STANDING BALANCE IN THAI CHILDREN MEASURED BY PEDIATRIC CLINICAL TEST OF SENSORY INTERACTION FOR BALANCE, SINGLE LIMB STANCE AND TANDEM WALK TESTS

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STANDING BALANCE IN THAI CHILDREN MEASURED BY PEDIATRIC CLINICAL TEST OF SENSORY INTERACTION FOR BALANCE, SINGLE-LIMB STANCE AND TANDEM WALK TESTS

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ABSTRACT

This study investigated standing balance performances in Thai children. A comparison between boys and girls and among four age groups: 4 years to 4 years 11 months, 5years to 5 years 11 months, 6 years to 6 years 11 months and 7 years to 7 years 11 months was done. The standing balance performances were tested by Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB), Single-limb stance and Tandem walk Test. The relationships among these tests were determined. Parameters for P-CTSIB were, degree of sway, stance duration and movement strategy; those for Single-limb Stance were degree of sway and stance duration; those for Tandem Walk Test were number of error steps. One hundred and twenty subjects participated in the study of which thirty subjects (15 boys and 15 girls) were in each age group.

Results revealed significant differences in balance performances from the P-CTSIB, Single-limb stance and Tandem walk test between genders in some age groups and significant differences between aged groups ($p<0.05$). In addition, relationships between degree of sway of P-CTSIB negatively correlated with duration from Single-limb Stance ($p<0.05$). Additionally, degree of sway of P-CTSIB negatively correlated to degree of sway of Single-limb stance ($p<0.05$). Moreover, number of error steps from tandem walk test was positively correlated to degree of sway of P-CTSIB, degree of sway and duration of Single-limb Stance ($p <0.05$).

The finding of this study suggest that balance performances obtained from the three clinical balance tests could determine balance performances between gender and age groups. Additionally, information on balance performances from these tests could be applied for early detection and planning of appropriate treatment for children with balance deficit.

KEY WORDS : STANDING BALANCE / THE PEDIATRIC CLINCAL TEST OF SENSORY INTERACTON FOR BALANCE (P-CTSIB) / SINGLE-LIMB STANCE / TANDEM WALK / CHILDREN

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การทรงตัวในท่ายืนของเด็กไทยเมื่อทดสอบด้วย Pediatric Clinical Test of Sensory Interaction for Balance, การยืนขาเดียวและการเดินต่อเท้าแบบแทนเด็ม (STANDING BALANCE IN THAI CHILDREN MEASURED BY PEDIATRIC CLINICAL TEST OF SENSORY INTERACTION FOR BALANCE, SINGLE-LIMB STANCE AND TANDEM WALK TESTS)

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บทคัดย่อ

วัตถุประสงค์ของการศึกษาครั้งนี้ เพื่อศึกษาความสามารถในการทรงตัวของเด็กไทยทั้งชายและหญิงใน 4 กลุ่มอายุคือ 4 ปีถึง 4 ปี 11 เดือน, 5 ปีถึง 5 ปี 11 เดือน, 6 ปีถึง 6 ปี 11 เดือนและ 7 ปีถึง 7 ปี 11 เดือน ความสามารถในการยืนทรงตัวทดสอบโดย Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB), การยืนขาเดียวและการเดินต่อเท้าแบบแทนเด็ม สำหรับ P-CTSIB มีตัวแปร 3 ตัวคือ องศาการเซ, เวลาที่ยืนทรงตัว และกลวิธีการเคลื่อนไหว ตัวแปรของการยืนขาเดียวคือ องศาการเซ และเวลาที่ยืนทรงตัว และตัวแปรของการเดินต่อเท้าแบบแทนเด็ม คือจำนวนก้าวที่ผิดพลาด ผู้เข้าร่วมการศึกษา 120 รายแบ่งเป็น 4 กลุ่มอายุ แต่ละกลุ่มอายุมีจำนวน 30 ราย (เพศชาย 15 รายและเพศหญิง 15 ราย)

ผลการศึกษาพบว่าความสามารถในการยืนทรงตัวเมื่อทดสอบโดย P-CTSIB, การยืนขาเดียวและการเดินต่อเท้าแบบแทนเด็มมีความแตกต่างกันระหว่างเพศ และระหว่างกลุ่มอายุอย่างมีนัยสำคัญทางสถิติ และความสัมพันธ์ระหว่างผลการทดสอบทั้งสาม พบว่ามีความสัมพันธ์ในระดับต่ำเมื่อเปรียบเทียบแต่ละคู่ของตัวแปรซึ่งได้จากการทดสอบ P-CTSIB, การยืนขาเดียวและการเดินต่อเท้าแบบแทนเด็ม

การศึกษานี้เสนอแนะว่า ความสามารถในการทรงตัวในเด็กที่ได้จากการใช้การทดสอบทางคลินิกทั้งสามนั้นใช้ทดสอบความสามารถในการยืนทรงตัวระหว่างเพศและกลุ่มอายุได้ และข้อมูลจากการทดสอบความสามารถในการทรงตัวทั้งสามนั้น ใช้คัดกรองเบื้องต้นและช่วยวางแผนการรักษาที่เหมาะสมสำหรับเด็กที่มีแนวโน้มมีปัญหาการยืนทรงตัว

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LIST OF ABBREVIATIONS

COG	=	center of gravity
BOS	=	base of support
ROM	=	range of motion
CP	=	cerebral palsy
SOT	=	sensory organization test
CTSIB	=	clinical test of sensory interaction for balance
P-CTSIB	=	pediatric clinical test of sensory interaction for balance
COM	=	center of mass
MS	=	mean speed
MR	=	mean radius
COP	=	center of foot pressure
ES	=	equilibrium score
SV	=	sway velocity
CNS	=	central nervous system
PRN	=	postronary nystagmus test
MMT	=	manual muscle testing
HHD	=	hand-held dynamometer
LD	=	learning disability
BOBS	=	bruininks-oseretsky balance subtest
SCSIT	=	southern california sensory integration test
SCPNT	=	southern california postronary nystagmus test
TBT	=	tilt board tip test
FBR	=	flat board reach
TBR	=	tilt board reach test

CHAPTER 1
INTRODUCTION

Postural control is the major component of physical movement especially in standing and walking (1-3). It is required for controlling individual to orient in space(3) and move from one position to another. Most authors give a definition of balance as the ability to maintain or control the body's center of gravity (COG) within the base of support (BOS) (1-2,4-10). In addition, there are many factors that influence postural balance, for example, gender, age, sensory systems, movement strategies, and other factors (11-13). Postural balance is a complex interaction of musculoskeletal and neural systems (1-2,10,14). The musculoskeletal system including range of motion (ROM), muscular properties, flexibility and biomechanical interaction between body segments involves postural control. In addition, sensorimotor process, the neural system including sensory with motor processes, are used to maintain balance during standing and walking. Sensorimotor process is usually examined in laboratory by platform experimental method (16).

The system model of postural control describes that multiple systems, including vestibular, visual and musculoskeletal systems, associate to the control (17-18). In standing position, motor process creates the movement to maintain posture through functions of trunk and leg muscles (6,19). Sensory process is related to the interaction of information from visual, somatosensory and vestibular system in order to evaluate position in space and make an appropriate motor output response (1,3,6,10,14,17,20-22). Somatosensory and visual systems give the information about body and head related to surfaces and objects in external surroundings (16).

Common problem in children who are diagnosed as having Cerebral Palsy (CP), motor dysfunction, and learning disabilities is postural balance deficits (17,23). The clinical information of postural balance is provided by motor strategy from the children (23). The children with motor dysfunction have problems in balance control which limit daily activities leading to developmental abnormality (2,13,17). Poor postural balance implies both a diagnostic indicator and a cause of functional impairment (9).

From motor control theory, there are at least three components that physical therapists examine. These components are biomechanical system, motor coordination and sensory organization (29). Assessment of the components of postural balance both static and dynamic are important to identify specific deficits. The treatment program is formulated from individual impairment (8).

The purposes of equilibrium evaluation is, firstly, to determine a treatment program. Secondly, therapists should concern whether the child has a visual target to successfully complete the task. The third is consideration in work load of the weight-bearing extremities. The last should consider whether it is the child or the therapist who required by the task (9).

Assessment of postural balance in children is difficult to quantify and measure, that leads to unreliable information (24). The assessments are sensory, motor and biomechanical systems (2,4,7,24). The applications of these tests should be chosen carefully (2). Horak (4) advised that the measurement of postural control should be quantitative, norm – referenced tools to evaluate both functional capacities and quality of movements of postural control system. Also, the measurements should be sensitive and specific to postural control abnormalities, reliability, validity and practical (2,4,8,25). Moreover, the advantages and disadvantages of each test should be considered prior to application (2,4,25). Inappropriate interaction of sensory inputs, inadequate muscular strength and uncontrol balance ability cause instability (1,6,24).

Therefore, the patients with postural balance disorder probably lack the ability to make an effective balance response (6,20).

Horak (4) showed that some clinical balance tests such as tiltboard, ball and other tests did not clearly define the expected postural behaviors. Thus, the information from these tests is inadequate for using to judge the balance disorder in children.

Sensory Organization Test (SOT) is the method frequently used to evaluate postural control. This test includes the quantitative standard dynamic posturography. Although SOT is a good technique for evaluating balance, this method is disadvantage. The equipment cannot be applied outside laboratory setting and is expensive. In addition the size of the equipment is not suitable for children. Therefore, the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) is an alternative method chosen to determine balance performances in children. This technique is proper to use in clinic for examining balance and sensorimotor recovery in patients. The advantage of the SOT is discrimination among situations that restrict sensory inputs or conditions, that use the motor strategies for maintaining balance (14,26-27). In 1986, Horak and Shumway – Cook proposed a simple method to evaluate sensory interaction for maintaining standing balance. This method is The Clinical Test of Sensory Interaction for Balance (CTSIB) or Foam and Dome test (1,4,6-7,13-14,19-22,24,26-30).

CTSIB is composed of six conditions. Each condition is observed for 30 seconds: the standing tests both on firm floor and compliant foam with the condition of eyes open, eyes closed and visual–conflict dome (1,4,6-7,13,20,22,24,26-30). Scoring of each condition was measured by length of time, degrees of sway and observed subjects'strategies (1,4,6,13,22,24,26,28-30). CTSIB is also appropriate to use in clinic because it is practical, inexpensive, movable and useful for screening patients with abnormal postural control and for planning suitable treatment in balance disorders (1,4,6-7,19-20,24,28-30). Recently, P-CTSIB was adapted from CTSIB and used for evaluation postural control of children (2,8,13,19-20,23,26-27,38). Methods of this test is resembled to the CTSIB and the score of the P-CTSIB were correlated

with functional ability of children. The test–retest reliability of the P-CTSIB is good with ICC 2,1 ranging from 0.55 - 0.88 (2,8,23-24,26,30).

Both simple measurement such as One – Leg Stance Test and complex instruments are used to assess postural balance. Complex instruments such as posturography provides more information than the simple instrument (18). The clinical, One - leg Stance Test is used to investigate impairment of postural balance (18). However, this test does not provide information on the ability of a person to control balance under sensory conflict situations such as a compliant surface (18). The balance performance is examined by multiple assessments because neurological and mechanical systems are contributed to balance. Couple between functional status assessment and tools are useful for identifying balance deficits because functional status, sometimes, could or could not reflect impairment of sensorimotor system (14).

In clinic, therapists commonly evaluate postural balance by the simple tests because it is easy and inexpensive. These tests do not require the sophisticated equipment and can be performed anywhere. In addition, the tests take not much tine in assessment. Other balance-related tests include one-foot hopping, tandem walking, single-limb stance position (9,22,26-27,31). Single-limb stance provides quantitative information about duration of stance time. It is frequently used in children and adults. These simple tests evaluate age-related motor skill development and permit to compare with normative data for skills areas or overall motor proficiency or both. These simple tests provide a gross assessment in balance disorders. Therefore, these simple tests are appropriate to use for screening or measuring age-related motor skill development.

From two studies (17,34), the test score in 3 years to 7 years old children demonstrated a transition period to mature responses in postural control. Shumway–Cook and Woollacott (17,34) suggested that children below 7 years old could not solve inaccurate sensory problem when information from sensory systems are confused or conflicted during postural control.

There is no study about P-CTSIB assessment in 4 to 7 years 11 months Thai children. It is difficult to objectively assess balance in young children because most instruments are not suitable for children. For example, computerized equipment is appropriate to assess balance performances in adults than children. Thus, the pediatric version was adapted from the CTSIB which could be another instrument to determine balance performances in children.

Therefore, this study focused on the balance performances in children aged 4 to 7 years 11 months and determined correlations among the performances obtained from the P-CTSIB and other simple balance tests. In addition, the database on balance performance of healthy children 4 to 7 years 11 months should be established in order to apply the information for planning the appropriated treatment to children who have balance deficit.

Purposes of the study

General Objective

Postural maintenance in healthy Thai children in four age groups; 4 to 4 years 11 months, 5 to 5 years 11 months, 6 to 6 years 11 months and 7 to 7 years 11 months using Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB), Single-limb Stance position while eyes opened and closed and Tandem Walking was investigated. In addition, the relationships among these tests, and difference comparisons between genders and among age groups were determined.

Specific Objectives

1. To compare the balance performances between healthy Thai boys and girls in four age groups using the P-CTSIB, Single-limb Stance position while eyes opened and closed and Tandem Walk Tests.
2. To compare the balance performances among four age groups of healthy Thai children using the P-CTSIB, Single-limb Stance position while eyes opened and closed and Tandem Walk Tests.
3. To determine the correlations among the balance performances obtained from the P-CTSIB, Single-limb Stance position while eyes opened and closed and Tandem Walk Tests.

Parameters of the study

1. The Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)
    - length of time (seconds)
    - degree of sway (degrees)
    - movement strategy
2. Single-limb Stance position while eyes opened and closed
    - length of time (seconds)
    - degree of sway (degrees)
3. Tandem Walk Test
    - number of error steps that walking on the reference line (steps)

Scope of the study

This study focused on balance performances in healthy Thai children aged between 4 to 7 years 11 months on the P-CTSIB, single-limb Stance position with eyes opened and eyes closed and Tandem Walk Tests. The study also compared postural maintenances between genders and among age groups and considered correlation among these tests.

Hypotheses of the study

1. There were significant differences in balance performances between boys and girls aged 4 years to 7 years 11 months on the P-CTSIB, Single-limb Stance Position while eyes opened and closed and Tandem Walk Tests.
2. There were significant differences in balance performances in children among different age groups on the P-CTSIB, Single-limb Stance Position while eyes opened and closed and Tandem Walk Tests.
3. There were significant correlation between the balance performances obtained from the P-CTSIB and the Single-limb Stance position while eyes opened and closed and Tandem Walk Tests.

Advantages of the study

1. The result of this study would provide preliminary reference database on balance performances in healthy Thai children aged between 4 to 7 years 11 months.
2. This study provided information on clinical tests to be used for early detection and planning appropriate treatments in the children with balance disorders.

CHAPTER 2
LITERATURE REVIEW

2.1. Postural control or balance

2.1.1 Definition of balance

Definition can be divided into constitutive and operational definitions. Constitutive definition is differ from operational definition, that is, constitutive definition was defined the concept from other concepts and the content of the concept (35). During operational definition referred as the concept meaning by describe about tasks or actions (35).

Postural control or balance can be defined to the ability to maintain the Center of Mass (COM) or the Center of Gravity (COG) within the Base of Support (BOS) to prevent falls in both static and dynamic postures (1,2,4-5,8,20,28,36).

Postural control or balance is a complex motor skill which involved integration of sensory information, neural processes, biomechanical factors and planning movement patterns in order to complete tasks (7,14-15,22).

