

Traumatic Brain Injury: Investigating Misconceptions among Graduate Students in Physical Therapy, Occupational Therapy, and Speech-Language Pathology

Michael Frazure¹, Rhonda Mattingly¹, Teresa Pitts^{1,2} and Alan F. Smith^{1*}

¹Department of Otolaryngology-Head/Neck Surgery and Communicative Disorders, University of Louisville, Louisville, KY, United States

²Department of Neurological Surgery, Kentucky Spinal Cord Research Centre, University of Louisville, Louisville, KY, United States

Abstract

This study utilized a convenience sample ($n=510$) to investigate misconceptions of traumatic brain injury (TBI) among first and second year graduate students in physical therapy (PT), occupational therapy (OT), and speech-language pathology (SLP) training programs. Eighty-six-point-seven percent of participants were female, and 87.70% were white. All participants completed a survey comprised of items relating to general information about TBI, coma and unconsciousness, memory loss, recovery, and concussion. Descriptive and summary statistics indicated the persistence of misconceptions regarding coma and unconsciousness, memory loss, recovery, and concussion among graduate students in PT, OT, and SLP training programs. Group comparisons were conducted to identify differences according to discipline (PT, OT, or SLP) and university designation (first or second year graduate student). Kruskal-Wallis analyses revealed no statistically significant difference in knowledge across disciplines regarding general information about TBI or recovery, however there was a statistically significant difference regarding knowledge of coma and unconsciousness, memory loss, and concussion. Mann-Whitney analyses revealed no significant difference in knowledge of general information about TBI, coma and unconsciousness, or recovery according to university designation, however there was a statistically significant difference in knowledge of memory loss and concussion.

Keywords: Physical therapy; Traumatic brain injury; Rehabilitation; Exercise; Brain injury; Occupational therapy

Introduction

Defining traumatic brain injury

Acquired brain injury (ABI) describes an injury to the brain that occurs after birth and is not hereditary, congenital, or degenerative (Brain Injury Association of America, 2015), and may arise from a wide variety of insults, such as a brain tumor, cerebrovascular accident (CVA), gunshot wound, birth trauma, hypoxia, anoxia, infection or toxicity [1]. Traumatic brain injury (TBI) is a type of ABI that arises from external trauma. Motor vehicle accidents (MVA), sporting accidents, occupational injuries, falls, violent crimes, domestic violence, child abuse and military actions are all possible etiologies of TBI [1]. Acceleration-deceleration forces act upon the skull following the traumatic event, contusing the brain and causing injury [1]. Further, TBI can be open, in which the cranial vault is penetrated, or closed, in which the meninges remain intact [1].

TBI may be classified as mild, moderate, or severe [1]. Initially, severity is determined by the survivor's medical condition. Once the individual is medically stable, quality of life concerns further determine severity. For example, an injury initially considered life threatening might result in minimal long-term impairments, while a less medically devastating injury might lead to persistent cognitive and physical deficits [1].

Previous research suggests that mild TBI accounts for 75%-86% of all cases [2-4]. These figures are likely an underestimation, as many incidents of mild TBI do not receive medical attention and therefore go unreported [1]. Ten to twenty percent of reported injuries are moderate, and the remaining cases are severe [2-4]. Although severe TBIs account for the least amount of cases, they are often the most visible, and are therefore likely overestimated by the public [1].

Numerous studies compiled by Hux et al. [1] have shown that

regarding age, gender, and other predisposing factors, certain individuals are at higher risk of sustaining TBI than others. Young adults aged 15-24 are at the highest risk of TBI, followed by elderly adults and young children under four years of age [2,4-10]. Males are approximately two times more likely than females to sustain a TBI [2,4,8,9,11-13]. Alcohol use, previous TBI, and pre-existing medical conditions such as heart disease, hypertension and psychiatric illness are also risk factors [14,15].

Accurate determination of the incidence and prevalence of TBI is difficult, because many cases of mild TBI go unreported [16]. In a comparison of multiple statistical reports, Merz et al. [16] conclude that each year nearly two million new cases of TBI occur in the United States, resulting in 1.4 million emergency department (ED) visits, 275,000 hospital admissions, 52,000 deaths annually [17], and 80-90,000 individuals suffering permanent disabilities [9]. Healthcare costs associated with TBI range from \$9-10 billion per year in the United States [18].

