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Narrative Discourse in Female Collegiate Athletes Pre- and Post-Concussion

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NARRATIVE DISCOURSE IN FEMALE COLLEGIATE ATHLETES PRE- AND POST-CONCUSSION

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Narrative Discourse in Female Collegiate Athletes Pre- and Post-Concussion

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Research has shown that narrative analysis can be an indicator of cognitive-linguistic changes after TBI of varying levels of severity. Is it unknown, however, how this research applies to women, who display greater levels of cognitive impairment and self-reported symptoms post-concussion than their male counterparts. The current study considered the use of narrative discourse analysis in delineating changes in cognitive-linguistic functioning in female athletes pre- and post-concussion. Nineteen collegiate athletes were asked to retell the story of Cinderella at two points in time: during a baseline screening prior to the start of the athletic season, and after sustaining a concussion. The pre- and post-concussion narratives were then compared on the basis of a number of microlinguistic and macrostructural measures. In addition, post-concussion narratives of women were compared to the post-concussion narratives of men from a previous study. Women's pre- and post-concussion narratives differed significantly only in terms of total number of verbal disruptions, with a greater number pre-concussion than post-concussion. Men produced more verbal disruptions and tangents than women both pre- and post-concussion. Post-concussion, men produced greater levels of thematic density than women, although this discrepancy was not noted pre-concussion. Results are discussed in light of potential practice effects and possible gender bias of the Cinderella story.

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Literature Review

Definition and etiology of concussion. Within the research literature, the terms concussion and mild traumatic brain injury (mTBI) have historically been used interchangeably to refer to the same types of injuries (McCrory et al., 2013). For instance, a 2003 report to Congress by the CDC lists "concussion" as a synonym of mTBI, but defines the term mTBI broadly to include any traumatically-induced period of alteration of consciousness, cognitive dysfunction, or symptoms, so long as loss of consciousness does not last longer than 30 minutes, post-traumatic amnesia does not last longer than 24 hours, and symptoms are not the result of a penetrating injury (Center for Disease Control, 2003). This lack of a clear distinction between the two terms can be seen in other papers and studies from the late 1990s and early 2000s (e.g. Kelly & Rosenberg, 1997; McCrea et al., 2003).

More recently, researchers have differentiated the two terms (Harmon et al., 2013; Khurana & Kaye, 2012; McCrory et al., 2013). The 4th International Congress on Concussion in Sport states that concussion is a type of mTBI, and that it is differentiated from other mild injuries by the fact that it is constellation of clinical symptoms that are functional and may not be the result of a pathological injury (McCrory et al., 2013). The American Medical Society for Sports Medicine also draws a distinction between the two terms, stating that, "concussions are a subset of mild traumatic brain injury on the less severe end of the brain injury spectrum and are generally self-limited in duration and resolution." In other words, in recent years there has been a consensus that concussions are differentiated from mild traumatic brain injuries in that they are functional, rather than structural, in nature.

This understanding leads to a contemporary definition of concussion. The 4th International Conference on Concussion in Sport defines concussion as “a brain injury and is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces” (McCrory et al., 2013). Several components are included in this operational definition. First, concussions are the result of a blow to the head or elsewhere on the body with forces transmitted to the head that generally result in short-lived neurological impairments that often resolve spontaneously. Furthermore, they are functional rather than structural in nature, although there may be neuropathological changes. The definition specifies that concussions follow a sequential resolution of symptoms that may or may not include loss of consciousness, though recovery may be prolonged (McCrory et al., 2013). Expanding upon this definition, the American Academy of Neurology identifies memory and orientation as those areas of cognition most often affected by concussion (Giza et al., 2013).

When an individual sustains a concussion by a blow to the head or elsewhere on the body, a complex chain of events often referred to as a “neurometabolic cascade” is initiated. First, acceleration forces result in structural trauma in which the membranes and axons of neurons stretch and deform, a disruption which may result in loss of consciousness (Giza & Hovda, 2001; Marshall, 2012). This deformation disrupts ion channels, resulting in depolarization and the subsequent release of glutamate, thereby setting off a metabolic cascade that alters the chemical properties of the brain. Following this period of excitation is a period of neuronal suppression, which is the physiological correlate of commonly noted concussion symptoms such as cognitive deficits and fatigue. In addition to the changes in the chemical landscape of the brain following concussion, cerebral blood flow decreases immediately following the insult, exacerbating changes in energy availability (Shrey, Griesbach, & Giza, 2011).

Diagnosis and management of sports-related concussion. In recent years, several groups have published guidelines regarding the assessment and management of concussion in sports (Giza et al., 2013; Harmon et al., 2013; McCrory et al., 2013). See West and Marion, 2013, for an overview and comparison of the guidelines from The American Medical Society for Sports Medicine, 4th International Conference on Concussion in Sport, and American Academy of Neurology. Although the specific recommendations of the guidelines differ slightly, all recommend sideline evaluation of players with suspected concussions by a licensed health care provider, followed by clinical assessment and management by a multidisciplinary team. A clinical diagnosis of concussion is made using symptom checklists, cognitive evaluation, balance testing, and standardized concussion assessment. All three sets of guidelines specify that athletes should not return to play until they are asymptomatic. When returning to play, both the American Medical Society for Sports Medicine and the 4th International Conference on Concussion in Sport advocate a stepwise progression of return to physical activity in which the player must demonstrate a lack of symptoms at each activity level before proceeding to the next (Harmon et al., 2013; McCrory et al., 2013).

Although there is a good deal of agreement among the sets of guidelines regarding the diagnoses and treatment of concussion in sports, adoption of these recommendations has not always translated to actual practice. Recent surveys of athletic trainers at the high school and college levels indicated that many do not implement the specific assessment recommendations proposed by these guidelines (Lynall, Laudner, Mihalik, & Stanek, 2013; Williams, Welch, Weber, Parsons, & Valovich McLeod, 2014).

Incidence of concussion. The precise number of concussions among athletes nationwide is not known, mainly due to two factors. First, concussion is thought to be under-reported by athletes, due to beliefs that symptoms are not serious enough to warrant medical attention, desire to stay in the game, or lack of realization on the part of the athlete that he/she has a concussion (McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004). Second, national statistics gather data on the number of mild traumatic brain injuries (mTBI) that result in hospitalization. Many concussions, however, are treated in non-hospital medical settings or are not treated at all (Center for Disease Control and Prevention, 2003). It has been estimated, however, that the incidence of sports-related traumatic brain injury (TBI) may be 1.6–3.8 million per year (Langlois, Rutland-Brown, & Wald, 2006). A recent epidemiology study estimated that, when under-reporting was taken into account, NCAA athletes alone experience 10,560 sports-related concussions annually, and that concussions comprise 6.2% of all NCAA sports-related injuries (Zuckerman et al., 2015). Concussion can be costly on an individual level as the affected person misses school, work, and sporting events. It also has an economic burden on a national level; in 2003, the CDC reported to Congress that mTBI costs nearly $17 billion per year (Center for Disease Control, 2003).

Concussion rates in athletics are generally reported as number of concussions per 1,000 athletic exposures, with each practice or game considered one exposure. A study of more than 10 million athlete-exposures (practices and games) among high school students found that, on average, athletes sustained concussions at a rate of 0.24 per 1,000 exposures across various sports (Lincoln et al., 2011). This figure was corroborated by a 2015 meta-analysis of concussion rates in youth athletes, which found an overall concussion rate of 0.23 per 1,000 athletic exposures (Pfister, Pfister, Hagel, Ghali, & Ronksley, 2015). In some sports, this rate has been reported to be substantially higher; for instance, in women's college soccer, the rate of concussion was found to be upwards of two per 1,000 exposures (Covassin, Swanik, & Sachs, 2003). Concussion rates may also be influenced by age/level of play. A study of rates in boys' and men's football found rates of 2.38 per 1,000 exposures for youth football, 2.01 for high school football, and 3.74 for college football (Dompier et al., 2015). This represents a substantial risk for the individual player. Among high school football players, 30% report a previous history of concussion, although only 47% of these concussions were reported at the time of the injury (McCrea et al., 2004). Presumably this rate would be higher for collegiate athletes due to more exposure as a function of more years of play. Moreover, concussion rates appear to be increasing, at least in some sports, although this may be due to increased awareness or more sensitive diagnoses than an actual increase in the raw number of incidents (Lincoln et al., 2011; Zuckerman et al., 2015).

Need for sensitive measures. Within the field of concussion assessment and management, there has been a call for sensitive, reliable measurements of impairment. This need is especially salient given that published guidelines for concussion management in sport specify that athletes should not be returned to play following concussion until signs and symptoms have entirely abated. These signs and symptoms of concussion may be divided into four broad categories (Harmon et al., 2013). The first category, physical signs and symptoms, includes headache, nausea, vomiting, and vestibular disruption, sensitivity to light and noise, and appearing "dazed" or "stunned." Cognitive symptoms comprise the next category, and include confusion about recent events, alterations in attention, memory, and processing speed, and the feeling of being "slowed down" or "foggy." Emotional symptoms may manifest as irritability, sadness, emotional lability, or nervousness. The final category addresses sleep disruptions such as drowsiness during waking hours, difficulty falling asleep, and sleeping more or less than normal.

When determining readiness to return to play, it has been suggested that cognitive-linguistic symptoms may be an sensitive indicator of recovery in sports-related mTBI. According to Wong, Murdoch, and Whelan (2010), assessment in this area, "therefore may serve as a guide as to whether or not a player is truly asymptomatic and capable of returning to play" (p. 1156). Tucker and Hanlon (1998) proposed that cognitive disruption following mTBI may manifest as subtle language disorders. They caution, however, that although those with mTBI might report difficulty with word finding or expressing themselves, "traditional language testing measures may be insufficiently sensitive to detect these deficits" (p. 783).

