Original Article

Centre of pressure during quiet stance and dual-task one month after mild traumatic brain injury: In adolescents

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Abstract

Background: Mild traumatic brain injury is a common neurological condition affecting adolescents in North America. In adults, symptoms related to balance are some of the most commonly reported.

Methods: The purpose of this study was to investigate the balance in adolescents with mild traumatic brain injury using linear and non-linear centre of pressure (COP) measures in quiet stance and during dual-task. Adolescents aged 13.00 to 17.99 years were tested once at one month following mild traumatic brain injury ($n = 25$), and healthy adolescents ($n = 22$) were tested once as controls in four conditions: standing with eyes open, standing with eyes closed, standing on a single leg and standing while performing a visual Stroop task.

Results: In general, compared to healthy adolescents, adolescents with mild traumatic brain injury demonstrated more variability ($p = 0.007$, 95% CI (0.9, 5.4) and $p = 0.049$, 95% CI (0.009, 4.0), mediolateral and anteroposterior, respectively), showed more cumulative movement (path length, $p = 0.016$, 95% CI (1.3, 11.9)) and required greater speed of movement ($p = 0.012$, 95% CI (0.99, 7.4) and $p = 0.035$, 95% CI (0.28, 7.5), mediolateral and anteroposterior, respectively) in maintaining balance, and in underlying temporal organization showed less local stability (mediolateral largest Lyapunov, $p = 0.033$, 95% CI (0.001, 0.027)), more short-term complexity anteroposteriorly ($p = 0.029$, 95% CI (0.005, 0.099)) and less long-term complexity mediolaterally ($p = 0.001$, 95% CI (0.015, 0.056)). Condition differences are additionally presented.

Conclusions: Findings suggest that, for adolescents with mild traumatic brain injury, when maintaining balance visual input is relied on differently, the effectiveness of control may be an issue during dual-task, and consequently, the challenge of dual-task may be on par with single leg stance.

Keywords

Centre of pressure, concussion, teens, largest Lyapunov exponent, scaling, dual-task, Stroop

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Introduction

Mild traumatic brain injury (mTBI), neurophysiological injury resulting from sudden acceleration and resulting in force to the brain, is one of the most common neurological conditions in Canada and the United States.[1] In the United States, the incidence in adolescents and young adults has been found to be approximately 2.3 to 2.5 mTBIs per 10,000 athletic exposures.[2,3]

Previous studies have recorded centre of pressure (COP) measures during quiet stance, walking, and during dual-tasks in young adults and adolescents

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following mTBI. The objectives of these studies were to identify potential variables for use in characterizing impairments in individuals with mTBI and documenting recovery after mTBI.[4–7] The variables used to characterize COP include position- and velocity-based measures. While position is likely an output measure, rather than a contributor to control mechanisms because of its low order, speed and velocity are related to momentum and are good candidates for characterizing postural control.[8,9]

Non-linear measures can additionally account for dimensionality and temporal patterns within COP movement beyond the spatial information provided by position and velocity. Two non-linear measures, the largest Lyapunov exponent[10] and scaling parameter,[11] provide information about temporal aspects of COP timeseries. The largest Lyapunov exponent quantifies the divergence of nearby state space trajectories and reflects local stability of the timeseries.[10] Higher values of the largest Lyapunov exponent correspond to increased divergence, and thus less local stability. The scaling parameter quantifies correlations in the timeseries at different time scales. Scaling parameter values can be compared to known values of certain scaling properties such as random walk or white noise (equal to 0.5), persistent power law correlation (between 0.5 and 1.0), anti-persistent power law correlation (between 0 and 0.5).[12] We describe dynamics associated with H values that are closer to 0.5, i.e. closer to random walk, as being less complex, and those for values of H that are farther from 0.5 as more complex. Therefore, larger values of short-term scaling and smaller values of long-term scaling correspond to more complex values of scaling.