Concussion

Concussion, also known as mild TBI, occurs when a blow to the body

***Corresponding author:** Alan F. Smith, Department of Otolaryngology-Head/Neck Surgery and Communicative Disorders, University of Louisville, 627 South Preston Street, Suite 220, Louisville, KY, United States, Tel: +8125508779; E-mail: afsmit01@louisville.edu

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transmits force to the head. Concussion causes metabolic imbalance within the brain rather than structural damage, which is associated with more severe injuries [19]. Unlike moderate and severe TBI, the mechanisms of mild TBI are not detected by computerized tomography (CT) or magnetic resonance imaging (MRI), necessitating clinical diagnosis through physical examination and neuropsychological testing [1,19]. Common signs and symptoms of concussion include headache, dizziness, disorientation, amnesia, nausea, confusion and cognitive impairment [20,21]. Research has shown that after concussion, it may take as long five to 10 days for neural homeostasis to occur [22]. Cognitive and physical rest are recommended following concussion. During the acute phase of recovery, patients should take time off from work or school and avoid reading, writing, visually stimulating activities, exercise and athletics [23,24].

Many individuals perceive concussion as an insignificant injury because it is classified as mild, and therefore do not seek medical treatment [1]. Further, brain injury, head injury, and concussion may be viewed as separate injuries due to the interchangeable usage of these terms [25]. A concussion must be recognized as a TBI and receive prompt, appropriate medical attention to ensure optimal recovery [19].

Rehabilitation

TBI is a challenging diagnosis for rehabilitation professionals due to the highly variable severity of injury and associated impairments [26]. Treatment of the behavioral, cognitive, communicative, emotional, and physical effects of brain injury requires specialized knowledge and skills from a team of medical and healthcare professionals [26]. In addition to treatment, each rehabilitation professional is responsible for educating patients and their families, and providing feedback on assessment and treatment outcomes [26]. Collaborating service providers may include general care and specialist physicians, physiatrists, nurses, psychologists, social workers, physical therapists (PTs), occupational therapists (OTs) and speech-language pathologists (SLPs) [26]. The current study will focus on OT, PT, and SLP graduate students and their knowledge of TBI.

PT interventions seek to improve impaired muscle strength, flexibility, endurance, balance, and coordination [27]. Rehabilitation targets functional goals such as increased ability to ambulate independently through interventions, compensations and implementation of assistive devices such as canes or walkers [27]. In addition to in- and out-patient rehabilitation programs, PT services may be administered in hospital intensive care units (ICU) to promote recovery following TBI [28]. Commonly used interventions include contracture prophylaxis, serial casting and mobilization therapy, an intervention in which the immobilized patient is brought into an upright position [28].

OTs evaluate and treat functional impairments associated with TBI [29]. During rehabilitation, OTs provide interventions to improve arousal and alertness, improve motor function, improve occupational performance, visual-perceptual, behavioural or emotional impairments, and improve performance of everyday activities, occupational duties and social participation [29]. Like PT, OT services may be provided through in- and out-patient rehabilitation programs, as well as hospital ICUs to promote recovery following TBI, with common treatments including sensory stimulation and activities of daily living (ADL) training [28].

SLPs assess, diagnose, and treat communicative and swallowing disorders. Therefore, SLPs play a vital role in the management of TBI [30]. According to the American Speech-Language-Hearing Association

[31], SLPs screen survivors for hearing, speech, language, cognitive-communication, and swallowing difficulties, conduct comprehensive assessments if determined necessary, facilitate comprehensive service provision through referral to other professionals, and develop treatment plans. SLPs provide acute care, in- and out-patient rehabilitation, and long-term care services to survivors of TBI [31]. In addition to rehabilitation, SLPs provide professional services such as identifying risk factors of TBI, providing intervention information to at-risk individuals, counselling and advocating for survivors and their families, providing education to prevent further complications associated with TBI, and advancing the knowledge base of TBI through research [31].

Although in a previous research by Hellweg [28] has shown that patients who receive therapy demonstrate earlier functional improvements, more research is needed to understand the complex, heterogeneous effects of TBI and determine specific evidence-based practices [8,32-36]. Further, present research reflects limited understanding of the educational and training needs of rehabilitation professionals, warranting further investigation of this topic. An improved understanding of professional needs will enable provision of appropriate resources for clinicians and optimal therapeutic outcomes for patients [26,37].

Misconceptions

Gouvier et al. [38] were the first to measure public knowledge of TBI. The researchers dispensed a survey designed to evaluate accuracy of TBI beliefs to members of the lay public, and participants responded using a 4-point Likert scale to endorse or reject each item. Items pertaining to unconsciousness, memory loss, and recovery were commonly missed [38]. Forty-one percent of respondents believed that "Even after several weeks in a coma, when people wake up, most recognize and speak to others right away" [38]; over 80% believed that "People can forget who they are and not recognize others but be normal in every other way" [38]; over 70% incorrectly denied that "People who have had one head injury are more likely to have a second one" [38]; and 46% believed that "Sometimes a second blow to the head can help a person remember things that were forgotten" [38].