This cautionary statement regarding traditional language batteries has been only somewhat borne out by research. For instance, one study found that most individuals with acute mTBI (2-14 days post-injury) performed within normal limits on the *Test of Adolescent/Adult Word Finding* (German, 1990) based on the test's psychometrics. They were, however, significantly less accurate than a control group, with latency (response time) being the most common error (King, Hough, Walker, Rastatter, & Holbert, 2006). Although mTBI/control group differences were apparent in an experimental setting, reinforcing the notion that mTBI may result in language disruptions, use of the *Test of Adolescent/Adult Word Finding* would not be clinically useful since a given individual with mTBI is likely to score within normal limits using the tests psychometrics despite slower response times.

Another study examined the performance of individuals in the chronic stages of mTBI (6 months post-injury) on a large battery of subtests (Wong et al., 2010). The battery included tests of general language (*Neurosensory Center Comprehensive Examination for Aphasia* and the

Boston Naming Test) (Spreen & Benton, 1977; Kaplan, Goodglass, & Weintraub, 1983), tests of high-level language (*Test of Language Competence: Expanded Edition* and *The Word Test-Revised*) (Wiig & Secord, 1989; Huisingh, Barrett, Zachman, Blagden, & Orman, 1990), as well as a cognitive assessment (*Scales of Cognitive Ability for Traumatic Brain Injury*) (Adamovich & Henderson, 1992). No significant group differences between the control group and the mTBI group were found. Interestingly, however, each of the four participants in the mTBI group demonstrated below-normal performance on at least one subtest of the high-level language portion of the battery. Areas of deficiency were highly variable among participants, and included verbal fluency, auditory comprehension, inferencing, and producing synonyms and antonyms. Although this suggests that language batteries can, in fact, identify some language deficits in mTBI, the clinical utility of this finding is limited both by the time required to administer a large battery and the fact that areas of deficit were not consistent among those with mTBI. It is also possible that language deficits were more apparent due to the long duration of the test battery.

Similiarly, Barwood and Murdoch (2013) administered large battery of tests to individuals in the chronic stages of mTBI, including measures of general language, semantic proficiency, metalinguistics, cognition, verbal memory, reading and writing, complex syntax, and expressive vocabulary. Significant differences were found between these individuals and a control group in a number of cognitive and higher level linguistic categories. In the cognitive realm, these differences included the overall score on the *Scales of Cognitive Ability for Traumatic Brain Injury* (SCATBI) (Adamovich & Henderson, 1992) and as well as several subtests of that assessment. It should be noted that the SCATBI was designed to assess "primary cognitive deficits secondary to right brain damage, anoxia, brain tumors, or subcortical brain lesions" (Adamovich & Henderson, 1992, p. 5), rather than mTBI. Significant group differences in language were noted on the *Boston Naming Test* (Kaplan et al., 1983), two subtests of the *The Word Test-Revised* (Associations and Synonyms) (Huisingh et al., 1990), two subtests of the *Wiig-Semel Test of Linguistic Concepts* (Temporal and Spatial) (Wiig & Semel, 1974), and the total score and most subtests of the *Test of Language Competence: Expanded Edition*. It was not clear from this study whether the scores of the individuals with mTBI fell outside the respective tests' psychometric norms, which would indicate clinical utility. It should also be noted that SLPs do not routinely include measures of higher level language in their assessment of individuals with TBI (Frith, Togher, Ferguson, Levick, & Docking, 2014).

Taken as a whole, these studies suggest that subtle language deficits are common in people with mTBI, but that there is an ongoing need for sensitive measures. Researchers have proposed various methods to accurately identify cognitive-linguistic features of concussion or mTBI, including confrontation naming tasks (King et al., 2006) and more sensitive or higher level language batteries (Barwood & Murdoch, 2013; Whelan & Murdoch, 2006; Wong et al., 2010). None of these studies, however, have yielded an assessment protocol that is time-efficient and that reliably distinguishes a given individual with mTBI from those without brain injuries. Tucker and Hanlon (1998) propose narrative discourse as a sensitive measure, stating that, "Narrative discourse production requires the integration of linguistic information within an overall theme, or macrostructure" (p. 784). This method of uncovering deficits to which standardized tests are less sensitive has been successfully used in moderate and severe TBI research (e.g. Biddle, McCabe, & Bliss, 1996; Coelho, Lê, Mozeiko, Krueger, & Grafman, 2012; Lê, Coelho, Mozeiko, & Grafman, 2011; Marini et al., 2011; Marini, Zettin, & Galetto, 2014), and to a lesser extent in mTBI research (Galetto, Andreetta, Zettin, & Marini, 2013; Stout, Yorkston, & Pimentel, 2000; Tucker & Hanlon, 1998).

Narrative discourse in moderate and severe TBI. Narrative analysis has been used extensively to investigate higher-level language disturbances among those with moderate and severe TBI. This body of research has yielded a framework for narrative analysis in which a given narrative may be examined on a number of levels. Multi-level analysis is indicated because often, individuals with TBI often do not present with impairments in grammar or syntax, but manifest impairments in coherence and informativeness (Galetto et al., 2013). Analysis procedures that have emerged from this body of literature may be applied to research examining narratives in mTBI or concussion.

The term "microlinguistic" refers to linguistic components at the sentence level, such as number of words and grammatical complexity, and errors at this level have been noted inconsistently in studies of narrative discourse post-TBI (Coelho, 2007). For instance, individuals with TBI have been reported to produce fewer propositions per t-unit than individuals without brain injury, resulting in less dense and syntactically complex output (Coelho, Grela, Corso, Gamble, & Feinn, 2005), and a slower speech rate (Marini et al., 2011). Other studies have found no differences at this level in terms of clauses per t-unit (Coelho et al., 2012), speech rate, or MLU between groups with and without TBI (Marini et al., 2014).

In contrast, many studies have found narrative impairments in individuals with TBI at the macrolinguistic level or macrostructural level. Included at this level of language production are measures of cohesion, informativeness, and thematic density (Marini et al., 2011). Individuals with TBI produce more errors of coherence/cohesion than their neurotypical counterparts, produce more utterances that do not further the story, fewer thematic units per utterance, and are less accurate (Davis & Coelho, 2004; Marini et al., 2014). In sum, this results in less efficient and less connected storytelling in individuals with TBI.

Several studies have implicated impaired executive functioning as an underlying cause of this reduced narrative performance at the macrostructural level. According to Mozeiko, Le, Coelho, Krueger, and Grafman (2011), who found a correlation between a card sorting task and story grammar, the ability to produce complete narratives is "closely aligned with [cognitive flexibility] in that it requires identification of goals, identification of an intended plan, and evaluation of the success or failure of the plan" (p. 832) Both a card sorting task, which relies on executive function, and test of immediate memory have been found to be significant predictors of story completeness (Le, Coelho, Mozeiko, Krueger, & Grafman, 2012). This relationship between cognitive skills and macrolinguistic measures of narrative production suggests that linguistic deficits found in TBI are the result of a disturbed interface between cognitive and linguistic processes rather than a specific disturbance of language (Andreetta & Marini, 2014).

Narrative production in mTBI. To date, there has only been one study of narrative discourse in acute sports-related concussion (Kovach, Hardin, & Ramsberger, 2015b). Several studies, however, have examined narrative discourse in the chronic stages of mTBI and provide justification for examining whether similar impairments in narrative production may be seen in the acute stages of concussion.

Galetto, et al. (2013) compared ten individuals with mTBI to 13 typical controls. All of the individuals in the control group were in the chronic phases of mTBI, with more than two years having elapsed since their injuries, and did not have aphasia at the time of the study. Each participant completed number of neuropsychological tests and told three stories using visual supports, which were analyzed on the basis of productivity, speech rate, lexical and syntactic encoding, textual organization, and informativeness. Two significant group differences emerged on the neuropsychological tests: the group with mTBI produced more non-perseverative errors on the *Wisconsin Card Sorting Task* (Heaton, Chelune, Talley, Kay, & Curtiss, 1993), and recalled fewer words on the delayed condition of *Rey's 15-word Immediate Recall and Delayed Recall* (Rey, 1964), indicating that the mTBI group was demonstrating impairments in executive function and memory. Group differences approached significance for perseverative errors on the *Wisconsin Card Sorting Task* and *Trail Making Test-A* (Heaton et al., 1993; Reitan & Wolfson, 1985). Although the group with mTBI had a slower speech rate than the control group, no other microlinguistic deficits (deficits at the sentence level or lower such as grammatical errors or paraphasias) were noted. Macrolinguistic differences were more pronounced, with mTBI group producing more errors of global coherence (tangential, incongruent, repetitive, and filler utterances) and fewer lexical information units (grammatically and pragmatically appropriate content units) than the control group. Negative correlations were found between neuropsychological variables and narrative production within the mTBI group; specially, non-perseverative errors on the Wisconsin Card Sorting Task (Heaton et al., 1993) correlated negatively with the percentage of lexical information units, leading the authors to speculate that, "inhibition might be important for monitoring the production of extraneous comments and derailments while telling a story." Scores on Rey's 15-word delayed recall task (Rey, 1964) correlated negatively with the number of global coherence errors, suggesting that underlying deficits in memory may negatively affect discourse planning.

Tucker and Hanlon (1998) studied neuropsychological variables and narrative discourse among eight individuals with mTBI, five individuals with moderate TBI, and five controls. Average time post-injury was 108 days for the mTBI group, and 177 days for the moderate TBI group. Study participants completed a series of neuropsychological tests that included a full-scale IQ and measures of executive function, memory, and learning. They also sequenced pictures to create a sequential story and then produced narratives using visual support. Both the mTBI and moderate TBI groups were significantly less accurate in describing the picture sequences than the control group, although the TBI groups did not significantly differ from each other. Participants were also asked questions to test understanding of implied meanings, or underlying information that was important to understanding the story but was not presented explicitly. Although group differences in stating implied meanings did not reach significance, the group with mTBI tended to state fewer implied meanings than the control group, and the group with moderate TBI tended to state fewer implied meanings than the mTBI group. The number of perseverative responses on the Wisconsin Card Sorting Test (Heaton et al., 1993) negatively correlated with the narrative composite scores (a sum score capturing information units, accuracy, and implied meanings) of the individuals with TBI. This suggested disruptions in high-level language were associated with cognitive deficits, leading the authors to conclude that, "executive disturbance, involving difficulty in the integration of multiple elements of information, may result in an inaccurate narrative production."

