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Application of Dual Task Performance in Pediatrics and Adults with Traumatic Brain Injury: A Systematic Review

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Background

In physical therapy practice, dual task training (DTT) has been utilized in patients with neurologic dysfunction, and there is consistent evidence in the literature to support the implication of such paradigms. Despite previous understanding that gait is largely an automatic skill, research has found that "gait is indeed an attention-demanding, high-level, controlled task".[1] Individuals with neurologic dysfunction have both cognitive and motor processing deficits that impact attention and functional abilities. Dual task performance is relevant in neurologic populations due to an inverse relationship between dual task costs and automaticity of gait.[1] Additionally, this association between attention and mobility is integral for appropriate navigation of complex environments encountered in daily life. Thus, the ability to divide attention and selectively orient to appropriate tasks is an important skill that precipitates everyday function.[2]

Dual task training is defined broadly as simultaneous performance of two concurrent tasks, this can be the combination of two motor tasks or a motor task and a cognitive task.[3]

Common sequelae of traumatic brain injury (TBI) include decreased sustained and divided attention, reduction in cognitive processing, impaired ability to complete motor tasks automatically, and compromised executive function.[2,4,5] Survivors of moderate to severe TBI may suffer from impaired attention and increased distractibility.[2,4,6,7] TBI affects 1.7 million individuals annually, and the rate has been continually increasing over time.[8] Based on these statistics, almost half a million hospital visits associated with TBI encompass children from birth through 14 years of age.[8] This further magnifies the need to identify effective rehabilitation interventions for improved community re-integration.

Purpose

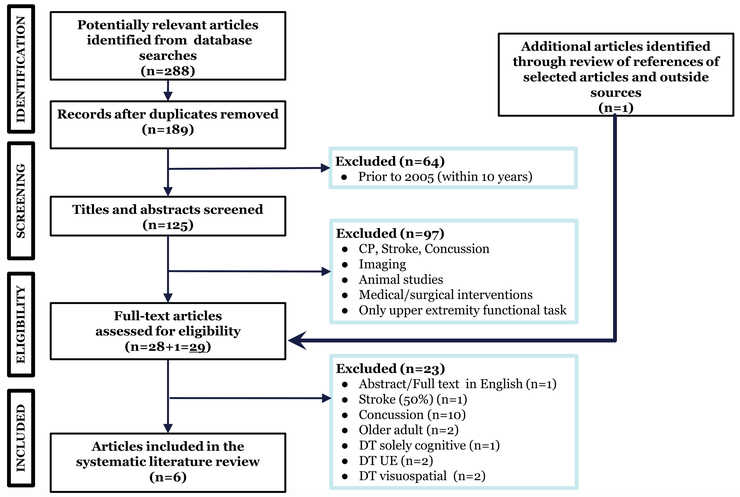
The aim of this systematic review of the literature is to investigate the application of cognitive and motor dual task paradigms in the physical therapy management of moderate to severe TBI population across the lifespan in physical therapy practice.

Methods

Preliminary Search

- **Databases Searched**: PubMed, Scopus, Medline Ovid, Google Scholar
- **Search terms**: brain injury, traumatic brain injury, physical therapy, physiotherapy, rehabilitation, dual-task, divided attention, pediatric, adolescent, children, attention, cognition and balance.
- **Search conducted**: individually by the five primary authors
- **Inclusion:** participants diagnosed with a moderate to severe traumatic brain injury; incorporation of a DT intervention (pairing a cognitive task with a lower extremity functional motor task); use of least one functional outcome measure; written in English and published within last 10 years (since 2005). (See exclusion criteria at each selection stage below)

Figure 1. Article Selection



Evaluation of Quality and Risk of Bias

- **Utilized:** Physiotherapy Evidence Database (PEDro) scale is based on the Delphi list.[9] Each of the included studies was read and graded by all five authors independently. The individual scores were compared, item by item, and any inconsistencies were discussed in order to determine an overall grading based on team consensus.

