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**RESEARCH ARTICLE**

# Perceptual motor outcomes in Egyptian Down syndrome children following Wii training.

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## Abstract

**Background:-** Children with Down syndrome (DS) have deficits in aspects of movement such as timing, balance and coordination as well as physiological aspects such as muscle tone and strength. Using the Wii can improve motor impairments in children with DS. This study aimed to determine the perceptual motor outcomes in Egyptian DS children following Wii training, it also aimed to determine the relation between the IQ and the perceptual motor outcomes in DS children following Wii training.

**Methods:-** Thirty four children suffering from DS participated in this study. Their age ranged from 8 to 10 years and IQ ranged from 35 to 67. The modified Quick Neurological Screening test (QNST) was used to assess Perceptual–motor functions before and after Wii training. The programme was conducted for 30 minutes, 2 times per week for 12 weeks.

**Results:-** Comparing the pre and post treatment mean values of the variables measured using QNST, revealed significant improvement in the perpetual motor outcomes after the Wii training. It also represented significant correlation between the total score of the QNST and the IQ of the children.

**Conclusion:-** It may be concluded that the Wii game training was effective the rehabilitation of Down's syndrome children.

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## Introduction:-

Down syndrome (DS) is the most chromosomal abnormality that occurs in infants [1, 2]. It results from the presence of an extra partial or complete 21 chromosome. This genetic material disturbance affects all aspects of an individual’s development especially sensory and perceptual motor skills [2]. The incidence of Down syndrome in Egypt is 1.6 million births/ year [3].

Children with Down syndrome have a wide variety of physical and functional disabilities [4]. They indicate specific deficits in aspects of movement such as timing [5], balance [5, 6] and coordination as well as physiological aspects such as muscle tone and strength [6].

The delayed acquisition of gross and fine motor skills may refer to muscle hypotonia, increased flexibility in joints, decreased strength, and short arms and legs. Congenital heart defects, chronic upper respiratory infections, and ear infections can limit endurance and balance [7-10]. This delay can interfere with cognitive development [11].

Intelligence is considered as ability of problem solving, adaptation and learning from experience, and is correlated with children's rate of information processing and cognitive development. The theory of multiple intelligences that proposed by Howard Gardner, focused on Bodily-kinesthetic skills as an aspect of intelligence [12].

Motor and perceptual developments in childhood are completely integrated and result in interrelating system; on the other hand, all voluntary movements include an element of perception and motor development resulting expansion of perceptual motor behavior. Scientists believe that motor skills acquisition is consequence of learning process [13, 14]. Problem solving ability and rate of information processing (factors related to intelligence) are considered as very effective factors in motor learning [15, 16]. Furthermore, Child attains ability of locomotion to environment through acquisition of motor skills ability, and develops his/her own perceptual and mental ability [16].

The most effective traditional approaches for treating sensorimotor problems in children with DS include sensory integrative (SI) therapy, the perceptual-motor (PM) approach, and neurodevelopmental treatment (NDT) [17].

However, traditional therapies for movement difficulties in children with disabilities are repetitive and offer very little to keep a young mind occupied [17]. Besides, children with disabilities tend to show difficulty in repeated practice of functional activities because of the nature of their disabilities (i.e. movement limitation, attention deficit, or cognitive impairments) or a lack of intervention context variability [18 & 19].

Interactive virtual reality (VR) can provide much wider array of activities and scenarios for movements. Virtual reality (VR) is defined as a means to a user–computer interface that consists of real-time environmental simulation, through which the users could interact with the scenario or environment via multiple sensory channels [20].

Virtual reality could create an exercise environment in which the practice intensity and positive sensory feedbacks (i.e. auditory, visual, and proprioceptive) can be manipulated systematically in different natural like environments to allow for individualized motor training programs [21]. Therefore, plenty of experimental evidence suggests that rapid advancement of VR technologies has great potential for the development of novel strategies for sensorimotor training in rehabilitation [17].