Misconceptions have also been noted among students preparing to be educational or health care professionals [39,40]. Hux et al. [39] found that students preparing to be special education professionals (SpEds) held misconceptions similar to those of the lay public. Regarding memory loss, 7% of undergraduate and 12% of graduate students refuted that "After head injury, people can forget who they are and not recognize others but appear normal in every other way" [39]. Concerning unconsciousness, less than half of undergraduate and graduate respondents agreed that "People in a coma are usually not aware of what is happening around them" [39]. On the topic of recovery, 38% of undergraduate and 32% of graduate students believed that "Complete recovery from a severe head injury is not possible; no matter how badly the person wants to recover" [39]. In a survey of SLP graduate students, Evans et al. [40] further observed poor understanding of unconsciousness, memory loss and recovery. Nearly half of graduating master's students denied that "People in a coma are usually not aware of what is happening around them" [40]; thirty-four percent disagreed that "After head injury, people can forget who they are and not recognize others but appear normal in every other way" [40]; and nearly half denied that "Complete recovery from a severe head injury is not possible, no matter how badly the person wants to recover" [40].

Additional research has shown that myths and misconceptions exist among rehabilitation professionals, including school psychologists

[41], educators [42], and U.S. army behavioural health professionals [43]. Like the lay-public, and students preparing to be SpEds or SLPs, misconceptions present among working professionals consistently relate to coma and unconsciousness, amnesia, and recovery [41,42,44]. Sixty percent of school psychologists surveyed believed that “After head injury, people can forget who they are and not recognize others but be normal in every other way” [41], and 53% denied that “Complete recovery from a severe head injury is not possible, no matter how badly the person wants to recover” [41]. Similarly, less than 25% of general educators surveyed agreed that “Children in a coma are usually not aware of what is happening around them” [42]; thirty-four percent disagreed that “Complete recovery from a severe head injury is not possible, no matter how badly the child wants to recover” [42]; and nearly half agreed that “Children who have survived a brain injury can forget who they are and not recognize others but be normal in every other way” [42]. Likewise, 76% of US military behavioural health personnel were found to believe that “When people are knocked unconscious, most wake up shortly with no lasting effects” [43]; seventy-three percent disagreed that “Complete recovery from a severe head injury is not possible, no matter how badly the person wants to recover” [43]; sixty-six percent believed that “After head injury, people can forget who they are and not recognize others but be normal in every other way” [43]; and 51% denied that “People with amnesia for events before the injury usually have trouble learning new things too” [43].

Research investigating TBI misconceptions has been ongoing for thirty years, beginning with Gouvier and colleagues’ landmark study [38]. Several repeat studies have consistently shown the presence of misconceptions regarding coma and unconsciousness, memory loss, and recovery. While individuals who have received TBI training tend to perform better overall than the general public, they still hold inaccurate knowledge of these aspects [39-43].

Upon analysis of brain injury misconceptions among SLP graduate students, Evans et al. [40] posit that education is powerful in the dissolution of false beliefs. The researchers found that graduating master’s students performed better overall on a survey testing general brain injury knowledge than entering master’s students, as well as the lay public. However, the researchers also observed persistent misconceptions among graduating master’s students: forty-nine percent denied that “People in a coma are usually not aware of what is happening around them” [40]; sixty-six percent endorsed the statement that “After head injury, people can forget who they are and not recognize others but be normal in every other way” [40]; and 44% denied that “Complete recovery from a severe head injury is not possible, no matter how badly the person wants to recover” [40].

Duff and Stuck [44] found that school-based SLPs who received TBI training did not perform significantly better on a concussion knowledge questionnaire than those who reported no TBI training. Conversely, school-based SLPs who received concussion training performed better across most areas [44]. These findings suggest that while education improves overall knowledge of TBI, comprehensive knowledge is achieved through specific, targeted training. Research has demonstrated inaccurate beliefs among graduating master’s students and practicing SLPs regarding coma and unconsciousness, memory loss, recovery [40], and concussion [44], indicating that graduate SLP curricula do not adequately address these aspects.

Specific aims

The objective of this study was to identify gaps in knowledge

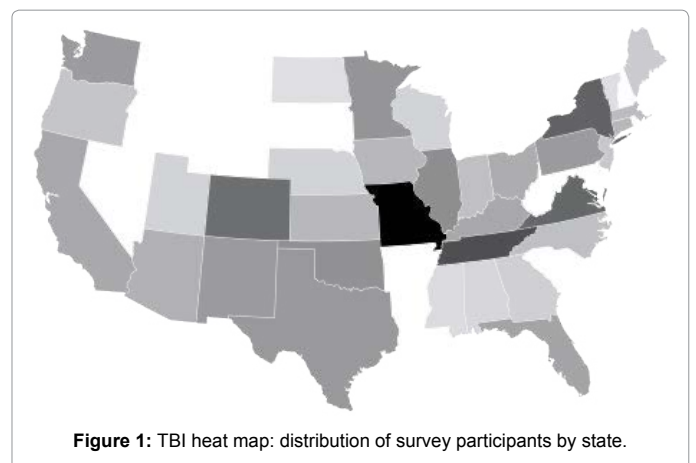
regarding TBI among students preparing to become rehabilitation professionals by surveying graduate students in PT, OT, and SLP programs on their knowledge of TBI and concussion. While past studies have assessed SLP graduate students’ knowledge of TBI overall (considering mild, moderate and severe injuries) and practicing SLPs’ knowledge of concussion (specifically mild TBI), this is the first to assess misconceptions of both TBI and concussion [40,44]. The current study is also novel in its inclusion of OT and PT graduate students, with little research on either group’s knowledge of TBI and/or concussion published at present.