These non-linear measures have previously been used to investigate COP from healthy young adults in normal quiet stance[13,14] and following lower limb muscle fatigue[15] as well as during quiet stance in individuals with multiple sclerosis[16] and Parkinson's disease.[17] These measures have also previously been used in young adults with recent mTBI, demonstrating a potential utility for investigating the neurophysiological effects of mTBI through balance.[18]

In adolescents, these measures may be similarly useful; therefore, the aim of this study was to investigate the changes to balance control using linear and non-linear COP measures in different balance conditions. It was hypothesized that adolescents with mTBI would demonstrate different balance output and control than healthy adolescents outwardly and in underlying aspects. Linear measures such as path length, mean speed, and variability are able demonstrate the outward aspects of balance output and control, while local stability (Lyapunov exponent) and scaling measures reflect underlying temporal aspects. One month post-mTBI, subtle effects on balance are still present.[19] It was also hypothesized that the differences in balance output and control shown by the adolescents with mTBI would be more evident in difficult balance conditions.

Methods

Participants

Study recruitment and mTBI assessment are fully described in another paper,[19] as these data were collected as part of a larger study.[20] This study was approved by the Ethics Boards of the University of Ottawa and the Children's Hospital of Eastern Ontario. Written informed consent and assent were obtained from the parents and participants, respectively. Adolescents who had been diagnosed with mTBI within 48 h of a head injury by an emergency department physician as defined by Zurich consensus[21] were enrolled in the study and were tested approximately one month post-injury (32.4 ± 3.4 days). Healthy adolescents were also invited to participate in the study as controls. These controls had not experienced a concussion in the year prior.

Data collection

A calibrated wireless mobile force platform (Nintendo Wii Balance Board video game controller) and a laptop computer with Bluetooth were used to measure COP. The use of the Wii Balance Board for COP measurement has been validated.[22,23] A free, open-source programmable input emulator (GlovePIE) was used to script a program for Bluetooth data acquisition at a frequency of 32 Hz. Raw sensor data from four load cells located at each corner of the platform were converted to mediolateral and anteroposterior COP in MATLAB (The Mathworks Natick, MA).

Participants were asked to stand quietly under four conditions: (i) 2 min with eyes open on two feet (EO); (ii) 2 min with eyes closed on two feet (EC); (iii) 2 min in single leg stance with eyes open (SIN), and (iv) on two feet while performing a visual Stroop colour-word task (DT) until the task was completed. For the Stroop colour-word task, a list of 100 words—red, yellow, green, blue—were presented in an incongruent ink colour. Incongruent Stroop tasks are well documented and have been widely used as a task to challenge cognition. Participants were asked to identify the colour of the text as quickly and as accurately as possible. For conditions EO, EC and DT, participants placed each foot in the demarcated area on the Wii Balance Board to maintain consistency in foot position across the study. When standing on one leg (SIN), participants positioned their foot in the centre of the platform.

Data analysis

COP data analysis was carried out in MATLAB with additional material from MATLAB Central.[24–26] COP measures were calculated as described in Table 1 using mediolateral, x_i, and anteroposterior, y_i, timeseries where $i = 1, 2, \ldots, N$ and $N = Tf$. For linear measures—path length, l, mean speed, $\bar{u}$, and variability, σ—a second-order, low-pass Butterworth filter with a cut-off frequency of 10 Hz was applied. Non-linear measures—the largest Lyapunov exponent, λ, and scaling parameter, H—were calculated using unfiltered timeseries. Scaling parameters estimates were calculated for the two scaling regions—a short-term region, H_1 and a long-term region, H_2—as previously described.[29]

Statistical analyses were performed in MATLAB and in SPSS (IBM Armonk, NY). Repeated measures mixed model analysis of variance was used to compare groups (healthy and mTBI) and conditions (EO, EC, SIN, and DT).

Results

One healthy participant and one participant with mTBI did not complete the dual-task and a second participant with mTBI did not complete the single leg condition.

Participant characteristics can be found in Table 2.

The majority of COP timeseries regions were classified as fractional Brownian motion (88.8% (309 out of 348) in healthy participants; 86.5% (339 out of 392) in participants with mTBI). The remaining regions were classified as fractional Gaussian noise. COP timeseries demonstrated short-term persistence, $H_1 > 0.5$ and long-term anti-persistence, $H_2 < 0.5$. As expected, scaling parameters of all randomized surrogate timeseries demonstrated random correlations.

Main effects and interactions

A main effect of group (healthy or mTBI) was found for both linear (path length, mean speed, and variability) and non-linear (mediolateral local stability, anteroposterior short-term scaling, and mediolateral long-term scaling) COP measures. All measures demonstrated a main effect of condition.