In pediatrics, there is evidence that using the Wii can improve motor impairments in children with Down syndrome [22, 23] and enhance visual-perceptual processing and postural control in an adolescent with cerebral palsy (CP) [24]. Wii training can improve short-term outcomes of postural control in children with lower extremity amputation [25]. Wii training is a feasible and enjoyable intervention for children with developmental delay [26].

The aim of this study is to: 1) Determine the perceptual motor outcomes in Egyptian Down syndrome children following Wii use. 2) Determine the relation between the IQ and the perceptual motor outcomes in Egyptian Down syndrome children following Wii use.

**Subjects, instrumentations and procedures:-**

**Subjects:-**

Sixty Egyptian children from both sexes (12 males, 48 females) suffering from Down Syndrome (DS) participated in this study. Their age ranged from 8 to 10 years with mean age $8.77 \pm 0.79$ years. They were divided into three groups according to the IQ level. This study was conducted in the period from September 2014 to May 2015. They were recruited from the schools of special needs and some private clinics, according to the following criteria:

1- They suffer from Down syndrome determined by the broad certified physicians.
2- The IQ was determined for each child before participated in this study by Stanford Beinet Test. The children were classified into three groups according to IQ. Group I: the children had severe mental retardation (IQ 10–30). Group II: the children had moderate mental retardation (IQ 35–50). Group III: the children had mild mental retardation (IQ 50–70)[27].
3- They had no history of coexisting autism, cerebral palsy, blindness and deafness.
4- They had no history of neurological disorders such as traumatic brain injuries, muscular dystrophies and epilepsy.

The study was approved by an Ethics Committee of the Cairo University. Child's parents were provided with a Volunteer Information Sheet and written consent informing them about the purpose of the study, its benefits and inherent risks and their committee with regard to time and money.

**Instrumentations.**
**For evaluation.**
**Modified Quick Neurological Screening test (QNST).**
Before evaluation, the purposes and procedures were fully explained to the children's parents. The modified Quick Neurological Screening test (QNST) was used to assess Perceptual–motor functions [28]. All the children were tested before and after Wii training program to determine the perceptual motor outcomes. The training programme was conducted for 30 minutes, 2 times per week for 12 weeks. Each child was evaluated and tested individually following the standard protocol.

## For treatment:-
The Wii training using Nintendo Wii SportsTM and NintendoWii FitTM was conducted to all children who participated in this study. The Wii training programme focused on the children's balance, walking, strength, weight bearing and aerobics. The training activities were selected to challenge the participant's balance, strength and walking. A personal profile was created for each child, and the selection of games and activities were individualized for each child based on their interests, functional limitations and abilities [26].

**Procedures:-**
**Testing procedures:-**
Each child was examined individually pre and post treatment, using the modified Quick Neurological Screening test (QNST), the examiner recorded the relevant data about the child being tested which included name, gender, and age. It was used to screen the following aspects:

- Child's maturity of motor development.
- Skill in controlling large and small muscles.
- Motor planning and sequencing.
- Sense of rate and rhythm.
- Spatial organization.
- Visual and auditory perceptual skills.
- Balance.

Ten tasks from the QNST were chosen. The scoring for each task was detected according the manual and recording form of the QNST. The total score of the QNST was represented by the summation of the scores for the ten tasks. The tasks were:
**1- Hand Skill:**
Each child was sit in front of his instrument form. He/she was directed to write his name at the top of last page of the recording form, and then write from six to eight words to observe any irregularities in the time.
**2- Thumb and finger circle:**
Examiner was demonstrating with the dominant hand how to place the thumb and forefinger together in a circle, how to form successive circles with the thumb and index, and then with the thumb and the other fingers. It was repeated three times at a rate of about three complete sequences per five second. It was repeated several times starting from the index to the finger.
**3- Arm and leg extension:**
The child was sitting with his extremities extended in front of him, back kept away against the chair. He/she asked to put his feet straight out, and his arm straight out, palms down and spread his finger as wide he/she can. He/she also was asked to do the procedure with closed eyes and keep the same position for 30 seconds.
**4- Finger to nose:**
The child was sitting in front of the examiner. Examiner held his right hand with finger extended and demonstrate by touching the tip of the child's nose. The child was straight his both arms at his sides at the level of the shoulder and then asked to flex and extend his right and left arm in order to touch the tip of his nose with index finger. He/she was asked to close his eyes and reached back and forward between examiner's hand and tip of his own nose.
**5- Rapid Reversing Repetitive Hand Movements:**
This task consists of a series of rapid, repetitive hand movements. Examiner was demonstrating the procedure of the test for the child. The child was sitting with his both feet on the floor while placed his hands on thighs, palms down. He/she turned his hands simultaneously started slowly at first and then rapidly acceleration for at least ten second.
**6- Stand On One Leg:**
The child was asked stand both feet for ten seconds to exclude any swaying. He/she was asked to stand on one foot,