The words " balance", "equilibrium" and "postural control" are same meaning for the concept of mechanism by control or prevent body from falling or losing balance (35).

2.1.2 Types of balance

Balance can be classified as static and dynamic balance (1,8,19,35). Static balance defined as the ability to control center of mass within stability limit and maintain a position in standing or sitting. On the other hand, the ability to maintain balance during movements or shift the center of gravity (COG) over the base of

support (BOS), for example reaching the object or during locomotion, is defined as dynamic balance.

Standing balance is a process which divided to two portions including sensory organization and muscle co-ordination. The first portion is sensory organization used for determining timing, direction and amplitude of postural ability that rely on the combination of information from visual, somatosensory and vestibular systems. The latter is muscle co-ordination used to describe processes that determine the temporal sequence and the contraction activity among muscles of trunk and leg which provide supportive reactions (16).

2. 2 Components of balance (1-3,14,22,35)

2.2.1 sensory inputs : somatosensory system (proprioceptive, cutaneous and joint), visual system, vestibular system

2.2.2 motor outputs

1) reflexes ; righting reflexes, equilibrium reflexes

2) postural responses ; long – looped muscle activation pattern ; ankle, hip, stepping, suspensory and crouch strategies

2.2.3 postural movement

The functional of various components of balance control are illustrated in Figure 2.1 (10). Different portion of balance is demonstrated by “the umbrella concept”. Balance can be divided to subdivision of motor skills, the umbrella concept shown in Figure 2.2, which is useful to challenge these motor skills to different levels and to measure the ability to control position (35).

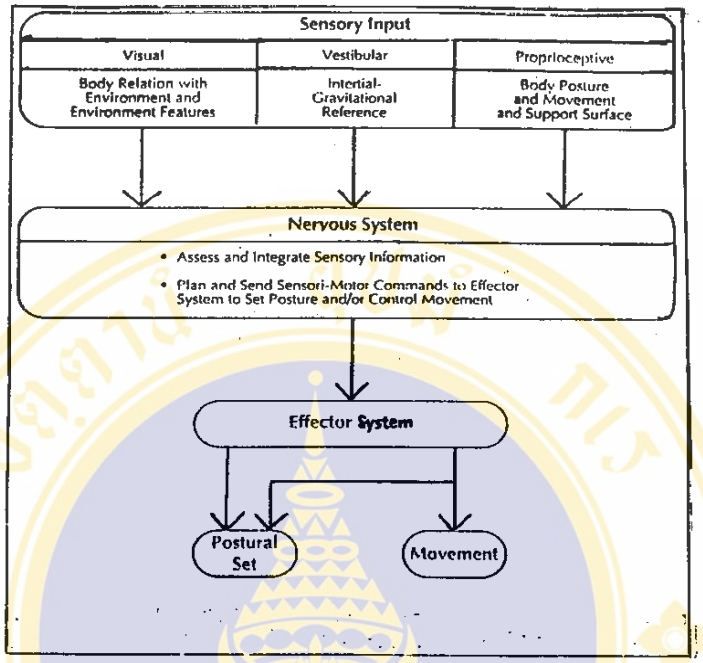

Figure 2.1 The components of balance control system.

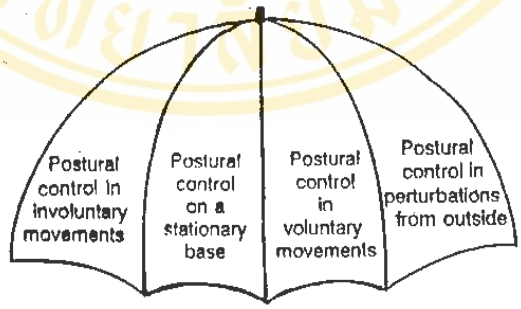

Figure 2.2 The umbrella concept of balance.

2.3 Factors Influenced Balance

2.3.1 Age and gender

Rine et al studied the feasibility to use the computerized sensory organization testing (SOT) and examined the score in the children aged between 3 to 7 years old (n = 23) and a half years of age (age between 21 to 30 years old, n=11). The result showed that the children were less stable and use movement strategies different than adults ($p \leq 0.0001$ and $p \leq 0.04$ respectively). The children aged between 3 to 7 years was reported a transition period. Thus, the SOT is useful for measuring the sensory system effectiveness and maturational change of balance control in young children (3).

Figura et al provided a description of the change in balance of children, age 6 to 10 years old and gender by three postural tests and force platform. Three postural tests are the Romberg test (feet together), One foot test and Tandem test (dominant foot placed behind non-dominant foot) and all tests performed with subject's eyes open. The mean radius (MR) of the posturogram and the mean speed (MS) of the center foot pressure (COP) were collected. The data presented a decrease with age in both MR and MS, thus balance ability was increased. No significant difference between age and sex and significant difference between in 10 years old group and adult group occurred only in more difficult test (12).

Richardson et al investigated the performance of normal children aged between 4 to 5 years on the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) and determined whether age and gender-related differences were present. P-CTSIB were administered in two feet positions, including feet together and heel-toe position. Each position composed of six conditions, thus twelve conditions were tested. When compared between 4 and 5 year olds, significant duration difference were found in 4 – 6 conditions in heel - toe position of the P-CTSIB. The age-related differences on the remaining 2 heel - toe conditions, as well as on condition six of feet together position, approached significance. No significance gender difference with 4 and 5 year olds in all conditions; however, girls tended to perform better than boys on

9 of 12 conditions of the P-CTSIB. The results indicated that the feet together position could discriminate between normal children and children with balance deficits, while the heel-toe position was difficult for normal children aged 4 to 5 years and has limited diagnostic value for this age group (19).

Foudriat et al used the posturography (Equi test) to test 82 healthy children aged 3 to 6 years. This study compared the performance in balance maintenance between genders in children aged 3 to 6 years old while altered sensory environments. The children were divided into 4 age groups. An equilibrium score (ES) was calculated depending on the amount of postural sway compared to the maximum sway possible without falling. The higher ES presented the greater postural stability.

Improvement in postural stability was revealed between 4 and 5 years of development when the sensory environment was fixed. In dynamic sensory environment, age - related improvements in postural stability were not unique and relied on the specific sensory condition. In addition, postural stability was greater when visual inputs were sway-referenced compared with conditions that were support surface sway-referenced. The data showed the predominance of visual – vestibular of balance control giving way to a somatosensory – vestibular dependence by 3 years old, but the transition to adult - like responses were not completed for all conditions even 6 years old (37).

Hytönen et al in 1993 examined the effect of visual, pressoreceptor and propioception on the postural stability at different ages. Body sway in 212 healthy volunteers, aged between 6 - 90 years, were evaluated by a computerized force platform. The subjects were divided into 6 groups: these are aged between 6 to 15 years old (n=18) in group 1, aged between 16 to 30 years old (n=45) in group 2, aged between 31 to 45 years old (n=18) in group 3, aged between 46 to 60 years old (n=100) in group 4, aged between 61 to 75 years old (n=16) in group 5 and the last group aged between 76 to 90 years old (n=15). During each measurement, vibration was applied on the calf muscles to evaluate the contribution of the propioception system to the postural strategy. The sway velocity (SV) was recorded from a force

platform. This study was performed with eyes open and eyes closed during quite stance on a bare platform and a foam plastic covered surface. The result indicated that the children and the elderly swayed most. The postural stability in children was sensitive to propioceptive and pressoreceptor perturbation. In the elderly subjects, visual information is necessary for control of upright stance (38).

Sellers JS studied the relationship, the quality of antigravity and postural control, and determined whether sex and ethnic group differences correlate with differences in antigravity and postural control in young children. One hundred and seven children were participated in this study, aged from 50 to 66 months (x = 61 months). The measurements consisted of static balance, dynamic balance, prone extension and supine flexion. The results revealed significant relationships between antigravity and postural control. The performance of subject's supine flexion was significant related to the quantity and quality of their static and dynamic balance performance, while prone extension performance related only the quality of dynamic balance performance. From the quality scale, the children had not yet developed full antigravity or postural control. This study reported differences between sexes in the quality of static balance and prone extension performance and ethnic differences in static and dynamic balance and prone extension performance (36).

Deitz et al assessed the performance of 82 normally children, both boys and girls, aged from 6 to 9 years on the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB). The children were divided into 4 age groups (6, 7, 8 and 9 years). The procedure of P-CTSIB was done on both the six feet together and the six heel-toe conditions. This study was focused on the differences among the duration for age groups and gender. The duration, total degrees of sway (anterior / posterior sway for feet together and lateral sway for heel-toe) were recorded.

No significant development differences progression of performance on this test for children 6 to 9 years of age. However, when 6 years old children compared to 9 years old children scores the same or lower in duration for all conditions except the 5th condition of heel-toe position. The developmental progression broke down a the data

from the 7 and 8 year olds, because there was no consistent pattern of 2 age groups. It was not clear about developmental progression in either the feet together or the heel – toe tests. However, the score of duration of stance of all conditions for the youngest children were as same as or lower than the oldest children. There was a little significant differences in genders. The P-CTSIB in feet together was easy for children 6 to 9 years of age, whereas the P-CTSIB heel-toe was difficult for them (13).

Riach et al examined the postural sway of 76 healthy children, aged between 2 to 14 years, by the force platform. The amplitude and spectral composition of excursion of the center of pressure of ground reaction force were analyzed and reported. Feet positions were parallel and 6 cm. apart. The postural sway was evaluated while the children stood with eyes open and eyes closed. The results showed that the postural sway decreased linearly with age. The boys tended to become more stable than the girls, but at the start point the boys had greater level of instability than the girls. The children's Romberg quotients, an index of the influence of eye - closed on sway magnitude, were lower than adults'. The results supported that the children use visual information to control balance that differed from adults, and it was not until after the age of 7 years that balance control strategies begin to like adult (39).

2.3.2 Sensory systems

2.3.2.1 Visual system

Visual inputs are important source of the information to the Central Nervous System (CNS) informing about external environment for controlling posture and locomotion especially the increase in complexity of task, for instance dancing. This system is used for maintaining the alignment of head in space and contributing to control balance (22). Sometimes visual inputs provide inaccurate information that leading to the wrong decision. For the balance control, this system might be chosen earlier (14,22).

Rine et al studied the effectiveness of visual, somatosensory and vestibular input in postural control in 23 children (aged from 3 to 7 years) and 11 adults (aged between 21 to 31 years). In the study the SMART Balance Master System was used to measure the postural stability. The results showed the somatosensory system in children 4 to 6 years old is adult-like pattern, while visual and vestibular effectiveness in balance control was not adult-like by 7 years and a half years of age (3).

Horak FB suggested that in most clinical tests the measurements were concerned only about somatosensory input but these tests did not altered the visual inputs, for example standing on one leg, standing on narrow rails. Therefore, these tests did not differentiate between sensory inputs which leading to acquire uncertain information (4).

Flores AM described the vision was increasingly necessary when it is used to compensate of a loss in one or both of the other sensory system. Visual input stimulates the restoration of balance when postural stability was perturbed (11).

Figura et al studied the ability to maintain balance in 90 normally children, both boys and girls, aged between 6 to 10 years. The subjects administered three balance static tests including the Romberg test (feet together), One foot test and Tandem test (dominant foot placed behind non-dominant foot) and all tests performed with subject's eyes open. The results revealed that significance eye effect was found on all tests while significant gender effect found in only the Tandem test (12).

Woollacott et al suggested that children under seven years old could not maintain balance efficiently when both visual and somatosensory systems were inaccurate or absent. The reason was that is this period of aged indicated inability to resolve intersensory conflict while maintaining balance (34).

Foudriat et al investigated the performance of balance control in 82 healthy children, aged from 3 to 6 years old by posturography. This study concerned about the performance during altered sensory environments. The results showed that predominance of visual-vestibular of balance control gave way to a somatosensory – vestibular dependence by 3 years old, but the transition to adult-like responses were not completed for all conditions even 6 years old (37).

Hytönen et al studied the receptor system that influenced balance in 212 normally subjects, aged from 6 to 90 years. In children, the result found little difference between the visual and absent visual conditions (38).

Riach et al examined the performance of postural control, postural sway and the influence of visual to the postural sway in 76 normally children, aged from 2 to 14 years. The data showed that the effect of eyes closed had little influenced on the postural stability (39).

2.3.2.2 Vestibular system

Vestibular system is inertial - gravitational, therefore it does not changed by external environment. It involved in the labyrinthine neck reflexes used for movement of head with respect to the body (16). The functional of vestibular system provided inputs to postural muscles, while somatosensory and visual were necessary for contributing balance greater than vestibular system in normal sensory situations (16-17,26). The major role of vestibular system appeared when subjects intend to control balance while altering sensory environments (16-17,26). The patients with vestibular deficits were unable to orient the information when somatosensory and visual inputs were inaccurate (15).

Rine et al studied the integrative components of balance by computerized sensory organization test (SOT) in 23 healthy children, 36 to 90 months

of age. This results presented that children at seven - half years of age, the effective of vestibular system in balance control was not adult-like (3).

Deitz et al studied sensory selection strategies in children with learning disabilities comparing with normal children. This study composed of 2 groups of children, normal children and children with learning disabilities groups, aged between 6 to 9 years, 36 children in each group. The Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) was administered to determine the performances to select sensory strategies.

The result of this study revealed that children with learning disabilities received significantly lower scores on 4 from 6 conditions. In addition, this study suggested that children with learning disabilities have deficits in sensory organization related to balance and motor deficits (17).

2.3.2.3 Somatosensory system

In normal situations, upright posture was maintained by somatosensory input, which involved the movement of legs with respect to the support surface (16). Somatosensory input was received from contact with fixed surface inputs, particularly necessary in generating automatic postural adjustment. In contrast, the influence of visual input on the postural reactions is stronger when disturbed the support surface is disturbed (16).

Rine et al investigated the developmental changes in the sensory and integrative components of postural control in 23 healthy children, 36 to 90 months of age. The result showed that the somatosensory system, in children 4 to 6 years old is adult-like pattern (3).

2.3.3 Movement strategies

The strategies consist of 5 strategies including ankle, hip, stepping, suspensory and crouch strategy. The chosen of the strategy depends on the configuration of the support surface and the magnitude of perturbation and the other factors such as the height (1,4,7,11).

- Ankle strategy is used for small antero-posterior perturbations on a firm. The COM is controlled by the rotational movement occurred at ankle joint with minimal movement of hip or knee joint.
- Hip strategy is used for the large perturbations and ankle strategy are insufficient to control the center of mass (COM) in order to maintain balance. It involves flexion and extension of hip joint to shift the COM.
- Stepping strategy is used for very large and fast perturbations. It appears steps, hops or stumbles in the same direction of external perturbation.
- Suspensory strategy is used when the other strategies are insufficiency, the combination of the strategies is performed in order to decrease the COM that movement occurred at hip, knee and ankle joints.
- Crouch strategy is relied upon observations the children with Cerebral Palsy (CP). The movement appears lower pelvis vertically with minimal antero-posterior sway.

2.4 Assessment of balance

Evaluation of balance control in children is divided into 3 system approaches, including sensory, motor and biomechanical systems. Each of approached system has many tests, thus the application should be chosen carefully with considering about these reliabilities, validities, quantitative, evaluate both functional capacities and quality of movement of postural control system. Moreover, the advantages, disadvantages, practical to use, inexpensive method should be considered before the application.

2.4.1 Methods of measuring the sensory system (2,4,11).

The tests provided in this section are designed to evaluate the integration of 3 sensory systems (visual, somatosensory and vestibular system) that maintain postural stability. The rationale of the usage of these tests is accuracy assessment of sensory systems which are able to identify deficits in processing affecting the ability in appropriate postural response. In this system approach has many test, such as Postronary Nystagmus test (PRN), Posturography, the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) and the other tests.

