyze longitudinal data that include missing data (Raudenbush & Bryk, 2002). The hierarchical model is generally more flexible in terms of its data requirements because the repeated observations are viewed as nested within the person rather than as the same fixed set for all persons; both the number of observations and the timing of those observations may vary over participants. Unlike conventional methods, HLM can readily incorporate all participants who have been observed at least once, and results of the analysis can be interpreted as if no missing data were present under the assumption that the data are missing at random (Raudenbush & Bryk, 2002).

**Results**

**Preliminary Analyses**

Of the total sample group, participation ranged from 95% (\( n = 580 \)) at Time 1 to 54% (\( n = 327 \)) at Time 4 (60 months after initial discharge; see Table 2). There were no significant differences in the attrition rates between men and women. Means and standard deviations for the self-report measures at each assessment are presented in Table 3.

The injury severity ratings were modestly yet significantly cor-

**Table 2**

<table>
<thead>
<tr>
<th>Number of Observations for Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement occasion</td>
</tr>
<tr>
<td>Time 1</td>
</tr>
<tr>
<td>Time 2</td>
</tr>
<tr>
<td>Time 3</td>
</tr>
<tr>
<td>Time 4</td>
</tr>
</tbody>
</table>

Note. FIM = Functional Independence Measure; LSI = Life Satisfaction Inventory.

* Although the total number of participants was 609, not all of the participants completed a measure at Time 1. However, because of the properties of hierarchical linear modeling, all participants completing measures on at least 1 time period are included in the analyses.

related with the three FIM variables (see Table 4). To prevent complicating subsequent models with potentially redundant information, injury severity was not included in the trajectory analyses.

In the subsequent analyses, three separate multilevel linear growth models to predict the rates of change in life satisfaction—

**FIM total.** Modeling total FIM scores (FIMTot) and gender with the rates of change in life satisfaction, the intercept (\( est = 9.52, SE = .402, p = .000 \)), time (\( est = -.448, SE = .120, p = .000 \)), and FIMTot (\( est = .733, SE = .107, p = .000 \)) were significantly predictive of life satisfaction (see Table 5). This finding suggests that at the first measurement higher FIMTot scores—i.e., less functional impairment—was significantly associated with greater life satisfaction. Additionally, life satisfaction generally decreased over time for the entire sample, and participants with higher FIMTot scores had higher life satisfaction at all time points.

An interesting significant result was in the interaction between FIMTot and time (\( est = .119, SE = .032, p = .000 \)) with trajectories indicating that individuals with higher FIMTot had a lower rate of change in life satisfaction than individuals with lower FIMTot scores (i.e., greater functional impairment), holding all other variables constant. This interaction is depicted in Figure 1. It is interesting to note that gender did not factor significantly into the model. Consequently, men and women did not differ in their trajectories of life satisfaction over time.

**FIM cognitive.** This analyses revealed a similar pattern in the relation of the cognitive subscale of the FIM (FIMCog) in that intercept (\( est = 10.304, SE = .377, p = .000 \)), time (\( est = -.431,
SE = .118, p = .000), and FIMCog (est = .474, SE = .089, p = .000) were significant predictors of life satisfaction (see Table 6). The interaction between FIMCog and time (est = -.093, SE = .028, p = .001) was also significantly predictive of the rates of change in life satisfaction. Similar to the FIMTot results, less cognitive impairment (represented by higher scores on the FIMCog) was initially associated with greater life satisfaction. Although life satisfaction declined significantly over time for the entire sample, higher FIMCog scores were associated with greater life satisfaction.

As depicted in Figure 2, the significant interaction indicates that higher FIMCog scores were significantly associated with a slower rate of decrease in life satisfaction. In contrast, greater cognitive functional impairment (lower FIMCog scores) was significantly associated with a steeper decline in life satisfaction, holding other variables constant. Finally, gender was not a significant factor alone or in an interaction, indicating that rates of change in life satisfaction were not significantly influenced by participant gender.

**FIM motor.** Similar to the previous models, the intercept (est = 9.462, SE = .523, p = .000), time (est = -.406, SE = .146, p = .005), FIMFIMMot (est = .336, SE = .073, p = .000), and the FIMFIMMot × time interaction term (est = .068, SE = .021, p = .001) were significant contributors to the model (see Table 7). Higher FIMFIMMot scores were initially associated with greater life satisfaction, and this relationship was maintained at each time point. While there was an overall decrease in life satisfaction for the sample, higher FIMFIMMot scores were associated with a slower decline in life satisfaction, and greater motor impairment (lower FIMFIMMot scores) were significantly associated with steeper declines in life satisfaction, in the context of the other variables included in the model (see Figure 3). Gender did not significantly contribute to the prediction of rates of change in life satisfaction, indicating that the significant results applied to both men and women.