and then on the other foot without requesting which one begin the test. He/she was asked to make the same procedure with starting with right foot and then the left one. There were five seconds intervals between each test. Balance of the child was detected as well as observation of the right and left discrimination.

**7- Tandem walk:**

In this test child was asked to walk in a straight line, placing his heel of each foot directly against the toe of the opposite foot. The child was asked to walk forward and backward with the same manner in a straight line and the procedure was repeated with closed eyes.

**8- Skip:**

The child was asked to skip across the room. Procedure was repeated with right and then the left one. Examiner was observing how child follow directions with good balance.

**9- Right and left discrimination:**

Examiner demonstrated to the child how to make the test. The child was asked to hold up his right hand at first, and then hold his left hand.

**10- Eye tracking:**

The child was to sit about 18 inches away from the examiner. An object was held at the same level of the eyes of the child. Examiner made a smooth horizontal line tracking from right to left three times then from the left to right direction. The procedure was repeated as the same manner with stopping in the midway once in each direction. The child was asked to hold his head while let his eyes moved follow the object.

**The Scoring of QNST:**

**1. A high score (A total score exceeding 50).**

It shows a child is likely to have a serious trouble. (A high total score must have some individual tasks scored in the high range).

**2. A suspicious score (A total score exceeding 25).**

Usually results from one or more symptoms, which may be developmental or neurological, depending on the age of the child and the severity of the symptom.

**3. Normal score (A score of 25 or less).**

It is always achieved by persons who have no specific disability or abnormality. A normal total score must have no individual tasks scored in high range.

## Treatment procedures:-

In each training session, the child played games such as strength (Lunges and Single Leg Stance), balance (Soccer Heading, Penguin Slide and Tightrope) and aerobics (Basic Run, Hula Hoop and Basic Step). Each session was concluded by playing one of the following games based on the interest of the child: Baseball, Boxing or Bowling. Each training session was supervised by a therapist from one of the clinical sites [26].

## Statistical analysis:-

The mean value and standard deviation were calculated for each measured variable during this study. Comparative studies were conducted between the mean differences of the selected items from QNST before and after interventions by using analysis of variance (ANOVA). We used level of significance as 0.05.

## Results:-

**Descriptive data:**

The general characteristics of the subjects conducted in this study including gender and IQ were represented in table (1).

Table(1): Descriptive analysis for gender and IQ

| Item | Gender | | | |
|---|---|---|---|---|
| Group | Male | Female | Total | IQ mean ± SD |
| Group I | 6 | 20 | 26 | 9.07 ± 10.98 |
| Group II | 3 | 16 | 19 | 39.63 ± 3.40 |
| Group III | 3 | 12 | 15 | 58.00 ± 5.28 |

The mean value and SD of the items of QNST (pre and post treatment measurements) were calculated and represented in table (2).

