Visual Motor Integration, Visual Perception and Motor Coordination in Children with Horizontal Strabismus

Dr Edwin Pheng Chin Meng

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DISCLAIMER

I hereby certify that the work in this dissertation is my own except for quotations and summaries which have been duly acknowledged. I declare that I have no financial of interest in the instruments and the computer software in this study.

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TABLE OF CONTENTS

ABSTRAK

Pengenalan

Strabismus atau mata juling terjadi apabila kedua-dua belah mata tidak selari dan melihat ke arah yang berlainan. Keadaan ini boleh memberi kesan negatif kepada fizikal dan mental seseorang. Kesan negatif ini boleh menjejaskan perkembangan seseorang kanak-kanak. Integrasi visual-motor didefinisikan sebagai darjah sejauh mana persepsi visual dan koordinasi motor halus jari tangan dapat berintegrasi dengan baik. Ia merupakan satu kebolehan yang penting untuk perkembangan seseorang kanak-kanak. Tujuan kajian ini adalah untuk meninjau perbezaan integrasi visual-motor seseorang kanak-kanak juling berbanding dengan kanak-kanak tanpa juling.

Objektif

Mengenalpasti perbezaan tahap intergrasi visual-motor integrasi antara kanak-kanak juling dengan kanak-kanak tanpa berumur 6 hingga 17 tahun

Kaedah Kajian

Kajian ini melibatkan kanak-kanak seramai 90 orang iaitu 45 kanak-kanak juling dan 45 kanak-kanak kawalan. Skor min integrasi visual-motor direkod dengan mengunakan ujian *The Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery-VMI) with the supplemental Developmental Tests of Visual Perception and Motor Coordination*. Kaedah Independent t-test dan one way analysis of covariance digunakan untuk analisis statistik,

Keputusan

Didapati bahawa skor min integrasi visual-motor *Berry-VMI* kanak-kanak juling adalah rendah berbanding dengan kanak-kanak kawalan ($p<0.001$). Skor min persepsi visual dan koordinasi motor di kalangan kanak-kanak juling adalah rendah berbanding kanak-kanak kawalan ($p<0.001$). Perbezaan ini kekal walaupun setelah melaraskan umur, jantina, sukan, bilangan adik-beradik dan stereopsis.

Kesimpulan

Skor min integrasi visual-motor, persepsi visual dan koordinasi motor yang diperolehi oleh kanak-kanak juling adalah rendah berbanding kanak-kanak kawalan walaupun setelah mengambil kira faktor-faktor yang mungkin mempengaruhi min skor *(Beery-VMI).* Kanak-kanak juling mungkin memerlukan rawatan dan terapi yang lebih untuk meningkatan integrasi visual-motor mereka.

Kata kunci: Integrasi visual motor, visual perception, motor coordination, juling, kanak-kanak

ABSTRACT

Introduction

Strabismus refers to misalignment of the eyes, in which the eyes are pointing in different directions. This condition has many health and social implications which may disrupt normal development in a child. Visual motor integration, the ability of a person to perceive visual input and coordinate a motor response, is an essential skill to learn and master in a normal developing child. Exploring the visual motor integration of children with strabismus may allow healthcare providers to provide crucial services to these children.

Objective

This cross-sectional study aims to evaluate visual motor integration of children 6 to 17 years old with and without horizontal strabismus.

Methodology

A total of 90 children were recruited in this study (control vs test group). The ability of a child to integrate their visual and motor abilities was recorded using The Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery-VMI) with the supplemental Developmental Tests of Visual Perception and Motor Coordination. The scores between both groups were analysed using independent t-test and one way analysis of covariance.

Results

There were significant differences in the mean Berry-VMI score between children with horizontal strabismus and children without strabismus ($p<0.001$). Similarly, the visual perception score and motor coordination score in children with strabismus was significantly lower than in children without strabismus ($p<0.001$). These differences persisted even after adjustment for age, gender, favorite sport activities, number of siblings and the presence of stereopsis.

Conclusion

The mean score of children with horizontal strabismus is significant lower in Beery-VMI, Visual Perception and Motor Coordination when compared with children with normal eye alignment, even after adjustment for potential confounding factors. These finding give us an insight that children with strabismus may require extra attention and services to improve their visual motor integration compared to normal children.