2.4.2 Methods of measuring the motor system (2,4,11).

The observation of motor coordination while controlling balance is a method of evaluation. The patterns to control body while standing in children and adults including ankle, hip, stepping and suspensory strategy. Choices of strategies are related with the rate and force of perturbation and the support surface. Therapists observed the motor coordination or muscular contraction during controlling balance by placing the child on a movable surface and judged the motor response during perturbation. The methods of this system are the P-CTSIB, Posturography, Side reach test.

2.4.3 Methods of measuring the biomechanical system (2,4,11).

Force output and range of motion (ROM) are main biomechanical factors related to the balance control in children. Force output is related to the functional measures of movement. The method for evaluating of force output are manual muscle testing (MMT), hand-held dynamometer (HHD) and Isokinetic testing device. ROM is evaluated by standard goniometric technique and video goniometry.

2.5 Sensory Organization Test (1-4,7,13-17,19-20,22,24,26,29,35)

2.5.1 Definition of the Sensory Organization Test

Sensory Organization defined as the combination of the sensory information in the Central Nervous System (CNS) (22). Di Fabio et al described that Sensory Organization balance Test is the systematic approach to evaluate of ability to switch among somatosensory, visual and vestibular information to maintain balance (14). Sensory Organization is used for providing the process which describe timing, direction and amplitude of the postural alignment depending on the combination of information from visual, vestibular and somatosensory inputs (16).

Sensory Organization balance Test (SOT) is a systematic approach of ability to switch reliance on somatosensory, visual and vestibular input while altered sensory environment. The conflict of sensory environment evaluates balance by building the conditions which visual and somatosensory inputs diminished or inaccurate. The SOT is used for assessing balance and sensorimotor recovery in the patient. The advantage of this technique is discrimination among sensory inputs or motor strategies that used for maintaining balance. This method frequently uses in order to evaluate the postural stability, including the computerized posturography, the Clinical Test of Sensory Interaction for Balance (CTSIB) and the pediatric version of CTSIB (P-CTSIB) (13,17,26-27).

Posturography is the computerized laboratory method, measured the visual and somatosensory informations unreliable by the support surface or force plate that moved both anteroposterior and rotation, and composed of six conditions. The support surface and visual surrounding can be rotated to occur the postural sway. Postural sway is measured during standing for 30 seconds under six sensory altered conditions. In addition, this equipment is useful for evaluating type of the patients with balance deficit. It provided functional information from the patient's balance abilities, emphasized on balance deficit of patients with daily living activities, and choosing appropriate treatment to individual patient. This equipment was presented a good

reliability and validity, however, disadvantages of equipment are expensive, unmovable and impractical for using at home.

The simple clinical test is proposed from Horak and Shumway – Cook in 1986, called the Clinical Test of Sensory Interaction for Balance (CTSIB) (13,17,26-27). The CTSIB was developed from Nashner concept, the dynamic posturography. It is similar to and correlate with the posturography. The CTSIB is used for evaluating many types of patients that provided the balance problems. Reliability, test - retest, validity of this method was preformed to be good. In addition, this method is low cost, practical, movable, need few equipments.

Later on, the pediatric version is adapted to measure the balance in children, called the Pediatric the Clinical Test of Sensory Interaction for Balance (P-CTSIB) (13,17,26-27). The procedure of this study is resembled the CTSIB. Intrarater reliability, interrater reliability, test-retest of this method showed moderate to good. P-CTSIB consisting of six conditions are follows;

1) eyes open with standing on the floor
2) eyes closed with standing on the floor
3) the visual conflict dome with standing on the floor
4) eyes open with standing on the density foam
5) eyes closed with standing on the density foam
6) the visual conflict dome with standing on the density foam

A piece of high-density foam was used for reducing the somatosensory input (13,17,26,29). A visual conflict dome was used for producing inaccurate information of visual input (13,17,26,29). Durations, degree of sway and movement strategies are recorded during performed the P-CTSIB (13,29). The maximum time to maintain balance in each condition is 30 seconds recorded by a digital stopwatch. Measurement of timing is useful when evaluation of sensory co-ordination in patients, for example patients with vestibular dysfunction and with Hemiplegia (29). Degree of sway is evaluated by a backdrop that radiated 2 degrees incremental from central axis.

Movement strategy is observed when subject demonstrating the strategy to prevent falling.

Pellegrino et al studied the test-retest reliability of static standing balance test of sensory organization which used the Pediatric Clinical Test of Sensory Interaction for Balance or the P-CTSIB and the dynamic balance, used the Functional Reach Test or the FRT. Eighteen children, aged between 5 to11 years, were identified by physical therapist or occupational therapist as have standing balance problems and were participated in this study. Other criterion for participation were able to stand independently at least 30 seconds and were able to follow simple directions (8).

The test-retest reliability of the P-CTSIB combined with sensory condition scored ranging from r = 0.55 to 0.88 (ICC2,1). These results are similar to test-retest reliability on the children without standing balance problems. During the test-retest reliability of the FRT was poor, r =0.31(ICC 2,1). When comparing with the previous test, result showed that twelve children were received the greater score. From the result of the study was suggested that the application of the P-CTSIB should be a cautious when assessing across time. For the FRT, the study should be re-assessed when this test was applied to the children with standing balance dysfunction (8).

Lisa et al examined the reliability of judging the motor strategy on the P-CTSIB in the Cerebral Palsy (CP) children. In addition, inter-rater reliability and intra-rater reliability of the study was observed at the picture on the videotape. Twenty-six children aged from 6 to 14 years who diagnosed spastic CP were participated in the study. Children were recorded the postural sway during performing the P-CTSIB. Children were asked to maintain balance under six conditions, which are the combination between two support surfaces and three visual situations (23).

The ankle, hip or crouch strategies is the method for maintaining body equilibrium. Children performed one or more strategies to maintain balance. Two real-time examiners observed motor strategy while performing the P-CTSIB. Three independent raters observed the videotape of the children in real-time and recorded

only motor strategy. This study suggested that reliability to determine motor strategy is difficult when viewed videotape only one time. Observation in the real-time may not be reliable. The clinical implication was received from assessing motor strategy used by children with CP while performing the P-CTSIB (23).

Deitz et al assessed the performance of 82 normal children, both boys and girls, aged from 6-9 years on the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB). The children were divided into 4 age groups (6, 7, 8 and 9 years). The procedure of P-CTSIB was done on both the six feet together and the six heel-toe conditions. This study was focused on the differences among the duration for age groups and genders. The duration, total degrees of sway (anterior / posterior sway for feet together and lateral sway for heel-toe) were recorded.

No significant development differences progression of performance were show on this test for children 6 to 9 years of age. However, when comparing 6 years old with 9 years old children the scores of duration for all conditions except the 5th condition of heel-toe position were the same or lower. The developmental progression broke down at the data from the 7 and 8 year olds, because there was no consistent pattern of 2 age groups. This study found not clear of developmental progression for either the feet together or the heel-toe tests. However, the score of stance duration for all conditions of the youngest children were present similar to or lower than the oldest children. Significant gender differences were reveal minimal. The P-CTSIB in the conditions of feet together was perform easier than conditions of heel-toe position in the children 6 – 9 years of age (13).

2.6 Clinical test of balance

2.6.1 Single-limb Stance

The base of support and integrative information for interlimb coordination is decreased in single-limb stance. When the support surface is narrowed, for example single – limb stance, postural balance is based on visual input (22).

Usui et al studied developmental change in postural sway, center of gravity or COG and contact surface area of the sole of foot by standing with feet together and standing on one foot in the children 3 to 11 years old. During 1988 to1992, 1,188 children (612 girls and 576 boys) were participated in this study. The children less than 6 years old were asked to stand upright on the podoscope, with feet together. In addition, during testing they looked at a target in the front that placed 2 meters far away. The children were standing as they could. Twenty seconds were the record time. The children aged over 6 year could stand on one foot for 10 seconds of each foot, that the left foot was first and the right foot was latter.

The Stasio-analyzer was used for recorded the COG, postural sway and contact surface area of the soles. Results showed the contact surface of the sole increased with age, particularly in boys and girls aged between 3 years old, 5 years old and the ages of 7 to 9 standing on contact surface area. Moreover, 6 and 7 years old children showed little increase in contact surface area. The average value of the contact surface area for girls was less than boys in every aged group. Nevertheless, significant difference was found between girls and boys were found in 10 years old group. No significant difference was found between contact surface area on the left foot and right foot, although, the value of the contact surface area on the left foot was greater than the right in both girls and boys aged between 3 to 5 years. Eight years old boys and girls and boys aged at 10 had a greater contact surface area on the right foot than the left. No significant difference both girls and boys age 11 years old.

Total sway area for both boys and girls standing on one foot were became smaller with age. Girls 8 years old had a significantly smaller values on the right than on the left. No significant difference between the right and left foot at other aged group. Boys aged under 10 years swayed greater than girls. Result from the study found the significant difference in total sway area between boys and girls in feet together and all aged group (31).

Bundy et al examined postural control in 50 boys, age between 6 to 13 years. The children were diagnosed Learning – Disability or LD and at least average intelligence. Fifty children were divided to 2 groups. The first group demonstrated

impaired vestibular system functioning and another group without vestibular dysfunction.

Procedure of the test composed of 2 phases. First, the Bruininks-Oseretsky Balance Subtest (BOBS) was administered to standard instructions by the same therapists who performed the prior Southern California Sensory Integration Tests (SCSIT), Southern California Postrotary Nystagmus Test (SCPNT) and clinical observation. Second phase are five tests of balance administered to children includes the Tilt Board Tip test (TBT), the Flat Board Reach (FBR), the Tilt Board Reach test (TBR), Standing Balance with Eyes open or SBO (the part of SCSIT) and Standing Balance with Eyes Closed or SBC (the part of SCSIT). All children were examined the ability to assume and maintain the prone extension posture, and the SCPNT was administered. The rest time between two phases of testing were approximately 3 months. The order of testing was systematically randomized to control the effects of order and fatique. The SCPNT was always performed last. Three of these balance tests, as TBT, FBR and TBR, were performed as a group. The remaining of tests, as prone extension posture, SBO and SBC, were administered before or after the TBT, FBR and TBR. In addition, the SBO was always tested prior to the SBC.

The results showed the correlation between TBR and FBR in the first group. Another group, boys without suspected vestibular dysfunction showed the correlation between BOBS and SBC. In addition, low correlation between the test scores meaned that multiple measurements of balance are necessary for properly evaluation (9).

CHAPTER 3
MATERIALS AND METHODS

3.1 Subjects

Healthy Thai children, both genders, aged between 4 years to 7 years 11 months, were recruited from public schools in Thunyaburi and Bangkapi districts. The subjects were divided into 8 groups (Appendix C). A consent form that described the methods of the study was signed by the parents of each child prior to the testing session (Appendix A and B). The followings were subject's selection criteria (1-5) :-

- learning in regular classroom with no disability as reported by a classroom teacher
- no history of delayed development, neurological problems, learning disabilities and seizures as reported by parents.

The children were excluded if they did not pass a physical ability screening consisting of strength and range-of-motion tests of trunk and lower extremity (1-5).

3.2 Instrumentations

The equipments used in the study were:

1. A form for recording the data of subject
2. A stopwatch for measuring the balance maintaining duration
3. A video camera for recording child's postural sway
4. A videotape for recording child's response during the tests
5. The Clinical Measurement of Standing Balance

5.1 The Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) (1-2,6,13,17,26) consisted of (Figure 3.1)

- A visual conflict dome was constructed from a spherical white paper with pliable wire, cut opened on one side to admit the child's head. This dome

had a headband for strapping on the child's head. Distance between child's nose and the dome's portion was approximately 10 inches. In addition, the dome provided inaccurate visual input and limited peripheral visions at the top, bottom and lateral sides. A tape mark was placed in front of the dome as a reference point.

- A piece of medium density foam (18 inches x 18 inches x 3 inches) that provided inaccurate somatosensory input.

- A backdrop with lines radiating in 2 degree increments from the central axis on the floor was placed on the wall on lateral side of the subject to measure amount of sway. A maximum sway of 16 degrees was measured on each side, therefore, the total amount of sway was 32 degrees (Figure 3.2).

- A digital stopwatch recorded the time that children could maintain in standing balance.

Figure 3.1 A visual conflict dome and a density foam.

Figure 3.2 A backdrop.

5.2 Single – limb stance position

The material for Single – limb stance position was a digital stopwatch for recording the maximum time that children could maintain standing balance.

5.3 Tandem Walk Test

The material for Tandem Walk Test was a ten-feet-straight line taped on the floor.

3.3 Examiner

The present investigator was the only one examiner to administer three balance tests to all children in the study. Prior to data collection, an intra-tester

reliability of scoring was conducted using a convenient sample of ten children aged 4 to 7 years 11 months. Therefore, the present examiner could practice test administration until familiar with the test procedure from several children and observed postural sway from a videotape while the pilot study.

3.4 Procedures

3.4.1 Subject preparation

Before starting the test, subject was instructed to take off the shoes and was examined the physical ability screening test (in Appendix C). All subjects performed the three balance tests in the same sequence of the P-CTSIB, Tandem Walk Test, the Single - limb stance tests, respectively.

1) P-CTSIB

All movements were recorded by a camera recorder. The video camera was positioned at three meters away from the left side of the child at a height approximately 50 centimeters from the floor.

P-CTSIB was used for evaluating duration of standing balance, amount of body sway and balance strategy under the six different sensory conditions (Figure 3.3 and Table 3.1). Combination of three visual and two support variables were used. Visual variables included eyes opened, eyes closed and sway referenced vision. Sway referenced vision was obtained by a visual conflict dome that produced inaccurate visual input for orientation. The support surface conditions were standing on hard flat surface and standing on firm, compliant medium-density foam which reduced accuracy of somatosensory input.

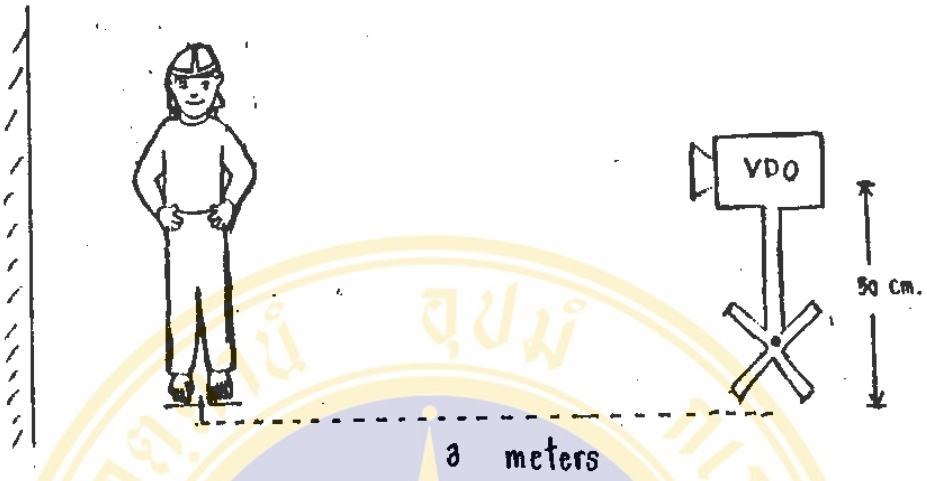

Figure 3.3 The position of video camera used for recording child's postural sway.

Subjects were barefoot for all conditions. Starting position of subjects were standing with feet apart (distance between heels was approximately 3 centimeters) and hands placed on hips (positioned at iliac crest). Sensory information of each condition was gradually altered.