The overall effect of the condition on mediolateral local stability and mediolateral long-term scaling was dependent on whether the group was healthy or had sustained mTBIs (Table 3).

Table 1. COP measures.

Measure	Symbol	Equation/method	Description
Path length (normalized)	l	$\frac{1}{T}\sum_{i=1}^{N}\sqrt{(x_{i+1}-x_i)^2+(y_{i+1}-y_i)^2}$	The equation normalizes the timeseries by the total time, *T*, to account for minor differences in length (number of samples); therefore, it can also be considered an estimate of average speed.
Mean speed	$(\bar{u}_x, \bar{u}_y)$	$\left(\frac{\lvert x_{i+1}-x_i\rvert}{t_s}, \frac{\lvert y_{i+1}-y_i\rvert}{t_s}\right)$	Mean speed (the mean instantaneous speed of the timeseries), unlike velocity, disregards direction when the absolute value (or square root of the squared velocity) is taken to avoid having the negative and positive values cancel. Unlike path length, it is calculated at each time step. Note: $t_s = 1/f$.
Variability	(σ_x, σ_y)	$\left(\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i-\bar{x})^2}, \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(y_i-\bar{y})^2}\right)$	Variability of the timeseries is described by the standard deviation.
Largest Lyapunov exponent (local stability)	(λ_x, λ_y)	Rosenstein's algorithm[10]	Estimates the average local stability of a timeseries by quantifying the exponential divergence of initially close trajectories (the largest overtakes all others and is representative of the evolution of the state space volume). The algorithm uses the embedding dimension, lag determined by false nearest neighbours[27] and the mean period of the timeseries.
Scaling	(H_x, H_y) for each region	Multiple methods were averaged to yield an estimate: aggregated variance, absolute values, R/S[11,28]	The scaling parameter quantifies self-similarity—using correlations/dependence within the timeseries at different time scales. Methods use the original, differenced or summed series, as appropriate, depending on classification of the series as fGn or fBm.

Table 2. Participant characteristics.

	No. of participants	Age (±SD) years
Healthy	n=22 (7 males, 15 females)	14.8±1.6
mTBI	n=25 (10 males, 15 females)	14.2±1.3

mTBI: mild traumatic brain injury.

Table 3. Main effects and interactions (*p*-values).

	P (α = 0.05, significant *p*-values denoted in bold)		
Measure	Group	Condition	C×G
Path length, l	**0.016**	**<0.0005**	0.119
Mean speed, $\bar{u}$			
m/l	**0.012**	**<0.0005**	0.080
a/p	**0.035**	**<0.0005**	0.348
Variability, σ			
m/l	**0.007**	**0.026**	0.161
a/p	**0.049**	**<0.0005**	0.491
Local stability, λ_{max}			
m/l	**0.033**	**<0.0005**	**0.028**
a/p	0.202	**<0.0005**	0.156
Short-term scaling, H_1			
m/l	0.295	**<0.0005**	0.797
a/p	**0.029**	**<0.0005**	0.900
Long-term scaling, H_2			
m/l	**0.001**	**0.013**	**<0.0005**
a/p	0.316	**<0.0005**	0.462

Group differences (adolescents with mTBI and healthy adolescents)

For all conditions, mediolateral variability (Figure 1 (d)) was significantly greater for adolescents with mTBI than for healthy adolescents. For the dual-task condition, path length (Figure 1(a)) and mediolateral mean speed (Figure 1(b)) were significantly greater and mediolateral local stability (Figure 2(a)) was reduced for adolescents with mTBI when compared to healthy adolescents. In the eyes closed condition, anteroposterior variability (Figure 1(e)) was significantly greater for adolescents with mTBI than for healthy adolescents. In both the eyes open and eyes closed conditions, mediolateral long-term scaling (Figure 2(c)) was significantly less complex and anteroposterior short-term scaling (Figure 2(d)) was significantly more complex in adolescents with mTBI than in healthy adolescents.

Condition comparisons

These results can additionally be found in Appendix 1 with accompanying Bonferroni adjusted *p*-values.

Single leg stance versus two leg stance. Only adolescents with mTBI demonstrated significantly more complex mediolateral and anteroposterior long-term scaling when standing on a single leg versus two with eyes open (Figure 2(c)).

