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Mild Traumatic Brain Injury: A Study of Gender Differences in Post-Concussive Syndrome in a Paediatric Sample Four to Six Weeks Post-Injury

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Abstract

The present study focuses on post-concussive symptomology in sixty-two paediatric patients who attended the Emergency Department of Bristol Children's Hospital four to six weeks previously with Mild Traumatic Brain Injury. Gender differences were investigated in instance, severity and change in symptoms across four symptom groups: 'emotional', 'physical, 'cognitive' and 'sleep-related'. The findings of this study refute previous evidence that females are more susceptible to post-concussive syndrome (PCS), showing that males are more symptomatic approximately one-month into recovery. This was exclusively a result of higher reporting of the 'emotional' symptom 'irritability' in males. Despite this, males' symptoms generally showed improvement, whereas females' worsened or stayed the same, indicating slowed recovery in paediatric females post mTBI. No significant gender differences were observed across other symptom groups. Future research into the nature of post-concussive symptoms and corresponding risk factors is recommended to increase our limited understanding about PCS in the paediatric population.

Keywords: *Mild Traumatic Brain Injury; Concussive Syndrome; Gender Differences*

Introduction

Each year over one million people attend Emergency Departments (EDs) in England and Wales due to a recent head injury; of these around half are children under fifteen years [1]. Ninety-five percent of this paediatric population present with normal or minimally impaired conscious level (Glasgow Coma Scale greater than twelve) and thus their injuries are referred to as mild Traumatic Brain Injuries (mTBIs) [2]. It is known that within these samples males are more highly represented than females, potentially due to strong disparity in terms of sport and recreational activity participation with highest rates of injury [3].

MTBI may be defined as a 'traumatically induced physiological disruption of brain function' [4], alongside a period of loss of consciousness or any anterograde or retrograde amnesia [5]. This definition is distinct from concussion, which may be understood as a brief neurological deficit that resolves spontaneously and does not require loss of consciousness [6]. Although no universal consensus has been reached in defining concussion and mTBI distinctly [7], concussed individuals most likely represent a subgroup of mTBI and both may result in post-concussive symptoms which can be protracted in course [5]. It is understood that females are apparently more susceptible to these symptoms [8].

Post-concussive syndrome (PCS) is a term used to refer to the complex of symptoms which may arise after mTBI, although there is not one accepted definition of PCS [5]. This lack of definition contributes to varying rates of reported instances and thus increases existing confusion associated with the occurrences and nature of post-concussive symptoms. This is illustrated by the fact that DSM-IV PCS criteria are met by only eleven percent of the paediatric mTBI population, whereas ICD-10 criteria are met by as much as sixty-four percent of this same group [5]. The current guidelines for diagnosis and treatment of mTBI are the same for males and females despite evidence that gender differences may be clinically significant [3].

Data on the economic impact of PCS in the United Kingdom (UK) is limited, partially due to the fact that injuries are diagnosed and managed in a variety of different settings [9]. We do know, however, that the cost of head injury and subsequent sequelae in the United States is estimated to be around forty-eight billion dollars per annum, which may give us some idea of the financial burden these injuries place on the National Health Service (NHS) in the UK [5]. There is limited availability of data referencing the economic impact of head injury of PCS in males and females individually, but due to higher incidence in males it might be expected that the corresponding costs will be higher in this group of individuals [8]. Overall, total cost of these injuries is undoubtedly underestimated due to difficulties in availability of this data and evaluating other costs such as lost days of work (of parents providing care) and long-term diminished work capabilities [9]. Therefore, although incidence in males may be higher, if females take longer to recover from these injuries, as is indicated by previous findings, secondary costs of care may result in equally high economic burden in paediatric females post mTBI [3].

Despite these staggering statistics, our knowledge about the course and nature of post mTBI symptomology is limited and consequently so is our evidence to guide patient care [10], particularly this might be true in the UK, due to lack of research of UK samples [5]. Although there is some limited evidence of gender differences in PCS, diagnosis and treatment of mTBI are still the same in these groups [3]. Recent studies, however, have focused on the duration and course of post-concussive symptoms in male and female participants; a group of 'physical', 'emotional', 'behavioural' and 'cognitive symptoms', which commonly occur after mTBI [3,10,11]. Additionally, 'Sleep-related' symptoms are also common after mTBI and can persist to up to three months post-injury [12]. Importantly, sleep disturbances may exacerbate other common sequelae of mTBI, including pain, cognitive impairments and psychological disorders [13]. It may, therefore, be beneficial to closer attend to the nature of these specific symptoms as their own symptom group as well. Particularly those symptoms that are considered the most common post mTBI, which are insomnia, increased need for sleep and excessive daytime sleep [13].

There are some discrepancies regarding the duration of post-concussive symptoms, although it has been suggested that females may take longer to recover than males [3]. It is known from empirical evidence that these symptoms can endure for longer than might be expected, with some still reported as long as ninety days after the sustained injury [10]. It has been shown that in five to thirty percent of childhood mTBI cases, post-concussive symptoms may last for years after injury [14], this is referred to by some as Persistent PCS [5]. This should be of particular concern to clinicians and researchers because of broader public health impacts of these injuries, including long-term economic and health consequences. PCS has been associated with higher levels of stress [15], Post-Traumatic Stress Disorder (PTSD) [16], increased family burden [17], ongoing behavioural problems [18] as well as cognitive, somatic and emotional disturbances [14].

The majority of patients, however, do not have such long lasting symptoms and recent research has shown the median time resolution for all post-concussive symptoms is thirteen days, with a smaller number of patients still symptomatic four weeks after injury [19]. This is indicative of the idiosyncratic nature of head injuries and their sequelae, which may be influenced by any number of physical, environmental or social factors. It is important to consider that symptom severity is not necessarily related to the nature or severity of the head injury and therefore relatively minor injuries may result in extremely incapacitating symptoms adding another level of complexity to the management of post-concussive symptoms [5].