Method

Participants

This study utilized a convenience sample ($n=510$) to investigate misconceptions of TBI-including concussion-among graduate students training to become rehabilitation professionals. All participants were asked to complete an online survey concerning misconceptions about TBI, with the following categories represented: general knowledge about brain injury; coma and unconsciousness; memory loss; recovery, and concussion. The researchers used a between groups design to analyze responses from graduate students in PT, OT, and SLP. Approval was granted by the Institutional Review Board (IRB) of the University of Louisville, IRB# 17.0202.

The researchers contacted PT, OT, and SLP program directors across the United States of America by e-mail. Each director received an explanation of the current study and a link to the survey instrument *via* Qualtrics (Qualtrics, Provo, UT). Participating programs forwarded the link to their students on a voluntary basis under advisement that only responses from first and second year PT, OT, and SLP graduate students would be included in this study. Inclusionary criteria included enrollment as a first or second year graduate student in an accredited PT, OT, or SLP training program. There was no gender, age-related, ethnic background, or health status requirements as per this study. This study excluded all other non-therapy disciplines. Undergraduate students, faculty personnel, and/or staff members were also excluded from participating. After data screening, 228 responses were excluded, with 510 eligible responses remaining. The sample ($n=510$) utilized in this study consisted of 271 first year and 239 second year graduate students in accredited PT (42%), OT (26%), and SLP (32%) programs, most of whom were white (88%) and female (87%). Participants throughout the United States of America were included in this study, with distribution by state illustrated in Figure 1.



Setting and instrumentation

Graduate students in PT, OT, and SLP training programs completed an online survey *via* the Qualtrics platform. The survey was accessible by tablet, laptop, smartphone, or desktop computer, and was designed to take 15 minutes or less. The survey was open for approximately two weeks, and respondents were asked to complete the survey once. Prior to accessing the survey, participants were informed of the possible risks and benefits of the study, and that the opening, completion, or submission of the survey implied consent for inclusion. Participants were advised that there were no foreseeable risks other than possible discomfort from answering personal questions. The survey requested no personal identifying information. Responses were stored on a password protected computer behind a locked door.

The survey was comprised of demographic probes and previously validated questionnaires regarding knowledge of brain injury and concussion. Seventeen true-false statements about TBI knowledge and 16 true-false statements about concussion knowledge were offered. The researchers synthesized the survey instrument from past studies on TBI knowledge and misconceptions; the TBI knowledge items are identical to the validated questionnaire used by Hux et al. [39] and Evans et al. [40], which was adapted from the original questionnaire by Gouvier et al. [38]. The 16 concussion statements are identical to the validated survey of concussion knowledge used by Duff and Stuck [44].

Variables

Independent variables: The demographic section included the independent variables of discipline and university designation. Self-administered response choices asked participants to indicate their chosen field of study (PT, OT, or SLP) and enrollment status (first year or second year graduate student). These independent variables enabled comparison of dependent variables.

Dependent variables: The survey portion measured the following dependent variables: general knowledge of brain injury; knowledge of coma and unconsciousness; knowledge of memory loss; knowledge of recovery, and misconceptions of concussion. The survey included 17 true-false statements about TBI knowledge (four general knowledge items, three coma and unconsciousness items, four memory loss items, six recovery items) and 16 items about concussion. Respondents indicated their degree of agreement with all TBI and concussion statements on a seven-point Likert scale spanning: Strongly agree, mostly agree, somewhat agree, neutral, somewhat disagree, mostly disagree, and strongly disagree. Responses including strongly agree, mostly agree, and somewhat agree were recoded and scored as correct if statements were true, and incorrect if statements were false. Responses including strongly disagree, mostly disagree, and somewhat disagree were recoded and scored as correct if statements were false, and incorrect if statements were true. Neutral responses were recoded and scored as incorrect for all statements. Responses were coded where 1=correct and 2=incorrect.

Control variables: The demographic section included the control variables of ethnicity and gender. These control variables aided in determining the maximum level of variance for the dependent variables. Gender was coded where 1=male and 2=female. Ethnicity was coded where 1=white and 2=non-white.