Only the healthy group demonstrated significantly greater mediolateral mean speed (Figure 1(b)) and reduced anteroposterior local stability (Figure 2(b)) when standing on a single leg versus two legs during dual-task.

In both groups, all linear measures (Figure 1) were significantly greater when standing on a single leg versus two legs with eyes open or closed and in the case of path length and anteroposterior mean speed even during dual-task, mediolateral local stability (Figure 2(a)) was significantly reduced when standing on a single leg versus two (all other conditions), and anteroposterior local stability (Figure 2(b)) was significantly reduced when standing on a single leg versus two with eyes open. In both groups, anteroposterior short-term scaling was significantly less complex when standing on a single leg versus two, albeit with eyes closed for adolescents with mTBI and during dual-task for healthy adolescents (Figure 2(d)).

Eyes closed versus eyes open. Only adolescents with mTBI demonstrated significantly greater path length and mediolateral mean speed and significantly more complex anteroposterior long-term scaling when challenged with eyes closed versus eyes open (Figures 1(a), 2(b), and 2(d)).

In both groups, anteroposterior mean speed was significantly greater and mediolateral and anteroposterior local stability were significantly reduced with eyes closed versus eyes open (Figures 1(c) and 2(b)).

Dual-task. Only adolescents with mTBI demonstrated significantly greater path length and mediolateral and anteroposterior mean speed (Figure 1(a) to (c)) as well as significantly reduced mediolateral and anteroposterior local stability (Figure 2(a) and (b)) during the dual-task versus eyes open.

Both healthy adolescents and adolescents with mTBI demonstrated more complex anteroposterior long-term scaling during the dual-task versus eyes open (Figure 2(d)).

Discussion

That, one month after injury, adolescents with mTBI demonstrate different balance output and control than healthy adolescents was supported by the main effect of group in both linear measures demonstrating outward and non-linear measures demonstrating underlying aspects. Adolescents with mTBI showed greater