Duration of stance, degree of sway (peak to peak degree of sway) and type of movement strategy were recorded. Duration was timed until the child took hands off hips (positioned at iliac crest), opened eyes if the condition had to close eyes or required assistance from examiner to prevent a fall. Maximum duration of each condition was continued up to 30 seconds. A digital stopwatch was used to record duration.

A paper screen with lines radiating in two degree increments for 32 degrees in total was use to measure degree of sway. During the feet-together condition, anterior/ posterior sway was recorded by video camera that the pointer was used as a reference

point. Each condition was tested twice and the best trial was recorded. The best trial was defined as the one with the longest duration, or if durations were the same, the one with the least sway was chosen. After the first trial of each condition was completed, subjects had approximately 2 minutes rest before performing the second trial. Between each condition, subjects were allowed to have 3 minutes rest.

Table 3.1 Sensory systems available and compromised in the six conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)

Conditions	Sensory systems available	Sensory systems compromised
Condition 1 **- normal surface ,** **eyes open**	Vision Somatosensory Vestibular	-
Condition 2 **- normal surface ,** **eyes closed**	Somatosensory Vestibular	Absent Vision
Condition 3 **- normal surface** **visual conflict dome**	Somatosensory Vestibular	Inaccurate Vision
Condition 4 **- Foam , eyes open**	Vision Vestibular	Inaccurate Somatosensory
Condition 5 **- Foam , eyes closed**	Vestibular	Absent Vision Inaccurate Somatosensory
Condition 6 **- Foam , visual conflict dome**	Vestibular	Inaccurate Somatosensory and vision

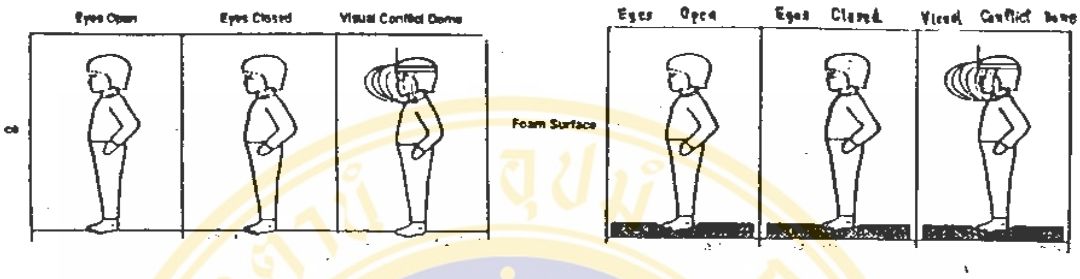

Figure 3.4 Six conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB).

In order to maintain standing balance, movement strategy was selected following degrees of disturbation. Selection of movement strategy was judged from 5 categories including Ankle strategy, Hip strategy, Stepping strategy, Suspensory strategy and Undetermined (Appendix C). Total time to administer for all six conditions of the P-CTSIB was approximately 30 minutes.

a) Front view

b) Lateral view

Figure 3.5 The P-CTSIB testing.

2) Tandem Walk Test

Tandem Walk Test was evaluated only one trial. The method of this test is the following (Figure 3.7) :

2.1 Before testing, the subjects' hands were placed on hips (positioned at iliac crest). The subject was instructed to stand in tandem position (heel-to-toe) and keep the erect position.

2.2 When the subject was ready, the examiner told him/her to walk in heel-to-toe on a straight line and counted the number of step so that subject could walk with error.

The error step was defined as follows:

- Feet were not in heel-to-toe position when walking.
- Feet apart from the other or step off the referenced line.
- Grasp the objects or the examiner.

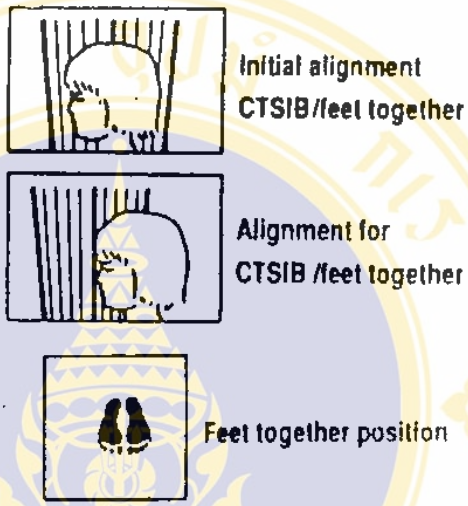

Figure 3.6 Alignment for testing and backdrop used for measuring degree of sway for the P-CTSIB.

3) Single-limb stance position

Single – limb stance position was performed on each leg with both eyes open and closed. Duration of balance maintained was recorded by a digital stopwatch. The dominant leg was first performed for only on trial, then testing the other leg. Dominant leg could be judged using the simple dominant leg tests (in Appendix C). The method of this test was as follows (Figure 3.8) :-

3.1 The subject was instructed to place hands on hips (positioned at iliac crest) and stand in single-limb stance (both dominant and non-dominant leg) with eyes open. When the subject was ready, the examiner measured the time that subject could maintain balance in erect position.

3.2 Next, the subject placed hands on hips and stood on one leg with eyes closed. When the subject was ready, the examiner measured the time that subject could maintain balance in erect position.

3.3 Degrees of sway from each condition was observed and measured from the videotape recorded while the subject performed the test.

Figure 3.7 Tandem Walk Test.

Figure 3.8 Single – limb Stance testing.

Procedure of the Study

Random selection of subjects from public schools
for each of 8 groups (Appendix C)

↓

Subjects received a physical ability screening test

↓

Subjects who failed the screening test were replaced by
random selection from the rest of the students in his/her classroom

↓

P-CTSIB testing, each condition performed 2 trials
(2 minutes rest between each trial and between each condition)

↓

3 minutes rest

↓

Subjects performed tandem walk test (only one trial)

↓

3 minutes rest

↓

Subjects performed single-limb stance with eyes opened and eyes closed
(both dominant and non-dominant legs)

3.5 Data analysis

The SPSS for Windows Release 10.0.0 program was used for statistical analysis in this study. The statistical significant was set at $p \leq 0.05$.

1. Komogorov - Smirnov goodness of fit-test was used for testing for normal distribution of the data.
2. Independent t–test was used to test the difference on the following variables; degree of sway of the P-CTSIB, degree of sway and duration of stance from the Single-limb Stance between genders when data showed normal distribution.
3. Mann-Whitney U test was used to test the difference on the following variables; degree of sway of the P-CTSIB, degree of sway and duration of stance from the Single-limb Stance between genders when the data was not normally distributed.
4. Kruskal–Wallis test was used to determine the difference between 4 age groups. Moreover, when calculated results showed significant differences, multiple comparison analysis was selected to test the difference between each pair of age groups.
5. Spearman Rank Correlation was used to assess the relationship among ordinal data or not normally distributed data.

CHAPTER 4
RESULTS

Comparisons of all parameters between genders and age groups while performing 3 tests including the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB), the Single–limb Stance and Tandem walk test in 120 healthy Thai children aged 4 years to 7 years 11 months were investigated.

4.1 Comparison of variables between genders

4.1.1 Comparison of age between genders

A convenient sample of 120 children aged from 4 years to 7 years 11 months were included in this study. They were divided into 4 age groups; 4 years to 4 years 11 months, 5 years to 5 years 11 months, 6 years to 6 years 11 months and 7 years to 7 years 11 months as shown in Table 4.1. Each age group was composed of 30 subjects; 15 boys and 15 girls. There was no significant difference in age between boys and girls in each age groups ($p>0.05$).

Table 4.1 Comparison of age between boys (n = 15 in each group) and girls (n = 15 in each group)

Groups	Boys (month) (mean ± SD)	Girls (month) (mean ± SD)	p-value
Age 4 years to 4 years 11 months	56.47 ± 3.07	57.53 ± 1.13	0.572[a]
Age 5 years to 5 years 11 months	67.67 ± 2.16	68.27 ± 1.94	0.272 [a]
Age 6 years to 6 years 11 months	77.60 ± 4.12	78.33 ± 3.18	0.462 [a]
Age 7 years to 7 years 11 months	88.80 ± 2.76	89.00 ± 3.02	0.851[b]

a = Mann-Whitney U test
b = Independent Sample t-test
* = Statistical Significant at $p < 0.05$

4.1.2 Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)

1) Comparison of degree of sway between genders

Table 4.2 shows the comparison of degree of sway while performing 6 conditions of the P-CTSIB between boys and girls.

There were significant ($p<0.05$) differences in degree of sway in the condition of eyes closed, wearing visual conflict dome while standing on floor, eyes open and wearing visual conflict dome while standing on density foam between boys and girls aged between 4 years to 4 years 11 months as shown in Table 4.2 and Figure 4.1. Additionally, significant ($p<0.05$) difference in degree of sway between boys and girls aged between 5years to 5 years 11 months was found in the condition of wearing visual conflict dome while standing on floor (Figure 4.2). It was revealed that significant ($p<0.05$) difference in degree of sway in the condition eyes open while standing on floor was found between boys and girls aged between 6 years to 6 years 11 months (Figure 4.3). However, no significant difference in degree of sway in all P-CTSIB conditions between boys and girls aged between 7 years to 7 years 11 months was observed (Figure 4.4).

Table 4.2 Comparison of degree of sway while performing 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) between boys (n=15) and girls (n=15) in each age group

Conditions	Degrees of sway (°)											
	4 years – 4 years 11 months			5 years – 5 years 11 months			6 years – 6 years 11 months			7 years – 7 years 11 months		
	Boys	Girls	p-value [a]	Boys	Girls	p-value	Boys	Girls	p-value [a]	Boys	Girls	p-value [a]
Eyes open + floor	3.60±1.35	2.87±0.83	0.153	3.13±0.83	2.67±1.11	0.180 [a]	2.60±0.83	1.93±0.46	0.011 *	2.47±0.74	2.13±0.83	0.258
Eyes closed + floor	4.67±1.35	3.47±0.74	0.014 *	3.67±1.18	3.20±0.94	0.227 [a]	3.40±0.91	2.87±0.74	0.110	3.00±1.13	2.53±0.85	0.742
Dome + floor	4.47±0.92	3.73±0.70	0.026 *	4.40±1.12	3.53±0.99	0.046 [a] *	3.33±0.72	3.67±1.11	.0.374	3.00±1.00	3.67±1.40	0.204
Eyes open + foam	4.40±1.18	3.53±0.99	0.040 *	3.20±1.01	3.40±0.99	0.442 [a]	3.07±0.80	3.40±0.91	0.291	2.60±0.74	2.40±0.83	0.430
Eyes closed + foam	6.07±1.44	5.20±1.15	0.082	5.07±1.16	4.53±1.64	0.313 [b]	4.67±1.35	4.13±0.83	0.369	4.07±0.96	3.60±0.99	0.174
Dome + foam	5.87±1.13	5.07±0.88	0.046 *	5.07±1.33	4.40±1.06	0.132 [a]	4.40±1.24	3.67±0.82	0.117	3.60±0.99	3.80±1.26	0.678

a = Mann – Whitney U Test
b = Independent samples t-test
* = Statistical Significant at $p < 0.05$

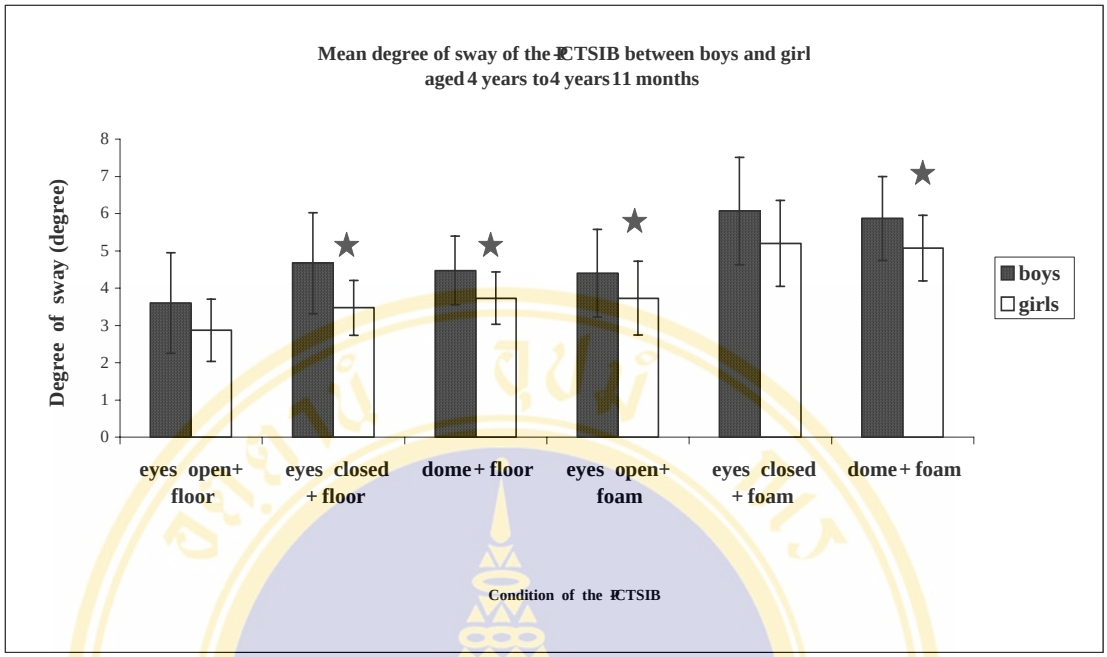

Figure 4.1 Comparison of degree of sway obtained from P-CTSIB between boys and girls aged 4 years to 4 years 11 months.

★ Significant ($p<0.05$) difference from boys

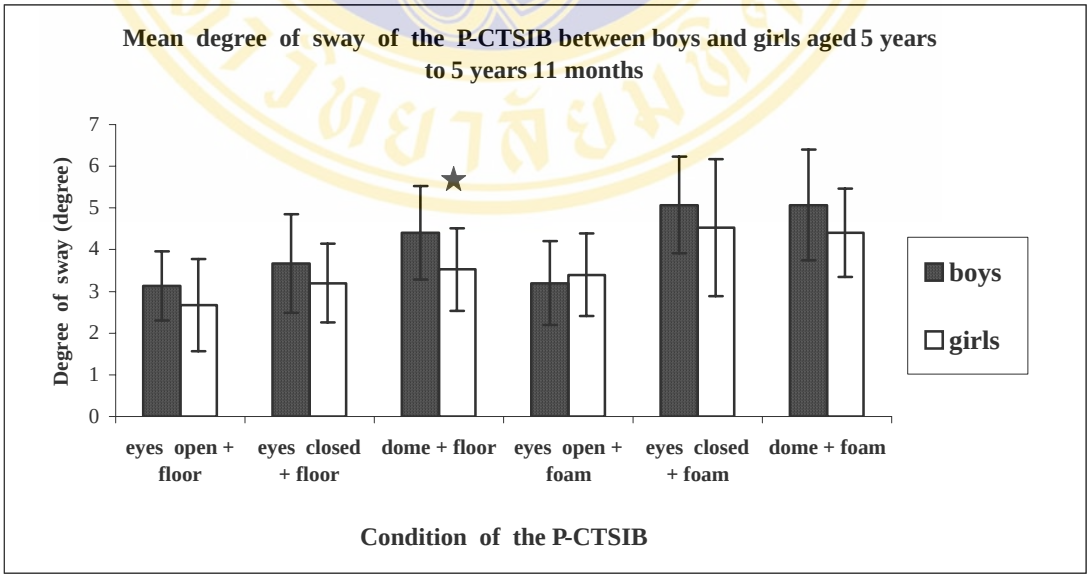

Figure 4.2 Comparison of degree of sway obtained from P-CTSIB between boys and girls aged 5 years to 5 years 11 months.