This complexity is also evident in identifying risk factors for sustaining and managing head injuries. Understanding these factors, however, is integral to identifying those at higher risk of suffering from PCS and allows development of clinician guidelines and more effective intervention [20]. This complexity is particularly evident when observing gender differences in PCS, potentially due to the lack

of research on this topic, which is why this is the key focus in the present study. Although males are typically considered more prone to head injuries, literature suggests female subjects seem to be more susceptible to PCS one to three months post injury [8] and may have worse outcomes than men [3].

There is limited research on gender differences in children and adolescents, although notable differences have been shown between the genders in areas such as cognitive function post mTBI [3]. Although the reasons for these gender differences are unclear, there are many theories, which include psychosocial factors, differences in symptom reporting and use of diagnostic criteria [8]. The most prevalent theory suggests that these are a result of hormonal differences between genders [3]. This is supported by the fact that these gender differences are not consistently demonstrated in individuals under thirteen [3], which shall also be investigated in this study.

The present study considered symptomology in a sample of children from the Bristol NHS Children's Hospital, who had sustained mTBI four to six weeks previously. The study investigated gender differences in incidence, severity and change in symptom (to indicate potential improvement or worsening of PCS), observed across four groups of symptoms: 'emotional', 'sleep-related', 'physical' and 'cognitive'. These gender differences were also considered in reference to age of participants to investigate whether these differences may be attributable to hormonal changes associated with onset of puberty [3].

Methods

Definition of mild traumatic brain injury

MTBI was defined in accordance with the WHO recommended definition of mTBI outlined by Kristman., *et al*. [21] as an acute brain injury resulting from mechanical injury to the head from external physical forces. Presence of one or more of the following was required for a diagnosis of mTBI: confusion or disorientation, loss of consciousness for thirty minutes or less, posttraumatic amnesia for less than twenty-four hours and a Glasgow Coma Scale (GCS) score of thirteen to fifteen at the time of ED attendance. Manifestations of mTBI were not a consequence of treatment for other injuries or caused by other problems (such as coexisting medical conditions) or caused by penetrating craniocerebral injury [21]. Although there has historically been no consensus between concussion and mTBI definition [7], in this study concussed individuals were classed as having sustained mTBI and are therefore included under this category and not as a distinct group. Patients were excluded from the study if there was involvement of law enforcement or social workers in order to ensure that post-injury symptoms reported were not attributable to other injuries or psychological stresses associated with assault [10].

Procedure and population

The final data set was obtained from the parents of 62 participants, 42 males and 20 females, comprising of children aged between 6 and 16 years old at the time of assessment. These were patients who presented at Bristol Children's Hospital ED who had sustained mTBI four to six weeks earlier. Patients were identified via the Bristol Children's Hospital ED records on Medway, excluding those who indicated that they did not wish to participate. Participants were included if they fit the criteria of mTBI according to the previous description.

Cover letters were sent asking parents of patients who fit the criteria whether they would consent to participation. Those parents who consented were then called and asked to take part in a Post-Concussion Symptom Questionnaire based on the Acute Concussion Evaluation and Post-Concussion Symptom Inventory published at the Children's National Medical Centre [22]. The use of modified Acute Concussion Evaluation tools has been supported in pediatric samples [23] and has been demonstrated to exhibit reasonably strong psychometric properties as an assessment tool for mTBI [24]. Symptoms were grouped into four categories: 'physical', 'cognitive', 'emotional' and 'sleep-related'. The symptoms were listed to the parents of patients who were asked to report whether that particular symptom was present at the time of the call (four to six weeks post-injury), to rate this symptom's severity on a scale of one to ten (with ten being the most severe) and whether this symptom was better, worse or the same as it had been at the time of ED attendance.

Consent and ethical approval

This study was approved as a service evaluation based on an issued QIS approval in May 2015. QIS ref: 734. Parents of patients were asked to complete the questionnaire and provided informed verbal consent to participate. Participants were reminded at the end of the questionnaire that they were free to retract their responses at any time. Data regarding the patient's medical history was removed from the questionnaire reports.

Statistical analysis

Percentage of patients who were symptomatic was calculated by dividing the number of patients reporting the symptom at the time of data collection by the total number of patients who met criteria for inclusion in the study. The symptoms were entered as one factor (area of complaint) with four levels ('physical', 'cognitive', 'emotional' and 'sleep-related') and the proportion of reported symptoms in each group were calculated; if a score of .5 for one group of symptoms was obtained by a participant, then this represents that this participant endorsed half the amount of symptoms in that group (e.g. if there were 8 symptoms in that symptom group, 4 were reported present). In this way an appropriate comparison was able to be made between the groups of symptoms despite differing amounts of symptoms in each group. The presence of symptoms was coded 0 (not present) or 1 (present). Male and female were coded (1 = male 2 = female). Symptom change was coded worse = -1, better +1 and stayed the same 0. Symptom severity ranged from 1 to 10.

A series of unrelated sample t-tests were used to see if males and females differed in the separate symptom groups. To determine whether the incidence of the four reported symptom categories ('physical', 'cognitive', 'emotional', 'sleep-related') differed, a single factor related ANOVA with symptom category as the factor was then performed.

Supplementary analysis (one-factor related ANOVA), was conducted to see differences within the 'emotional' symptom group, this was run alone and then again separately for males and females. An independent sample unrelated t-test was then carried out to assess patterns between males and females in this subdomain group.

Changes in symptoms were compared using independent sample t-tests to observe changes in 'physical', 'emotional', 'cognitive' and 'sleep-related' symptoms since the time of the injury. A one sample t-test, testing against the value of zero, was used to examine the patterns of changes in these subdomains for males and females. Symptom severity by gender was also investigated using an independent samples t-test.