Results

Table 1. Study Participant Demographics

Articles	Participants: TBI participants Gender	TBI participants Mean Age (years)	Control participants Gender	Control participants Mean Age (years)	Mechanism of Injury	TBI Severity	Time Since Injury
Cantin[10] (2007)	M: 8 F: 2	37 ± 13.7	M: 8 F: 2	38.4 ± 13.3	Not stated	GCS 7.6 ± 2.6	5.4 ± 8.4 months
Fritz[11] (2013)	F:1	26	N/A	N/A	MVA	Rancho V/ evolving Rancho VI day 57 post injury	46 days 65 days when DTT began
Katz-Leurer[12] (2011)	M:9 F:6	9. 5 ± 2.2	M:10 F:5	9.9 ± 1.3	"post-severe closed head injury"	GCS ≤ 8 at time of admission to ER	Average 3.5 years (Range 1.5-7 years)
McCulloch[13] (2010)	M: 18 F: 6	39.4 ± 13.3	N/A	N/A	- MVA: 12 - Fall: 9 - Other: 3	Not stated	117.8 ± 125.2 months
Vallee[14] (2006)	M: 8 F: 1	39.3 ± 13.0	M: 8 F: 1	39.7 ± 12.3	Not stated	GCS 7.8 ± 2.6	1-28.2 months
Zharikova[15] (2011)	Total: 14	25.7 ± 4.7	Total: 40	29.8 ± 2.47	"multiple bilateral brain injury, 5 had diffuse axonal lesion"	Group 1 (satisfactory) GCS:11.5 (9.25-12.0) Group 2 (severe) GCS: 5 (3.25-7.5) 5	3 - 6 months

F-female; M-male

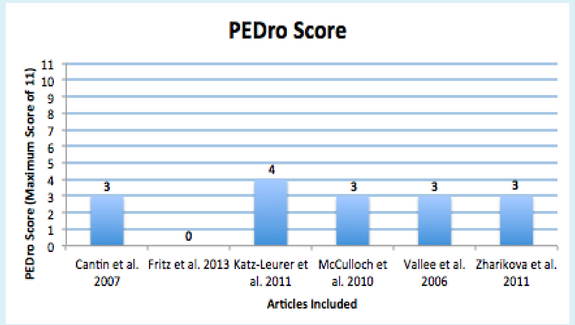
Table 2. Results

Articles	Study Design	Results of Outcome Measures
Cantin[10] (2007)	Group comparison study	- ↑ time for the TBI group for the Trail Making B, Stroop Color, Stroop Word, and Stroop Interference tests - ↓ scores for the TBI group on the Symbol Digit Modalities Test and the Brown-Peterson test - Significant relationship between Trail Making B results to obstacle clearance margin for: Stroop Bar with narrow obstacle for lead and trail limb **; Stroop Word with narrow obstacle trail limb **; Stroop Word with narrow obstacle lead limb *; Stroop Bar with deep obstacle for lead and trail limb*; Stroop Word with deep obstacle for lead and trail limb*
Fritz[11] (2013)	Case study	- ↑ in FIM level - ↓ error and ↓ time for completion of WWTT simple and WWTT complex in Phase B - ↓ error and ↓ time for completion of significant value in Phase B Trail Making Test - ↑ gait speed in Phase A with < ↑ of gait speed in Phase B (3x) - ↓ time to descend 10 stairs in Phase A reduced by 2.66 sec - ↓ time to descend 10 stairs in Phase B reduced by 7.49 sec
Katz-Leurer[12] (2011)	Group comparison study	- ↑ mistakes in sound recognition assignment in TBI group** - ↓gait velocity with dual task conditions (both groups showed ↓, but TBI more significant)** - ↑ mean step time in dual task condition compared to baseline for both groups** - ↓ step length in the sound assignment
McCulloch[13] (2010)	Cross-Sectional study	- Correlation between DTC to BBS, FSST, and HiMAT (3 balance measures) were highest (P≤0.004) - SDMT and MARS scores were also significantly correlated to a lesser degree (p≤ 0.05) - Subjects reporting at least 1 fall in the past 6 months (n=13) ↓ BBS (P≤0.03) and ↑ time FSST (P≤0 .01) than subjects reporting no falls (n=11) - Nonfallers ↑ HiMAT compared to nonfallers (P≤0.03)
Vallee[14] (2006)	Group comparison study	- ↑ reading time for the TBI group to perform the Stroop Bar while avoiding the narrow obstacle (p=0.05), and in performing the Stroop Word task while avoiding the wide obstacle (p=0.019) - ↓ walking speed in the TBI group compared to the control for the most complex dual task (p=0.042) (wide obstacle and Stroop Word task) - ↓ crossing speeds while stepping over the wide obstacle in combination with division of attention, Stroop Bar (p=0.02) or Stroop Word (p=0.027) compared to unobstructed walking in TBI pts - ↓ lead limb stride length for the two obstacle conditions with the Stroop Bar (p=0.002) and with the Stroop Word (p=0.05 for the narrow, p=-.003 for the wide obstacles) - ↓ lead limb stride length with performance of Stroop Word > Stroop Bar during unobstructed walking - ↑ lead limb clearance margins for TBI group for all conditions (p<0.001)
Zhariko[15] (2011)	Group comparison study	- ↓ quality of cognitive subtask for the TBI group in both separate and dual task significantly worse than in the healthy controls; especially for C2 subtask and G2* - ↑ quality of C1 subtask by G1 in the dual task of M2C1 compared to the separate performance* - ↓ velocity, sig below the normative values for G1 motor subtask during M2C2* - + correlation improvement in performance of both subtasks and the degree of preservation of cognitive function, level of adaptation and degree of cognitive deficit