Data analyses

All completed surveys were exported to Microsoft Excel 2016 and numerically coded in preparation for analysis. The data were

then exported to SPSS Version 24 for statistical analyses (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY). Descriptive and summary statistics characterized demographics, as well as scores on general TBI knowledge, knowledge of coma and unconsciousness, knowledge of memory, knowledge of recovery, and knowledge of concussion. Significant outliers (>4 SD) were observed for some of the independent variables (general knowledge of TBI; knowledge of coma and unconsciousness). However, outliers were not excluded from analyses, as there was not reasonable rationale for the removal of outliers as these were test score data. An independent-samples Kruskal-Wallis test was used for analyses exploring differences in scores between disciplines. The researchers were unable to run the two samples t-test, due to violation of the assumption of normality. Therefore, an independent-samples Mann-Whitney U test was used in analyses exploring differences in university designation.

Results

Descriptive statistics

Descriptive and summary statistics characterized demographics, as well as scores on general TBI knowledge, knowledge of coma and unconsciousness, knowledge of memory, knowledge of recovery, and misconceptions about concussion. A total of 510 participants were included in this study, of whom 86.70% were female and 87.70% were White. Descriptive and summary statistics are shown in Table 1.

Respondents in all groups achieved mean scores greater than 90% on items pertaining to general TBI knowledge. Mean scores ranged from 75%-88% on questions assessing knowledge of concussion, 65%-74% on items testing knowledge of recovery, and 60%-70% on items regarding knowledge of coma and unconsciousness. Mean knowledge of memory loss scores were below 50%, except second year SLP students, who achieved an average of 51%. Mean category scores are summarized in Figure 2.

Accurate perceptions

Greater than 90% of participants responded correctly to all general TBI knowledge items, as well as some items related to recovery and concussion. Concerning general information about TBI, most respondents agreed that “A head injury can occur even if the person is not knocked out” is true (96%); “Whiplash injuries to the neck can cause brain damage even if there is no direct blow to the head” is true (96%); “Emotional problems after head injury are usually not related to brain damage” is false (93%); and “Most people with brain damage look and act disabled” is false (94%). Regarding recovery, nearly all participants agreed that “Once a recovering person feels back to normal, the recovery process is complete” is false (97%). On the topic of concussion, the majority of participants agreed that “A concussion is a brain injury”

Discipline	Designation	n	Percentage
PT	First Year	102	20
	Second Year	111	22
	Total	213	42
OT	First Year	76	15
	Second Year	54	11
	Total	130	26
SLP	First Year	130	18
	Second Year	74	14
	Total	167	32

Table 1: Descriptive and summary statistics (n=510).

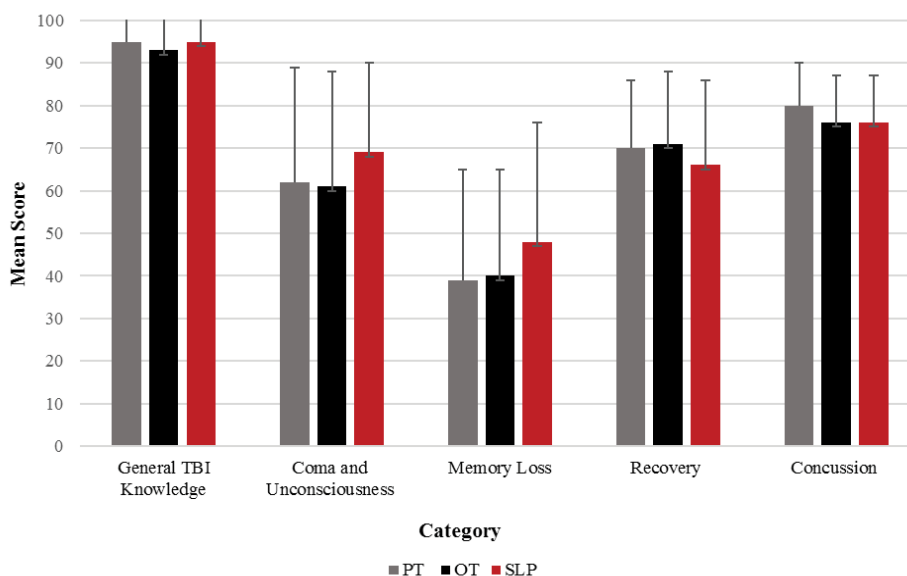


Figure 2: Mean TBI survey scores by discipline and category.

is true (98%); “Concussion can affect academic performance” is true (98%); “Concussion can occur in individual or group recreational sport or activity” is true (99%); “A repeated concussion that occurs before the brain recovers from the first can slow recovery or increase the likelihood of having long-term problems” is true (97%); “The signs and symptoms of concussion can overlap with symptoms of other disorders such as depression, anxiety, and attention-deficit disorder” is true (95%); and “A loss of consciousness is required for a diagnosis of concussion” is false (91%).