A series of independent samples t-tests were used to assess the relationship between age and symptomology. This was done by re-running analysis of severity, instance and change in 'emotional' symptoms minus 5 participants who were older than 13 (2 males and 3 females). Correlations between symptomology and age were then assessed using a Pearson's correlational analysis.

T-test results for symptom severity are averaged over the group of individuals who had complained of one or more symptom, as a two-way separation (gender: male/female) and complainers (yes/no) would have resulted in numbers that were too low for significant comparison.

Levene's test of equality of variance was used, where this had been violated original degrees of freedom were retained and the corrected t-values and p-values were given. If Mauchly's test of sphericity was violated, then the Huynh-Feldt corrections were used for F-value and p-value with original degrees of freedom retained. Values were considered statistically significant if $P \leq .05$. This analysis was conducted using IBM SPSS version 23.0.0.0 for Mac [25].

Results

Symptom instances

Overall 47% of the sample were still symptomatic 4 to 6 weeks post-injury. A series of independent-samples t-tests were used to compare whether there were differences in males and females across symptom groups ('emotional', 'physical', 'sleep-related' and 'cognitive'). Males reported slightly more 'physical' symptoms t(60) = .674, p = .503, 'cognitive' symptoms t(60) = .578, p = .566 and 'sleep-related' symptoms t(60) = .738, p = .463, although these were all non-significant. Overall, males reported significantly more 'emotional' symptoms than females. t(60) = 2.38, p = .020. Means and Standard Deviations are shown in table 1 and These findings are illustrated in figure 1.

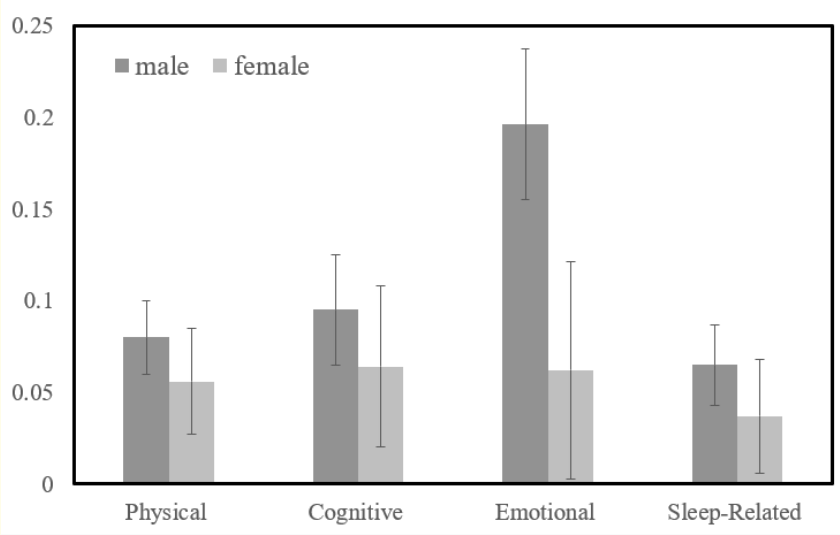

Figure 1: *Mean incidence of symptoms across symptom groups in male and females.*
y-axis: mean incidence.
x-axis: symptom groups.

Measure/Variable	Male	Female	p-value of difference
Number	42	20	
Age (years)	8.50 (2.5)	9.40 (3.0)	.230
Emotional Symptoms[1]			
Incidence	.196 (0.305)	.063 (.147)	.020
Severity	1.089 (2.042)	.313 (.747)	.034
Change	.058 (.227)	-.013 (.056)	.066
Physical Symptoms[2]			
Incidence	.080 (0.135)	.563 (.125)	.503
Severity	.369 (.730)	.213 (.569)	.404
Change	.048 (.123)	-.019 (.124)	.052

Cognitive Symptoms[3]			
Incidence	.095 (.206)	.064 (.176)	.566
Severity	.422 (.857)	.379 (1.077)	.865
Change	.056 (.174)	-.013 (.056)	.057
Sleep-related Symptoms[4]			
Incidence	.0655 (.146)	.038 (.122)	.463
Severity	.327 (.744)	.188 (.579)	.462
Change	.012 (.095)	-.038 (.122)	.087

Table 1: *Descriptive statistics for the sample as a function of gender (standard deviations in parentheses).*

[1]Mean based on 4 areas.

[2]Mean based on 8 areas.

[3]Mean based on 7 areas.

[4]Mean based on 4 areas.

To determine whether the incidence of the four reported symptom categories ('physical', 'cognitive', 'emotional', 'sleep-related') differed, a single factor related ANOVA with symptom category as the factor was conducted. This showed a main effect of symptom category ($F(3, 183) = 6.00$, $p = .002$) and post-hoc analysis, using the Bonferroni correction, only showed a higher incidence of 'emotional' symptoms (0.153) compared to 'physical' (0.073, $p = .036$), 'cognitive' (0.085, $p = .024$) and 'sleep-related' (0.056, $p = .017$) symptoms.

Descriptive Statistics			
	Mean	**Standard Deviation**	**N**
Physical Symptoms[1]	.073	.131	62
Cognitive Symptoms[2]	.085	.196	62
Emotional Symptoms[3]	.153	.269	62
Sleep Symptoms[4]	.057	.139	62

Table 2: *Descriptive statistics for symptom occurrence in the sample.*

[1]Mean based on 4 areas.

[2]Mean based on 8 areas.

[3]Mean based on 7 areas.

[4]Mean based on 4 areas.