Stout, Yorkston, and Pimentel (2000) conducted a study comparing the performance of a control group and a TBI group consisting of individuals with mild, moderate, or severe injuries. Participants completed a picture description task and a story retell task, and narratives were analyzed on the basis of efficiency measures (syllables per minute, concepts per minute, number of mazes, and words per maze) and quantity measures (number of concepts, number of syllables, and words per t-unit.) Significant differences between the control group and the TBI group were noted on three measures on the picture description task: syllables per minute, concepts per minute, and words per maze. In other words, individuals with TBI demonstrated a slower speech rate and remained in mazes for longer. On the story retell task, significant group differences emerged for measures of speech rate, number of concepts, and number of syllables; that is, narratives of the TBI group were both slower and shorter than those of the control group. Interestingly, the patterns of discourse for the three levels of traumatic brain injury (mild, moderate, and severe) were remarkably similar, although slight differences were noted between groups for number of concepts, with the severe group producing the fewest, and number of words per maze, with the severe group producing fewer than the mild or moderate groups.

As discussed previously, the terms mTBI and concussion are often used interchangeably within the literature; concussion, however, represents a distinct subcategory of mTBI. Although it is possible that some of the participants in studies of mTBI fit the contemporary definition of concussion, it is likely that many did not. Furthermore, while concussions often resolve spontaneously, most of the participants in studies of narrative discourse after mTBI were continuing to experience differences in cognition up to several months after their injuries. Therefore, the findings of the aforementioned studies do not necessarily apply to those with concussion.

Narrative language after concussion was addressed by Kovach, Hardin and Ramsberger (2015a, 2015b). The study's data was drawn from the Concussion Assessment and Rehabilitation Team (CAART) program at University of Colorado's Speech, Language, and Hearing Center. In this program, student athletes participating in high-risk sports complete a pre-season baseline screening of various cognitive and linguistic measures. If they sustained a concussion, they return for re-testing and are cleared to play or held from play based on performance compared to baseline. As part of the assessment battery, athletes told the *Cinderella* story after having reviewed it using visual supports. Data from twenty male student athletes were used for the purposes of the study, half of whom were immediately cleared to play after concussion, indicating cognitive functioning on standardized tests that was roughly equivalent to baseline levels, and half of whom were not cleared for return to play due to cognitive functioning below baseline levels and/or the presence of concussion symptoms.

The study first considered differences between narratives of the cleared and not-cleared groups post-concussion. The not-cleared group displayed higher levels of thematic density than the cleared group, regardless of whether thematic density was calculated as thematic units per t-unit or thematic units per utterance. The not-cleared group also produced considerably fewer instances of tangential statements than did the cleared group.

Next, pre- and post-concussion differences for each group were considered. For the not-cleared group, there was a significant increase post-concussion in the number of details, with corresponding increases in thematic density based on t-units or utterances and rate of thematic details (details per second.) There was also a decrease in the number of tangents post-concussion as compared to pre-concussion. The cleared group showed a similar profile, with more thematic units and thematic units per second post-concussion than pre-concussion. Although not reaching significance, for the cleared group there was also a trend towards more filler sounds and topic switches post-concussion, and a trend towards a decreased number of conceptually incongruent utterances.

In summary, participants, regardless of cleared or not-cleared status, produced post-concussion narratives that were more efficient than their pre-concussion narratives, and that this effect was more pronounced for those that were not cleared immediately and presumably had more severe cognitive and/or somatic symptoms. The authors attributed these surprising results to possible greater familiarity due to repeated administration or increased effort in an attempt to return to play sooner. In addition, the authors remarked upon the fact that most tangents were social in nature, and therefore a decrease in tangents indicated fewer attempts to involve the examiner in the task. They reasoned that before their concussions, participants were making more attempts to form social connections with their examiners in the form of tangents, whereas after their concussions, they focused more heavily on the narrative task.

Narrative discourse in other disorders. Narrative discourse has been shown to be a sensitive measure of language disruption in non-traumatic neurological disorders. In some cases, narratives revealed subtle language disruptions in the absence of abnormal findings on standardized tests of language (Ellis, Crosson, Gonzalez Rothi, Okun, & Rosenbek, 2015; Marini, 2012).

Researchers have noted changes in narrative language during the interictal period in individuals with temporal lobe epilepsy. In one study, participants were asked to produce a narrative three times in sequence. Unlike the control group, who generally used fewer words per narrative and completed the narrative in a shorter time span with repeated tellings, the group with epilepsy tended to become more verbose on each retelling, including more words and taking slightly longer (Field, Saling, & Berkovic, 2000). Another study found that when producing procedural discourse, individuals with temporal lobe epilepsy performed similarly to controls. When producing narrative discourse, however, they had a slower rate of speech, produced more non-communication words, and produced fewer total story components than the control group. Impaired discourse for these individuals was correlated with a measure of working memory, but did not correlate with other measures of cognitive function, including executive function, or with performance on the *Boston Naming Test* (Kaplan et al., 1983; Bell et al., 2003).

Deficits in narrative discourse in the absence of a frank language disorder may be seen in individuals who have had right hemisphere strokes. Marini (2012) investigated the narrative productions of individuals with right hemisphere damage subsequent to a focal ischemic stroke who were not classified as having aphasia. Although these individual did not differ from a control group in terms of microlinguistic differences, they demonstrated lower levels of lexical informativeness and more global coherence errors; that is, they produced a lower proportion of relative and accurate details compared to tangents, incorrect information, filler words, and incongruent information. These deficits were more pronounced in those with frontal lesions, leading the author to speculate that damage to this region may impair the organizational capabilities needed to produce narratives.

Changes in narrative discourse have also ben seen in individuals with degenerative neurological diseases. One study compared individuals with mild cognitive impairment (MCI), Alzheimer's disease (AD), and a control group. Differences existed between the control group and the AD group on almost all measures, with the narratives produced by the AD group having poorer global coherence, fewer macropropositions, and being less complete and effective. The narrative performances of the group with MCI was, as expected, less impaired than that of the AD group, but more impaired than that of the control group. The most notable group difference between those with MCI and the controls was that the MCI group produced more irrelevant information. Of the three standard language tasks administered (naming, phonemic verbal fluency, and semantic verbal fluency), those with MCI only differed on naming (Drummond et al., 2015). Another study used a customized computer-based analysis to analyze large number of variables (parts of speech, syntax, agrammatism, use of highly familiar words, lexical diversity, information content, repetitiveness, and acoustics) in the narratives of those with and without Alzheimer's disease. The program correctly classified the narratives as belonging to the control group or the Alzheimer's disease group with 92% accuracy, with semantic impairment, acoustic abnormality, syntactic impairment, and information impairment contributing most to measures of variance (Fraser, Meltzer, & Rudzicz, 2015).

In Parkinson's disease, one study showed that changes in narrative production may be apparent early in the disease course. Although the individuals with Parkinson's disease produced a similar number of content units, words, and cohesive ties as a control group, the cohesive ties they produced were more likely to be incomplete or erroneous (Ellis et al., 2015). Impairments in narrative discourse may also be seen in those with Parkinson's disease with dementia and dementia with Lewy bodies, with these groups producing fewer connections between events and demonstrating more difficulty stating the overall theme of a story (Ash et al., 2011).

Finally, a study by Ash et al. (2014) found that those with amyotrophic lateral sclerosis (ALS) demonstrated impairments in local connectedness and were less likely to state the overall theme of a narrative than a control group. Imaging studies found that these impairments were related to atrophy of the right dorsolateral prefrontal and bilateral inferior frontal regions of the brain.

Word retrieval following concussion/mTBI. Deficits in word retrieval have been inconsistently noted following concussion, mTBI, and in post-concussive syndrome (PCS). In the acute phases of mTBI (two to 14 days post-injury), King et al. (2006) found that individuals demonstrated lower scores on the *Test of Adolescent/Adult Word Finding* (TAWF) (German, 1990) than a control group. The TAWF assesses word finding in relatively constrained contexts: picture naming of nouns, sentence completion using clozes, naming a word based on attributes, picture naming of verbs, category naming, and comprehension of incorrect items. Most were errors of latency, suggesting that deficits in processing speed were the underlying cause of errors, rather than loss of or lack of access to the underlying semantic item. The same study found that on the *Test of Word Finding in Discourse* (TWFD) (German, 1991), which calculates productivity, number of word finding behaviors, and number of t-units based on elicited narratives, no differences were noted between the two groups. Because latency is considered an error on the TAWF but not the TWFD, the authors speculated that discourse, which does not have strict latency requirements, is not a sensitive indicator of word-finding deficits following mTBI.

Peterson, Ferrara, Mrazik, Piland, & Elliott (2003) examined retrieval fluency, as indicated by the Controlled Oral Word Association Test (COWAT) (Benton & Hamsher, 1978), as part of a larger battery of cognitive-linguistic testing. The experimental group consisted of college athletes two, three, and ten days post-concussion. In this study, no differences in retrieval fluency emerged between the athletes with concussion and a control group, nor were differences noted in the areas of concentration or memory. Significant differences did emerge, however, in processing speed, with the experimental group demonstrating slower processing speed than controls, as well as impairment in measures of postural stability and vestibular function.

Other studies have examined word finding and retrieval fluency in the chronic stages of mTBI or PCS. Again, research presents a mixed picture. Baillargeon, Lassonde, Leclerc, & Ellemberg (2012) found no difference on COWAT performance between asymptomatic individuals up to one year after their concussions and a control group, perhaps unsurprisingly. Barwood and Murdoch (2013) reported that while individuals with mTBI did not display deficits in retrieval fluency or naming six to eight months post-injury, they did display ongoing semantic difficulties as indicated by lower scores on the word associations and synonyms subtests of *The Word Test–Revised* (Huisingh et al., 1990) than a control group.