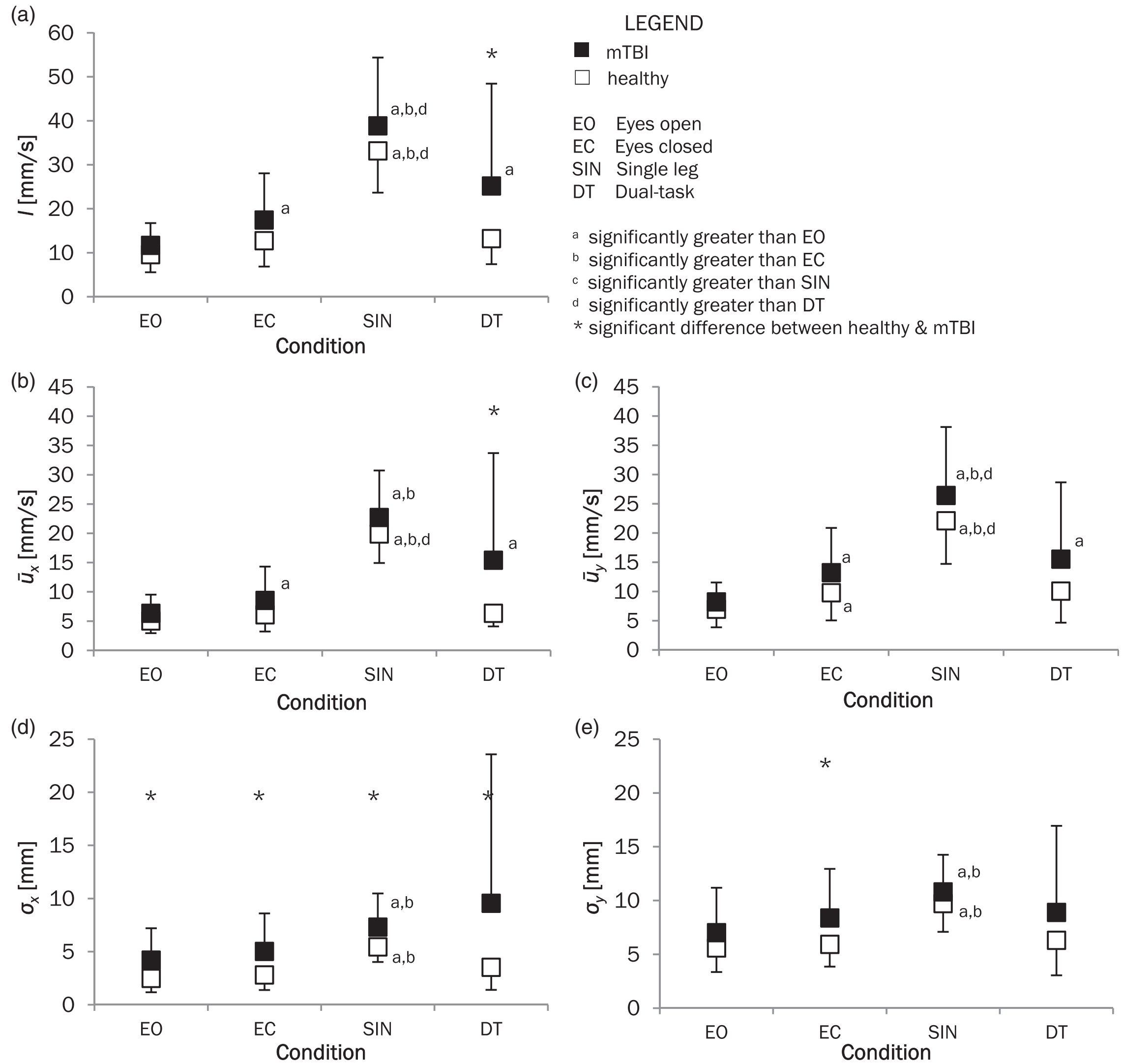

Figure 1. Linear COP measure results. (a) Normalized path length, *l*, (b) mediolateral and (c) anteroposterior mean speed, $\bar{u}$, (d) mediolateral and (e) anteroposterior variability, σ, of mTBI and healthy groups (mean±SD). As shown in the legend, significant group comparisons are denoted by an asterisk; significant condition comparisons within each group are denoted by superscript letters.

variability in maintaining balance, and required greater speed, and more cumulative movement to maintain this output. Less local stability and more complexity of the underlying temporal organization of COP movement also indicated changes to balance output and control requirements in adolescents with mTBI.

That differences in balance output and control shown by adolescents with mTBI are more evident in difficult balance conditions was only partially supported; rather, the relative difficulty of certain conditions may be different for adolescents with mTBI as suggested by three main findings: For adolescents with mTBI, visual input is relied on differently, the challenge of dual-task may be on par with single leg stance, and in dual-task the effectiveness of control may be an issue.

Firstly, standing with a reduced base of support (on a single leg) is typically the most challenging condition; however, for adolescents with mTBI, standing on two legs while diverting attention (dual-task) is also highly challenging; therefore, in these adolescents, the difference between single leg and dual-task results is not so obvious. On a reduced base of support, all adolescents demonstrated greater variability, greater speed of movement, more cumulative movement to maintain balance, and, in the underlying organization of the COP movement, less local stability. When compared to a wide base but with diverted attention resources, although all adolescents also showed greater speed anteroposteriorly, more cumulative movement to maintain balance, and less local stability mediolaterally, only healthy adolescents also showed greater