A supplementary analysis, in the form of a single factor related ANOVA, conducted to observe the patterns of complaints within the 'emotional' symptom group, with four levels of symptom sub-domains ('irritability', 'sadness', 'more emotional' and 'nervousness'). Maximum differences were found for irritability (Table 3). A second related ANOVA was run separately for males and females and showed that there was a main effect for the different emotions among males $F(3, 123) = 3.255$, $p = .024$ but not females $F(3, 57) = 1.498$, $p = .225$.

An independent samples t-test was then run on each of the four 'emotional' symptoms and revealed higher incidence of 'emotional' problems reported by males was exclusively due to higher reporting of 'irritability' $t(60) = 3.814$, $p = .000$ (See table 3). There were no significant differences between males and females in reports for 'sadness' $t(60) = 1.520$, $p = .134$, 'more emotional' $t(60) = .977$, $p = .333$ and 'nervousness' $t(60) = .603$, $p = .549$. Means and Standard Deviations are shown in table 3.

Descriptive Statistics	Males (N = 42)		Females (N = 20)	
	Mean	Standard Deviation	Mean	Standard Deviation
Irritability	.262	.445	.000	.000
Sadness	.167	.377	.050	.224
More Emotional	.262	.445	.150	.366
Nervousness	.097	.297	.050	.224

Table 3: *Descriptive Statistics for 'emotional' symptom incidence as a function of gender.*

Symptom changes

Changes in symptoms were compared using an independent sample t-test looking at changes in 'physical', 'cognitive', 'sleep-related' and 'emotional' symptoms, between male and female participants. When reporting 'physical' symptoms, males were more likely to say their symptom had improved whereas females mostly rated their symptoms as having stayed the same ($t(60) = 1.980$, $p = .052$). Males tended to rate 'cognitive' symptoms as having improved whereas females tended to say these had become worse ($t(60) = 1.939$, $p = .057$). Females had rated 'sleep-related' symptoms as worsening, whereas males generally said these had improved, ($t(60) = 1.743$, $p = .087$). Males generally rated improvement for 'emotional' symptoms, whereas females had rated these as having worsened ($t(60) = 1.881$, $p = .066$). Means and Standard Deviations are shown in table 1.

A one sample t-test against the value of zero revealed that females' change in symptoms since injury tended to be negative for 'physical' $t(19) = -.679$, $p = .505$, 'sleep-related' $t(19) = -1.37$, $p = .421$, 'cognitive' $t(19) = -.1.000$, $p = .330$ and 'emotional' change $t(19) = -1.000$, $p = .330$. Males, however, tended to report positive change for 'sleep-related' $t(41) = .813$, $p = .421$, 'physical' $t(41) = 2.503$, $p = .016$ and 'cognitive' symptoms $t(41) = 2.091$, $p = .043$ and generally rated no change for 'emotional' symptoms $t(41) = 1.641$, $p = .109$. Means and Standard Deviations are shown in table 1.

Symptom severity

A series of independent samples t-tests were performed to assess how different genders rated symptom severity. Although, males scored higher for 'emotional' symptom severity compared to females (Table 1) this was not shown to be significant, $t(17) = 1.731$, $p = .103$. Although this was potentially due to the reduced sample size, specifically of female participants (23 males, 6 females). No significant gender differences were found for 'physical' symptom severity, $t(17) = .543$, $p = .594$, 'cognitive' symptom severity $t(17) = .518$, $p = .611$, or 'sleep-related' symptom severity $t(17) = -.244$, $p = .810$. Means and Standard Deviations are shown in table 1.

Age

An independent samples t-test was used to determine the effect of age (whether participants were younger or older than 13) on the gender differences in instance, severity and change in 'emotional' symptoms. Reanalysis of the data excluding the 5 participants who were older than 13 (2 males and 3 females), showed the same pattern of effects for severity $t(55) = 2.048$, $p = .045$, instance $t(55) = 2.211$, $p = .031$ and change $t(55) = .1.12$, $p = .269$ in 'emotional' symptoms, indicating there was no relationship between the discrepancies in symptom reporting between genders and age. Means and Standard Deviations are shown in table 4.

A Pearson's correlational analysis was then run, which showed no significant correlation between age and symptom incidence across groups, where $p < .05$ (Table 5).

Descriptive Statistics	Males (N = 40)		Females (N = 17)	
	Mean	Standard Deviation	Mean	Standard Deviation
Severity	.1.09	2.08	.309	.788
Instance	.188	.298	.059	.141
Change	.044	.211	.015	.061

Table 4: *Descriptive Statistics for participants under thirteen.*

Gender			Physical Symptoms	Cognitive Symptoms	Emotional Symptoms	Sleep Symptoms
Male (N = 42)	Age (years)	Pearson Correlation	-0.037	0.251	0.014	0.203
		Sig. (2-tailed)	0.814	0.108	0.932	0.198
Female (N = 20)	Age (years)	Pearson Correlation	-0.046	-0.167	0.032	0.211
		Sig. (2-tailed)	0.846	0.482	0.892	0.373

Table 5: *Correlations between age and symptom incidence across symptom groups as a function of gender for whole sample.*

Discussion

Literature surrounding the nature of PCS in pediatric samples is extremely limited, particularly in the UK [5,10]. This body of literature becomes even more sparse when we consider the nature of PCS in pediatric samples in reference to gender differences [3]. What we can infer from previous findings, though, is that females are generally considered more susceptible to PCS [8]. The results of the present study refute this suggestion and instead indicate that males exhibit more symptoms four to six weeks post-injury. Exclusively, this was due to significantly higher reporting of the 'emotional' symptom 'irritability' (Table 1). Additionally, the relevant literature suggests that females appear to take longer to recover and have worse outcomes than males [3,26]. Interestingly, this is supported by the present findings, as females were more likely to have reported that their symptoms had worsened, unlike males who generally stated symptoms had either improved or stayed the same (Table 1). These findings support the theory that females show slower recovery from PCS, as they do not appear to experience the same positive changes in symptoms that males report four to six weeks post-injury.