Inaccurate perceptions

Half or more of all participants responded incorrectly to items related to certain aspects of memory loss, coma and unconsciousness, recovery, and concussion. On the topic of memory loss, a minority of participants agreed that “People with amnesia for events before the injury usually have trouble learning new things too” is true (32%); “After head injury it is usually harder to learn new things than to remember things before the injury is true” (40%); “After head injury, people can forget who they are and not recognize others but be normal in every other way” (18%). Concerning coma and unconsciousness, 32% of participants agreed that “People in a coma are usually not aware of what is happening around them” is true. Regarding recovery, 27% of respondents agreed that “Complete recovery from a severe head injury is not possible, no matter how badly the person wants to recover” is true. On the topic of concussion, 12% of participants agreed “Children show better recovery from concussion than older individuals” is false. The percentage of correct scores by survey item is summarized in Table 2.

Non-parametric analyses

Non-parametric tests were used to conduct group comparisons for hypothesis testing. Kruskal-Wallis non-parametric analyses examined difference between groups according to discipline (PT, OT, and SLP). Mann-Whitney analyses examined differences between groups according to university designation (first year graduate students versus second year graduate students). The findings are listed by group below.

% Accurate	General TBI Knowledge	Coma and Unconsciousness	Memory Loss	Recovery	Concussion
20-Oct	-	-	8	-	20
21-30	-	-	-	17	-
31-40	-	7	10-11	-	-
41-50	-	-	-	-	30
51-60	-	-	-	-	-
61-70	-	5	-	13	25,28,29
71-80	-	-	9	12,14,16	22,26,31
81-90	-	6	-	-	23
91-100	1-4	-	-	15	18-20,24,27,32,33

Table 2: Percentage of accurate responses by survey item and category.

OT vs. PT vs. SLP

Statistical analyses revealed no significant difference between disciplines regarding general TBI knowledge [$H(2)=2.377$, $p=0.305$] or recovery [$H(2)=5.470$, $p=0.065$].

SLP vs. OT/PT

Knowledge of coma and unconsciousness scores were significantly different based on discipline [$H(2)=7.274$, $p=0.026$]. Pairwise comparisons with adjusted p-values showed that there were no significant differences between scores in OT and PT students ($p=1.000$), no significant differences between scores in OT and SLP graduate students ($p=0.056$), and no significant differences between scores in PT and SLP graduate students ($p=0.063$). Independent samples T-Testing compared differences between SLP graduate students and graduate students in OT or PT programs regarding knowledge of coma and unconsciousness. There was a statistically significant difference between SLP graduate students ($M=69.06$, $SD=20.56$) and OT/PT graduate students ($M=62.02$, $SD=27.07$) in the knowledge of coma and unconsciousness [$t(509)=2.978$, $p=0.003$].

PT vs. SLP; PT vs. OT

Knowledge of memory loss scores were significantly different based on discipline [$H(2)=8.807, p=0.012$]. Pairwise comparisons with adjusted p-values showed that there were no significant differences between scores in OT and PT graduate students ($p=1.000$) and no significant differences between scores in OT and SLP graduate students ($p=0.062$). Significant differences in knowledge of memory loss were observed between PT and SLP graduate students ($p=0.017$).

Knowledge of concussion scores were significantly different based on discipline [$H(2)=18.262, p<0.001$]. Pairwise comparisons with adjusted p-values showed that there were no significant differences between scores in OT and SLP graduate students ($p=1.000$). However, significant differences were observed between OT and PT graduate students ($p=0.001$) as well as between SLP and PT graduate students ($p=0.001$) regarding knowledge of concussion.

First year vs. second year graduate students

Non-parametric analyses found no statistical difference between university designation regarding general TBI knowledge ($U=32,854.000, z=0.441, p=0.659$), coma and unconsciousness ($U=31,900.500, z=-0.324, p=0.746$), or recovery ($U=35,013.000, z=1.649, p=0.099$). A statistically significant difference was found regarding knowledge of memory loss and concussion. Results indicate that first year graduate students ($M \text{ rank}=236.19$) scored significantly lower on knowledge of memory than second year students ($M \text{ rank}=277.40$), ($U=37,617.500, z=-3.281, p=0.001$), and that first year graduate students ($M \text{ rank}=243.44$) scored significantly lower on misconceptions of concussion than second year students ($M \text{ rank}=269.18$), ($U=35,653.000, z=2.001, p=0.045$). Group differences by discipline and university designation are summarized in Table 3.

Discussion

Previous research has shown that misconceptions about TBI, particularly regarding coma, memory loss, and recovery, exist among students preparing to become SLPs and SpEds [39,40]. Misconceptions of concussion have also been observed among licensed school-based SLPs [44]. Evans et al. [40] cite education as a powerful tool in the dissolution of false beliefs with graduate students identified as a targeted group for such instruction. It is our hope that this study promotes a similar educational initiative through assessment of misconceptions present among graduate students in accredited PT, OT, and SLP training programs. To that end, responses to two validated surveys on TBI and concussion were evaluated: to identify common areas of misconception among graduate students, to analyze differences between disciplines, and to determine whether second year graduate students demonstrated more accurate knowledge than first year graduate students.