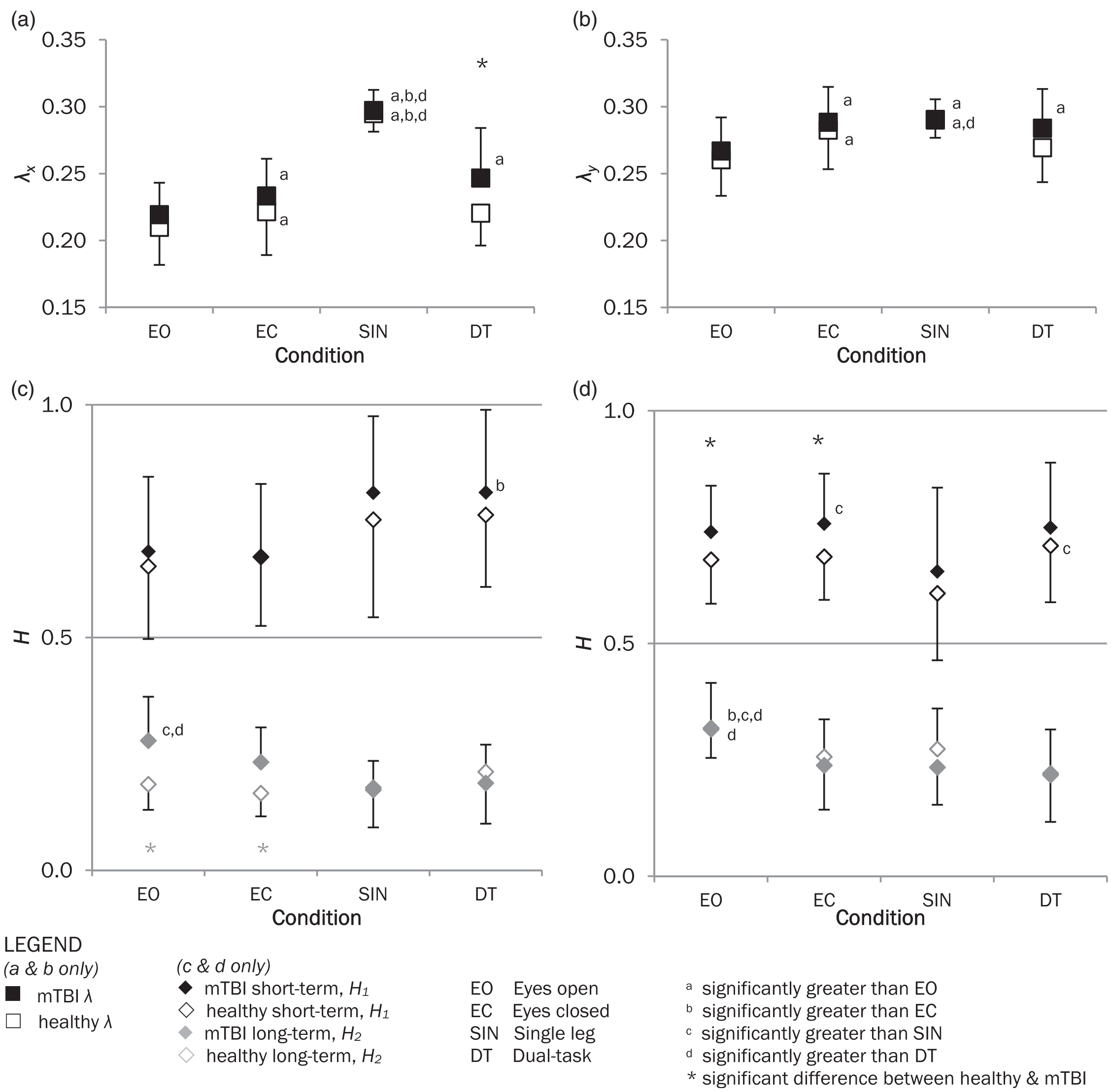

Figure 2. Non-linear COP measure results. (a) Mediolateral and (b) anteroposterior local stability, λ; (c) mediolateral and (d) anteroposterior scaling, H, of mTBI and healthy groups (mean$\pm$SD). Surrogate scaling results are not shown. In some cases, the healthy marker may be hidden by the mTBI marker. As shown in the legend, significant group comparisons are denoted by an asterisk; significant condition comparisons within each group are denoted by superscript letters.

speed mediolaterally and, in the underlying organization of the movement, less local stability and less short-term complexity (both anteroposteriorly). In contrast, adolescents with mTBI only showed differences between a reduced and a wide base while simply standing. In the underlying organization of the COP movement, less anteroposterior short-term complexity and more long-term complexity were evident.

Secondly, findings suggested that adolescents with mTBI relied on visual input differently than healthy adolescents to maintain balance. As expected, group differences demonstrated that adolescents with mTBI show greater variability in maintaining balance with eyes closed. Condition differences showed that, for all adolescents, removing visual input resulted in greater speed anteroposteriorly and reduced local stability than with visual input; however, only adolescents with mTBI showed more cumulative movement, greater speed mediolaterally, and more long-term complexity in the underlying organization of the movement.