Keywords: Visual motor integration, visual perception, motor coordination, strabismus, children

CHAPTER 1:
INTRODUCTION

1.1 Strabismus

Strabismus is described as a condition where the eyes do not align properly and are pointing in different directions (Hopkins & Simmons, 2020). It is a common eye condition in children (American Academy of Ophthalmology, 2022b). This condition usually is noticed by parents during developmental years of a child and often seen while child is looking at near object or is tired. Child may often complain of tiredness of eye, frequent rubbing of eye and is associated poor quality of life (Hatt et al., 2016). Adverse effects of this condition include disruption of visual development, alter physical appearances and psychological distress (Buffenn, 2021; Fiess et al., 2020a; He et al., 2020). Aside from that, patients with strabismus are at risk of developing amblyopia (Lingham et al., 2020). Therefore early detection and treatment are crucial to prevent visual impairment and psychological distress (Jost et al., 2014).

1.1.1 Classification of strabismus

Generally, strabismus can be classified into horizontal and vertical strabismus. Horizontal strabismus being the most common form which can further subdivide into exotropia or esotropia (Brad, 2015). Exotropia is defined as one eye deviated outward (away from the nose) while looking straight. Esotropia is defined as one eye deviated inward (towards the nose) while looking straight (American Academy of Ophthalmology, 2022b).

Exotropia in children can be further subdivided into constant exotropia and intermittent exotropia (Brad, 2015). Constant exotropia is where deviation of eye outwards is noted all the time while intermittent exotropia is where eye is only deviated at certain time. It is crucial for this subdivision as management of these condition may varies.

Esotropia in children can be subdivided into infantile esotropia and accommodative esotropia (American Academy of Ophthalmology, 2022b). Patient with infantile esotropia usually presented during first 6 months of life and with large angle of deviation. While accommodative esotropia usually presented later in life where child may have hyperopic refractive error.

Vertical Strabismus is not common compared to horizontal strabismus. It defined as vertical deviation of the eye while looking forward and generally subdivided into hypertropia (deviate upward) and hypotropia (deviate downward) (Brad, 2015).

1.1.2 Pathophysiology of strabismus

The pathophysiology of strabismus is complex and unclear. Our eyes are controlled by 3 pairs of extraocular muscle which govern our eye position. Synchronicity of these muscle depends on normal functioning cranial nerves, supranuclear pathways and cerebral controls.

Two theories that famously described strabismus are the Claude Worth theory which believe that strabismus is caused by inherent defect in fusional function and the Chavasse theory which suggested a primary motor dysfunction is the root cause of the problem in which prolong motor dysfunction leads to strabismus (American Academy of Ophthalmology, 2022a). There are two further laws that explain the intricate movement of our eye which are Sherrington law of reciprocal innervation which states that increased innervation of an agonist muscle is followed by the same amount of decrease innervation of an antagonist muscle (A. M. Smith, 1981) and Herring law of equal innervation which states that equal amount of innervation flow through yoke muscle during conjugate gaze (Ono, 1980).

1.1.3 Diagnosis of Strabismus

Strabismus is a clinically diagnosis detect via thorough history taking and physical examination (Tenorio Albuquerque Madruga Mesquita et al., 2021). Additional test such as Hirschberg test, Maddox rod and cover test are done by ophthalmologist to complete the diagnosis (Chen et al., 2018; Helveston, 2010). Fundus examination is also vital to rule out secondary causes of strabismus. After analysis of clinical finding and history, ophthalmologists can classify the type of strabismus and their severity which enable ophthalmologist to map out the best course of management for the patient.

1.1.4 Treatment of Strabismus

Treatment of strabismus will depend on type of strabismus and severity of the condition. Options includes non-invasive treatment and invasive treatment. Example of non-invasive treatment is orthoptic treatment such as prisms exercise and pencil push up exercises (Asadi et al., 2009). Invasive treatments include surgical correction or botulinum toxin injection.

Surgical option involves weakening of overacting extraocular muscle or strengthening of underacting extraocular muscle to obtain realignment of the extraocular muscle. Examples are recession, resection, repositioning or detachment of muscle (Brad, 2015).

Botulinum toxin in a neurotoxin that blocks neurotransmission and cause muscle paralysis (Binenbaum et al., 2021). Injection of botulinum toxin into the extraocular muscle causes weakening of the muscle and serve as an alternative to patient who refuse or not fit for surgery. The effect of injection usually last for 3 months and in some cases ocular alignment maybe achieve permanently after injection (Binenbaum et al., 2021).