**Post-hoc analyses.** To allay possible concerns that participant age may have contributed to our results, we conducted a final model in which we included age as a Level 2 predictor. When adding age as a predictor, only the intercept was statistically significant (β₀ = 12.64, SE = .509, p = .000), indicating that older age was associated with greater life satisfaction at the first assessment. No other significant effects or differences were observed for age on the trajectory of life satisfaction over 5 years. These results indicate that there was a significant difference in life satisfaction ratings between age groups at the first assessment, but participant age did not significantly predict life satisfaction trajectories reported by men and women over time.

**Discussion**

To our knowledge, the present study is the first to prospectively examine covarying predictors of rate of change in life satisfaction in the first 5 years of living with TBI. Although limited by a lack of neuropsychological information about the concomitants and severity of TBI, multilevel modeling tech-

### Table 4
Correlations of Injury Severity With FIMTot, FIMCog, and FIMMot

<table>
<thead>
<tr>
<th>Variable</th>
<th>IS</th>
<th>FIMTot</th>
<th>FIMCog</th>
<th>FIMMot</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury severity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIMTot</td>
<td>-.20*</td>
<td>3.00</td>
<td>.88</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIMCog</td>
<td>-.20*</td>
<td>.89*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIMMot</td>
<td>-.14*</td>
<td>.62*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. IS = Injury Severity Index; FIMTot = FIM total score; FIMCog = FIM Cognition score; FIMMot = FIM Motor score; FIM = Functional Independence Measure.

*p < .01.

### Table 5
Estimates of Fixed Effects for FIMTot, Gender, and Time on Life Satisfaction

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. error</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>9.515</td>
<td>.402</td>
<td>.000</td>
</tr>
<tr>
<td>Time</td>
<td>-.448</td>
<td>.120</td>
<td>.000</td>
</tr>
<tr>
<td>FIMTot</td>
<td>.733</td>
<td>.107</td>
<td>.000</td>
</tr>
<tr>
<td>Female gender</td>
<td>.799</td>
<td>.707</td>
<td>.258</td>
</tr>
<tr>
<td>Female × time</td>
<td>.367</td>
<td>.215</td>
<td>.088</td>
</tr>
<tr>
<td>FIMTot × female</td>
<td>-.236</td>
<td>.204</td>
<td>.247</td>
</tr>
<tr>
<td>FIMTot × time</td>
<td>.119</td>
<td>.032</td>
<td>.000</td>
</tr>
<tr>
<td>FIMTot × female × time</td>
<td>-.053</td>
<td>.063</td>
<td>.397</td>
</tr>
</tbody>
</table>

*Note. FIMTot = Functional Independence Measure total score.

### Table 6
Estimates of Fixed Effects for FIMCog, Gender, and Time on Life Satisfaction

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>SE</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>10.304</td>
<td>.377</td>
<td>.000</td>
</tr>
<tr>
<td>Time</td>
<td>-.431</td>
<td>.118</td>
<td>.000</td>
</tr>
<tr>
<td>FIMCog</td>
<td>.474</td>
<td>.089</td>
<td>.000</td>
</tr>
<tr>
<td>Female gender</td>
<td>.240</td>
<td>.714</td>
<td>.737</td>
</tr>
<tr>
<td>Female × time</td>
<td>.297</td>
<td>.227</td>
<td>.191</td>
</tr>
<tr>
<td>FIMCog × female</td>
<td>-.133</td>
<td>.171</td>
<td>.437</td>
</tr>
<tr>
<td>FIMCog × time</td>
<td>.093</td>
<td>.028</td>
<td>.001</td>
</tr>
<tr>
<td>FIMCog × female × time</td>
<td>-.036</td>
<td>.055</td>
<td>.514</td>
</tr>
</tbody>
</table>

*Note. FIMCog = Functional Independence Measure cognition score.*
niques revealed several consistent patterns. First, the trajectory of long-term life satisfaction is significantly associated with functional impairment. Second, the associations between functional impairment and the trajectory of life satisfaction are consistent among men and women in the first 5 years after TBI. Finally, the significant association of functional impairment to the rates of change in life satisfaction holds true for both cognitive and motor impairment, as assessed by the FIM.

Subsequent research must determine if the current results—and the use of multilevel modeling—represent true advances in our empirical understanding of life satisfaction following TBI. In this attempt to advance our knowledge of adjustment after TBI with new statistical techniques that complement developmental perspectives of adjustment and personal growth, we have obtained insights that resolve many of the limitations posed by cross-sectional designs that are ultimately reliant on set time points and unable to assess trajectories of change. Additional research is necessary to determine if the current results will replicate in a fairly consistent manner with samples recruited in different contexts (e.g., participants in the TBI Model Systems project).