★ Significant ($p<0.05$) difference from boys

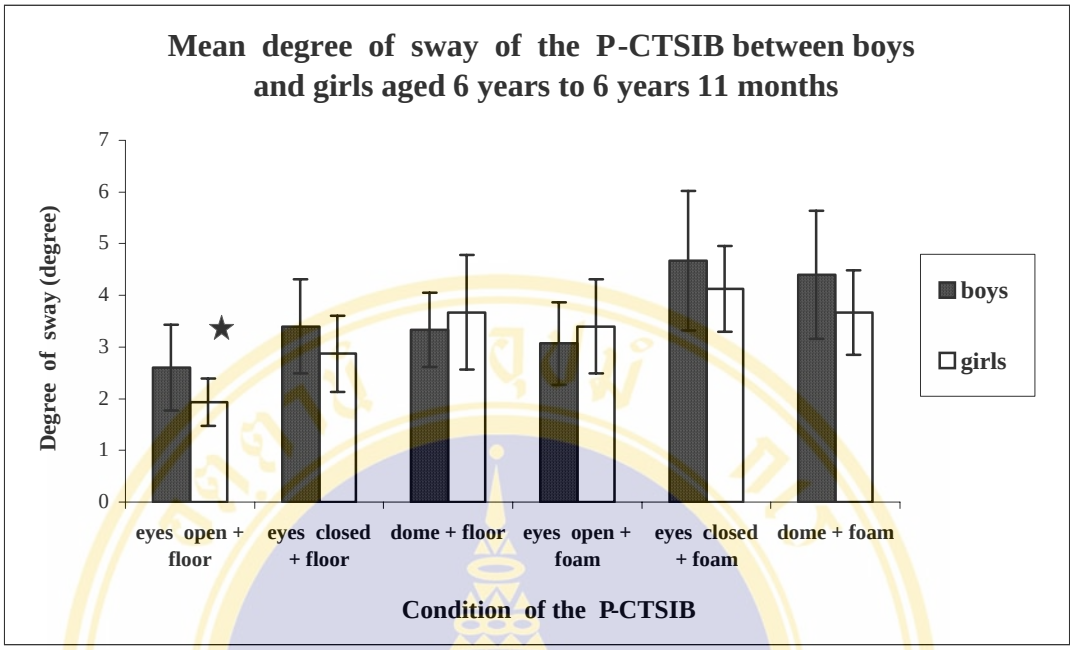

Figure 4.3 Comparison of degree of sway obtained from P-CTSIB between boys and girls aged 6 years to 6 years 11 months.

★ Significant ($p<0.05$) difference from boys

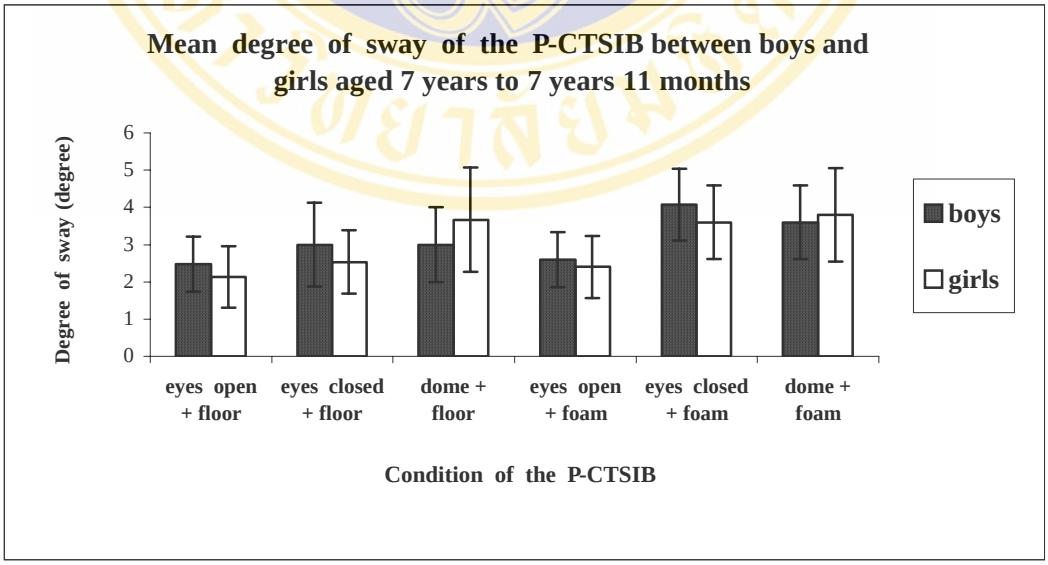

Figure 4.4 Comparison of degree of sway obtained from P-CTSB between boys and girls aged 7 years to 7 years 11 months.

2) Comparison of duration of stance while performing 6 conditions of the P-CTSIB between boys and girls

Results of duration while performing 6 conditions of the P-CTSIB showed that both boys and girls could stand for 30 seconds in each conditions. Thus, there was no significant difference in this parameter for all conditions of the P-CTSIB between boys and girls.

3) Comparison of strategy movement while performing 6 conditions of the P-CTSIB between boys and girls

The comparison of movement strategy while performing 6 conditions of the P-CTSIB between boys and girls aged between 4 years to 4 years 11 months, 5 years to 5 years 11 months, 6 years to 6 years 11 months and 7 years to 7 years 11 months are shown in Table 4.3, 4.4, 4.5 and 4.6, respectively.

From Table 4.3, it was shown that girls aged between 4 years to 4 years 11 months tended to use suspensory strategy more frequently than boys of the same age. In addition, girls aged 7 years to 7 years 11 months tended to use hip strategy in the conditions eyes open while standing on density foam, eyes closed while standing on density foam often than boys. For the other age groups, both boys and girls showed similar movement strategies as shown in Table 4.4, Table 4.5 and Table 4.6.

Table 4.3. Comparison of movement strategy while performing 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) between boys (n= 15) and girls (n = 15) aged between 4 years to 4 years 11 months

Sex / P-CTSIB	Movement Strategy (%) for children aged 4years to 4 years 11 months							
	Boys (Frequency)				Girls (Frequency)			
	A	H	ST	SU	A	H	ST	SU
Eyes Open + Floor	100.00	-	-	-	100.00	-	-	-
Eyes Closed + Floor	93.33	6.67	-	-	93.33	6.67	-	-
Dome + Floor	100.00	-	-	-	86.66	6.67	-	6.67
Eyes Open + Foam	60.00	40.00	-	-	53.33	33.33	-	13.34
Eyes Closed + Foam	6.67	66.66	-	26.67	6.67	53.33	-	40.00
Dome + Foam	-	73.33	-	26.67	6.67	66.66	-	26.67

A = Ankle Strategy
H = Hip Strategy
ST = Stepping Strategy
SU = Suspensory Strategy

Table 4.4. Comparison of movement strategy while performing 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) between boys (n= 15) and girls (n = 15) aged between 5 years to 5 years 11 months

Sex / P-CTSIB	Movement Strategy (%) for children aged 5 years to 5 years 11 months							
	Boys (Frequency)				Girls (Frequency)			
	A	H	ST	SU	A	H	ST	SU
Eyes Open + Floor	100.00	-	-	-	100.00	-	-	-
Eyes Closed + Floor	100.00	-	-	-	100.00	-	-	-
Dome + Floor	80.00	20.00	-	-	86.66	13.34	-	-
Eyes Open + Foam	33.33	66.67	-	-	40.00	60.00	-	-
Eyes Closed + Foam	6.67	80.00	-	13.34	-	80.00	-	20.00
Dome + Foam	-	53.33	6.67	40.00	-	73.33	-	26.67

A = Ankle Strategy
H = Hip Strategy
ST = Stepping Strategy
SU = Suspensory Strategy

Table 4.5. Comparison of movement strategy while performing 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) between boys (n= 15) and girls (n = 15) aged between 6 years to 6 years 11 months

Sex / P-CTSIB	Movement Strategy (%) for children aged 6 years to 6 years 11 months							
	Boys (Frequency)				Girls (Frequency)			
	A	H	ST	SU	A	H	ST	SU
Eyes Open + Floor	100.00	-	-	-	100.00	-	-	-
Eyes Closed + Floor	100.00		-	-	100.00	-	-	-
Dome + Floor	86.66	13.34	-	-	93.33	6.67	-	-
Eyes Open + Foam	66.67	33.33	-	-	93.33	6.67	-	-
Eyes Closed + Foam	80.00	-	-	20.00	20.00	73.33	-	6.67
Dome + Foam	6.67	60.00	-	33.33	20.00	73.33	-	6.67

A = Ankle Strategy
H = Hip Strategy
ST = Stepping Strategy
SU = Suspensory Strategy

Table 4.6. Comparison of movement strategy while performing 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) between boys (n=15) and girls (n =15) aged between 7 years to 7 years 11 months

Sex / P-CTSIB	Movement Strategy (%) for children aged 7 years to 7 years 11 months							
	Boys (Frequency)				Girls (Frequency)			
	A	H	ST	SU	A	H	ST	SU
Eyes Open + Floor	100.00	-	-	-	100.00	-	-	-
Eyes Closed + Floor	100.00	-	-	-	100.00	-	-	-
Dome + Floor	100.00	-	-	-	100.00	-	-	-
Eyes Open + Foam	86.67	13.33	-	-	73.33	26.67	-	-
Eyes Closed + Foam	60.00	33.33	-	6.67	20.00	73.33	-	6.67
Dome + Foam	73.33	13.33	6.67	6.67	20.00	73.33	-	6.67

A = Ankle Strategy
H = Hip Strategy
ST = Stepping Strategy
SU = Suspensory Strategy

4.1.3 The Single-limb Stance

1) Comparison of degree of sway between boys and girls while performing single-limb stance

Table 4.7 shows the means and standard deviation of degree of sway while performing the Single-limb Stance in the condition of eyes open and eyes closed while standing on dominant and non-dominant leg between boys and girls aged between 4 years to 4 years 11 months, 5 years to 5 years 11 months, 6 years to 6 years 11 months and 7 years to 7 years 11 months, respectively.

There were no significant difference in degree of sway between boys and girls aged 4 years to 4 years 11 months (Figure 4.5), aged 5 years to 5 years 11 months (Figure 4.6) and aged 6 years to 6 years 11 months (Figure 4.7) while performing in all conditions of the single-limb stance ($p>0.05$).

However, there was significant difference in degree of sway between boys and girls aged 7 years to 7 years 11 months in the condition of standing on dominant leg with eyes closed. No difference was observed in degree of sway between boys and girls at this age in the condition of standing on dominant leg with eyes open, standing on non-dominant leg with eyes either open or closed (Figure 4.8).

Table 4.7 Comparison of degree of sway while performing the single-limb stance on dominant and non-dominant leg with eyes open and eyes closed between boys (n = 15) and girls (n = 15) in each age group

Conditions	Degrees of sway (°)											
	4 years – 4 years 11 months			5 years – 5 years 11 months			6 years – 6 years 11 months			7 years – 7 years 11 months		
	Boys	Girls	p-value	Boys	Girls	p-value[b]	Boys	Girls	p-value[b]	Boys	Girls	p-value[b]
Eyes open + dominant	3.67±1.63	3.60±1.64	0.912[a]	3.80±1.37	3.60± .06	0.446	3.67±0.82	3.53±1.51	0.777	3.40±1.24	3.13±1.36	0.327
Eyes closed + dominant	2.20±0.86	2.33±1.29	0.742[a]	1.73± .88	2.53±1.36	0.063	2.53±1.06	2.40±1.18	0.600	3.20±1.26	2.20±1.01	0.029*
Eyes open + non-dominant	3.60±1.12	3.67±1.68	0.816[b]	3.27± .09	3.67±1.40	0.237	3.47±0.99	3.47±1.25	0.949	2.67±0.98	2.80±1.26	0.930
Eyes closed + non-dominant	1.93±0.88	2.67±1.23	0.088[b]	2.47±1.51	2.27±0.96	0.931	2.53±1.36	2.60±1.18	0.730	2.20±0.94	2.33±1.05	0.679

a = Independent Sample t-test
b = Mann – Whitney U Test
* = Statistical Significant at $p < 0.05$

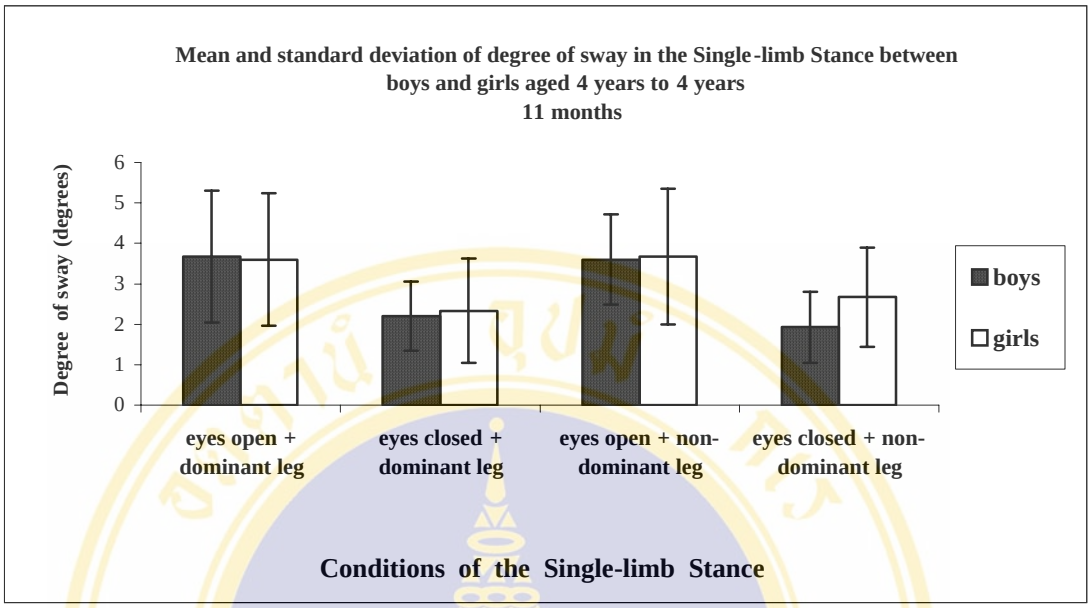

Figure 4.5 Comparison of degree of sway obtained from the Single-limb Stance between boys and girls aged 4 years to 4 years 11 months.

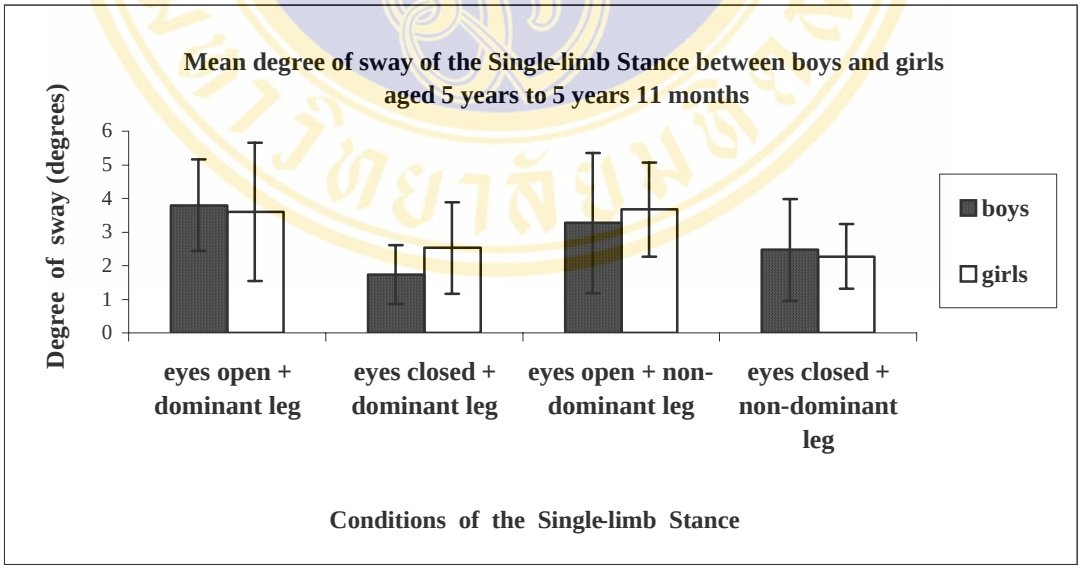

Figure 4.6 Comparison of degree of sway obtained from the Single-limb Stance between boys and girls aged 5 years to 5 years 11 months.