Gender differences in concussion presentation and recovery. A number of studies have found differences in how men and women sustain and recover from concussions. Female gender is considered a risk factor for concussion, with women sustaining higher rates of concussion within comparable sports than men (Covassin et al., 2003). This is not to say that more females than males sustain concussions in terms of absolute numbers, but rather that a female playing soccer or basketball is more likely to sustain a concussion during a practice or a game than her male counterparts. When injuries occur also differs by gender; female athletes have higher rates of concussion during games (as opposed to practices) than male athletes (Covassin et al., 2003).

Three mechanisms have been proposed to explain this disparity in concussion rates. First, females' necks tend to be smaller in mass and less stable than males', resulting in greater acceleration and displacement of the head in response to blows (Tierney et al., 2005). Interestingly, while protective headgear decreases head acceleration rates for males, it actually increases acceleration rates for females, possibly resulting in a higher risk of concussion (Tierney et al., 2008). A second reason that females might have a greater concussion risk than men under similar conditions is the influence of female sex hormones. Rat studies in this area have been highly contradictory, however, with some suggesting that estrogen is neuroprotective in TBI and others suggesting it to be detrimental (Bramlett & Dietrich, 2001; Emerson, Headrick, & Vink, 1993; O'Connor, Cernak, & Vink, 2005). Men and women's brains show physiological differences, as well, with females demonstrating higher rates of metabolism (Andreason, Zametkin, Guo, Baldwin, & Cohen, 1994) and blood flow (Esposito, Van Horn, Weinberger, & Berman, 1996), which might result in differences in the physiological presentation of concussion.

When females sustain concussions, they tend to report more symptoms than males (Broshek et al., 2005; Colvin et al., 2009; Covassin, Elbin, Harris, Parker, & Kontos, 2012). It is not clear whether this is because females experience more symptoms, or because they are more likely to report them. Researchers have suggested that men might try to hide their symptoms, or that women might be more concerned about their future health and therefore more likely to report symptoms (Covassin, Elbin, Harris, Parker, & Kontos, 2012). Findings regarding which symptoms are reported more often based on gender are inconsistent. For instance, Frommer et al. (2011) found that female high school athletes were more likely to endorse drowsiness and noise sensitivity, whereas their male counterparts were more likely to report amnesia and confusion/disorientation. Covassin et al. (2007), on the other hand, found that male college athletes reported sadness and vomiting at higher rates than females, and that females were not significantly more likely to report any particular symptoms.

Females are also 1.7 times more likely than males to experience cognitive impairments post-concussion compared to their own baseline performances (Broshek et al., 2005). Different areas of cognition may also be affected depending on gender. Women are reported to show greater impairment in response times (Broshek et al., 2005) and visual memory (Covassin et al., 2012; Covassin et al., 2007) than men on neurocognitive tests following concussion. More severe post-injury symptoms have also been noted in TBI; according to a meta-analysis by Dick (2009), women with TBI have worse outcomes than men in 85% of 20 measured variables.

Studies that only compare post-concussion measures in men and women should be interpreted with a degree of caution, however, since pre-injury differences in symptoms and cognition may be present. Differences between men and women have been noted in cognitive function and reported symptoms at baseline, with women endorsing more mild baseline symptoms and performing better on measures of verbal memory, and men performing better on measures of visual memory (Covassin et al., 2006).

Female gender may also be a risk factor for prolonged recovery from concussion. In one study, females were significantly more likely to have post-concussive symptoms one month post injury, and a trend towards significance in the number symptoms was seen at three and six months post-onset (Bazarian et al., 1999). Other research disputes this finding, with Covassin et al. (2007) reporting no significant sex-by-time interaction for athletes tested at baseline, up to three days post-concussion, and up to ten days post-concussion.

Gender differences in discourse. Different patterns of language usage between men and women have been noted across discourse types, although effect sizes for these differences are typically very small. In recent years, technology has allowed for large corpora of written language and transcribed oral language to be analyzed quickly and accurately. One such study of over 14,000 samples found that across discourse types and modalities, men tended to produce longer words and more numbers, articles, and prepositions, whereas women used more pronouns, social words, words referring to psychological processes, and verbs (Newman, Groom, Handelman, & Pennebaker, 2008). When the same study analyzed conversation, which was transcribed from a spoken modality, no significant differences were noted in sentence length or in overall word count, although women produced more questions and more tentative speech.

These gender-based findings are not consistent across studies. A large meta-analysis by Leaper and Ayres (2007) found that across a large number of studies, men were more talkative than women as measured by number of words or utterances, rate, duration, total turns, or total statements, and that women used more affiliative speech. This study also found that gender differences in language production vary as a function of age, context, group size, and conversational partner.

Hancock, Stutts, & Bass (2014) analyzed narratives, specifically, by comparing personal stories produced by males and females on the basis of number of t-units, words per t-unit, dependent clauses, fillers, qualifiers, hedges, and a several semantic-level variables. Their analysis found only four significant differences between men and women's personal narratives. Men produced more language overall than women, with a greater number of t-units, more dependent clauses, and more words per t-unit. Contrary to stereotypes of gendered language, men produced more pronouns than women. On all other measurements, including those typically associated with male or female language, such as hedges and fillers, no significant differences were observed.

Gender and the *Cinderella* story. Fromm, MacWhinney, Forbes, & Holland (2011) investigated whether *Cinderella* story retell tasks were biased based on gender by comparing a large number of samples from healthy controls and from people with aphasia. They found that for healthy individuals, there were no gender differences in *Cinderella*-story retells in terms of total utterances, total words, or lexical diversity. For people with aphasia, gender differences emerged on only one measure, lexical diversity. Hudspeth, Campbell, Williams, Dillow, and Richardson (2013), on the other hand, explored the possibility of a gender bias in the Cinderella story by comparing the number of details produced by participants to the total number details in the story. They found that women exhibited greater familiarity with the Cinderella as evidenced by producing more details.

Conclusions of the current literature. Concussion is a complex injury resulting in impairments in a number of cognitive and linguistic areas. Although research indicates that higher level linguistic skills are negatively impacted by concussion, it is not routinely being assessed, and there is a need for sensitive and efficient measurement tools. Narrative discourse analysis might be once such tool, and has been used successfully to delineate subtle linguistic deficits in those with moderate and severe TBI.

Males and females have different experiences with concussion at all stages, from pre-injury baseline measurements, to injury rates, to symptomology, to recovery. In general, females are more strongly impacted by concussions than males, and have higher rates of cognitive impairment and report a greater number of symptoms. These global differences in gender differences in presentation and response must be considered when studying concussion-related deficits, including language. In addition, although gender differences in language use are generally small and highly context-dependent, differentiated patterns have been noted often enough to suggest that males and females would be expected to differ on some measures of discourse regardless of injury status.

Purpose of the Present Study

This study seeks to expand the current knowledge base regarding narrative discourse and concussion by comparing narrative samples taken pre- and post-concussion from female athletes. The existing research base provides strong evidence that mTBI affects narrative production. Because most of the existing research was conducted those in the chronic stages of mTBI, however, results of these studies are not necessarily generalizable to individuals in the acute stages of concussion, which is understood to be a subtype of mTBI. Indeed, the results of the study by Kovach et al. (2015b) suggest that individuals in the acute stages of concussion may present with a very different language profile than has been seen in other studies examining narrative discourse in mTBI or moderate or severe TBI. With only one study examining the affects of acute concussion, further research is warranted and may help confirm the existence of high-level language disruptions following this type of injury. It is also important to consider that the available research on narrative production in mTBI was conducted on mixed-gender groups (where specified), and that Kovach et al. (2015b) examined only male athletes. It is well-documented, however, that men and women show different impairment and recovery patterns post-concussion. Just as women demonstrate cognitive profiles post-concussion that differ from their male counterparts', it is possible that they also show different patterns of narrative deficits. Therefore, the present study considered only female athletes.

Changes in narrative discourse post-concussion are of interest both academically and from a clinical perspective. From an academic perspective, further investigation in this area will help fill a gap in the current understanding of how concussion affects complex language. Furthermore, if changes in narrative language are a sensitive indicator of cognitive-linguistic dysfunction following concussion, the production of narratives may be a valuable tool in assessing those who have sustained concussions. Because narrative analysis is a time-consuming process, however, it would also be useful in a clinical setting to know which, if any, aspects are most sensitive to changes following concussion so that assessment is focused and streamlined. A gender-specific investigation may also help clinicians understand and interpret findings if they choose to include narrative discourse in their assessments.

Another area of interest for this study was to compare the narratives produced by men in Kovach et al. (2015b) to those produced by women in the current study. Because both sets of data were drawn from the same clinical program, the men in the Kovach et al. (2015b) and the women in the current study were given the same task and stimulus items, making a direct comparison possible. If gender-based differences in post-concussion narrative discourse were to emerge, such a comparison could both further delineate gender-differentiated responses to concussion and provide justification for considering single-gender groups in future concussion research.

This study therefore compared the narratives of young female athletes produced at two points in time: prior to the start of the season as a baseline measure, and again after the athlete had experienced a concussion. Because the current literature on post-TBI narrative discourse has demonstrated deficits at multiple levels (microlinguistic and macrostructural), and because discourse following concussion is not yet well-understood, samples were subjected to multiple analyses within the areas of syntactic complexity, coherence, productivity, and accuracy.

Hypotheses. Based on the literature to date, the hypotheses for this study are:

- There will be no significant differences in microlinguistic components of *Cinderella* narratives pre- and post-concussion

- There will be significant differences in macrostructural components of *Cinderella* narratives pre- and post-concussion
- There will be significantly more instances of self-revisions, a macrostructural measure, in the *Cinderella* story post-concussion
- Post-concussion, not-cleared women will have more macrostructural errors in the *Cinderella* story than not-cleared men

Method

Data for this research project were drawn from the Concussion Assessment And Rehabilitation Team (CAART) program at University of Colorado-Boulder's Speech, Language, and Hearing Clinic (SLHC). The program, developed by Kathryn Hardin, CCC-SLP, CBIST, is responsible for establishing baseline and post-injury cognitive, linguistic, and vestibular function for student athletes participating in club sports that carry a high risk of concussion.

