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Reaction and Movement Time in Down syndrome Children under Different Visual Feedback Conditions

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Abstract

Background

The purpose of this study was to determine the reaction time (RT) and movement time (MT) in Down syndrome children under two different visual feedback conditions.

Methods

An observational cross-sectional study was conducted in which30 mild to moderate Down syndrome children were allocated randomly into two groups. The full visual feedback group comprised 15 participants with an average age of 12(± 1.4) years, and the no visual feedback group comprised 15 participants with an average age of 12(± 1.7) years. All the participants repeated the same activity 20 times with the order of conditions randomized across individuals.

Results

RT and MT were analyzed while participants performed the movement sequence. After 20 trials, both groups showed significant differences in their MT but no significant differences in RT. Intergroup analysis also showed that there was no statistically significant difference in either RT or MT.

Conclusion

Down syndrome children exhibited longer movement and RTs than normal children regardless of vision condition. Knowledge of their performance at regular intervals and encouragement helped to improve their MT. Down syndrome children were less affected by the elimination of visual feedback and showed no significant variation in RTs.

Keywords: Down syndrome; Reaction time; Movement time

Introduction

Down syndrome (DS), also known as trisomy 21, is a genetic disorder caused by the presence of all or part of a third copy of chromosome 21 [1]. A survey of DS in Hyderabad by Isaac et al. gave an incidence of 1.17 per 1000 or 1 in 853 live births [2]. In the Delhi region, the frequency of DS was 0.81/1000 [3]. Verma et al. found 600 cases out of 645 DS from Delhi (93%) with free trisomy, translocations in 26 (4%), and 17 (2.6%) with mosaicism. It is estimated that more than 30,000 babies are born with DS every year in India [4,5]. DS is one of the most common birth defects in the United States with approximately 6000 births annually, resulting in an estimated birth prevalence of 14 per 10 000 live births [6].

DS has serious implications for the neural, physiological, and biomechanical systems, which causes individuals to present some peculiarities such as being “clumsy”, i.e., as having a movement profile characterized by slow movements and impaired coordination [7]. These include a variable and delayed pattern of motor development, deficits in tasks involving balance, speed and visuomotor control, bilateral coordination, and being hypotonic [8]. Anatomical investigations have revealed that the size of the cerebellum is smaller in people with DS; thus, the motor performance and learning of new skills tend to be impaired compared with normal participants [9]. Motor development in DS is the same but delayed and exhibits great variability in motor progress with slow reaction and movement times compared with age-matched controls [10-12].

Individuals with DS often exhibit perceptual-motor deficits. Parents, teachers and physical therapists agree that when a person with DS is told how to perform a movement (e.g., buttoning a shirt), he/she does not perform as well as when the movement is demonstrated to them [13]. Some experimental studies have shown that adults with DS are more successful at learning new movements in response to visual cues than to verbal instructions. Previous research has indicated that individuals with DS have difficulties processing auditory movement information relative to their peers with undifferentiated developmental disabilities. The implication of this is that children and adults may learn new skills better by modeling or copying them than by being given verbal instructions [14]. In terms of target-aiming consistency, participants with DS were actually less affected by the elimination of visual feedback than participants in other mentally disabled groups [15]. Based on skill performance scores, participants in the verbal-motor performance group demonstrated a lower level of proficiency and an increased number of performance errors when compared with participants in the visual-motor performance group [16].

Different approaches have been used to rehabilitate or promote the cognitive functioning of young children with DS. The cognitive strategy approach is one in which children are provided with instructions and/or prompts to use cognitive strategies such as attention, rehearsal, practice, or planned action sequences as they participate in a variety of learning activities [17]. The present study was undertaken to determine reaction and movement time in DS children while performing a movement sequence under different visual feedback conditions with knowledge of the results.

Subjects and Methods

Participants

Thirty DS children were divided into two groups. The full visual feedback (FVF) group comprised 15 participants (13 male, 2 female) with a mean age of 12 ± 1.4 years, and the no visual feedback (NVF) group comprised 15 participants (14 male, 1 female) with a mean age of 12 ± 1.7 years. Demographic characteristics such as chronological and mental age, gender and hand dominance are shown in Table 1.