The indication of the present findings, that males endorse more 'emotional' symptoms, specifically 'irritability', may be of interest to clinicians because of the negative consequences this may have on their social functioning [27]. This seems particularly pertinent considering school-aged children with mTBI are already at a higher risk of developing behavioral problems [28]. Despite the fact 'irritability' was reported exclusively by males, it was still the most proportionally prevalent symptom overall (Table 3) and is also highly represented in other pediatric mTBI samples [10]. The importance of the focus on this specific symptom in males, therefore, may be key to understanding more about the nature of PCS in this sample.

Although no significant gender differences were observed in relation to symptom severity overall, males rated slightly higher severity of 'emotional' symptoms. This result may not have shown as significant due to the lack of female participants in comparison to males and further research may benefit from looking closer at this trend with larger sample sizes. These findings are not necessarily in line with previous research which has indicated that females are more likely to report increased discomfort post mTBI [3]. If females do report more discomfort, the present findings suggest that this may not be attributable to any increased experience of severity of symptoms; it is conceivable that this phenomenon may, instead, be due to differences in social expectations and gender norms and thus symptom report (Chaplin and Aldao, 2013).

When reporting changes of symptoms, females were more likely to have rated symptoms as either having stayed the same or worsened, whereas males rated all symptoms areas as having improved except 'emotional' symptoms. Significantly, this indicates that males are not only reporting higher prevalence and severity of 'irritability', they are also reporting that this symptom has not got any better since injury. This is in line with previous research by Eisenberg., *et al*. [10], who found that 'emotional' symptoms of concussion, including 'irritability', were among the longest lasting symptoms overall. Importantly, though, no participants reported full recovery from symptoms and all those who reported no symptoms at all expressed that they had never experienced any post-concussive symptomology. Therefore, all of the participants who had experienced PCS in one form or another were all still symptomatic four to six weeks post-injury. This represented a significant proportion of the mTBI sample (47%) and has important implications for the amount of individuals we should expect to be suffering with PCS approximately one-month post injury.

As with any research concerning symptomology in mTBI, determining potential contributory factors of high instances of symptoms can be extremely difficult. Differences in symptom occurrence may be a result of physiological consequences the injury, hormonal differences, psychosocial factors or any combination of the above. The most prevalent theory currently suggests that gender differences in symptom presentation in mTBI may be due to hormonal differences [3]. Previous research has shown evidence in support of this suggestion indicating that gender differences in symptom presentation are not observed in samples under the age of thirteen, when onset of puberty may be generally considered to occur and corresponding hormonal changes are thought to ensue [3]. The present study, however, did not find this to be the case and instead indicated that these gender differences were, in fact, present in participants under the age of thirteen.

Although Traveneer., *et al*. [3] may have considered thirteen to be a suitable cut off for comparison between adolescents and non-adolescents, other researchers have suggested that onset is more likely to occur anywhere between ten and twenty years [29]. Consequentially, trivially drawing a cut off at this age may be inappropriate and therefore the present study additionally considered correlations between age and patterns of symptomology observed in the different genders within the whole sample. No significant correlation to suggest that age had any impact on gender differences in symptom presentation was observed thus the present study does not support the suggestion that hormonal differences between genders in adolescents and non-adolescents significantly impacts PCS.

The increased presence of 'emotional' symptoms in males alternatively may be explored in terms of psychosocial influences. Gender differences in emotional expression are observed in the general population and therefore differences in the presentation of 'emotional' symptoms within this clinical sample may not be surprising (Chaplin and Aldao, 2013). Chaplin and Aldao (2013) showed that in children, males are more likely than females to show emotions such as anger, which may be regarded as similar to 'irritability'. It is conceivable that these gender differences in the general population may influence the way children then express 'emotional' symptoms after mTBI. Additionally, females are generally shown to be less likely to engage in high risk physical activities such as full-contact collision sports [3]. Females may feel less frustration during the recovery period after mTBI because they have not been restricted as much as males from participating in their usual activities, as they are less high risk, which may contribute to higher instances of 'irritability' in males. The evidence that males engage more in these high risk sporting activities than females, which is how these injuries are often sustained in males [3], may also imply potential differences in mechanisms of injury, which could cause different PCS symptomology between the genders. Males, for example, appear more likely to experience loss of consciousness after mTBI due to higher impact injuries and this has been shown to increase incidence of post-concussive symptoms [3]. This may explain the higher levels of reported symptoms in males in the present study compared with females.

Previous research has shown a higher incidence of depression in adolescents who have sustained concussion [30]. It is also known that depression strongly influences post-concussive symptom reporting following mTBI [31] and that nine out of ten depressed patients meet the requirements for PCS [32] which may arouse confusion as to whether symptoms presented during follow up are contributable to depression or PCS. It is important, therefore, to consider depression as a potential cause of higher prevalence of emotional symptoms in males. The present study, however, found no significant differences between males and females on ratings of 'sadness' and therefore

we cannot attribute the presence of higher levels of 'irritability' in males to depression. It may be pertinent, though, to consider whether it is possible that lower ratings might have occurred due to lack of willingness of parents to report depressed mood or depression due to social stigma associated with the condition [33]. Although no significant associations were observed in the present study, patients with mTBI should be screened for depression due to its high co-morbidity with PCS [30].

Traveneer., *et al*. [3]. demonstrated differences in cognitive functioning in male and female pediatric participants after mTBI. The present study did not find any significant gender differences in cognitive symptoms reported post-mTBI, although measures found to be significant in their sample, such as visual memory, verbal memory and impulse control were not represented on the symptom list. It is, therefore, possible that these differences exist but may have gone unnoticed by the present study. The presence of cognitive symptoms within the sample may be expected as cognitive symptoms, such as executive function difficulties, are often found to persist after mTBI [34]. It should, however, be considered further how these symptoms may differ in male and female participants in larger samples. Risk factors other than gender have been identified for congitive impairment, though, including having sustained a previous head injury, having preexisting learning difficulties, or having neurological or family problems which can be identified in the ED and monitored [35]. Importantly, cognitive reserve is an important moderator for outcomes of mTBI in children and adolescents [20].