This research project attempted to replicate the study conducted by Kovach et al. (2015a, 2015b) with female instead of male athletes. Certain aspects of that study were not able to be replicated, however, due to the available data. Specifically, the Kovach et al. study compared the narratives of matched groups of athletes who were either cleared (C) or not cleared (NC) to return to play immediately when assessed within a few days of their concussions, based on ongoing symptoms and cognitive function. Of the available female participants, only three had been cleared immediately, making it impossible to create matched groups of cleared and not cleared players.

Participants

Participants in this study were female student athletes attending the University of Colorado-Boulder who participated in the CAART program. Although completing baseline testing and follow-up testing in the event of a concussion is mandatory to play certain club sports, participation in the study was optional, and consent was obtained at the time of baseline testing. Narratives from 20 women, all of whom completed baseline testing and later sustained concussions and completed follow-up testing, were analyzed. One participant was excluded from the study because she had a concussion at the time of baseline testing.

All participants were college-aged women (M=20.3 years, SD=1.2 years). Before baseline testing, each participant self-reported information about herself including number of prior concussions and presence or absence of mental disorders, sleep disorders, learning disabilities, attention deficit/hyperactivity disorder (ADHD) and headaches.

Table 1

Participant Demographics

Participant number	Cleared / not cleared	Age	Number of prior concussions	Prior conditions
1	Cleared	23	1	--
2	*Excluded*	*Excluded*	*Excluded*	*Excluded*
3	Not cleared	19	0	Sleep disorder
4	Not cleared	21	1	Anxiety
5	Not cleared	21	1	--
6	Not cleared	20	3	Headaches
7	Not cleared	22	1	--
8	Not cleared	20	4	ADHD Headaches
9	Not cleared	19	2	Headaches
10	Not cleared	19	0	LD ADHD
11	Not cleared	20	0	Headaches Depression
12	Not cleared	21	1	Headaches
13	Not cleared	21	0	--

14	Cleared	21	0	Headaches
15	Not cleared	21	2	Headaches Anxiety
16	Not cleared	20	4	Headaches Anxiety Sleep disorder
17	Not cleared	19	0	Headaches
18	Cleared	18	0	--
19	Not cleared	21	0	--
20	Cleared	19	2	--

Procedure

Each participant completed a baseline cognitive-linguistic screening prior at the beginning of the season. Most athletes were re-screened within a few days of their concussions, depending on scheduling, although one participant's post-concussion data came from a second re-screen, at which point she was cleared. All cognitive-linguistic assessments were conducted by graduate student clinicians in speech-language pathology under the supervision of clinical faculty members. *Cinderella* story re-tellings were the second task of a larger battery, and each participant completed this task both pre- and post-concussion (see Appendix A). Before retelling the story, participants were allowed to look at a wordless picture book to refresh their memories of the story. The visual supports were then withdrawn, and participants were instructed to tell the story of *Cinderella* based on what they remembered about it and the pictures they had just seen. Although participants were timed during the story retell task, they were not informed of a specific time limit.

All baseline screenings and re-screenings were audio- and video-taped with the athletes' permission, and those that wished to allow data from their sessions to be used for research purposes completed an additional release. The present study considered only the *Cinderella* story retellings; therefore, only de-identified audio files were provided to protect the participant's privacy. This study was approved by the University of Colorado's Institutional Review Board.

Narrative Analysis

Narrative analysis procedures were drawn from Kovach et al. (2015a) and were carried out by the main investigator for this study, who was blinded to pre-/post-injury status. The procedure developed by Kovach et al. (2015a), compiled from literature analyzing narratives following moderate and severe TBI, divided analyses into two broad categories: microlinguistic components and macrolinguistic components.

Microlinguistic measures were those occurring at or below the level of the sentence. Speech rate was calculated in words per minute, and syntactic complexity was represented by the number of subordinate clauses per t-unit. T-units were defined as an independent clause and all supporting subordinate clauses. Tangential utterances were not considered separate t-units. Also included at the microlinguistic level of analysis were three productivity measures: number of words, number of t-units, and words per t-unit.

Macrostructural measures were those that considered the narrative as a whole. They were broken down into three categories: efficiency, informativeness/accuracy, and coherence. The first category, efficiency, included three time-based measures: total time in seconds, seconds per t-unit, and words per second. In addition, the number of disruptions (e.g. "um," "uh") and filler words (e.g. "like," "I think," "and stuff") were counted and converted to a ratio of disruptions and fillers per t-unit. Finally, the number of thematic units (story details) per second was calculated. The next category, informativeness, provided measures of the amount of information conveyed and its accuracy by counting the total number of thematic units, thematic density as represented by the number of thematic units per utterance, and the number of inaccurate story details.

Coherence was broadly divided into local coherence and global coherence. Local coherence measures relatedness of ideas with a t-unit or adjacent t-units. This was measured by the number of pronouns without a clear referent and the number of topic switches. Overall percentage of local coherence errors was also calculated. Global coherence refers to how the story hangs together as a whole. This measure included the number of tangential utterances, number of incongruent utterances (those that are unrelated to the story or inaccurate), number of propositional repetitions, and number of groups of filler words. These measurements were combined to derive a percentage of global coherence errors.

One additional measure that was not part of the Kovach et al. (2015b) study was included in the current analysis based on coder observations of the high frequency of this type of error. This measure was termed “self-revisions” and referred to instances in which the participant repeated all or part of an utterance before continuing, with or without revisions at a semantic or syntactic level. If semantic revisions occurred, errors were only coded as “self-revisions” if the revised utterance was expressing the same concept as the unrevised utterance; in other words, topic switches were coded separately. In some cases, self-revisions appeared suggested word finding difficulties in that the speaker would change one word upon revision, either to make it more specific or correct it. For example, in the statement, “But they ended up— the prince's, I dunno, assistant, ended up finding Cinderella and figured out that the shoe fit,” the speaker has revised her utterance to clarify that “they,” a non-specific pronoun, referred to the prince’s assistant. In other cases, the reason for the revision was less clear, for instance when a participant said, “A little girl and her father who’s a— her father who’s a widower.” In a case like this, the underlying reason for the revision could have been processing speed, with the speaker using the repeated content as filler language while she formulated the second part of the utterance. Finally, some errors coded as self-revisions contained revisions at the syntactic level. For example, in the utterance, "But she's made to— the stepmother makes her stay back and clean," the speaker has revised her original construction from passive voice to active voice.

Table 2

Multi-Leveled Narrative Analysis Procedures

Microlinguistic Measures

- ***Speech rate***
    - *Words per minute*
- ***Syntactic complexity***
    - *Number of subordinate clauses per T-unit*
- ***Productivity*** (word counts)
    - *Total number of words*
    - *Total number of T-units*
    - *Words per T-unit*

Macrostructural Measures

- ***Efficiency*** (Galetto et al., 2013; Marini et al., 2011b)
    - Time ratios
        - *Total time in seconds*
        - *Seconds per T-unit*
        - *Words per second*
    - Verbal disruptions and hesitations
        - *Number of disruptions* (e.g., "uh," "um," "er")
        - *Number of filler words* (e.g., "I believe," "I think," "I guess," "like," "well")
        - *Disruptions and filler words per T-unit*
    - *Thematic units per second*
- ***Informativeness/Accuracy***
    - Accurate and relevant information (Galetto et al., 2013; Marini et al., 2011b)
        - *Number of thematic units* (i.e., a main idea or detail in a narrative)
        - *Thematic density* (i.e., the number of thematic units divided by the number of utterances)
    - Inaccurate and/or irrelevant information
        - *Number of inaccurate story details*
- ***Coherence***
    - ***Local coherence*** (Galetto et al., 2013; Marini et al., 2011a, 2011b)
        - *Local coherence errors* – the production of words that are missing a clear

referent and the number of topic switches
        - *Words without a clear referent*
        - *Number of topic switches*
    - *Percentage of local coherence errors* = 100 multiplied by (the number of local coherence errors divided by the number of utterances)
- ***Global coherence*** (Galetto et al., 2013; Marini et al., 2011a, 2011b)
    - *Global coherence errors* – "the production of utterances that may be tangential, conceptually incongruent with the story, propositional repetitions, or simple fillers" (Galetto et al., 2013, *p*. 654)
        - *Number of tangential utterances*
        - *Number of productions that are conceptually incongruent with the story* (i.e., an idea that is unrelated to the story or introduces inaccurate information)
        - *Number of propositional repetitions* (i.e., repetition of content information that does not add new information)
        - *Number of fillers* (i.e., occasions in which filler words are used)
    - *Percentage of global coherence errors* = 100 multiplied by (the number of global coherence errors divided by the number of utterances)

Note. Table reprinted from Kovach et al. (2015a)

Reliability Measures

For the purposes of establishing intrarater and interrater reliability, 20% of narratives were re-coded by the principle investigator, and 20% of narratives were coded by an outside coder, both of whom were blinded to pre-/post-injury status. In addition, the principle investigator for this study re-coded 20% of the narratives used in Kovach et al. (2015b) so that comparisons could be made between the narratives of college-aged men and women. For all three sets of reliability data, narratives were randomly selected. Reliability statistics were only conducted on direct measures and counts, as all other values were derived from these numbers, and were analyzed using intraclass correlation coefficients. Values above 0.8 were considered adequate reliability.

Most intrarater reliability coefficients were very high (above 0.9), and adequate reliability was attained for all but one measure, incongruent statements, which had borderline reliability.

This was likely due in part to the low occurrence of these types of errors. All samples in this set of narratives had between zero and two errors of this nature, magnifying the effects of coding disagreements at the two time points.