To a certain extent, the results of the present study confirm the conclusions of a recent meta-analysis of TBI outcomes: Greater disability soon after injury is associated with less-optimal outcomes over time (Willemse-van Son, Ribbers, Verhagen, & Stam, 2007). In the present study, greater functional impairment was significantly predictive of a declining trajectory of life satisfaction. Individuals who incur greater cognitive and motor impairment with TBI may merit further support and intervention in the community if such declines are to be avoided. In contrast with this meta-analysis, however, we found no apparent influence of participant age in the rates of change in life satisfaction for either men or women (despite the older age of women in the sample that was consistent with prior research).

The lack of gender differences in the present study suggests that other factors may account for differences observed between men and women after TBI. For example, gender differences have been observed in employment rates (Corrigan et al., 2007), and we do not account for these and other psychosocial variables that might influence the functional impairment-life satisfaction relationship. In addition, we did not study other important factors, such as substance use, that can adversely affect adjustment. Perhaps future work could address these and other variables that move beyond the study of biological sex to psychological characteristics (such as gender-role beliefs) that have been meaningfully related to substance use and adjustment among persons with TBI (and other acquired disabilities; Good et al., 2008).

We did not have detailed information about the neuropsychological sequelae of TBI for participants in the study, nor did we have other specific diagnostic information about the TBIs. However, our reliance on the FIM as an indicator of functional impairment in the prediction of life satisfaction is congruent with the World Health Organization model of disablement (Peterson & Elliott, 2008). Future research is needed to determine the prospective predictive value of neuropsychological data in the prediction of the rates of change in life satisfaction following TBI.

There are other limitations of the study that should be considered. Outcome variables were assessed by self-report and in telephone interviews. No measures of distress were administered; therefore, our analysis did not take distress into account. However, greater distress usually influences a negatively valenced report on quality of life measures. The study also relied on a volunteer sample, and at times unmeasured characteristics of individuals who volunteer for research can be related to variables under investigation (Tucker & Reed, 2008). For example, the sample was

![Figure 2. Rates of change in life satisfaction by levels of the Functional Independence Measure (FIM) cognitive score. High and low FIM scores were determined to be one standard deviation above (high) and below (low) the mean Rasch FIM Motor score. LSI = Life Satisfaction Inventory.](image1)

![Figure 3. Rates of change in life satisfaction by levels of the Functional Independence Measure (FIM) motor score. High and low FIM scores were determined to be one standard deviation above (high) and below (low) the mean Rasch FIM Motor score. LSI = Life Satisfaction Inventory.](image2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>SE</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>9.462</td>
<td>.523</td>
<td>.000</td>
</tr>
<tr>
<td>Time</td>
<td>-.406</td>
<td>.146</td>
<td>.005</td>
</tr>
<tr>
<td>FIMMot</td>
<td>.336</td>
<td>.073</td>
<td>.000</td>
</tr>
<tr>
<td>Female gender</td>
<td>.946</td>
<td>.849</td>
<td>.265</td>
</tr>
<tr>
<td>Female × time</td>
<td>.347</td>
<td>.243</td>
<td>.153</td>
</tr>
<tr>
<td>FIMMot × female</td>
<td>-.117</td>
<td>.130</td>
<td>.366</td>
</tr>
<tr>
<td>FIMMot × time</td>
<td>.068</td>
<td>.021</td>
<td>.001</td>
</tr>
<tr>
<td>FIMMot × female × time</td>
<td>-.034</td>
<td>.038</td>
<td>.379</td>
</tr>
</tbody>
</table>

*Note.* FIMMot = Functional Independence Measure motor score.
recruited under circumstances that differ considerably from samples recruited to participate in the TBI Model Systems project. Consequently, the generalizability of the current results is unclear.

Despite these limitations, however, this research represents a potentially meaningful advance in the study of outcomes following a disability or illness. Future longitudinal research that studies postdisability or postillness outcomes, such as quality of life, life satisfaction, or response to treatment, should utilize more advanced multilevel-modeling statistical techniques such as HLM. In terms of TBI outcomes specifically, this study has several important implications. First, since individuals with TBI are not a heterogeneous group in terms of injury severity and degree of impairment caused by TBI, HLM permits the study of life satisfaction trajectories by TBI severity (e.g., mild, moderate, and severe). Particular attention should be paid to cognitive functioning that appears to show improvement over time (e.g., over a 5-year period: cognitive speed, visuconstruction, and verbal memory; Millis et al., 2001). The possible relations of cognitive changes to functional ability, community integration, and social mobility warrant rigorous scrutiny with the best available and contemporary methods. Future studies should also examine the impact of psychological variables (e.g., comorbid PTSD; Hoge et al., 2008) and other factors, such as family environment, substance abuse, and vocational rehabilitation, based on their demonstrated effects in the extant literature.

References


Received September 2, 2008
Revision received December 23, 2008
Accepted December 24, 2008