A majority of participants, regardless of discipline or university

designation, correctly responded to all four general knowledge of TBI items, with accuracy ranging 94%-96%. These findings are consistent with prior studies [39,40], where a majority of all participants, including the lay public, replied correctly to the same four statements. In the current study, no statistically significant difference in general knowledge was observed between first and second year graduate students. As such, general knowledge of TBI, insofar as Items 1-4, could be considered common public knowledge. Although a basic understanding of brain injury does not appear to necessitate specialized education, current and past research have demonstrated improved knowledge of more specific aspects of TBI (coma, memory loss, recovery, and concussion) as a result of advanced training [39,40,44].

SLP graduate students scored significantly higher than OT and PT graduate students on test items concerning coma and unconsciousness. Further analysis revealed no statistically significant difference in knowledge of coma between first and second year graduate students. However, Evans et al. [40] found a statistical difference between SLP graduate students nearing graduation and the lay public, with improved performance on all three coma items by the SLP graduate students. An improved understanding of coma among graduate students illustrates the potential of education; however the current study indicates that misconceptions of this topic are still present among graduate students. Coma and unconsciousness mean scores were 62% (PT), 62% (OT), and 69% (SLP), respectively. Low averages in this section may be explained by one test item in particular: a minority of students agreed that "people in a coma are usually not aware of what is happening around them" (32%). Additionally, fewer than 75% of respondents appeared to understand the persistent side effects associated with loss of consciousness. Similarly, fewer than 85% appeared to understand the ongoing difficulties associated with long-term coma. Poor performance on these items, coupled with a lack of improvement between first and second year graduate students suggests that students, collectively, might benefit from additional training in the area of coma and unconsciousness.

When tested on knowledge of memory loss, SLP graduate students scored significantly higher than PT graduate students. There was also a statistically significant difference according to university designation, with second year graduate students scoring higher than first year graduate students. Evans et al. [40] also found a statistical significance between SLP graduate students who were beginning their program and those nearing graduation on three of four memory loss items. The benefits of education are further illustrated by Evans et al. [40], with beginning and graduating SLP graduate students performing significantly better than the lay public.

Education has been shown to improve knowledge of memory loss between graduate students and the lay public, as well as between graduate students at the beginning and end of their course of study

Category	PT		OT		SLP		Group Differences	
	1	2	1	2	1	2	Designation (U)	Discipline [H(2)]
	M ± SD	M ± SD	M ± SD	M ± SD	M ± SD	M ± SD		
General TBI Knowledge	95 ± 14	96 ± 10	91 ± 18	96 ± 9	95 ± 14	95 ± 12	32,854	2.377
Coma and Unconsciousness	62 ± 30	62 ± 25	61 ± 27	62 ± 27	69 ± 22	69 ± 19	31,900	7.274*
Memory Loss	25 ± 25	45 ± 25	38 ± 26	44 ± 24	45 ± 28	51 ± 28	37617.5**	8.807*
Recovery	68 ± 17	71 ± 14	69 ± 17	73 ± 16	66 ± 19	65 ± 22	35,013	5.47
Concussion	79 ± 11	81 ± 9	75 ± 12	77 ± 11	76 ± 11	76 ± 12	35653*	8.262**

* $p<0.05$, ** $p<0.01$

Table 3: Category mean scores and group differences by discipline and university designation.

[39,40,45]. However, in the current study, memory loss mean scores were 40% (PT), 40% (OT), and 48% (SLP) respectively. Less than half of participants across disciplines correctly answered the following items: "After head injury, people can forget who they are and not recognize others but be normal in every other way" (18%); "People with amnesia for events before the injury usually have trouble learning new things too" (32%); and "After head injury, it is usually harder to learn new things than it is to remember things from before the injury" (40%). Past research corroborates the widespread persistence of these misconceptions regarding memory loss among the lay public and graduate students alike [38-40,45]. Further, nearly two in 10 respondents believed that "Sometimes a second blow to the head can help a person remember things that were forgotten after a first blow to the head," nearly ten points higher than the endorsement level previously recorded among beginning and graduating SLP graduate students [40]. While education has proven beneficial to understanding of memory loss, current data suggests that PT, OT, and SLP graduate students might benefit from additional instruction on the nature of memory loss and its treatment. There was not a significant difference in knowledge of recovery processes among disciplines, nor was there a difference between first and second year graduate students. Past research comparing participants with varying educational status have shown that those with the most education endorsed fewer misconceptions related to recovery from TBI [39,40]. Evans et al. [40] found that graduating master's students in SLP performed statistically significantly higher than the lay public on five recovery process items, and Hux et al. [39] found that undergraduate and graduate students scored statistically significantly higher than the lay public on one recovery item. Mean knowledge of recovery scores were 70% (PT), 71% (OT), and 66% (SLP), respectively. Less than a third of respondents in the current study correctly answered the following item: "Complete recovery from a severe head injury is not possible, no matter how badly the person wants to recover" (27%), consistent with a previous study in which 31% of graduating SLP master's students responded correctly to the same item [40]. Although fewer misconceptions of recovery have been observed among undergraduate and graduate students than the lay public, the current study shows no statistical improvement in knowledge of recovery between first and second year graduate students. These findings indicate that PT, OT, and SLP graduate students might benefit from more education on the course of recovery from TBI during their graduate training.