Although the present study refutes that females are more susceptible to PCS [8] and that gender differences in symptomology are most likely associated with hormonal differences [3], the results support the existence of gender differences in PCS, such as prolonged recovery in females, which are in line with some previous findings [3,26]. With each emerging piece of research, the existence of gender differences in PCS becomes more apparent and necessitates change in the current guidelines for diagnosis and treatment of mTBI, to ensure tailoring of accurate and adequate treatment of each individual patient [3]. It is generally perceived that treatments for PCS are mostly ineffective and unavailable [5]; this includes recommendation of strict rest, medication, hypnosis and psychotherapy [36-38]. With more specific knowledge of the nature of PCS, however, more effective treatment may be provided. Importantly, education early on post-injury appears to be one of the most effective forms of treatment for PCS [5,39,40], consequently, the more we understand about the nature of PCS, the more effectively we can educate and therefore treat, patients.

Study Limitations and Conclusion

The present study did not include a control group and therefore we cannot conclude with certainty that symptoms reported by participants are necessarily attributable to mTBI or from other factors, such as psychosocial, environmental or otherwise [41]. Research has indicated, however, that post-concussive symptoms are more frequent in mTBI patients than in other injured patients [10,42]. Additionally, as is the case in any mTBI research measuring specific symptoms, confusion may arise surrounding symptom etiology, for example the 'physical' symptom 'sensitivity to noise', may present in a broad range of neuropathologies such as migraine or could be an emotional or cognitive response to different levels of awareness [10]. Furthermore, the present study does not consider whether these symptoms were present before the time of injury, which may have led to a better understanding of whether the symptom was attributable to the injury.

An information booklet outlining possible symptoms, avoidance strategies and details to arrange follow up sessions for further support was issued to all participants in the present study. This has been shown to be a powerful tool to forewarn patients of symptoms they might expect following a head injury and providing reassurance that their experiences post mTBI are normal [3,39,40]. This technique, however, has been criticized as inducing what is referred to as the 'Good Old Days Bias', whereby patients and their parents have been known to underestimate symptom prevalence before injury and overestimate after [43]. It is possible that this may result in over-reporting of symptoms when studying and managing mTBI [44]. and therefore this may have occurred in the present study.

The study used parental report alone, which may have limited insight into the child's functioning. Past studies, though, have found source of symptom reporting did not affect the findings of gender differences in PCS [8]. In fact, parental report may give clearer insight into child functioning; particularly in the case of younger children who might not be able to fully understand or accurately report symptoms such as 'dizziness' [45].

The study had a limited sample size, with unequal representation of males and females, which may have impacted results and affected the ability for generalisation from the present findings. Given, however, that in the UK there are very few studies that focus on this area [5], this contribution may still be significant. There are some benefits to the sample, in particular that it comprised of all eligible patients who presented at the ED and therefore represented a well-rounded sample of mTBI patients, rather than focusing on a particular mTBI pediatric subgroup [46].

Future Directions

Future research into gender differences in symptom reporting, symptom severity and recovery post-mTBI would benefit healthcare providers to facilitate timely intervention and treatment which is more specific and relevant to the patient. The higher prevalence of 'emotional' symptoms in males should be investigated further and considered by clinicians when dealing with childhood mTBI, due to the potentially negative implications this may have on long-term prognosis. Additionally, research which considers potential causes of these gender differences may aid identification and treatment of PCS. Any further focus on UK mTBI populations is recommended to add to our understanding of PCS, particularly focusing on patient demographics and how these might influence vulnerability to injury or recovery.

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Appendix A: Information Letter

Department of Neuropsychology

Psychological Health Services

Bristol Children's Hospital

Upper Maudlin Street

Bristol

BS2 8BJ

Tel 0117 342 2784

Email: neuropsychology@UHBristol.nhs.uk

website: www.uhbristol.nhs.uk

Dear Sir or Madam,

Service planning questionnaire

We are writing to you because your child recently attended the Emergency Department at the Bristol Royal Hospital for Children with a minor head injury or concussion.

Please be assured that we are not sending you this letter because we have any specific concerns about your child.

We are carrying out a review of our care at the Children's Hospital, to see whether we need to set up a new specialist service to deal with this type of accident. To help us decide this we are carrying out a telephone survey. We would like to speak to parents / guardians approximately six weeks after they came to the Children's Hospital, to see how their child is getting on. The survey takes around 10 minutes to complete and involves a member of our team asking you questions on the telephone about your child's current health.

If you do not wish to participate in this survey then please contact us using the details at the top of this letter.

If we do not hear from you, an experienced member of our team (<<insert name>>) will telephone you in the next few days. At that point you can choose to opt out, complete the survey over the phone, or arrange to take part at a more convenient time.

Participation in this survey is completely voluntary. If you do decide to take part, please be assured that staff at the University Hospitals Bristol are committed to ensuring that people who take the time to tell us when we get things wrong, or if things could be improved, are not discriminated against when it comes to their future treatment and care. Any answers you give will be treated in the strictest confidence.

Please note that we are carrying out this survey to help us plan our future services: if you are in any way concerned about your child then please follow the advice you were given when you attended the Emergency Department, rather than wait for us to phone.

Thank you for your time. If you have any questions about this survey then please do not hesitate to get in touch with myself or my team via the details at the top of this letter.