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

Results (cont.)

Graph 1. PEDro Scores



Each study was assessed for strength using the PEDro Scale[9]:

- A maximum score is 11 points.
- Scores are inherently lower due to the fact this scale is designed to evaluate randomized control trials. This review did not consist of any randomized control trials, but is the standardized scale for evaluation of physical therapy interventions.

Common areas of weakness

- Subjects were not randomly allocated to groups
- Allocations were not concealed
- Subjects, therapists, and assessors were not blinded
- One key outcome measure was not obtained from more than 85% of subjects
- Not all subjects in which outcome measures were available received treatment or control condition as allocated.

Discussion

The application of cognitive and motor dual task paradigms in the moderate to severe traumatic brain injury population may improve functional outcomes and rehabilitation progression to everyday tasks and environments. Results of these studies demonstrated that there is a relationship between DTT and the four outcomes of mobility (gait speed, step/ stride length, balance, and foot clearance) across the lifespan but further research is required to illustrate the significance of such a relationship. There was also a correlation found between performance on the neuropsychological assessments and performance of DTT.

The majority of the studies reviewed demonstrated a decrease in gait speed with the introduction of DTT, with the exception of the case study that utilized dual task as an intervention. All other mobility outcomes identified had variable results, making it difficult to generalize to the TBI population. These variations were due to:

- several discrepancies in outcome measures chosen
- inconsistencies between DTT protocols
- range in time elapsed from injury to the application of the DTT

Therefore, the implementation of dual task as an intervention over a period of time in the moderate to severe TBI population is recommended to further clarify the relationship between dual task and gait parameters.

Future Research

Future research regarding DTT in the moderate to severe TBI population across the lifespan should focus on the following:

- Pilot studies that aim to develop recommendations for pediatric specific outcome measure, such as the TBIEDGE for adults [16]
- Outcome measures assessed in both controlled settings versus functional environments to determine when complex environments are appropriate to introduce in patients recovering from TBI
- Recommendations for the introduction of DTT along the lifespan

The Ideal Study

- Randomized control trial with a control group and two experimental TBI groups: [17]
  - Large sample size
  - Homogenous injury severity found using standardized brain injury assessment tools (GCS, Rancho Los Amigos Scale)
  - Functional mobility and cognitive standardized assessment tools [16, 18]
  - DTT applied as an intervention over a period of time, with a functional motor subtask

Conclusion

Due to the possibility of attention and cognitive processing deficits in the TBI population, there is a necessity for physical therapists to address motor skills within functional daily scenarios. Interventions requiring dual tasking could help with addressing these persistent attentional deficits that interfere with daily living after a TBI. However, there is insufficient quality of evidence to support and justify using DTT during physical therapy for patients with moderate to severe TBI. Further research among adults and pediatric TBI populations is warranted due to the ubiquity of dual task paradigms in everyday tasks.

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