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Original Research Article

Influence of upper extremity motor task and cognitive task on gait velocity and stride length in normal children aged between 7-13 years - a descriptive observational study

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ABSTRACT

Background: Walking is the basic functional activity of daily living. Most of the functional activities involve dual or multi task constraints, performing more than one activity at a time. While performing two or more activities simultaneously a person may not perform well, as one has to distribute his/her attention in both the activities. Such activities are considered to be difficult and challenging which in turn increase the safety risk. Children often need to perform cognitive and motor task simultaneously while walking. Therefore, the study was aimed to observe the influence of upper extremity motor task and cognitive task on gait velocity and stride length in normal children 7-13 years of age.
Methods: As per the selection criteria, 84 normal children aged between 7-13 years were included. They were asked to walk on Hi-Tech 3D motion and gait analyzer to perform the walking tasks - simple walking task; walking with upper extremity motor task (carrying a tray consisting of seven tennis balls) and walking with cognitive task (walking while backward counting from 100). Gait velocity and stride length were recorded and compared between all the three tasks.
Results: Gait velocity and stride length were found reduced while walking with motor task and cognitive task as compared to simple walking task. While walking with motor task, both the gait parameters were found reduced as compared to walking with cognitive task.
Conclusions: The study noticed extra concentration of children while walking with tray in hands as compared to the walking while backward counting.

Keywords: Walking, Motor task, Cognitive task, Gait velocity, Stride length

INTRODUCTION

Human locomotion was considered to be an automatic function which required minimum cognitive processing but recent researches proved that gait activity needs attention (cognitive function.[1-5] Walking is a complex motor activity that involves neural control systems which produce coordinated movements of limbs. It is a motor developmental milestone which is developed by the age of 12 to 14.5 months in full term infants. Gait development is characterized by rapid improvements by the age of three years. With increasing age children show more improvements in spatiotemporal gait variables which includes gait velocity, stride length, step length, cadence, single limb support, and reach a mature gait pattern at the age of seven years in typically developing children and also that it keeps developing across the childhood and adolescence.[5,6]

It is difficult to carry out day to day activities in isolation, that is performing one task/activity at a time.[7,8] Children often need to perform activities that involve performance of cognitive and motor task simultaneously. Dual or multi task is a result of interaction of cognitive, perceptual, mechanical and neurological mechanisms.[9]

During the performance of dual task, if there is no reduction in the performance of either task, then attention is assumed to have been divided successfully. Woollacott and Shumway-Cook defined attention as "the information processing capacity of an individual" and also asserted that all the types of tasks require attention. While performing two or more activities simultaneously a person may not perform well, as he or she has to distribute their attention in both the activities and this may lead to hazards or accidents. Therefore, the current study was aimed to observe the influence of upper extremity motor task and cognitive task on gait velocity and stride length in normal children aged between 7-13 years.

METHODS

A descriptive observational study was conducted on 84 normal children (44 girls and 40 boys) aged between 7-13 years from December 2024 to November 2025. Sample size was estimated on the basis of study conducted by Hung et al.[7] After approval from the Institutional Ethics Committee written consents were obtained from the parents of the participating children. The children with any musculoskeletal, neurological or cardiovascular disorders, any known physical disability or condition impairing independent walking, any cognitive disability, and those engaged in specific sports training were excluded from the study. An appointment was given as per the convenience and availability of time of the parent, child and researcher. The participants came to the institute and the study procedure was carried out.

RM Ingenierie Hi-Tech gait and motion analyzer (Figure 1a and b) was used to record gait velocity and stride length as outcome measures. It has the walk way of 5.2 meter long, with 1.5-meter pressure sensor mat. Children performed the activities bare feet. Child was first asked to perform simple walking task. The child was asked to walk on the gait analyzer at its normal pace and arm swing then gait velocity and stride length were recorded. Child was instructed to walk normally the way he walks on a level ground (Figure 3).

After this the child was asked to walk with upper extremity motor task, walking while carrying a tray loaded with seven table tennis balls. The tray used in procedure was 39 cm long and 26 cm wide. The seven Tennis Ball with diameter 6.54-6.86 cm, mass 56.0-59.4 g, color - fluorescent yellow/optic yellow were kept in the tray. (Figure 2).[6] The child was instructed to keep the elbows flexed at 90° and to hold the tray at a distance such that it does not contact the body. Gait velocity and stride length were recorded (Figure 4). Child then asked to walk with cognitive task. The child was asked to walk while backward counting from 100 at self-selected rhythm. Gait velocity and stride length were recorded.[9] To familiarize the children with the walkway system, each child was given one demonstration and one practice trial before the recordings for all walking tasks.