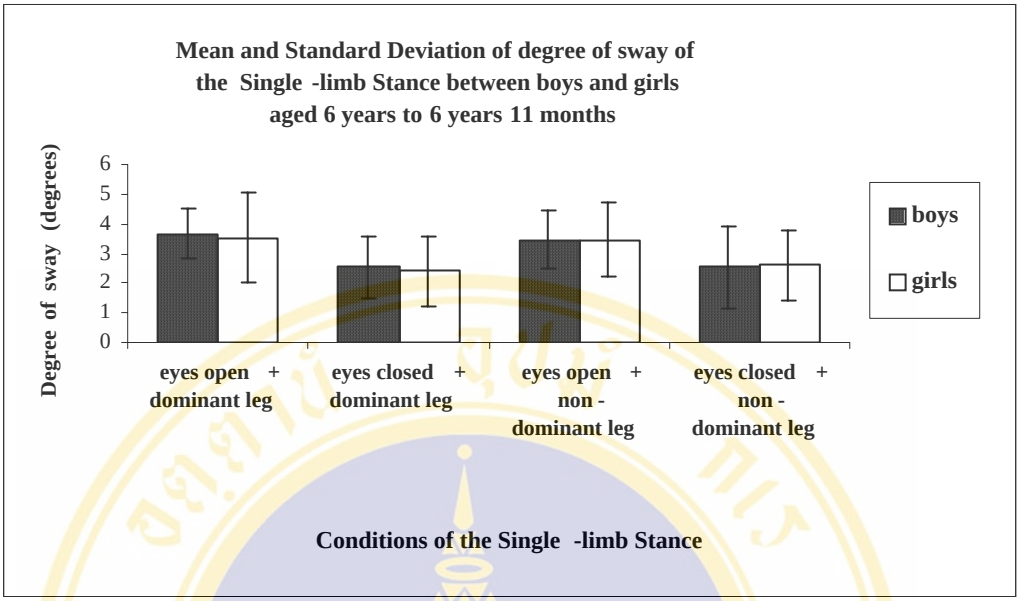

Figure 4.7 Comparison of degree of sway obtained from the Single-limb Stance between boys and girls aged 6 years to 6 years 11 months.

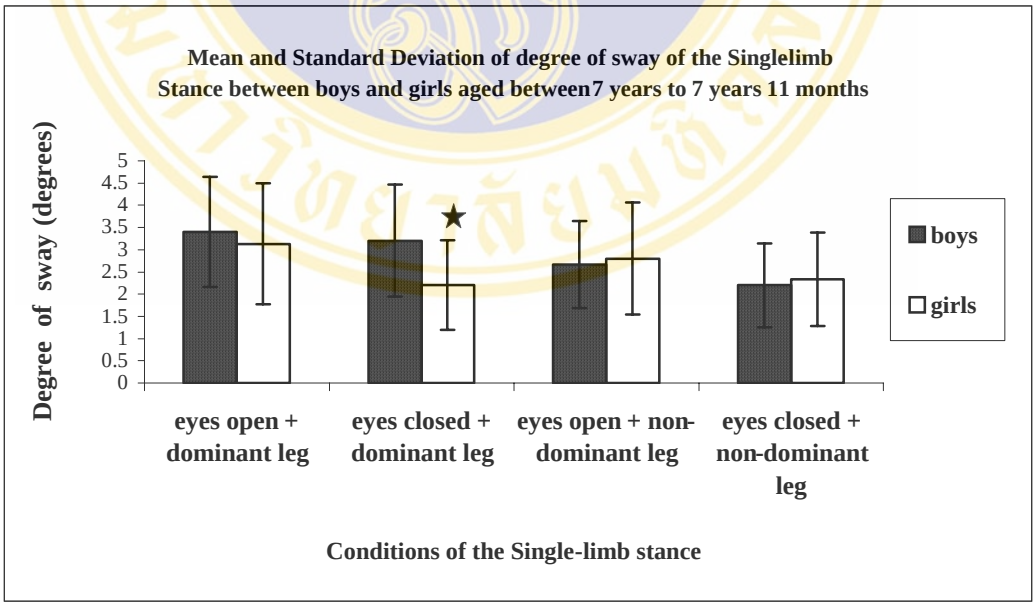

Figure 4.8 Comparison of degree of sway obtained from the Single-limb Stance between boys and girls aged 7 years to 7 years 11 months.

★ Significant ($p<0.05$) difference from boys

2) Comparison of duration of stance while performing the Single-limb Stance between boys and girls

Table 4.8 presents means and standard deviation of duration of Single-limb Stance in the condition of eyes open and eyes closed while standing on dominant and non-dominant leg.

There were significant ($p<0.05$) differences in duration of single-limb stance in the condition of eyes open while standing on dominant leg and in the condition of eyes closed while standing on non-dominant leg between boys and girls aged 4 years to 4 years 11 months (Table 4.8 and Figure 4.9). In addition, significant ($p<0.05$) differences in duration of stance between boys and girls aged 6 years to 6 years 11 months in the conditions of eyes open while standing on dominant and non-dominant leg were found (Table 4.8 and Figure 4.11).

There was no difference in stance duration between boys and girls aged 5 years to 5 years 11 months (Figure 4.10) as well as boys and girls aged 7 years to 7 years 11 months (Figure 4.12) in all conditions of single-limb stance.

Table 4.8 Comparison of duration of Single–limb Stance between boys (n=15 in each age group) and girls (n=15 in each age group) in 4 aged groups

Conditions	Duration of Single – limb Stance (sec.)											
	4 years – 4 years 11 months			5 years – 5 years 11 months			6 years – 6 years 11 months			7 years – 7 years 11 months		
	boys	girls	p-value[a]	boys	girls	p-value[a]	boys	girls	p-value[a]	boys	girls	p-value[a]
Eyes open + Dominant	11.33±7.83	19.40 ± 11.51	0.030*	15.67 ± 11.79	15.80 ± 10.26	0.950	18.60 ± 9.83	27.20 ± 5.61	0.006*	17.67 ±10.61	22.80 ± 9.20	0.187
Eyes closed + Dominant	3.40 ± 3.44	5.33 ± 5.50	0.257	3.60 ± 4.27	3.87 ± 1.81	0.123	2.80 ± 2.11	8.47 ± 9.20	0.234	6.60 ± 7.94	8.27 ± 10.62	0.475
Eyes open + Non-dominant	11.33 ± 7.55	14.80 ± 11.99	0.588	12.60 ± 13.16	16.00 ± 9.99	0.315	11.67± 11.61	24.93 ± 8.10	0.003*	16.33± 9.98	22.87 ± 8.77	0.093
Eyes closed + Non-dominant	1.73 ± 1.33	6.00 ± 5.41	0.001*	3.00 ± 3.66	3.13 ± 2.67	0.444	4.40 ± 3.44	7.47 ± 7.20	0.242	5.40 ± 7.36	5.40 ± 6.13	0.486

a = Mann – Whitney U Test

* = Statistical Significant at $p < 0.05$

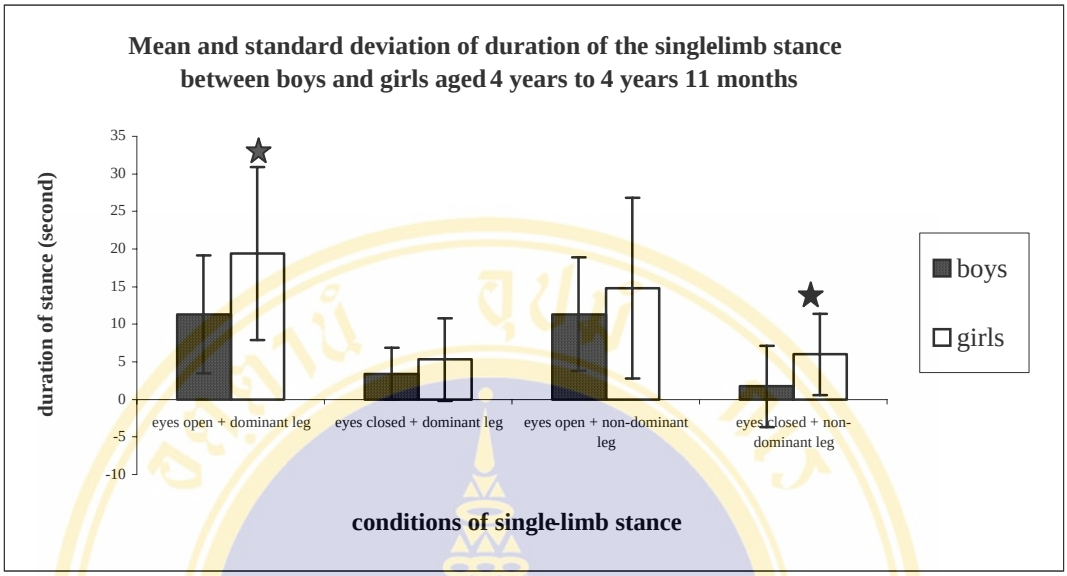

Figure 4.9. Comparison of stance duration obtained from the Single-limb Stance between boys and girls aged 4 years to 4 years 11 months.

★ = Significant ($p<0.05$) difference from boys

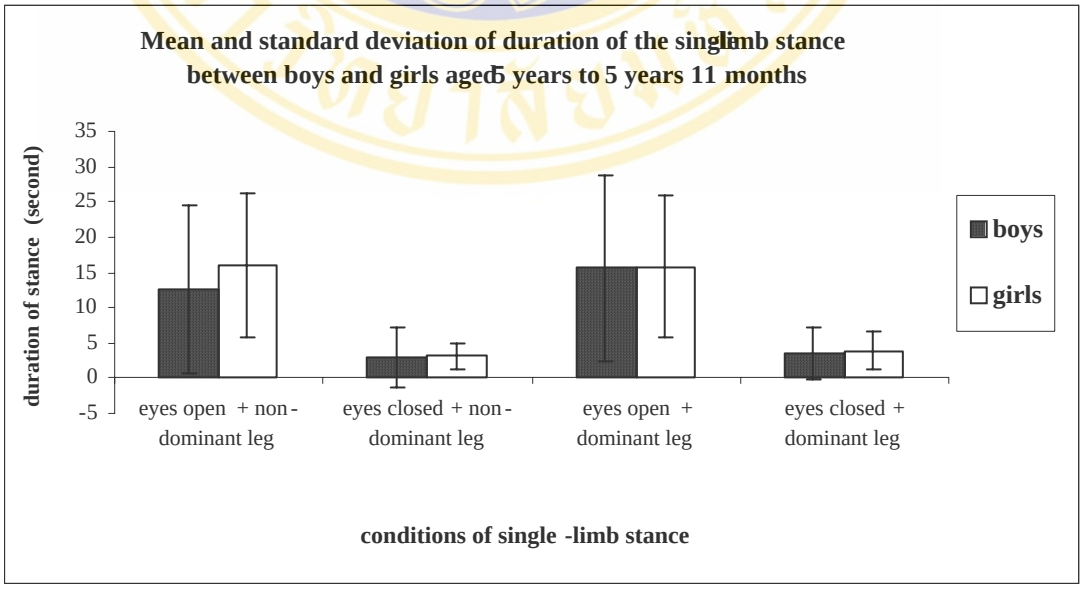

Figure 4.10. Comparison of stance duration obtained from the Single-limb Stance between boys and girls aged 5 years to 5 years 11 months.

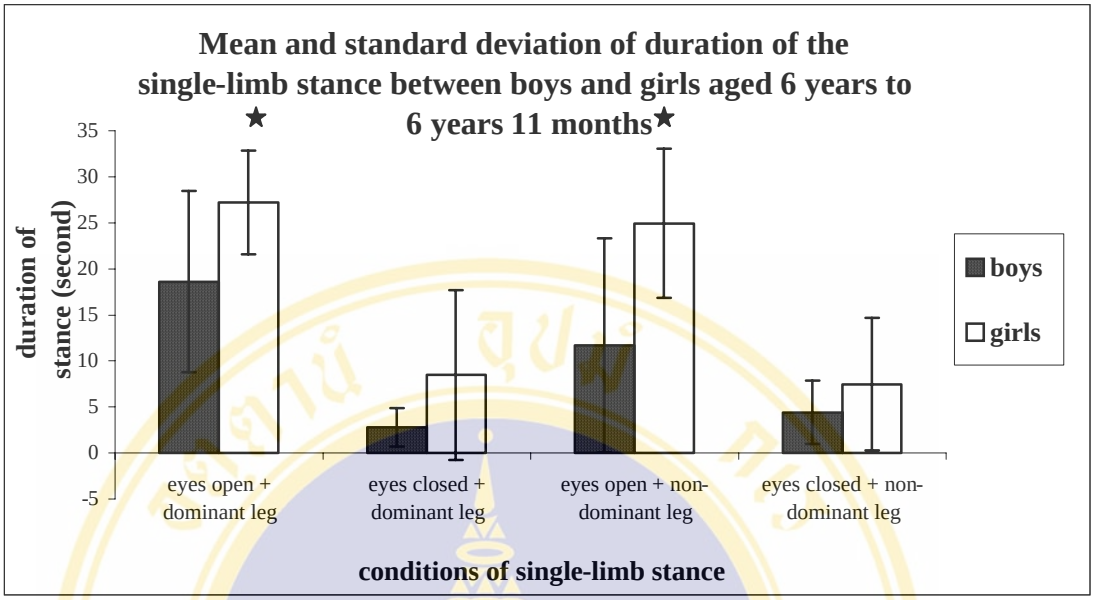

Figure 4.11. Comparison of stance duration obtained from the Single-limb Stance between boys and girls aged 6 years to 6 years 11 months.