Yours faithfully,

Dr Ingram Wright

Consultant Clinical Neuropsychologist

Appendix B: Post-Concussion Symptom Questionnaire

We would like to know whether your child is experiencing any of these following problems. Please indicate whether the symptoms that I will read to you are 'present' or 'absent' (P) or (A). I will then ask you to rate the symptoms, that you state as present, on a scale of 1-10 (10 being the most problematic that the symptom could possibly be). Finally, I will ask you to indicate whether the symptom is either: getting better, staying the same, or getting worse.

Physical	Present (1) or Absent (0)	Rate problem on scale 1-10	Better (+) same (/) worse (-)
Headaches			
Nausea			
Vomiting			
Balance Problems			
Dizziness			
Sensitivity to light			
Sensitivity to noise			
Numbness or tingling			
Cognitive			
Feeling mentally foggy			
Feeling slowed down			
Difficulty concentrating			

Difficulty remembering			
Appeared dazed or stunned			
Confused about events			
Answers questions slower than usual			
Emotional			
Irritability			
Sadness			
More emotional			
Nervousness			
Sleep			
Drowsiness			
Sleeping less than usual			
Sleeping more than usual			
Trouble falling asleep			

Lastly, are there any other symptoms that your child has experienced since leaving inpatient care, which have not been mentioned?

Physical	Present (1) or Absent (0)	Rate problem on scale 1-10	Better (+) same (/) worse (-)

Questionnaire is based on the 'Acute Concussion Evaluation' and the 'Post-Concussion Symptom Inventory'; published by Gerard Gioria and Micky Collins at the Children's National Medical Centre.

Appendix C: Telephone transcript

Hi my name is _____, I'm calling from the Children's hospital in Bristol. I am calling you because [**your son/daughter**] has recently attended the Emergency Department at Bristol Children's hospital with a minor head injury/concussion and I was wondering if you received the letter about the service evaluation we are conducting?

If yes: is now a convenient time to ask you some survey questions? It shouldn't take longer than 10 minutes. As it says in the letter, any information you give us will be strictly confidential and your responses will be anonymised. If you have any significant clinical concerns about your child we will point you in the right direction of who to contact.

If no: We are interested in improving our service for children with minor head injuries and would be very interested to hear how your child is at the moment. Participation in the survey is completely voluntary. If you do decide to take part, please be assured that staff at the University Hospitals Bristol are committed to ensuring that people who take the time to tell us when we get things wrong, or if things could be improved, are not discriminated against when it comes to their future treatment and care. If you consent, we would like to ask you some survey questions that shouldn't take longer than 5 minutes. Any information you give us will be strictly confidential and your responses will be anonymised. If you have any significant clinical concerns about your child we will point you in the right direction of who to contact.

If don't consent: Thank you very much for your time. (End phone call).

If consent: I am going to ask if ___has had some symptoms or not, how bad they are and if they're getting better or worse. You can say yes/no/unsure and we can come back to any ones that you might need to think about. (Proceed to ask questions from Post-Concussion symptom Questionnaire).

After questions asked: That's the end of the survey. The data will be used in our service evaluation. If you want to retract your responses at any time please let us know by phoning or emailing and your data will be deleted. Thanks very much for your time. Goodbye.

Bibliography

1. Headway. Acquired Brain Injury (2015).
2. National Institute for Health and Care Excellence (2014).
3. Tanveer S., *et al*. "Gender differences in concussion and postinjury cognitive findings in an older and younger pediatric population". *Pediatric Neurology* 70 (2017): 44-49.
4. Williams WH., *et al*. "Mild traumatic brain injury and postconcussion syndrome: a neuropsychological perspective". *Journal of Neurology, Neurosurgery, and Psychiatry* 81.10 (2010):116-122.
5. Reuben A., *et al*. "Postconcussion syndrome (PCS) in the emergency department: predicting and pre-empting persistent symptoms following a mild traumatic brain injury". *Emergency Medicine Journal* 31.1 (2014): 72-77.
6. McCroy P., *et al*. "Consensus statement on concussion in sport the third international conference on concussion in sport". *Journal of Clinical Neuroscience* 43.1 (2009): 755-763.
7. Meehan WP and Mannix R. "Pediatric concussions in United States emergency departments in the years 2002 to 2006". *The Journal of Pediatrics* 157.6 (2010): 889-893.
8. Preiss-Farzanegan SJ., *et al*. "The relationship between gender and postconcussion symptoms after sport-related mild traumatic brain injury". *Physical Medicine and Rehabilitation* 1.3 (2009): 245-253.
9. McCrea M. "Mild traumatic brain injury and postconcussion syndrome: The new evidence base for diagnosis and treatment". Oxford University Press, USA (2008).
10. Eisenberg MA., *et al*. "Duration and course of post-concussive symptoms". *Pediatrics* 133.6 (2014): 999-1006.
11. Hung R., *et al*. "Systematic review of the clinical course, natural history, and prognosis for pediatric mild traumatic brain injury: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis". *Archives of Physical Medicine and Rehabilitation* 95.3 (2014): S174-S191.
12. Schmidt AT., *et al*. "A Longitudinal Investigation of Sleep Quality in Adolescents and Young Adults After Mild Traumatic Brain Injury". *Cognitive and Behavioral Neurology* 28.2 (2015): 53-62.
13. Ouellet MC., *et al*. "Sleep-wake disturbances after traumatic brain injury". *The Lancet Neurology* 14.7 (2015): 746-757.
14. Yeates KO., *et al*. "Longitudinal trajectories of postconcussive symptoms in children with mild traumatic brain injuries and their relationship to acute clinical status". *Pediatrics* 123.3 (2009): 735-743.
15. Ponsford J., *et al*. "Impact of early intervention on outcome after mild traumatic brain injury in children". *Pediatrics* 108.6 (2001): 1297-1303.