Statistical software STATA version 14.0 was used for data analysis. One way ANOVA test was used to compare gait velocity and stride length in all the three tasks. Bonferroni multiple comparison test was used to compare significant differences between any two groups. P<0.05 was considered as statistical significance.

RESULTS

Total 84 children (44 girls and 40 boys) aged between 7–13 years with mean age±standard deviation 10.3±2.01 were included in the study (Table 1). Statistical analysis showed significant difference in all the three walking tasks in respect to gait velocity and stride length (Tables 2 and 3). While walking with cognitive task, children demonstrated reduced gait velocity and stride length, as compared to simple walking task with p value 0.003 and 0.024 respectively (Tables 2 and 3). Similar results were found while walking with upper extremity motor task with p value <0.001 in both the gait parameters as compared to simple walking task (Tables 2 and 3). When dual tasks compared, the gait velocity and stride length in walking with upper extremity motor task was significantly found reduced as compared to walking with cognitive task with p value 0.022 and 0.014 respectively (Table 3).

Table 1: Age wise and gender wise distribution of participants.

S. no.	Age groups (years)	No. of children, N (%)		Total, N (%)
		Girls	Boys	
1	7– 9	16 (19.04)	12 (14.28)	28 (33.33)
2	9–11	15 (17.85)	13 (15.47)	28 (33.33)
3	11–13	13 (15.47)	15 (17.85)	28 (33.33)
Total		44 (52.38)	40 (47.6)	84 (100)

Table 2: Comparisons of mean with SD values of velocity and stride length in three walking tasks.

Walking task	Gait velocity (m/s)			Stride length (m)		
	Mean	SD	Range	Mean	SD	Range
Simple walking task	0.94	0.086	0.72—1.17	1.03	0.081	0.84—1.23

Continued.

Walking task	Gait velocity (m/s)			Stride length (m)		
	Mean	SD	Range	Mean	SD	Range
Walking with motor task	0.85	0.086	0.54—1.09	0.95	0.10	0.67—1.17
Walking with cognitive task	0.89	0.097	0.056—1.18	0.99	0.10	0.71—1.26
F-value	18.57			15.26		
P value	<0.0001			<0.001		

Table 3: Bonferroni multiple comparison test for comparison of mean score of gait velocity and stride length among tasks.

Comparison	Gait Velocity(m/s)		Stride length (m)	
	Mean difference	P value	Mean difference	P value
Simple walking–walking with motor task	-0.084	<0.001	-0.082	<0.001
Simple walking–walking with cognitive task	-0.047	0.003	-0.039	0.024
Waking with motor task-walking with cognitive task	0.037	0.022	0.042	0.014

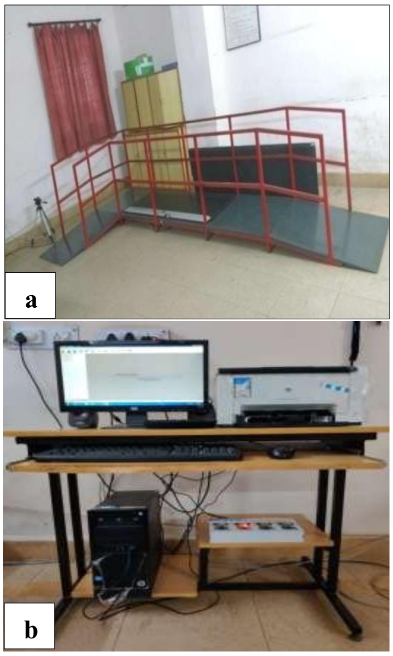

Figure 1: RM Ingenierie Hi-Tech gait and motion Analyzer: (a) walkway, and (b) monitor.

Figure 2: Tray and balls.

Figure 3: Child while performing simple walking task and walking with cognitive task (backward counting).

Figure 4: Child while walking with upper extremity motor task (carrying a tray with seven tennis balls).