PT graduate students scored significantly higher than OT and SLP graduate students on test items related to concussion. Further, second year graduate students achieved higher statistically significant scores than first year graduate students on survey items related to knowledge of concussion, indicating that participants who had received more graduate-training endorsed fewer misconceptions of concussion. In their survey of school-based SLPs, Duff et al. [44] found that participants who had received specialized concussion training during their undergraduate/graduate training or during continuing education courses demonstrated improved knowledge of concussion on most test items. However, only 21.2% of practicing school-based SLPs polled had received training specific to concussion [44]. In the current study, mean knowledge of concussion scores were 80% (PT), 76% (OT), and 76% (SLP), respectively. Most participants believed that "Children show better recovery from concussion than older individuals," when in reality, concussion poses a harmful interruption to pediatric development [46,47]. Consistent with Duff et al. [44] who found that 8% of school-based SLPs disagreed with this statement, 12% of graduate students in the current study recognized this misconception of pediatric

concussion. Additionally, nearly 60% of graduate students in the current study believed that "Concussions result in structural damage that is visible on CT or MRI scans," and 20-30% held inaccurate knowledge of recovery from concussion and its associated long-term impacts. Past and current research demonstrates the efficacy of education in the improvement of concussion knowledge [44]. However, as less than 25% of school-based SLPs surveyed have received specialized concussion training, and misconceptions of concussion have been documented among practicing SLPs and graduate students alike, graduate students currently enrolled in PT, OT, and SLP training programs may benefit from education specific to concussion [44].

While statistical significance between first and second year graduate students in this study clearly indicates that graduate student knowledge of memory loss and concussion was improved by graduate-level training, the meaning of differences between disciplines is open to interpretation. There was no statistically significant difference between disciplines in knowledge of general TBI knowledge, coma, or recovery. SLP graduate students endorsed the fewest misconceptions of coma and memory loss, while PT graduate students endorsed the fewest misconceptions of concussion. Such differences may be related to the varied curricular programs of studies and the vast clinical experiences across PT, OT, and SLP graduate training programs. However, as brain injury rehabilitation is included in the scope of practice of PT, OT, and SLP, it is arguable that graduate students across the rehabilitative disciplines should demonstrate adequate and equitable knowledge of TBI and concussion.

Some limitations should be considered by future researchers. First, the current study is comprised of survey responses from graduate students across the United States, without focus on one region or university in particular. While results are representative of PT, OT, and SLP graduate students across the United States, they do not indicate which universities were most, or least effective at providing education on TBI and concussion. Participants were not asked if they had received prior training specific to TBI or concussion, or expected to receive such training as part of their respective graduate programs. Further, the current study does not differentiate between participants with clinical practicum experience and participants with only classroom/academic experience. It should also be noted that while most OT and SLP graduate programs are two years in duration, the majority of PT graduate programs are three years in length. Third year PT graduate students were not included in the current study. By comparing first and second year graduate student responses, the researchers were able to grouped respondents by years of training. However, whereas second year OT and SLP graduate students are in their final year of study, second year PT graduate students are not. As such, further research examining TBI instruction in graduate training programs for rehabilitation professionals is warranted.

Conclusion

The current study reflects the persistence of misconceptions about TBI among graduate students in accredited PT, OT, and SLP training programs. Although no acceptable standard margin of error for TBI knowledge exists at this time, Hooper [41] suggests a threshold of <5% (i.e. accuracy of at least 95%). Consistent with previous studies on TBI and concussion, the current study also identified prevalent misconceptions related to graduate student knowledge of memory loss, coma, and recovery [40,45] as well as concussion [44]. Accredited training programs and students alike might consider the results of this study as an impetus for academic change with increased focus placed

on course offerings that emphasize coma, memory loss, recovery, and concussion. It is our hope that this study has helped to narrow the gap in the available literature so that professionals and students alike are better able to effectively evaluate and treat TBI, serve as patient advocates, collaborate across disciplines, and engage the community on issues pertaining to brain injury.

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