	Chronological Age (M±SD)	Mental age	Gender	Hand dominance
FVF group	12 ± 1.4	5.6	M-13 F-2	12-R; 1-L 2-R
NVF group	12 ± 1.7	6.2	M-14 F-1	14-R 1-R
FVF-Full visual feedback, NVF-No visual feedback, M-males, F-females, R&L-right and left hand dominance				

Table1: Descriptive statistics of the sample

Recruitment progressed with the help of a nongovernmental organization. Participants were aged between 12 and 15 years and were classified as mild to moderate, according to the International Classification of Functioning, Disability, and Health (ICF). Participants who were unable to follow the instructions and perform the task were excluded. All the participants and parents were made aware of the purpose and procedure of the study. A signed informed consent was obtained. This study was approved by the ethics committee of the Maharishi Markendeshwar University, Mullana. Full Visual Feedback (FVF): In this condition, the button board and the participants' arms and hands were fully visible. No Visual Feedback (NVF): In this condition, the room darkened and only the buttons on the board were visible. Participants could not see their arms and hands.

Apparatus

A chair with an armrest at the appropriate height and width, a wooden table for the placement of the apparatus, a button board attached to the software and a chart painted with fluorescent paint (Delhi Science Projects, District center, Janakpuri, New Delhi) were used. This apparatus can be used to record reaction and movement times in normal participants, psychiatric patients and neurologically affected patients. Sixteen buttons were arranged in four columns and four rows on a square board. Fluorescent paint was applied to the buttons to ensure visibility in the darkened room.

A picture representing the button board and the sequence of buttons to be depressed was placed on the wall in front of the participant. Fluorescent paint was applied to the diagram so that participants could see the diagram when the room was darkened. A stopwatch was used to note the time required to perform the sequence and the time gap between two audible tones was maintained at 0.04 seconds.

Procedure

A closed environment with the least possible distraction was selected as the site for data collection. The participants performed the activity after a demonstration and a few practice trials. They were seated and asked to place their limb in a comfortable position. They were instructed to switch the start button with the finger of the dominant hand as soon as they were ready for the response to the stimulus. After the participant pressed the start button, an auditory tone was presented, alerting them to perform the sequence. After a gap of a few seconds, a second tone was emitted and participant was requested to press a prescribed sequence of five buttons. Once the second tone was heard, the timer began and each participant removed his or her hand from the start button, depressed, and released buttons as quickly and accurately as possible. The digital timer started with the initiation of the stimulus. Participants were given knowledge of the results of their total movement time (in seconds) after every five trials. The entire task was presented as a game, and movement time information was given as a "score" after each trial. Participants were also given verbal encouragement throughout the task and an appropriate rest period between the trials. The participants of both groups repeated the activity 20 times with variation in the order of conditions randomly from individual to individual. The effects of visual information on reaction time and movement time were observed in the two conditions.

Results

Data was analyzed using SPSS-21 software. The chronological age of the participants was 12 to 15 years and the majority was right-hand dominant. After familiarization with the test, each participant carried out 20 trials with knowledge of their movement time after every five trials. A paired t-test for within group and an unpaired t-test assuming equal variance were used to analyze the data.

Reaction time (RT)

The mean RT for the first and 20th trials in the FVF group was 921.67 ± 193.58 and 810 ± 167.41 ms, respectively. There was no significant improvement at $p<0.05$. The mean RT for the first and 20th trials in the NVF group was 1070 ± 271.79 and 941.34 ± 202.52 ms, respectively. No significant difference was observed at p<0.05. There was also no significant difference in RT between the groups.

Movement time (MT)

The mean MT for the first and 20thtrials in the FVF group was 7440 ± 1260.72 and 6513.4 ± 1110.25 ms, respectively. In the NVF group it was 8013.34 ± 1754.13 and 6613.34 ± 1513.22 for the 1st and 20th trials, respectively. Within the groups, a significant improvement in MT was observed, but there was no significant difference between the groups at p<0.05. DS children were less affected by the elimination of visual feedback. The results of this study showed that reaction and movement times were prolonged in DS children regardless of visual condition. However, MT can be improved given knowledge of results.