| Table(2): Descriptive analysis of pre and post treatment measurements for the items of QNST | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Item | | Group I | | | Group II | | | Group III | | |
| | | Mean ± SD | Min | Max | Mean ± SD | Min | Max | Mean ± SD | Min | Max |
| Hand Skill | Pre | 4.46±0.58 | 4 | 6 | 2.53±0.51 | 2 | 3 | 0.80±0.41 | 0 | 1 |
| | Post | 4.42±0.64 | 3 | 6 | 2.10±0.46 | 1 | 3 | 0.07±0.26 | 0 | 1 |
| Thumb and finger circle | Pre | 7.0±0.80 | 6 | 8 | 4.47±0.51 | 4 | 5 | 2.0±0.76 | 1 | 3 |
| | Post | 6.88±0.99 | 5 | 8 | 3.42±0.69 | 2 | 5 | 0.27±0.59 | 0 | 2 |
| Arm and leg extension | Pre | 14.77±2.39 | 12 | 18 | 5.53±1.12 | 3 | 6 | 3.0±0.00 | 3 | 3 |
| | Post | 14.42±2.94 | 9 | 18 | 2.84±1.57 | 0 | 6 | 0.00±0.00 | 0 | 0 |
| Finger to nose | Pre | 5.00±1.06 | 4 | 8 | 2.52±0.51 | 2 | 3 | 1.00±0.00 | 1 | 1 |
| | Post | 4.96±1.11 | 3 | 8 | 1.21±0.63 | 0 | 2 | 0.00±0.00 | 0 | 0 |
| Rapid Reversing Repetitive Hand Movements | Pre | 5.77±0.76 | 5 | 7 | 3.63±0.50 | 3 | 4 | 1.47±0.52 | 1 | 2 |
| | Post | 5.73±0.78 | 5 | 7 | 2.32±0.82 | 1 | 3 | 0.07±0.26 | 0 | 1 |
| Stand On One Leg | Pre | 3.81±0.40 | 3 | 4 | 2.53±0.51 | 2 | 3 | 0.87±0.35 | 0 | 1 |
| | Post | 3.81±0.40 | 3 | 4 | 1.53±0.51 | 1 | 2 | 0.00±0.00 | 0 | 0 |
| Tandem walk | Pre | 9.81±0.80 | 9 | 11 | 6.84±0.83 | 6 | 8 | 4.07±0.70 | 3 | 5 |
| | Post | 9.81±0.80 | 9 | 11 | 5.11±1.20 | 4 | 7 | 1.80±0.86 | 1 | 3 |
| Skip | Pre | 4.62±0.50 | 4 | 5 | 3.21±0.42 | 3 | 4 | 1.67±0.49 | 1 | 2 |
| | Post | 4.62±0.50 | 4 | 5 | 1.95±0.71 | 1 | 3 | 0.13±0.35 | 0 | 1 |
| Right and left discrimination | Pre | 3.00±0.00 | 3 | 3 | 2.26±0.45 | 2 | 3 | 1.60±0.51 | 1 | 2 |
| | Post | 3.00±0.00 | 3 | 3 | 1.26±0.45 | 1 | 2 | 0.20±0.41 | 0 | 1 |
| Eye tracking | Pre | 7.54±0.65 | 7 | 9 | 5.26±0.73 | 4 | 6 | 3.53±0.52 | 3 | 4 |
| | Post | 7.54±0.65 | 7 | 9 | 4.10±0.88 | 3 | 5 | 2.13±0.74 | 1 | 3 |
| Total QNST score | Pre | 65.77±2.80 | 60 | 73 | 38.79±1.40 | 37 | 41 | 20.00±1.81 | 16 | 22 |
| | Post | 65.19±3.02 | 60 | 73 | 25.84±2.43 | 22 | 32 | 4.67±1.29 | 3 | 7 |

Pre: Pre treatment. Post: Post treatment. SD: Standard deviation.
Min: Minimum. Max: Maximum.

**Analysis of variance of the items of QNST:-**

The differences between pre and post treatment scores of the items of QNST were statistically treated by analysis of variance (ANOVA) test. The results represented a significant difference among the pre and post treatment scoring in all items of the QNST at the 0.05 levels as shown in table (3).