★ = Significant ($p<0.05$) difference from boys

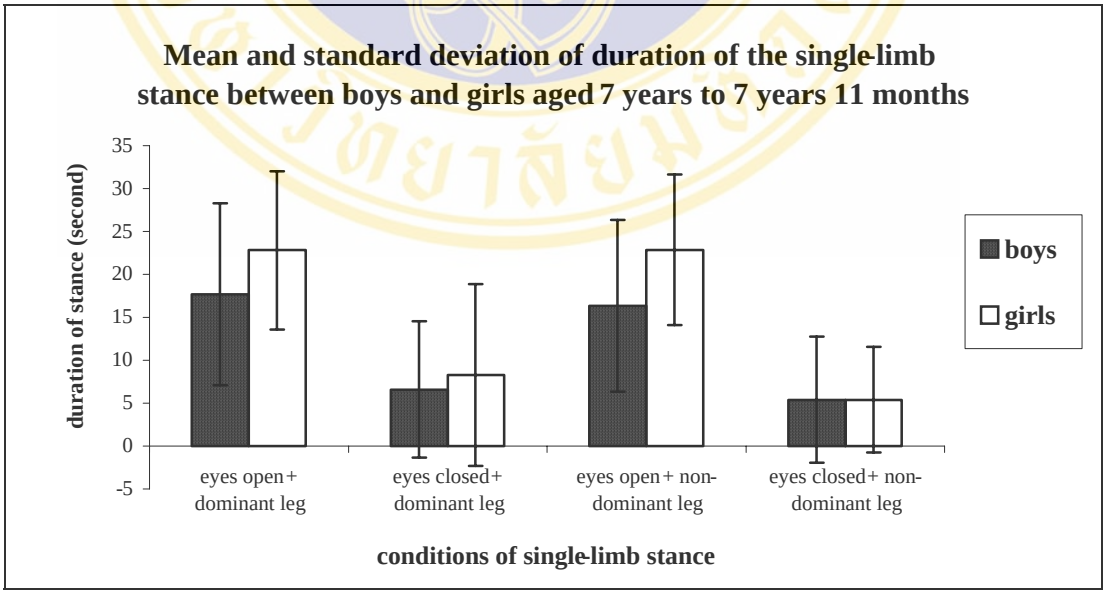

Figure 4.12. Comparison of stance duration obtained from the Single-limb Stance between boys and girls aged 7 years to 7 years 11 months.

4.1.4 Tandem walk test

1) Comparison of the number of error step between genders

Parameter of tandem walk test was the number of error steps. Table 4.9 presents the minimum, maximum and median from number of error steps between boys and girls in each age groups.

From Table 4.9, the number of error steps in boys were higher than in girls at the same age. However, the minimum in number of error steps were equal between boys and girls. Median number of error steps in boys tended to be less than girls in the same age.

Table 4.9. Number of error steps in Tandem walk test between boys (n=15 in each group) and girls (n=15 in each group)

Age groups	Number of error steps (step)					
	minimum		maximum		median	
	boys	girls	boys	girls	boys	girls
4 years – 4 years 11 months	0	0	16	14	5.00	6.00
5 years –5 years 11 months	0	0	15	9	3.00	2.00
6 years – 6 years 11 months	0	0	14	7	3.00	2.00
7 years –7 years 11 months	0	0	15	9	1.00	2.00

4.2 Comparison of variables between age groups

4.2.1 Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)

1) Comparison of degree of sway between age groups

Mean and standard deviation (SD) of degree of sway for 6 conditions of the P-CTSIB obtained from 4 age groups are shown in the Table 4.2. Result from the Kruskal wallis Test revealed the significant ($p<0.05$) differences between age groups in 6 conditions of the P-CTSIB. Therefore, multiple comparison was used to determine the significant difference between each pair of mean degree of sway.

In Table 4.10 and 4.11 and Figure 4.13 and 4.14 presents the comparison of degree of sway between 4 age groups obtained from the P-CTSIB of boys and girls, respectively.

There was significant ($p<0.05$) differences in degree of sway between boys aged 4 years to 4 years11months and 5 years to 5 years 11 months in the conditions of eyes closed while standing on floor and eyes open while standing on density foam (Table 4.10, Figure 4.13).

Table 4.10. Comparison of degree of sway obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) in boys between 4 age groups (n =15 in each age group)

Conditions	P – value[#]					
	Group1 and Group2	Group1 and Group3	Group1 and Group4	Group2 and Group3	Group2 and Group4	Group3 and Group4
Eyes open + floor	0.583	0.032*	0.006*	0.100	0.029*	0.507
Eyes closed + floor	0.039*	0.005*	0.002*	0.625	0.070	0.176
Dome + floor	0.846	0.001*	0.001*	0.008*	0.003*	0.271
Eyes open + foam	0.003*	0.002*	0.000*	0.929	0.071	0.106
Eyes closed + foam	0.088	0.004*	0.000*	0.191	0.019*	0.232
Dome + foam	0.087	0.002*	0.000*	0.168	0.003*	0.071

[#] = Kruskal Wallis Test and multiple comparison when appropriated
* = Statistical Significant at $p < 0.05$
Group 1 = boys aged between 4 to 4 years 11 months
Group 2 = boys aged between 5 to 5 years 11 months
Group 3 = boys aged between 6 to 6 years 11 months
Group 4 = boys aged between 7 to 7 years 11 months

Table 4.11. Comparison of degree of sway obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) in girls between 4 age groups (n=15 in each age group)

Conditions	P – value[#]					
	Group1 and Group2	Group1 and Group3	Group1 and Group4	Group2 and Group3	Group2 and Group4	Group3 and Group4
Eyes open + floor	0.542	0.001*	0.027*	0.030*	0.161	0.518
Eyes closed + floor	0.281	0.042*	0.151	0.369	0.660	0.659
Dome + floor	0.449	0.654	0.438	0.731	0.983	0.813
Eyes open + foam	0.776	0.859	0.003*	0.948	0.007*	0.006*
Eyes closed + foam	0.208	0.007*	0.001*	0.667	0.084	0.089
Dome + foam	0.036*	0.000*	0.006*	0.057	0.147	0.931

[#] = Kruskal Wallis Test and multiple comparison when appropriated
* = Statistical Significant at $p < 0.05$
Group 1 = girls aged between 4 to 4 years 11 months
Group 2 = girls aged between 5 to 5 years 11 months
Group 3 = girls aged between 6 to 6 years 11 months
Group 4 = girls aged between 7 to 7 years 11 months

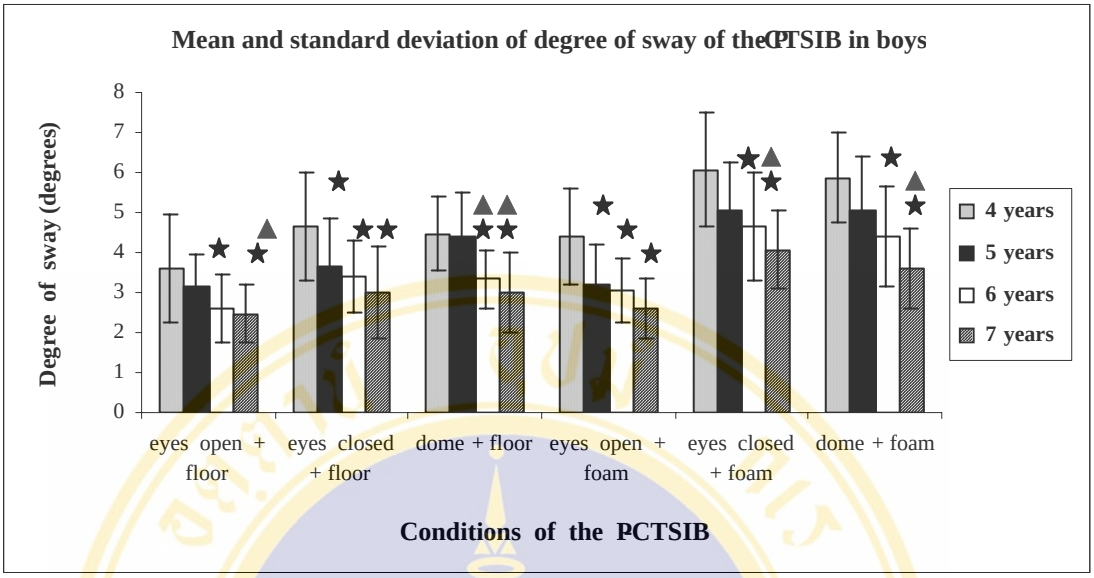

Figure 4.13. Mean and Standard Deviation (SD) of degree of sway from 6 conditions of the P-CTSIB 4 age groups of boys.

★ = $p < 0.05$ significant difference from 4 years to 4 years 11 months

▲ = $p < 0.05$ significant difference from 5 years to 5 years 11 months

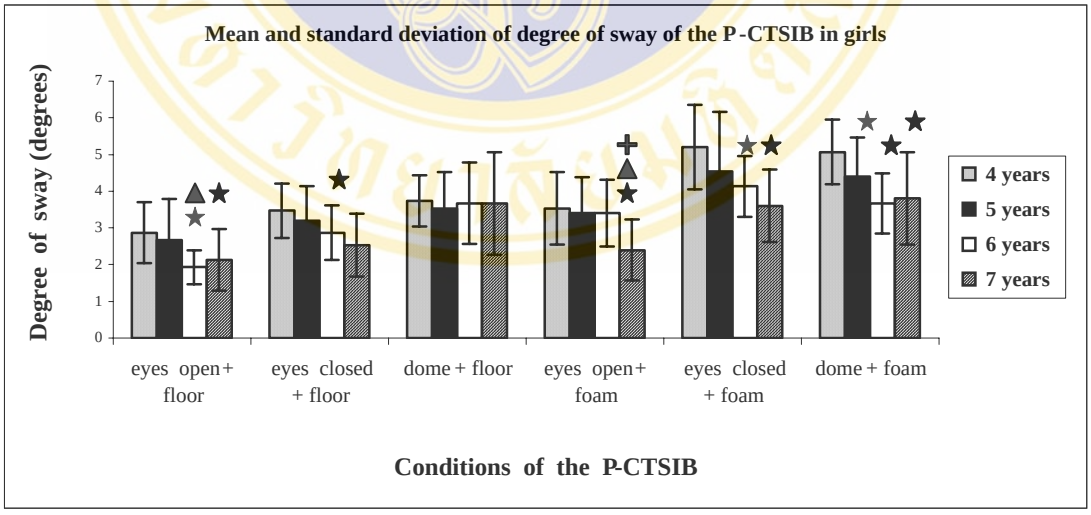

Figure 4.14. Mean and Standard Deviation (SD) of degree of sway from 6 conditions of the P-CTSIB in 4 age groups of girls.

★ = $p < 0.05$ significant difference from 4 years to 4 years 11 months

▲ = $p < 0.05$ significant difference from 5 years to 5 years 11 months

✚ = $p < 0.05$ significant difference from 6 years to 6 years 11 months

Moreover, comparison of degree of sway between boys aged 4 years to 4 years 11 months and aged 6 years to 6 years 11 months as well as between boys aged 4 years to 4 years 11 months and aged 7 years to 7 years 11 months showed significant ($p<0.05$) differences in all conditions of the P-CTSIB.

There were significant ($p<0.05$) differences in degree of sway of the P-CTSIB between boys aged 5 years to 5 years 11 months and aged 6 years to 6 years 11 months in condition of wearing visual conflict dome while standing on floor. Comparison of degree of sway between boys aged 5 years to 5 years 11 months and aged 7 years to 7 years 11 months found significant ($p<0.05$) differences in the conditions of eyes open, wearing visual conflict dome while standing on floor and eyes closed, wearing visual conflict dome while standing on density foam.

However, comparison of degree of sway between boys aged 6 years to 6 years 11 months and aged 7 years to 7 years 11 months presents no significant differences ($p>0.05$) in all conditions of the P-CTSIB. Table 4.11 shows the difference in degree of sway in girls aged 4 years to 4 years 11 months to 7 years to 7 years 11 months in all conditions of P-CTSIB.

A significant ($p>0.05$) difference in degree of sway was observed between girls aged 4 years to 4 years 11 months and 5 years to 5 years 11 months in the condition of wearing visual conflict dome while standing on density foam (Table 4.11 and Figure 4.14).

Comparison of degree of sway between girls aged 4 years to 4 years 11 months and 6 years to 6 years 11 months found significant ($p<0.05$) differences in the conditions of eyes open as well as eyes closed while standing on floor, eyes closed as well as wearing visual conflict dome while standing on density foam. The significant ($p<0.05$) difference in the P-CTSIB degree of sway between girls aged 4 years to 4 years 11 months and 7 years to 7 years 11 months was found in the conditions of eyes

open while standing on floor and eyes open, eyes closed and wearing visual conflict dome while standing on density foam (Table 4.11 and Figure 4.14).

Comparison between girls aged 5 years to 5 years 11 months and 6 years to 6 years 11 months found significant ($p<0.05$) differences in the condition of eyes open while standing on floor. In addition, there was significant ($p<0.05$) difference in degree of sway between girls aged 5 years to 5 years 11 months and 7 years to 7 years 11 months in the condition of eyes open while standing on density foam (Table 4.11 and Figure 4.14).

As shown in Table 4.11 and Figure 4.14, there was significant ($p<0.05$) difference in degree of sway between girls aged 6 years to 6 years 11 months and 7 years to 7 years 11 months in the condition of eyes open while standing on density foam.

2) Comparison of duration while performing 6 conditions of the P-CTSIB between 4 age groups

Results of stance duration performed in 6 conditions of the P-CTSIB showed that all children in 4 age groups could stand for 30 seconds. Therefore, there was no significant difference between age groups in stance duration for all conditions of the P-CTSIB.

3) Comparison of strategy of movement while performing 6 conditions of P-CTSIB between 4 age groups

Table 4.12 shows the frequency of movement strategies in each age group. All children in all aged group used ankle strategy in the condition of eyes open while standing on floor.

As shown in table 4.12, all children aged 5 years to 7 years 11 months used ankle strategy in the condition of eyes closed while standing on floor. However,

most children aged 4 years to 4 years 11 months (73.33%) selected ankle strategy in the condition of eyes closed while standing on floor. There was 6.67% of children aged 4 years to 4 years 11 months using hip strategy in this condition.

In the condition of wearing visual conflict dome while standing on floor, all children aged 7 years to 7 years 11 months used ankle strategy. Most children aged 6 years to 6 years 11 months (90%), 5 years to 5 years 11 months (83.33%) and 4 years to 4 years 11 months (93.34%) selected ankle strategy in this condition. The rest of children aged 6 years to 6 years 11 months (10%) and 5 years to 5 years 11 months (16.67%) used hip strategy. For the rest of children aged 4 years to 4 years 11 months selected hip strategy (3.33%) and suspensory strategy (3.33%) for controlling standing balance in this condition (Table 4.12).

In the condition of eyes closed while standing on foam, most children aged 7 years to 7 years to 11 months (80%), 6 years to 6 years 11 months (80%) and 4 years to 4 years 11 months (56.66%) selected ankle strategy for standing balance. However, most children aged 5 years to 5 years 11 months (63.33%) used hip strategy and the rest of children (36.67%) used ankle strategy in this condition. The rest of children aged 7 years to 7 years 11 months (20%), aged 6 years to 6 years 11 months (20%) selected hip strategy. For the rest of children aged 4 years to 4 years 11 months selected hip strategy (36.67%) and suspensory strategy (6.67%) for controlling standing balance in this condition (Table 4.12).

In the condition of eyes closed while standing on density foam, most children aged 4 years to 4 years 11 months, 5 years to 5 years 11 months, 6 years to 6 years 11 months and 7 years to 7 years 11 months (60%, 80%, 76.67% and 53.33% respectively) selected hip strategy for standing balance. The rest of children aged 4 years to 4 years 11 months (33.33%), aged 5 years to 5 years 11 months (16.67%), aged 6 years to 6 years 11 months (13.33%) and aged 7 years to 7 years 11 months (6.67%) used suspensory strategy. For the rest of children aged 4 years to 4 years 11 months (6.67%), aged 5 years to 5 years to 11 months (3.33%), aged 6 years to 6

years 11 months (10%) and 7 years to 7 years 11 months (40%) selected ankle strategy for controlling standing balance in this condition (Table 4.12).