Variables	First trial (M ± SD)	20th trial (M ± SD)	t value	p-value
				(P≤0. 05)
Full visual feedback (FVF)	921.67 ± 193.58	810±167.41	1.689	0.102*
No visual feedback (NVF)	1070 ± 271.79	941.34±202.52	1.47	0.153*
t-value	−1.721	−1.935		
P value((P ≤ 0. 05)	0.096*	0.063*		
*No significant differences in the reaction time				

Table 2: Pre and post values of the reaction time

Variables	First trial (M ± SD)	20th trial (M ± SD)	t value	p-value
				(P≤0. 05)
Full visual feedback (FVF)	7440 ± 1260.72	6513.4 ± 1110.25	2.136	0.04**
No visual feedback (NVF)	8013.34 ± 1754.13	6613.34 ± 1513.22	2.34	0.02**
t-value	−1.028	−0.206		
p-value(P ≤ 0. 05)	0.312*	0.838*		
*No significant differences in the movement time between the groups				
**Significant differences in movement time within the groups				

Table 3: Pre and post values of the Movement time

Discussion

In the present study, reaction time and movement time were analyzed while DS children performed a movement sequence with knowledge of the results. Our results indicate that there was no significant variation in reaction time or movement time variables in the different visual feedback conditions. By offering appropriate feedback after every five trials, children in both groups improved their movement time after 20 trials but no substantial differences in reaction time were found. The possible explanation for improvement in movement time is proprioceptive feedback provides sufficient information to coordinate goal directed movements. There is improvement in the RT but not statistical significant difference observed. In this study, verbal feedback and encouragement toward goal-directed improvement helped participants to act better in successive trials irrespective of differing visual feedback. The results showed that a goal-directed movement sequence involving multi-joint movement with appropriate feedback and learning of a motor task can enhance motor learning irrespective of different visual feedback conditions.

There is evidence that individuals with DS present a deficit in performing tasks that have predominance in perception requirements, mainly in tasks that demand time synchronization because of atypical patterns of brain organization that can be partially attributed to structural characteristics of the brainstem and cerebellum [7]. Several investigators have noted that children with DS tend to treat a movement sequence as a series of separate tasks, causing their movements to appear jerky and hesitant [18]. This awkward form of movement can add to feelings of frustration, as movement and movement sequences during action become inefficient and thus ineffective as related to the task. The execution of a simple task differs from a more complex one, which presumably depends on the functioning of association cortex in the cognitive domain. Recent work has suggested that both pre motor and supplementary motor areas may be involved in the performance of a sequential task [19]. Knowledge of results is one important form of extrinsic feedback that supplements intrinsic feedback, providing terminal feedback about the outcome of the movement. Motor learning in adolescents with DS suggest that random practice is not superior to blocked practice in this group of learners [20,21] .The keys to successful motor training are repetition, correctly performed practice of functional skills, and sufficient learning time to facilitate skill retention and transfer.

In a study examining the processing of visual feedback in goal-directed movements in adults with DS, we showed that participants with DS exhibited longer movement times than participants without DS, suggesting that people with DS are either more dependent on response-produced feedback, or that they require more time to process feedback [15,22]. Individuals with DS have much greater variability in the timing of the onset of muscle activation, such that distal muscle activation often precedes proximal muscle activation, and deficiencies in proprioception could be probable explanations for longer movement and reaction times [23,24]. Research has shown that this may also be because of short-term auditory memory deficits [25]. Language supported by visual and/or symbolic movements does help children with DS. Further, there is some evidence to suggest that people with DS may consolidate visual information, such that positive transfer is seen when they are switched from a visual to a verbal mode of learning [26]. Moreover, improvement in the acquisition of this movement sequence with knowledge of the results can facilitate the implementation of other motor skills.

The study demonstrates the influence of cognitive rehabilitation in the learning abilities of children with DS. Participants were chosen based on their gross disability, but individual features that may have affected their performance were not taken into consideration and small sample size forms the limitation of the study.

Future Research

Continued research is needed to determine the interaction between motor performance, feedback and practice in learning-impaired children with DS. Future research is needed to understand multi-joint sequences of movement within a functional context, and will directly examine the different types of feedback that are most useful to individuals with DS.

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