Table 3

Intrarater Reliability

Measure	Intraclass correlation coefficient
Time in seconds	1.000*
Words (excluding disruptions)	1.000*
T-units	0.999*
Subordinate clauses	0.993*
Thematic units from expanded norms	0.974*
Thematic units from un-expanded norms	0.971*
Instances of inaccurate information	0.964*
Self-r nevisions	0.980*
Words without clear referent	0.965*
Topic switches	0.973*
Tangents	Not calculated[a]
Conceptually incongruent statements	0.792
Propositional repetitions	0.873*
Filler units	0.959*
Disruptions (um, uh, er, etc.)	0.977*
Filler words	0.887*

*Acceptable levels of reliability (> 0.8)
[a] Intraclass correlation coefficient was not able to be derived for tangents because all values were zero for both original and reliability coding.

Interrater reliability for the narratives considered in this study was generally high, with 13 out of 16 measures demonstrating adequate agreement. The three areas that did not display adequate agreement were: instance of inaccurate information, words without clear referent, and conceptually incongruent statements. All three of these counts generally had very low rates of occurrence, which again meant that counts that were off by one number were had very low levels of agreement. In addition, the nature of narrative analysis is inherently subjective and, in the case of inaccurate information and conceptually incongruent statements, relies on the rater's own understanding of the story being told. Therefore, individual differences between raters may also result in a different analysis of a given narrative.

Table 4

Interrater Reliability for Women's Narratives

Measure	Intraclass correlation coefficient – Average measures
Time in seconds	0.997*
Words (excluding disruptions)	0.999*
T-units	0.964*
Subordinate clauses	0.981*
Thematic units from expanded norms	0.963*
Thematic units from un-expanded norms	0.909*
Instances of inaccurate information	0.329
Revisions	0.876*
Words without clear referent	0.533
Topic switches	0.866*
Tangents	1.000*
Conceptually incongruent statements	0.432
Propositional repetitions	1.000*
Filler units	0.891*
Disruptions (um, uh, er, etc.)	0.946*
Filler words	0.966*

* Acceptable levels of reliability (> 0.8).

Data from Kovach et al. (2015b) for the purposes of reliability and comparison was provided by S. Kovach (personal communication, July 10, 2015 and March 13, 2016). Interrater reliability measures between the principle investigator for this study and the principle investigator for the Kovach et al. (2015b) study were generally high; however, there were several areas of considerable disagreement. The two raters appeared to have different conceptualizations of what constituted a word without a clear referent and a conceptually incongruent statement, as indicated by extremely low rates of agreement. Low rates of agreement for number of topic switches and propositional repetitions may have been due in part to legitimate disagreements about whether or not a given statement should be coded as an error. It is also possible, however, that part of the discrepancy was due the additional measure that was included in the current study, self-revisions. This measure was not included in the Kovach et al. (2015b) study and encompassed errors that may have otherwise been coded as topic switches or propositional repetitions.

For the purposes of this study, only items that achieved adequate interrater reliability were directly compared when considering the differences between men and women's narratives. It should be noted that one measure, "time" was not re-coded by the second coder. It may be assumed that time measurements would be consistent between coders based on high levels of reliability for this measure in both the current study and the Kovach et al. study. However, all time-based ratios were excluded from further analysis since reliability was not specifically addressed.

Table 5

Interrater Reliability for Men's Narratives

Measure	Intraclass correlation coefficient - Average measures
Words (excluding disruptions)	1.000*
T-units	0.993*
Subordinate clauses	0.956*
Thematic units from expanded norms	0.970*
Thematic units from un-expanded norms	0.970*
Instances of inaccurate information	0.888*
Self-revisions	0.876*
Words without clear referent	0.130
Topic switches	0.364
Tangents	0.969*

Conceptually incongruent statements	-0.479
Propositional repetitions	0.595*
Filler units	0.990*
Disruptions (um, uh, er, etc.)	0.997*
Filler words	0.950*

*Acceptable levels of reliability (> 0.8)

Statistical Analyses

Hypothesis one. The first hypothesis was that there would be no significant differences in microlinguistic components of *Cinderella* narratives pre- and post-injury. All pre- and post-concussion microlinguistic measures were compared using a series of two-tailed, paired t-tests. No significant differences were found between the two groups for any of the microlinguistic components: speech rate, syntactic complexity, or productivity measures of the total number of words, number of t-units, words per t-unit, number of utterances, or words per utterance ($p > .05$ for all measures). The first hypothesis was, therefore, accepted.

Table 6

Microlinguistic Components

Measure	Mean for Pre-concussion	Mean for Post-concussion	t value	p value
Speech rate (words/minute)	156.69 (SD=25.96)	147.10 (SD=25.72)	1.249	.228
Syntactic complexity (subordinate clauses/T-unit)	0.34 (SD=0.17)	0.37 (SD=0.20)	-0.460	.651
Number of subordinate clauses	9.21 (SD=5.59)	8.52 (SD=6.27)	0.602	.555
Productivity measures				
Number of words	253.26 (SD=111.48)	224.26 (SD=106.99)	-1.32	.205
Number of T-units	25.84 (SD=9.77)	22.68 (SD=10.19)	1.614	.124
Number of words per T-unit	9.60 (SD=1.70)	10.00 (SD=1.88)	-0.626	.539
Number of utterances	26.53 (SD=10.42)	22.84 (SD=10.07)	1.741	.099

Number of words per utterance	9.40 (SD=1.64)	9.87 (SD=1.70)	-0.850	.406

Note: Table layout adapted from Kovach et al. (2015a)

Hypothesis two. The second hypothesis was that there would be significant differences in macrostructural components of *Cinderella* narratives pre- and post-injury. All pre- and post-concussion macrostructural measures were compared using a series of two-tailed, paired t-tests.

Pre- and post-concussion narratives were only significantly different for one macrostructural measure, total number of verbal disruptions. This combined measure reflects the number of interjections such as “um” and “uh” as well as filler words such as “like” and “you know.” A higher raw number of verbal disruptions was noted for pre-concussion narratives ($M = 12.57$, $SD = 10.04$) than for post-concussion narratives ($M = 7.79$, $SD = 5.45$); $t(18) = 2.128$, $p = .047$. The ratio of verbal disruptions to t-units, however, was not different for pre- and post-concussion narratives, $t(18) = 0.710$, $p = 0.487$. It should also be noted neither component of this combined measure was significantly different between the two conditions. The components were interjections such as “um” and “uh,” $t(18) = 1.653$, $p = .116$, and filler words $t(18) = 1.753$, $p = .097$.

No significant differences were found for any other macrostructural measures. Notably, there were no differences in pre- and post-concussion narratives in terms of thematic density per t-unit, $t(18) = -1.645$, $p = 0.117$, or per utterance, $t(18) = -1.844$; percent local coherence errors, $t(18) = -0.101$; or percent global coherence errors $t(18) = 1.800$, $p = 0.089$. As a whole, therefore, hypothesis two was considered to be incorrect.

Table 7

Macrostructural Components

Measure	Mean for Pre-concussion	Mean for Post-concussion	t value	p value
Efficiency				
Total time (seconds)	96.74 (SD=41.19)	92.32 (SD=43.34)	.576	0.572
Time ratios				
Words per second	2.61 (SD=0.43)	2.45 (SD=0.43)	1.249	0.228
Seconds per T-unit	3.73 (SD=0.76)	4.19 (SD=1.06)	-1.364	0.190
Seconds per utterance	3.65 (SD=0.74)	4.13 (SD=0.95)	-1.570	0.134
Total number of verbal disruptions	12.57 (SD=10.04)	7.79 (SD=5.45)	2.128	0.047*
"um," "uh," "ah"	5.00 (SD=4.28)	3.63 (SD=3.00)	1.653	0.116
Filler words	7.57 (SD=7.17)	4.16 (SD=4.35)	1.753	0.097
Verbal disruptions per T-unit	0.47 (SD=0.37)	0.41 (SD=0.30)	0.710	0.487
Thematic units/second	0.21 (SD=0.05)	0.20 (SD=0.04)	0.318	0.754
Informativeness/Accuracy				
Thematic density				
Measured per T-unit	0.76 (SD=0.16)	0.83 (SD=0.18)	-1.645	0.117
Measured per utterance	0.75 (SD=0.16)	0.82 (SD=0.16)	-1.844	0.082
Number of thematic units (i.e., details)				
Details from norms	15.21 (SD=4.34)	14.68 (SD=5.07)	0.615	0.546
Fully expanded details from norms	18.95 (SD=6.70)	18.2 (SD=7.34)	0.631	0.536
Number of inaccurate details	1.42 (SD=1.71)	0.79 (SD=0.79)	1.555	0.137
Local coherence				
Local coherence errors				
Words without a clear referent	0.632 (SD=0.76)	0.632 (SD=0.83)	.000	1.000
Number of topic switches	1.89 (SD=1.59)	1.37 (SD=1.07)	1.455	0.163
Percentage of local coherence errors	9.76 (SD=8.30)	10.01 (SD=8.65)	-0.101	0.920
Global coherence				
Global coherence errors	6.95 (SD=7.78)	3.63 (SD=3.56)	1.800	0.089
Tangents	0.68 (SD=1.60)	0.16 (SD=0.37)	1.606	0.606
Conceptually incongruent utterances	0.63 (SD=1.01)	0.32 (SD=0.58)	1.466	0.163
Propositional repetitions	0.63 (SD=1.07)	0.47 (SD=0.70)	0.459	0.652
Filler units	5.00 (SD=5.06)	2.68 (SD=3.13)	1.754	0.096

Percentage of global coherence errors	25.46 (SD=22.39)	18.80 (SD=19.70)	1.042	0.311

Note: * = level of significance <.05
Table layout adapted from Kovach et al. (2015a)

Hypothesis three. Hypothesis three stated that there would be significantly more instances of self-revisions in the *Cinderella* story post-concussion. The number of self-revisions pre- and post-concussion were compared using a two-tailed, paired t-test. The number of self-revisions pre-concussion (M = 2.01, SD = .46) and post-concussion (M = 1.89, SD = 1.52) was not significantly different, t(18) = 1.396, p = .180. Hypothesis three was, therefore, rejected.