Thirdly, when attention resources were diverted, the difference between healthy adolescents and adolescents with mTBI appeared to be related to the effectiveness of the control and the resulting output when maintaining balance. While all adolescents demonstrated more long-term complexity anteroposteriorly in the underlying organization of movement to maintain balance when attention was diverted compared to simply standing, only adolescents with mTBI actually showed less local stability in the underlying organization of the movement and showed greater speed and more cumulative movement in maintaining balance.

Comparison with results and findings in the literature

In healthy adolescents, our results for path length were found to be comparable to Hytönen et al.'s[30] results (called sway velocity) for young adults (aged 16 to 30). Our linear results were also comparable to young adults in other studies.[8,29]

In a previous study that examined quiet stance, COP measures differed with age.[30] In particular, children (aged 6 to 15) and young adults (aged 16 to 30) were notably different from one another. Fifty-nine per cent of our healthy adolescent group and 76% of our mTBI group were aged 13 to 15, indicating that comparison of our results with results from young adults may not always be appropriate. Nevertheless, because of a dearth of mTBI and non-linear COP data, results from studies with young adults are used. While previous studies report a wide range for largest Lyapunov exponent results that make comparison difficult,[16,31] similar findings of scaling behaviour (short-term persistence, long-term anti-persistence) are found when reviewing other studies that report two-region quiet-stance scaling parameters.[13,15]

In our previous study, which characterized healthy quiet stance in young adults, we found that when standing on one leg, greater variability, greater speed in control, and less local stability were evident when compared to standing with eyes open or closed.[27] Like healthy young adults, in this study, all adolescents demonstrated greater variability, greater speed, less local stability, and additionally more cumulative movement in maintaining balance on a single leg compared to standing with eyes open or closed. However, in young adults, greater short-term mediolateral complexity and greater long-term anteroposterior complexity were also evident. In the present study, adolescents with mTBI only showed greater long-term complexity in agreement with healthy young adults. These differences may be related to age or to mTBI and require further study.

In other studies that have examined COP in quiet stance (or dual-task) with mTBI, Powers et al.[5] reported findings of increased anteroposterior displacement and velocity in young adults with mTBI and Dorman et al.[4] also reported increased velocity in adolescents with mTBI. Our results support these findings with increased COP speed, albeit in the mediolateral direction in adolescents with mTBI.

To our knowledge, largest Lyapunov exponents and scaling parameters of COP have not previously been used in adolescent mTBI populations or in adolescents when performing dual-tasks. Local stability of COP in quiet stance (using the largest Lyapunov exponent) has been studied in pathologies such as multiple sclerosis.[16] Huisinga et al.[16] found that in individuals with multiple sclerosis, the largest Lyapunov was less than in healthy controls and smaller when standing with eyes closed condition in comparison to eyes open. This "decreased divergence of sway" was attributed to less ability to reorganize the system with reduced information because of inflamed central nervous system pathways in multiple sclerosis.[16] In contrast, our mTBI study demonstrated that there was no difference in local stability between healthy adolescents and adolescents with mTBI in simple quiet stance, and both groups demonstrated a difference in local stability between standing with eyes open and with eyes closed. This suggests the mechanisms that are present in multiple sclerosis are not a factor in mTBI.

Complexity in quiet stance COP using scaling parameters has been studied in fatigue.[15] When the plantar flexor muscles were fatigued, scaling parameters indicated that a long-term mechanism was at play. In our study, in challenging conditions, adolescents showed both short-term and long-term changes to complexity. This may an interesting area of future study.

The challenge of dual-task

Many differences between healthy and mTBI adolescents were only apparent as a result of diverting attention resources during the dual-task (Stroop task and quiet stance). During Stroop tasks, positron emission tomography scans have shown activation of extensive networks in the brain.[32] While the Stroop task is associated with prefrontal function, it also requires inhibition of posterior areas of the brain.[33] In addition, studies have shown that the parts of the prefrontal network activate only during dual-tasks or in poorly performing subjects which suggest supplementary process are provided "on-demand."[34] Because the Stroop task is associated with multiple areas in the brain, the effect on quiet stance while performing the Stroop task found in this study may demonstrate an aspect of widespread changes arising from mTBI.