| Table (3): Analysis of variance (ANOVA) of the items of QNST | | | | | | |
|---|---|---|---|---|---|---|
| Source of variation | | DF | SS | MS | F | Sig |
| Hand Skill | Bet Grs | 2 | 4.80 | 2.40 | 16.07 | 0.000 |
| | Wi Grs | 57 | 8.53 | 0.25 | | |
| | Total | 59 | 13.33 | | | |
| Thumb and finger circle | Bet Grs | 2 | 26.45 | 13.22 | 71.55 | 0.000 |
| | Wi Grs | 57 | 10.54 | 0.19 | | |
| | Total | 59 | 36.98 | | | |
| Arm and leg extension | Bet Grs | 2 | 91.26 | 45.63 | 65.04 | 0.000 |
| | Wi Grs | 57 | 39.99 | 0.70 | | |
| | Total | 59 | 131.25 | | | |
| Finger to nose | Bet Grs | 2 | 19.92 | 9.96 | 112.03 | 0.000 |
| | Wi Grs | 57 | 5.07 | 0.09 | | |
| | Total | 59 | 24.98 | | | |
| Rapid Reversing Repetitive Hand Movements | Bet Grs | 2 | 26.62 | 13.31 | 84.45 | 0.000 |
| | Wi Grs | 57 | 8.98 | 0.16 | | |
| | Total | 59 | 35.60 | | | |
| Stand On One Leg | Bet Grs | 2 | 13.20 | 6.60 | 217.04 | 0.000 |
| | Wi Grs | 57 | 1.73 | 0.03 | | |
| | Total | 59 | 14.93 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Tandem walk | Bet Grs | 2 | 59.57 | 29.78 | 256.53 | 0.000 |
| | Wi Grs | 57 | 6.62 | 0.12 | | |
| | Total | 59 | 66.18 | | | |
| Skip | Bet Grs | 2 | 28.78 | 14.38 | 110.51 | 0.000 |
| | Wi Grs | 57 | 7.42 | 0.13 | | |
| | Total | 59 | 36.18 | | | |
| Right and left discrimination | Bet Grs | 2 | 21.73 | 10.87 | 172.06 | 0.000 |
| | Wi Grs | 57 | 3.60 | 0.06 | | |
| | Total | 59 | 25.33 | | | |
| Eye tracking | Bet Grs | 2 | 24.06 | 12.03 | 111.94 | 0.000 |
| | Wi Grs | 57 | 6.13 | 0.11 | | |
| | Total | 59 | 30.18 | | | |
| Total QNST score | Bet Grs | 2 | 2702.36 | 1351.18 | 722.31 | 0.000 |
| | Wi Grs | 57 | 106.63 | 1.87 | | |
| | Total | 59 | 2808.98 | | | |

Bet Grs: between groups. Wi Grs: within groups. DF: degree of freedom.
SS: Sum Squares. MS: Mean Squares. Sig: significance.

**Comparison between pre and post treatment mean differences of the items of QNST:-**

The least significant difference (LSD) test was conducted and represented in table (4). Significant differences was observed between the three groups at P<0.05.

Table(4): The mean differences (MD) between pre and post treatment measurements of the items of QNST

| Item | Gr I : Gr II | | Gr I : Gr III | | Gr II : Gr III | |
|---|---|---|---|---|---|---|
| | MD | Sig | MD | Sig | MD | Sig |
| Hand Skill | 0.38* | 0.002 | 0.69* | 0.000 | 0.31* | 0.023 |
| Thumb and finger circle | 0.94* | 0.000 | 1.62* | 0.000 | 0.68* | 0.000 |
| Arm and leg extension | 2.34* | 0.000 | 2.65* | 0.000 | 0.34 | 0.280 |
| Finger to nose | 1.28* | 0.000 | 0.96* | 0.000 | 0.32* | 0.003 |
| Rapid Reversing Repetitive Hand Movements | 1.33* | 0.000 | 1.36* | 0.000 | 0.03 | 0.819 |
| Stand On One Leg | 1.00* | 0.000 | 0.87* | 0.000 | 0.13* | 0.031 |
| Tandem walk | 1.74* | 0.000 | 2.27* | 0.000 | 0.53* | 0.000 |
| Skip | 1.26* | 0.000 | 1.53* | 0.000 | 0.27* | 0.034 |
| Right and left discrimination | 1.00* | 0.000 | 1.40* | 0.000 | 0.40* | 0.000 |
| Eye tracking | 1.16* | 0.000 | 1.40* | 0.000 | 0.24* | 0.037 |
| Total QNST score | 12.37* | 0.000 | 14.76* | 0.000 | 2.39* | 0.000 |

[*] The mean difference is significant at the 0.05 level.