DISCUSSION

The study showed significant influence of upper extremity motor task and cognitive task on gait velocity and stride length while walking in normal children. While walking with cognitive task, children demonstrated reduced gait velocity and stride length, as compared to simple walking task. These findings are in concurrence with previous study done by Boonyong et al, Toosizadeh et al, Huang et al, Hausdroff et al, and Hung et al.[2,3,9-11] They reported an interference effect of concurrent cognitive tasks on walking for the reduction in gait velocity and stride length. Cognitive tasks, therefore, can affect the performance of a very basic and highly practiced walking skill in children who are developing typically.[3] Hocking et al noticed reduction in cognitive task while walking in children. They gave priority to walking at the expense of cognitive performance.[12]

The reason for this finding may be attributed to mental rehearsal of backward counting which children might have done spontaneously. Audible backward counting recitation and recall might have imparted a slower rhythm to the children's gait patterns. Other reason for reduced gait parameters may be that the children focused more on backward counting task and less on walking which caused uneven distribution of concentration between the two tasks. This is in accordance with attentional resource theory, which suggests that the decline in performance under dual-task conditions is due to interference of the attentional resources between both the tasks.[13]

The current study results showed reduced gait parameters in walking while performing upper extremity motor task as compared to simple walking task. This result is in accordance with the results of previous studies done by Hinton and Vallis; Kunstler et al; Rehage and Alberts, Hung et al, Abbruzzese et al, Hung et al, and Lara et al.[7,13-15,17,18]

Pitts et al evaluated the effect of age, gait speed (motor task) and cognitive task on gait in young adults and older adults. They noticed larger reduction in gait speed and step length while performing the cognitive tasks in all the participants irrespective of age. When the gait speed was increased, they found reduction in cognitive task performance.[8] Laatar et al investigated the effect of dual and triple task on walking in children, adolescents and young adults. They noticed negative impact of multi-tasking on gait parameters in all age groups.[19] Cinar et al. in their meta-analysis of 22 studies, noticed reduction in gait speed, cadence and stride length and increase in double support time during dual task walking in typically developing children.[20]

Reduction in concurrent performance of two motor tasks may be caused by the increased attentional demands required to achieve the goal (i.e., to carry the tray level and away from the body with elbows flexed at 90^0) and to maintain the dynamic postural control at the same time. The performance of a complex concurrent task requires more attention resulting less attention to gait due to the limited processing capacity.[16] Therefore, children might have walked more slowly (with reduced velocity) with shorter stride lengths to perform both the tasks at once successfully and safely.[17]

A decline in gait velocity and stride length was observed under dual-task condition and the reason for this can be while executing two continuous tasks simultaneously, resource sharing takes place. This suggests that two tasks can be performed in parallel, but the amount of processing capacity is strictly limited. Due to limited resources, the available processing capacity is to be shared between the two tasks, which lead to less efficient processing for both tasks.[15]

Walking with upper extremity motor task involved carrying of a tray loaded with seven Tennis Balls whereas walking with cognitive task involved backward counting. It is already stated in previous studies that walking itself requires attentional resources. It requires visual input to produce somatosensory output. Therefore, performing a concurrent task while walking places even higher demands on the individual.[21]

During walking with backward counting task, the child had to think about numbers and their backward sequence. Whereas, while walking with carrying the tray loaded with balls the forearm coupling was required, to maintain the tray at a level such that the elbows remained flexed at 90° without touching the tray to the body. Child slowed down more and took smaller steps. It is also possible that movement of the balls on the tray was a more salient visual cue for error detection (to make sure that the ball should not fall from the tray). This additional visual monitoring required during upper extremity motor task could have produced greater decline in gait performance as compared to cognitive task.[17,22] Hence, walking while carrying a balls loaded tray placed more attentional demands on the child due to which there was significant reduction in gait velocity and stride length in upper extremity motor task as compared to cognitive task while walking.

Though, this study yields an important data about gait parameters while walking with different tasks in normal children, has certain limitations. Small sample size and the recruitment of children from one geographic region and within the limited periphery of research place, the result of the current study cannot be generalized. while walking with different tasks, the apprehension towards unfamiliar equipment and environment of setup was noticed in some children. Further studies should consider the recruitment of larger sample size from the urban and rural areas with different cultural background to enhance the strength of the findings.

CONCLUSION

This study concludes that the gait parameters (gait velocity and stride length) are seen to be reduced in children while performing a concurrent task with walking. This reduction was greater in concurrent motor task as compared to cognitive task. The attentional demands were increased in both the motor as well as cognitive concurrent task but the requirement of attention was observed higher while walking with upper extremity motor task as compared to the walking with cognitive task.

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