Conclusion

While there are limits to what conclusions can be drawn from a study on a small group with little previous literature available for comparison, this study nevertheless makes a contribution to the growing body of knowledge concerning mTBI which can direct further study. In adolescents with mTBI, the increased challenge of dual-task, altered reliance on visual input, and change to effectiveness of control during dual-task are shown by changes the output, control, and underlying temporal organization of movement in balance and support the premise that mTBI results in widespread disruption of processing networks and resource allocation in the brain. These alterations may be seen as impairments or as adaptations that facilitate maintaining balance despite network disruption. Future study can investigate the relationship between the findings, i.e. visual input changes, visual-input related dual-task, and the increased challenge of that task.

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Appendix 1

	Conditions							
	Eyes open (EO)		Eyes closed (EC)		Single leg (SIN)		Dual-task (DT)	
Measure	Healthy	mTBI	Healthy	mTBI	Healthy	mTBI	Healthy	mTBI
l (mm/s)	9.60±4.05	11.70±5.04	12.76±5.91	17.49±10.57[a]	33.18±9.51[a,b,d]	38.88±15.50[a,b,d]	**13.24±5.84**	**25.21±23.25**[a]
	p=0.1251		p=0.0623		p=0.1374		**p=0.0219**	
$\bar{u}$ (mm/s)								
m/l	5.07±2.14	6.37±3.16	6.10±2.88	8.55±5.75[a]	19.92±4.98[a,b,d]	22.74±8.00[a,b]	**6.35±2.26**	**15.42±18.29**[a]
	p=0.1101		p=0.0682		p=0.1561		**p=0.0241**	
a/p	6.98±3.11	8.23±3.29	9.78±4.75[a]	13.22±7.64[a]	22.11±7.39[a,b,d]	26.43±11.69[a,b,d]	10.07±5.41	15.54±13.13[a]
	p=0.1896		p=0.0679		p=0.1386		p=0.0712	
σ (mm)								
m/l	**2.50±1.32**	**4.22±2.98**	**2.82±1.43**	**5.03±3.56**	**5.45±1.42**[a,b]	**7.32±3.15**[a,b]	**3.54±2.14**	**9.57±14.00**
	p=0.0132		**p=0.0075**		**p=0.0130**		**p=0.0479**	
a/p	5.60±2.24	7.02±4.16	**5.94±2.08**	**8.39±4.56**	9.73±2.65[a,b]	10.82±3.43[a,b]	6.32±3.27	8.91±8.04
	p=0.1465		**p=0.0214**		p=0.2399		p=0.1578	
λ_{max}								
m/l	0.210±0.028	0.219±0.024	0.222±0.032[a]	0.233±0.028[a]	0.295±0.013[a,b,d]	0.297±0.015[a,b,d]	**0.221±0.024**	**0.247±0.037**[a]
	p=0.2174		p=0.1879		p=0.5726		**p=0.0091**	
a/p	0.260±0.027	0.267±0.025	0.282±0.029[a]	0.288±0.026[a]	0.290±0.013[a,d]	0.291±0.015[a]	0.269±0.026	0.284±0.029[a]
	p=0.3824		p=0.4749		p=0.9223		p=0.0853	
H_1								
m/l	0.653±0.156	0.685±0.160	0.673±0.149	0.675±0.155	0.753±0.210	0.811±0.164	0.764±0.155	0.812±0.177[b]
	p=0.4952		p=0.9724		p=0.2975		p=0.3398	
a/p	**0.680±0.095**	**0.740±0.099**	**0.687±0.093**	**0.758±0.107**[c]	0.608±0.144	0.655±0.180	0.710±0.122[c]	0.749±0.139
	p=0.0394		**p=0.0201**		p=0.3322		p=0.3230	
H_2								
m/l	**0.185±0.055**	**0.278±0. 094**[c,d]	**0.166±0.050**	**0.232±0.074**	0.173±0.062	0.164±0.085	0.155±0.058	0.177±0.088
	p=0.0001		**p=0.0009**		p=0.8344		p=0.2871	
a/p	0.316±0.062[d]	0.319±0.097[b,c,d]	0.257±0.080	0.238±0.095	0.274±0.087	0.234±0.081	0.221±0.094	0.218±0.101
	p=0.9088		p=0.4804		p=0.1181		p=0.9123	

Applicable to between condition comparisons (Note: Bonferroni adjustment made when determining significance.).
[a]Significantly greater than EO.
[b]Significantly greater than EC.
[c]Significantly greater than SIN.
[d]Significantly greater than DT.