Hypothesis four. Hypothesis four was that post-concussion, not-cleared women would have more macrostructural errors in the *Cinderella* story than post-concussion, not-cleared men. To test this hypothesis, those measures that were considered suitably reliable, and ratios derived from these measures were subjected to a series of two-tailed, unpaired t-tests.

Several significant differences in the opposite direction than hypothesized (that is, with males demonstrating poorer performance than females) were noted. Males had more total verbal disruptions (M = 19.70, SD = 16.26) than females (M = 6.60, SD = 5.30), t(23) = 2.964, p = .007, as well as more instances of interjections such as "um" and "uh," t(23)=3.143, p = .004, and more individual filler words, t(23) = 2.150, p = .042. It should be noted that there was no significant difference in number of filler units between the two groups, t(23) = 1.828, p = .081, although there was a trend towards more men producing more filler units. Not-cleared men also produced more tangents (M = .30, SD = .48) than not-cleared women, who produced no tangents post-concussion (M = 0, SD = 0); t(23) = 2.432, p = 0.023.

One difference in the expected direction, with women performing more poorly than men, was noted. Men produced a higher level of thematic density than women, regardless of whether this was measured per t-unit, t(23) = 2.326, p = .029, or per utterance, t(23) = 2.091, p = .048.

Hypothesis four was, therefore, rejected due to the fact that most significant differences were in the opposite direction than hypothesized, with males making more errors than females.

Table 8

Comparison of Male and Female Post-concussion Narratives

Measure	Mean for Males Post-concussion	Mean for Females Post-concussion	t value	p value
Syntactic complexity (subordinate clauses/T-unit)	0.28 (SD=0.18)	0.35 (SD=0.18)	-0.889	0.383
Number of subordinate clauses	8.80 (SD=4.80)	8.93 (SD=7.75)	-0.854	0.402
Productivity measures				
Number of words	253.60 (SD=107.35)	239.13 (SD=129.69)	0.315	0.755
Number of T-units	23.50 (SD=8.64)	24.20 (SD=12.46)	-0.173	0.865
Number of words per T-unit	10.71 (SD=1.92)	9.83 (SD=1.33)	1.290	0.210
Number of utterances	23.80 (SD=8.51)	24.20 (SD=12.46)	-0.099	0.922
Number of words per utterance	10.53 (SD=1.86)	9.83 (SD=1.33)	1.047	0.306
Efficiency				
Total number of verbal disruptions	19.70 (SD=16.26)	6.60 (SD=5.30)	2.964	0.007*
"um," "uh," "ah"	10.20 (SD=9.58)	2.93 (SD=2.15)	3.143	0.004*
Filler words	9.50 (SD=9.13)	3.67 (SD=5.14)	2.150	0.042*
Verbal disruptions per T-unit	0.88 (SD=0.70)	0.31 (SD=0.23)	2.992	0.007*
Informativeness/Accuracy				
Thematic density				
Measured per T-unit	0.98 (SD=0.24)	0.82 (SD=0.12)	2.326	0.029*
Measured per utterance	0.97 (SD=0.24)	0.82 (SD=0.12)	2.091	0.048*
Number of thematic units (i.e., details)				
Details from norms	17.60 (SD=4.22)	15.40 (SD=5.58)	1.102	0.28
Fully expanded details from norms	22.60 (SD=7.65)	19.40 (SD=8.65)	1.020	0.318
Number of inaccurate details	1.90 (SD=2.28)	0.80 (SD=0.79)	1.738	0.096
Global coherence				

Tangents	0.30 (SD=0.48)	0.00 (SD=0.00)	2.432	0.023*
Filler units	4.80 (SD=4.96)	2.07 (SD=2.98)	1.828	0.081

Note: * = level of significance <.05
Table layout adapted from Kovach et al. (2015a)

Those components for which there were significant post-concussion differences between men and women were then further analyzed to see if there were also gender-based differences pre-concussion. For this set of analyses, pre-concussion narratives of the same participants (those that were not cleared after their concussions) were compared using a series of two-tailed independent t-tests. Pre-concussion, not-cleared men produced more interjections, t(23)=2.151, p=0.042; a higher number of verbal disruptions per t-unit, t(23)=3.084, p=.005; and more tangents than women, t(23)=2.387, p=0.026. The total number of verbal disruptions pre-concussion was not significantly different between men and women, although there was a trend towards men producing more verbal disruptions pre-concussion, t(23)=2.056, p=0.051. There were no significant differences between not-cleared men and not-cleared women pre-concussion in terms of number of filler words, t(23)=1.698, p=0.103; thematic density per t-unit, t(23)=0.010, p=0.992, or thematic density per utterance, t(23)=-0.668, p=0.511. Gender differences both pre- and post-concussion for those items that were significantly different post-concussion are summarized in the table below.

Table 9

Gender Differences Pre-concussion and Post-concussion

Measurement	Significant gender difference pre-concussion	Significant gender difference post-concussion	Direction of gender difference
Filler words	No	Yes	Men produced more post-concussion

"Um," "uh," "ah"	Yes	Yes	Men produced more pre- and post-concussion
Total verbal disruptions	No*	Yes	Men produced more post-concussion, trend towards men producing more pre-concussion
Verbal disruptions per t-unit	Yes	Yes	Men produced more pre- and post-concussion
Tangents	Yes	Yes	Men produced more pre- and post-concussion
Thematic density per t-unit	No	Yes	Men produced greater density post-concussion
Thematic density per utterance	No	Yes	Men produced greater density post-concussion

*Trend towards significant, p=0.051

Post-hoc Analysis

A post-hoc analysis was conducted to determine whether women had greater knowledge of the *Cinderella* narrative at the time of baseline testing as indicated by the total number of thematic units. Because these narratives were produced before any participants had sustained a concussion, both the narratives of participants who would go on to be cleared and the narratives of participants who would go on to be not cleared after sustaining were considered. The number of thematic units, calculated using both the expanded and unexpanded norms, for pre-concussion males and females were compared using a two-tailed unpaired t-test. Females produced a larger number of details from the expanded norms (M=18.95, SD=6.70) than males (M=13.35, SD = 9.18); $t(37)=2.164$, $p = .037$. Females also produced a larger number of details from the unexpanded norms (M = 15.21, SD = 4.34) than males (M = 10.80, SD = 6.64); $t(37) = 2.442$, $p = .020$.

Discussion

The primary purpose of this study was to determine if there were differences in narrative discourse, as indicated by retellings of the *Cinderella* story, in female college athletes pre- and post-concussion. A previous study by Kovach et al. (2015b) had demonstrated changes in narrative discourse at the macrostructural level pre- and post-concussion in male athletes; that study was partially replicated with the expectation that women would also have changes at this level. In addition, it was hypothesized that women's narratives post-concussion would demonstrate greater levels of linguistic disruption than males' given that women generally show more severe and persistent cognitive deficits than their male counterparts post-concussion. The results showed that although women's narratives pre- and post-concussion did not differ at the microlinguistic level, as expected, there was also very little change at the macrostructural level, contrary to expectations. For the one macrostructural measure on which the pre- and post-concussion narratives did differ, total number of verbal disruptions, results were counterintuitive, with individuals producing fewer verbal disruptions words post-concussion than pre-concussion. Although interesting, this finding has little clinical value since neither component of the combined "verbal disruption" measure, interjections such as "um" and "uh" and filler words, showed a significant difference pre- and post- concussion, and the ratio of verbal disruptions to content words was nonsignificant. The additional measure added to this study, self-revisions, believed to represent syntactic, word finding, and/or processing speed, did not differ between the pre- and post-concussion groups. Interestingly, although there were several significant differences between the post-concussion narratives of men and women, some of these were in the opposite direction than was predicted, with men producing a greater number of verbal disruptions and tangents. A similar pattern existed pre-concussion, however, with men producing more tangents than women and a trend towards men producing more verbal disruptions than women; therefore, this seems to reflect a gender bias in the Cinderella story rather than a gendered response to concussion. Whereas both men and women produced similar levels of thematic density pre-concussion, men produced thematically denser narratives than did women post-concussion, due to the fact that while men improved on this measure, women did not..

Possible Reasons for Outcomes Observed

There are several reasons why women's pre- and post-concussion narratives may not have demonstrated macrostructural differences as expected. Given the fact that women have higher rates of cognitive impairments following concussion than men (Broshek et al., 2005), it seems unlikely women in the current study were simply more resilient to changes in higher-level language than the men in the Kovach et al. (2015b) study or other studies of narrative discourse following mTBI. This is especially true given that the majority of the women in the current study were not cleared to return to play at the time that they produced their *Cinderella* narratives, indicating ongoing cognitive deficits as compared to baseline. It is worth considering, however, that the women may have been demonstrating cognitive deficits in areas that have less effect on narrative discourse. More specifically, most research that has specifically addressed the question has found a relationship between impaired executive function and impaired narrative discourse (e.g. Lê et al., 2012; Mozeiko et al., 2011). Further research would be required to determine if the women in this study failed to show narrative deficits post-concussion due to relatively preserved executive function.

Kovach et al. (2015b) discussed practice effects as a potential explanation for why the men in that study produced more efficient narratives post-concussion than they had pre-concussion. Practice effects may explain, or partially explain, the lack of significant findings here as well. During baseline testing, telling the *Cinderella* story was a novel, and unexpected, task, requiring participants to both recall details of a story as well as process task demands. In addition, seeing as *Cinderella* is typically considered a children's fairy tale, it is likely that many of the participants had had little exposure to it in recent years. During follow-up testing, participants were already familiar with the review-retell format, and so the task demands were reduced. In addition, regardless of whether or not they had given any thought to the Cinderella story in the interim between baseline testing and their concussions, they had a fairly recent exposure to it simply by having retold it once, and were essentially primed for the task. It is possible that in the absence of injury, this practice effect may have resulted in richer, more thematically dense narratives with fewer hesitations or fillers. Because the participants had experienced concussions, however, it is possible that practice effects essentially subsumed any changes in higher-level language that would otherwise be noted post-concussion. This explanation would account for why studies that used control groups (e.g. Galetto et al., 2013; Stout et al., 2000; Tucker & Hanlon, 1998) found macrostructural differences while the current study did not, since the narrative task would have been novel for all participants. Not all participants would benefit equally from a potential practice effect, however. While some participants may have sustained concussions and were re-tested within weeks or months of their baseline testing, other participants may have undergone baseline testing in a previous athletic season and therefore might not have been exposed to the task in over a year. In future research, it would be beneficial to determine if post-concussion narratives varied based on the interval between baseline testing and follow-up testing to further explore the impact of the practice effect.