The effectiveness of orthoptic treatment in strabismus remained unclear (Gallaway et al., 2002; Singh et al., 1992). There are studies that show that orthoptic treatment has very poor success rate especially with higher angle of deviation (Asadi et al., 2009; Heydarian et al., 2020). Most accepted treatment is tailored to the patient combining both surgical and non-invasive treatments (Figueira & Hing, 2006; Kelkar et al., 2015; Piano & O'Connor, 2011) to achieve a better outcome.

1.2 Visual motor integration

Visual motor integration (VMI) is the degree of ability to perceive visual input, process the information, and coordinate a motor response (Jane Case-Smith, 1996). VMI is essential for normal development as it serve as the basic for developing many other functional skill (Lim et al., 2015). Human development encompasses motor function together with psychosocial growth with the fastest growth occur during early childhood. During this period adequate stimulation allows proper brain and motor development (Kim, 2022).

Many studies have shown that poor VMI relate to poor academic achievement (Carames et al., 2022; Carlson et al., 2013; Taylor Kulp, 1999) and therefore predicts school performances (Fang et al., 2017). For instance, according to (Bellocchi et al., 2017) VMI is a significant predictor for the ability to read, (Barnhardt et al., 2005) found that poor VMI leads to poor writing skill in children age 8-13 years old and (Nesbitt et al., 2019) found that poorer mathematic performance

are found in children with poorer VMI. On top of that VMI has also been shown to predict school readiness of a child (Cameron et al., 2015)

Patients suffer from neurological disorders (van Hoorn et al., 2010), orthopaedic disorders, vestibular disorders (Fortenberry et al., 2012), cognitive or developmental delay (Di Blasi et al., 2007) usually score poorer in VMI. The Developmental test of Visual-Motor Integration (Beery-VMI) (Beery & Beery, 2006) is a common tool to measure VMI especially in America. Questions have been asked whether this tool is applicable to be use in different culture of the world. A study in Singapore shows significant differences in VMI performance between American pre-schooler and Singaporean pre-schooler (Lim et al., 2015). However, a study in Palestine and Israel shown that Beery VMI score is comparable and applicable to govern management in their population (Abdallah et al., 2014). Taiwanese children seem to score better in Beery-VMI compared to the American children (Mao et al., 1999). In a recent literature review, a study in Malaysia shows that Beery-VMI performance of pre-school children compare well with those counterparts in the America (Hairol et al., 2021).

1.2.1 Beery-Visual Motor integration

The Beery-VMI consist of geometric forms that is drawn with paper and pencil. It is design to evaluate an individual ability to integrate their visual abilities and motor abilities (eye-hand coordination). The test consists of 30-items or shapes that individuals were asked to copy. It can be administered to individuals or groups in about 10-15 minutes. It can be used with individuals

aged 2 to 100 years old. The test was first formulated after the author noted children's abilities to copy shapes is significantly correlated with their academic performances. The Beery-VMI has been extensively used in many countries for education, medical and other purposes. The sole purpose of the test is to identify the need to bring services of various kind to the person that at risk and not to have them practicing drawing various shapes.

Beside the main Beery-VMI test there are two supplemental standardised tests, the Visual Perception (VP) and Motor Coordination (MC). The rationale of the supplemental test is the understands more regarding the score of the main test. If an individual score poorly in Beery-VMI it can possible that they may have adequate visual perception and/motor coordination but unable to integrate or coordinate them properly. On the other hand, it is also may be cause by poor abilities in individual component.

The VP test consist of 27 items of various shaped stimulus shown to the individual and were asked to match exactly the shaped item among other items that are not exactly of the same shape. To make the test almost purely visual perception, the motor component is minimized to the bare minimal by just asking the individual to point to his or her choices.

The MC test consist of 27 items which the individual is asked to trace the stimulus forms without going outside a bordered path. The visual perception component is minimized by providing guided bordered path and starting dots (Beery & Beery, 2006).

1.3 Rationale

Childhood strabismus may lead to impaired visual development and long-lasting psychological damage. The current treatment of strabismus ranges from orthoptic interventions to surgery. Unfortunately, a significant number of patients are unaware of treatment availability or believe that its utility lies only in its aesthetic benefit. The lack of awareness and information regarding the effects of strabismus on development may deprive children with strabismus from receiving services which might enable them to reach their full potential. VMI may be an additional parameter when considering indications for intervention for strabismus, but the relationship between strabismus and VMI remains poorly defined. This study aims to fill this gap by comparing the VMI of children with and without horizontal strabismus, in the hope that this will open avenues to explore potential approaches of management.

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