16. Shorer M and Apter A. "The Relationship between Persistent Post Concussive Symptoms and Post Traumatic Stress Disorder in Children–A Call for an Integrative View". *Traumatic Stress Disorders and Treatment* 5 (2016): 1.

17. Ganesalingam K., *et al*. "Family burden and parental distress following mild traumatic brain injury in children and its relationship to post-concussive symptoms". *Journal of Pediatric Psychology* 33.6 (2008): 621-629.

18. Albicini MS., *et al*. "Ongoing daytime behavioural problems in university students following childhood mild traumatic brain injury". *International Journal of Rehabilitation Research* 39.1 (2016): 77-83.

19. Eisenberg MA., *et al*. "Time interval between concussions and symptom duration". *Pediatrics* 132.1 (2013): 8-17.

20. Fay TB., *et al*. "Cognitive reserve as a moderator of postconcussive symptoms in children with complicated and uncomplicated mild traumatic brain injury". *Journal of the International Neuropsychological Society* 16.1 (2010): 94-105.

21. Kristman VL., *et al*. "Methodological issues and research recommendations for prognosis after mild traumatic brain injury: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis". *Archives of Physical Medicine and Rehabilitation* 95.3 (2014): S265-S277.

22. Gioia GA and Collins MW. Acute concussion evaluation (ace) (2006).

23. Zuckerbraun NS., *et al*. "Use of modified acute concussion evaluation tools in the emergency department". *Pediatrics* 133.4 (2014): 635-642.

24. Gioia GA., *et al*. "Improving identification and diagnosis of mild traumatic brain injury with evidence: psychometric support for the acute concussion evaluation". *The Journal of Head Trauma Rehabilitation* 23.4 (2008): 230-242.

25. IBM Corp. Released. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp (2015).

26. Berz K., *et al*. "Sex-specific differences in the severity of symptoms and recovery rate following sports-related concussion in young athletes". *The Physician and Sports Medicine* 41.2 (2013): 58-63.

27. Hubbard JA and Coie JD. "Emotional correlates of social competence in children's peer relationships. *Merrill-Palmer Quarterly* 40 (1994): 1-20.

28. Taylor HG., *et al*. "Symptoms of persistent behavior problems in children with mild traumatic brain injury". *The Journal of Head Trauma Rehabilitation* 30.5 (2015): 302-310.

29. Steinberg L. "Age of opportunity: Lessons from the new science of adolescence". Houghton Mifflin Harcourt (2014).

30. Chrisman SP and Richardson LP. "Prevalence of diagnosed depression in adolescents with history of concussion". *Journal of Adolescent Health* 54.5 (2014): 582-586.

31. Lange RT., *et al*. "Depression strongly influences postconcussion symptom reporting following mild traumatic brain injury". *The Journal of Head Trauma Rehabilitation* 26.2 (2011): 127-137.

32. Iverson G. "Misdiagnosis of the persistent post-concussion syndrome in patients with depression". *Archives of Clinical Neuropsychology* 21.4 (2006): 303-310.

33. Quinn N., *et al*. "Nature and impact of European anti-stigma depression programmes". *Health Promotion International* 29.3 (2013).

34. Cossette I., *et al*. "Executive dysfunction following a mild traumatic brain injury revealed in early adolescence with locomotor-cognitive dual-tasks". *Brain Injury* 30.13-14 (2016): 1648-1655.

35. Ponsford J., *et al*. "Cognitive and behavioral outcome following mild traumatic head injury in children". *The Journal of Head Trauma Rehabilitation* 14.4 (1999): 360-372.

36. Ll Wood R. "Understanding the 'miserable minority': a diasthesis-stress paradigm for post-concussional syndrome". *Brain Injury* 18.11 (2004): 1135-1153.

37. Thomas DG., *et al*. "Benefits of strict rest after acute concussion: a randomized controlled trial". *Pediatrics* 135.2 (2015): 213-223.

38. Brooks BL., *et al*. "Test or rest? Computerized cognitive testing in the emergency department after pediatric mild traumatic brain injury does not delay symptom recovery". *Journal of Neurotrauma* 33.23 (2016): 2091-2096.

39. Ponsford J., *et al*. "Impact of early intervention on outcome following mild traumatic head injury in adults". *Journal of Neurology, Neurosurgery, and Psychiatry* 73(2002): 330-332.

40. Andersson EE., *et al*. "Mild traumatic brain injuries: the impact of early intervention on late sequelae. A randomized controlled trial". *Acta Neurochirurgica* 149.2 (2007): 151-160.

41. Keightley ML., *et al*. "Psychosocial consequences of mild traumatic brain injury in children: results of a systematic review by the International Collaboration on Mild Traumatic Brain Injury Prognosis". *Archives of Physical Medicine and Rehabilitation* 95.3 (2014): S192-S200.

42. Barlow KM., *et al*. "Epidemiology of postconcussion syndrome in pediatric mild traumatic brain injury". *Pediatrics* 126.2 (2010): e374-e381.

43. Iverson GL., *et al*. ""Good old days" bias following mild traumatic brain injury". *The Clinical Neuropsychologist* 24.1 (2010): 17-37.

44. Brooks BL., *et al*. "Perception of recovery after pediatric mild traumatic brain injury is influenced by the "good old days" bias: tangible implications for clinical practice and outcomes research". *Archives of Clinical Neuropsychology* 29.2 (2014): 186-193.

45. Yeates KO., *et al*. "Mild Traumatic Bain Injury in Children and Adolescents". *Pediatric Neuropsychology* Second Edition Research, Theory, and Practice, New York, The Guilford Press (2010).

46. Ponsford JL., *et al*. "Fatigue and sleep disturbance following traumatic brain injury-their nature, causes, and potential treatments". *The Journal of Head Trauma Rehabilitation* 27.3 (2012): 224-233.

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