It should also be considered that post-concussion, participants may have simply been more motivated than they had been pre-concussion, and therefore may have put forth more effort when producing their narratives, thus overriding any changes that would otherwise be noted post-concussion. Certainly, when players know that their performance will determine whether or not they will return to the playing field, there is a powerful incentive to perform as well as possible. At the time of baseline testing, although participants may be trying their best, there is much less incentive to do well on a given task. Although the Cinderella story re-tell provides a measure of behavior, it is not possible to know whether participants are expending more effort at the time of re-testing without including an objective measure of neural activation.

Another potential reason for the lack of findings it that the *Cinderella* story may have been overly familiar for the women in this study, and therefore the re-telling may have recruited cognitive functions not generally affected by concussion. Fromm et al. (2011) found that the *Cinderella* story was unbiased for healthy men and women and only noted gender differences for only one measure, lexical diversity, for those with aphasia. A post-hoc analysis conducted during the current study, however, suggested that the women did in fact display greater familiarity the story than did in the men in Kovach et al. (2015b) prior to their injuries. This conclusion is based on the fact that at baseline, women produced significantly more story details than their male counterparts. This is not surprising given the fact that Disney's adaptation of the Cinderella story is primarily marketed to girls rather than boys. Interestingly, while men recalled more details of the *Cinderella* story post-concussion than they had pre-concussion (Kovach et al., 2015b), perhaps due to practice effects, women produced the same number of details pre-concussion and post-concussion. Based on these findings, it is theorized that young women generally have a more complete and detailed mental representation of the *Cinderella* story than do young men at baseline. If this is the case, while men may rely on various aspects of short-term memory and executive function to recall the picture stimulus and properly sequence events when retelling *Cinderella*, women may draw more heavily from remote memory. Assuming that remote memory is generally spared following concussion, this may allow women to produce adequate narratives even after an injury.

This explanation could, of course, also provide a rationale for why men's narratives both pre- and post-concussion had higher levels of some error types than women's. Men's lower levels of familiarity with the story could account for the increased number and proportion of verbal disruptions compared to women because they need additional time to process and sequence the events of the story. Men also produced a greater number of tangents both pre- and post-concussion than women, which Kovach et al. posited that (2015b) posited represented instances of social language and attempts to develop a connection with the examiner rather than an error of global cohesion. It should be considered, however, that tangents may have served other purposes, such as delaying the next part of the story to allow for further processing time or attempting to explain self-perceived poor performance to the examiner. In this case, an increase in tangents could, in fact, represent relatively poorer narrative performance. Of course, other factors may also account for differences in verbal disruptions and tangents. For instance, the men in the Kovach et al. study may been relatively impaired compared to women at baseline, perhaps due to a history of multiple concussions or other factors. If men also had lower scores on the neuropsychological components of the CAART protocol, that could also account for poorer performance than women in some aspects of narrative production.

Finally, women produced overall lower levels of thematic density than men post-concussion, but not pre-concussion. This finding appeared to be consistent with expectations that women's post-concussion narratives would be more impaired on macrostructural measures than men's. Considering, however, that there were no significant differences in the actual number of thematic units produced post-concussion, however, the interpretation of this finding is not straightforward. Pre-concussion, men and women produced similar levels of thematic density even though men's narratives had fewer details and were shorter overall; post-concussion, men and women produced similar numbers of details, but men had higher thematic density. The fact that the total number of thematic units was not different for the two groups post-concussion but that women had lower levels of thematic density indicates that women tended to produce more t-units that did not contain a thematic detail than men. A more careful narrative analysis would be needed to determine the content of these t-units and whether the difference was due to the addition of incongruent utterances, expansions upon one thematic unit that extended over multiple t-units, or details not included in the expanded norms. Depending on which combination of these categories best represents the t-units that did not contain thematic details, and thereby decreased the density of the women's narratives, this decreased density could represent more macrostructural errors or more elaborate storytelling.

Limitations and Directions for Further Research

The present study has several limiting factors. First, samples were gathered by different students clinicians. Although procedures for collecting data were standardized, there may have been some variability between examiners. For instance, on one narrative, which happened to be excluded from the analysis because the participant had a concussion at the time of baseline testing, the examiner instructed the participant to end her narrative after three minutes, while other narratives were allowed to continue slightly past this point. Second, the sample was relatively small. The current study examined pre- and post-concussion differences using paired t-tests; however, a more sensitive measure may have been change scores, which would have allowed a more fine-grained analysis of pre- and post-concussion changes of individual players. Third, because this study only considered college-age athletes, results are not necessarily generalizable to other populations. Finally, this study provides preliminary evidence that the Cinderella story is biased on the basis of gender, making it difficult to make a valid comparison of narratives produced by men and by women.

This suggests a number of possible avenues for future research. Based on the assumption that practice effects, the particular stimulus, or both may have affected results, it would be interesting to conduct a similar study using different methods that reduce or eliminate these potential confounding factors. One way to prevent the suspected bias of the *Cinderella* story would be to ask participants to narrate the events depicted in a wordless picture book such as was done in the Ash et al. (2014) study, or series of picture cards such as was done in the Tucker and Hanlon (1998) study. Practice effects could be avoided either by using a control group at two points in time corresponding to pre- and post-concussion for the experimental group, therefore determining the effects of practice in uninjured individuals, or by only completing the narrative task post-concussion and comparing results to that of a control group. In addition, variability introduced in the coding process could be reduced in future studies by using a computer coding. Although this technology has been emerging in recent years, however, it seems unlikely at this point in time that a program could make determinations such as matching a specific, pre-defined detail to an utterance in a narrative that might be worded quite differently.

Another area of considerable interest is the relationship between cognitive functions and narrative discourse. Although this study did not find significant differences pre- and post-concussion, future research might explore whether individual variation in performance, especially post-concussion, were correlated with performances on any of the subtests included in the larger battery of cognitive-linguistic testing conducted during the CAART screenings. The current study did not differentiate between those athletes who were immediately cleared to play when they returned for their cognitive re-screens and those who were not; a future study might consider whether there were differences in post-concussion performance between these two groups.

Conclusion

This study partially replicated an earlier study of narrative discourse in men pre-and post-concussion and found that, as expected, female athletes performed similarly pre-concussion and post-concussion on microlinguistic measures, consistent with a body of research suggesting that surface-level language is generally not affected in TBI. Contrary to expectations only one difference was found at the macrostructural level: the number of verbal disruptions, which decreased following concussion. The two components of this measure (filler words and interjections such as "um" and "uh,") and the overall ratio of verbal disruptions were not significant, however. The new measure added during this study, self-revisions, was not significantly different pre-concussion and post-concussion. Differences did, however, emerge between the post-concussion narratives of male athletes and the post-concussion narratives of female athletes. Male athletes produced more total verbal disruptions than female athletes, more instance of both interjections such as "um" and "uh" and filler words, and a higher ratio of these types of errors, in addition to producing more tangents. Women, on the other hand, had lower levels of thematic density than their male counterparts. Further research is needed to tease apart the reasons for these results. It is possible, however, that practice effects partially or entirely negated any impairments that would otherwise be seen in concussion. It is also possible that lack of significant changes pre- and post-concussion and the gender differences observed were due to gender biases inherent to the Cinderella story.

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Appendix A: CAART Testing Battery

- Diadochokinetic rates
- *Cinderella* story retell
- *Woodcock-Johnson Tests of Cognitive Abilities III* (WJ-III COG)
    - Test 6: Visual Matching
    - Test 7: Numbers Reversed
    - Test 12: Retrieval Fluency
    - Test 16: Decision Speed
- *Woodcock-Johnson Tests of Achievement* (WJ-III ACH)
    - Test 2: Reading Fluency
    - Test 3: Story Recall
    - Test 12: Story Recall – Delayed

Appendix B: Coding Examples

Inaccurate information:

- Cinderella was the *son* of a wealthy man
- And her dad finds this lady who's evil and has two evil *stepdaughters*

Topic switches:

- And so then in the town, the king um— his son the prince hadn't married and hadn't found someone to marry
- And um Cinderella— she— and the ugly stepsisters and the ugly stepmom get an invitation to the ball at the prince's castle

Self-revisions:

- and so they— so the stepmom says that she can go to ball, um I guess if she makes the dress
- and the stepsister realized that parts of her dress were stuff that they— was theirs,

Words messing a clear referent:

- and I think they— yeah, *they* mess up her dress
- and then he comes to *their* house

Tangential utterances:

- Oh my gosh, I'm all out of –
- I don't know if that's then but I just thought of it then.

Conceptually incongruent utterances:

- I forget, I think she pulls it off *("It" refers to the glass slipper)*
- And then finds out (it was Cinderella's) *(Before Cinderella tried on the glass slipper)*

Propositional repetitions:

- So she had to run away so she wouldn't be in rags and stuff. And she left her shoe, dropped her shoe, *she was running away*.
- And it took her to the ball and the only rule was she had to leave by midnight or else her stuff would turn back to shreds and a pumpkin. *And so she went to the ball*

Filler words:

- and *yeah* she grows up as *like* their servant maid
- And then, *you know*, the Prince was, "Oh, I'm in love with the girl,

Interjections “um,” “uh,” etc.:

- *Um*, and she dreams of going to the castle