**The correlation between IQ and the mean difference of the QNST:-**

As shown in figure (1) and table (5), there was a strong and positive significant relationship between the IQ and mean difference of the QNST at 0.05 significance level.

Table(5): The correlation between IQ and the mean difference of the QNST

| | | The mean difference of the QNST | | Sig |
|---|---|---|---|---|
| | | Correlation Coefficient | Sig. (2-tailed) | |
| Person correlation | IQ | 0.904** | 0.000 | Significant |

** Correlation was significant at the 0.01 level (1-tailed)/* Correlation was significant at the 0.05 level (2-tailed).

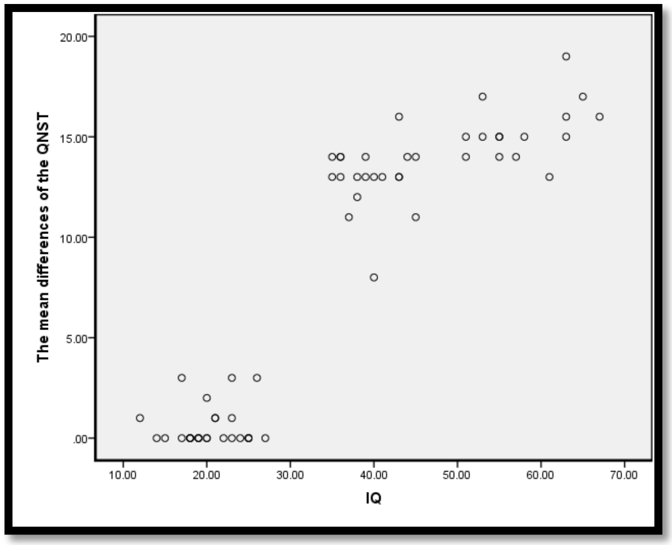


Fig (1): The correlation between IQ and the mean difference of the QNST

## Discussion:-

Researchers provided the evidence in their literature that the Down's syndrome children had perceptual motor deficits [29]. In the present study, the perceptual motor outcomes in Egyptian Down's syndrome children following Wii use and its relation to IQ were investigated. The perceptual motor outcomes were measured pre and post Wii use by the QNST which is reliable and valid [30].

The results of this study demonstrated that there was significant improvement in the perpetual motor outcomes after the Wii use. It also represented strong and positive significant correlation between this improvement and the IQ of the subjects participated in this study. This comes in agreement with Wuang et al ., (2011) who mentioned that Wii gaming technology is a successful intervention used in rehabilitation for Down syndrome to improve motor proficiency, visual integrative abilities and sensory integrative functioning [23].

It also comes in agreement with Salem et al., (2012) who support the use of Wii as a safe, effective and home routine intervention used in rehabilitation for children with developmental delay [26]. It also comes in agreement with Sourtiji et al., (2010) who stated that there is a direct relationship between the mental age (IQ) and motor age of the children suffering from Down syndrome [31].

The improvement in the perceptual motor functions for the children participated in this study may be referred to the concentrated sensorimotor stimuli provided by Wii games. This expansive range of sensory feedback act to evoke neurons that allow brain reorganization. This reorganization allow the children to interrelate the three dimensional scenario and the captured movement on the screen at the same time [32, 33].

Also, the use of Wii games provided augmented feedback that allows the child to detect the source of errors and the corrections which allow the subjects to practice tasks using timely feedback control in addition to feed forward preparatory control which is necessary for achieve balance specially in standing position. It also improves the regulation of movement amplitude, speed and precision which are necessary for achieving balance [34-36]. Wii games training provide active participation from the children in a fun, enjoyable and paly environment which help to keep the children motivated during therapeutic rehabilitation [37- 40].

## Conclusion:-

It may be concluded that the Wii game training was effective the rehabilitation of Down's syndrome children as it helps those children to their perceptual motor functions and to become more independent and participated in everyday activities.

**Declaration of interest:-** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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