In the condition of wearing visual conflict dome while standing on foam, most children aged 4 years to 4 years 11 months (70%), aged 5 years to 5 years 11 months (63.33%) and aged 6 years to 6 years 11 months (66.67%) selected hip strategy for standing balance. However, most of children aged 7 years to 7 years 11 months selected ankle strategy (46.67%) used hip strategy and used hip strategy (43.33%) for this condition. The rest of children aged 4 years to 4 years 11 months (26.67%), aged 5 years to 5 years 11 months (33.34%), aged 6 years to 6 years 11 months (20%) and aged 7 years to 7 years 11 months (6.67%) selected suspensory strategy. Rest of children aged 4 years to 4 years 11 months (3.33%), aged 6 years to 6 years 11 months (13.33%) used ankle strategy. For the rest of children aged 5 years to 5 years 11 months (3.33%) and aged 7 years to 7 years 11 months (3.33%) selected suspensory strategy for controlling standing balance in this condition (Table 4.12).

4.2.2 The Single-limb Stance

1) Comparison of degree of sway between age groups

Mean and standard deviation (SD) of degree of sway obtained from the single-limb stance in 4 age groups was shown in Table 4.7, Table 4.13, Table 4.14 and Figure 4.15 and 4.16 show the comparison of degree of sway obtained from the single-limb stance in 4 age groups. Results of the Kruskal wallis Test revealed significant differences between age groups ($p<0.05$) in degree of sway during Single-limb stance. Therefore, Multiple comparison was used to determine the difference in each pair of data.

Table 4.12. The percentage of each age groups from the movement strategy of 6 conditions the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)

Conditions	Movement strategy (%)															
	4 years to 4 years 11 months				5 years to 5 years 11 months				6 years to 6 years 11 months				7 years to 7 years 11 months			
	A	H	ST	SU	A	H	ST	SU	A	H	ST	SU	A	H	ST	SU
Eyes open + floor	100.00	-	-	-	100.00	-	-	-	100.00	-	-	-	100.00	-	-	-
Eyes closed + floor	93.33	6.67	-	-	100.00	-	-	-	100.00	-	-	-	100.00	-	-	-
Dome + floor	93.34	3.33	-	3.33	83.33	16.67	-	-	90.00	10.00	-	-	100.00	-	-	-
Eyes open + foam	56.66	36.67	-	6.67	36.67	63.33	-	-	80.00	20.00	-	-	80.00	20.00	-	-
Eyes closed + foam	6.67	60.00	-	33.33	3.33	80.00	-	16.67	10.00	76.67	-	13.33	40.00	53.33	-	6.67
Dome + foam	3.33	70.00	-	26.67	-	63.33	3.33	33.34	13.33	66.67	-	20.00	46.67	43.33	3.33	6.67

A = Ankle strategy
H = Hip strategy
ST = Stepping strategy
SU = Suspensory strategy

For boys, there were no significant differences ($p>0.05$) in degree of sway in the conditions of eyes open while standing on dominant leg and eyes closed while standing on non-dominant leg between any aged group as shown in Table 4.13 and Figure 4.15. However, there were significant differences ($p<0.05$) in degree of sway in the condition of eyes closed while standing on dominant leg between boys aged 4 years to 4 years 11 months and 7 years to 7 years 11 months, between boys aged 5 years to 5 years 11 months and 6 years to 6 years 11 months as well as between boys aged 5 years to 5 years 11 months and 7 years to 7 years 11 months. There was significant ($p<0.05$) difference in degree of sway in the condition of eyes open while standing on non-dominant leg between boys aged 4 years to 4 years 11 months with aged 7 years to 7 years 11 months.

Table 4.14 and Figure 4.16 show no significant differences in degree of sway obtained from the Single-limb Stance in girls between any aged groups in all conditions except for the condition of standing on non-dominant leg with eyes open. In this condition it was found that there was significant ($p<0.05$) difference in degree of sway between girls aged 5 years to 5 years 11 months and girls aged 7 years to 7 years 11 months.

Table 4.13. Comparison of degree of sway for all 4 conditions of the Single-limb Stance in boys between 4 age groups (n=15 in each age group)

Conditions	**P – value**[#]					
	Group1 and Group2	**Group1 and Group3**	**Group1 and Group4**	**Group2 and Group3**	**Group2 and Group4**	**Group3 and Group4**
Eyes open + dominant leg	0.899	0.813	0.524	0.880	0.482	0.444
Eyes closed + dominant leg	0.106	0.403	0.022*	0.024*	0.002*	0.122
Eyes open + non-dominant leg	0.261	0.731	0.028*	0.298	0.744	0.041*
Eyes closed + non-dominant leg	0.403	0.204	0.419	0.729	0.877	0.566

[#] = Kruskal Wallis Test and multiple comparison when appropriated
* = Statistical Significant at $p < 0.05$
Group 1 = boys aged 4 years to 4 years 11 months
Group 2 = boys aged 5 years to 5 years 11 months
Group 3 = boys aged 6 years to 6 years 11 months
Group 4 = boys aged 7 years to 7 years 11 months

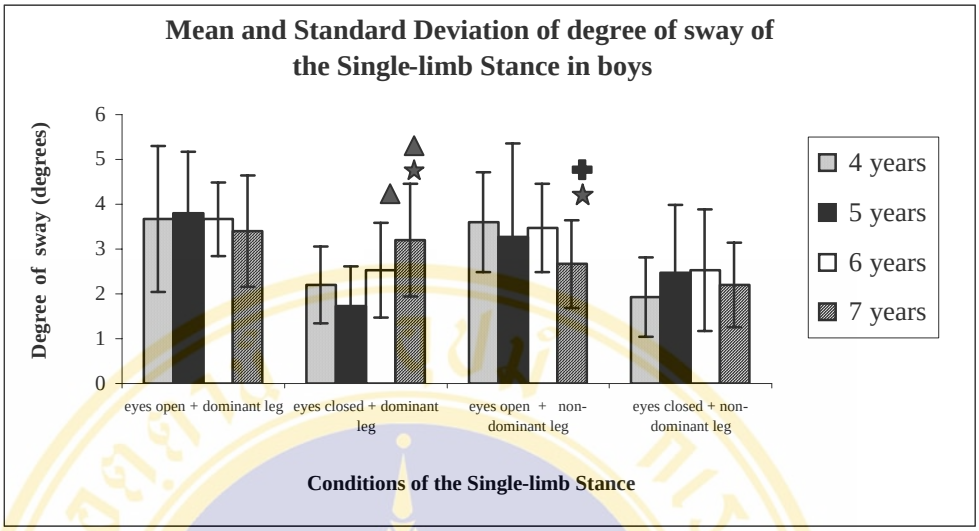

Figure 4.15. Mean and Standard Deviation (SD) of degree of sway obtained from the Single-limb Stance in 4 age groups of boys.

★ = $p < 0.05$ significance difference from 4 years to 4 years 11 months

▲ = $p < 0.05$ significance difference from 5 years to 5 years 11 months

✚ = $p < 0.05$ significance difference from 6 years to 6 years 11 months

Table 4.14. Comparison of degree of sway for all 4 conditions of the Single-limb Stance in girls between 4 age groups (n=15 in each age group)

Conditions	P – value[#]					
	Group1 and Group2	Group1 and Group3	Group1 and Group4	Group2 and Group3	Group2 and Group4	Group3 and Group4
Eyes open + dominant leg	0.655	0.881	0.257	0.671	0.650	0.253
Eyes closed + dominant leg	0.684	0.813	0.897	0.827	0.636	0.779
Eyes open + non-dominant leg	0.865	0.670	0.130	0.684	0.035*	0.139
Eyes closed + non-dominant leg	0.390	0.915	0.480	0.440	0.879	0.534

[#] = Kruskal Wallis Test and multiple comparison when appropriated
* = Statistical Significant at $p < 0.05$
Group 1 = girls aged 4 years to 4 years 11 months
Group 2 = girls aged 5 years to 5 years 11 months
Group 3 = girls aged 6 years to 6 years 11 months
Group 4 = girls aged 7 years to 7 years 11 months

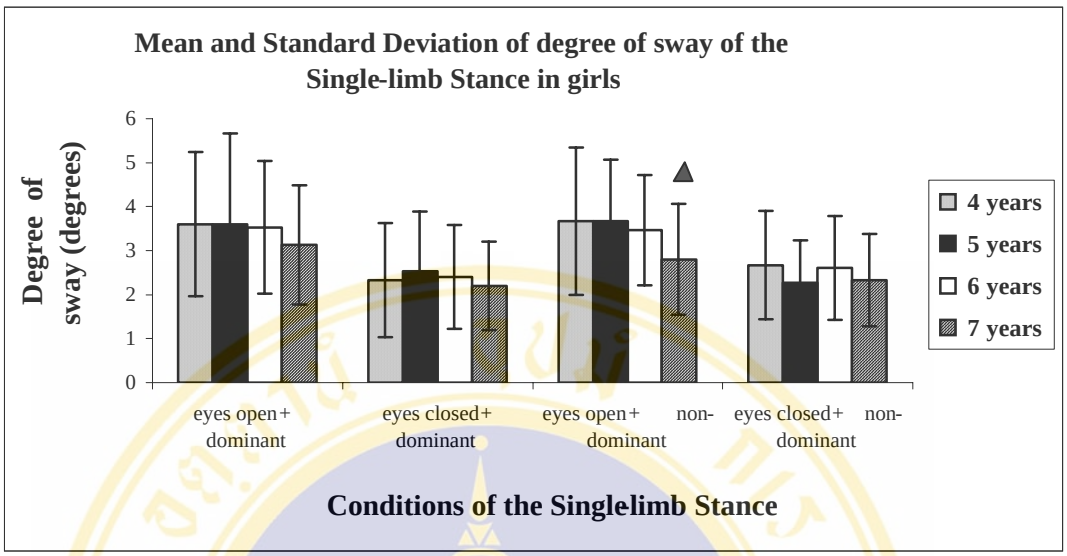

Figure 4.16. Mean and Standard Deviation (SD) of degree of sway obtained from the Single-limb Stance in 4 age groups of girls.

▲ = $p < 0.05$ significance difference from 5 years to 5 years 11 months

2) Comparison of duration of stance while performing the Single-limb Stance between 4 age groups

Mean and standard deviation (SD) of stance duration obtained from the single-limb stance in 4 age groups was shown in the Table 4.8, Table 4.15 and 4.16 and Figure 4.17 and 4.18 present the comparison of stance duration obtained from the single-limb stance in 4 aged groups. The Kruskal wallis Test revealed significant difference between age groups ($p<0.05$) of the Single-limb stance. Therefore, Multiple comparison was used to determine the different of data.

There was significant difference in duration of the Single-limb Stance between boys aged 4 years to 4 years 11 months and 6 years to 6 years 11 months in the conditions of eyes open while standing on dominant leg and eyes closed while standing on non-dominant leg. Moreover, there was significant difference in duration of Single-limb Stance between boys aged 4 years to 4 years 11 months and 7 years to 7 years 11

months in the condition of eyes closed while standing on non-dominant leg (Table 4.15 and Figure 4.17).

There was significant difference in duration of stance between girls aged 4 years to 4 years 11 months and 6 years to 6 years 11 months in the conditions of eyes open while standing on either dominant and non-dominant legs. Significant differences in duration of stance were found between girls aged 5 years to 5 years 11 months and 6 years to 6 years 11 months all conditions of the Single-limb Stance except in the condition of standing on dominant leg with eyes closed (Table 4.16 and Figure 4.18).

There were significant differences in duration of the single-limb stance between girls aged 5 years to 5 years 11 months and 7 years to 7 years 11 months in conditions eyes open while standing either dominant or non-dominant legs (Table 4.16 and Figure 4.18).

Table 4.15. Comparison of duration of the Single-limb Stance in boys between 4 age groups (n = 15 in each age group)

Conditions	**P – value[#]**					
	Group1 and Group2	**Group1 and Group3**	**Group1 and Group4**	**Group2 and Group3**	**Group2 and Group4**	**Group3 and Group4**
Eyes open + dominant leg	0.405	0.037*	0.119	0.514	0.501	0.630
Eyes closed + dominant leg	0.948	0.829	0.070	0.829	0.076	0.071
Eyes open + non-dominant leg	0.690	0.819	0.109	0.817	0.213	0.138
Eyes closed + non-dominant leg	0.267	0.006*	0.015*	0.088	0.148	0.628

[#] = Kruskal Wallis Test and multiple comparison when appropriated
* = Statistical Significant at $p < 0.05$
Group 1 = boys aged 4 years to 4 years 11 months
Group 2 = boys aged 5 years to 5 years 11 months
Group 3 = boys aged 6 years to 6 years 11 months
Group 4 = boys aged 7 years to 7 years 11 months

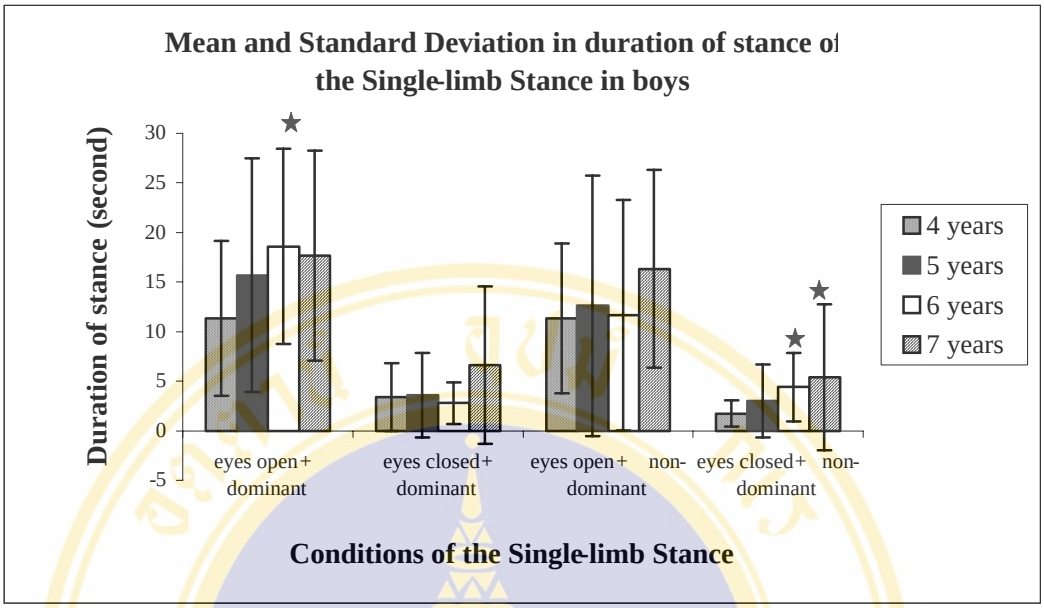

Figure 4.17. Mean and Standard Deviation (SD) of duration obtained from 4 conditions of the Single-limb Stance in 4 age groups of boys.

★ = $p < 0.05$ significant difference from 4 years and 4 years 11 months

Table 4.16. Comparison of duration of the Single-limb Stance in girls between 4 age groups (n = 15 in each age group)

Conditions	P – value[#]					
	Group1 and Group2	Group1 and Group3	Group1 and Group4	Group2 and Group3	Group2 and Group4	Group3 and Group4
Eyes open + dominant leg	0.277	0.026*	0.379	0.001*	0.050*	0.168
Eyes closed + dominant leg	0.834	0.658	0.983	0.850	0.674	0.702
Eyes open + non-dominant leg	0.723	0.024*	0.071	0.008*	0.041*	0.579
Eyes closed + non-dominant leg	0.054	0.530	0.462	0.039*	0.203	0.242

[#] = Kruskal Wallis Test and multiple comparison when appropriated
* = Statistical Significant at $p < 0.05$
Group 1 = girls aged 4 years to 4 years 11 months
Group 2 = girls aged 5 years to 5 years 11 months
Group 3 = girls aged 6 years to 6 years 11 months
Group 4 = girls aged 7 years to 7 years 11 months

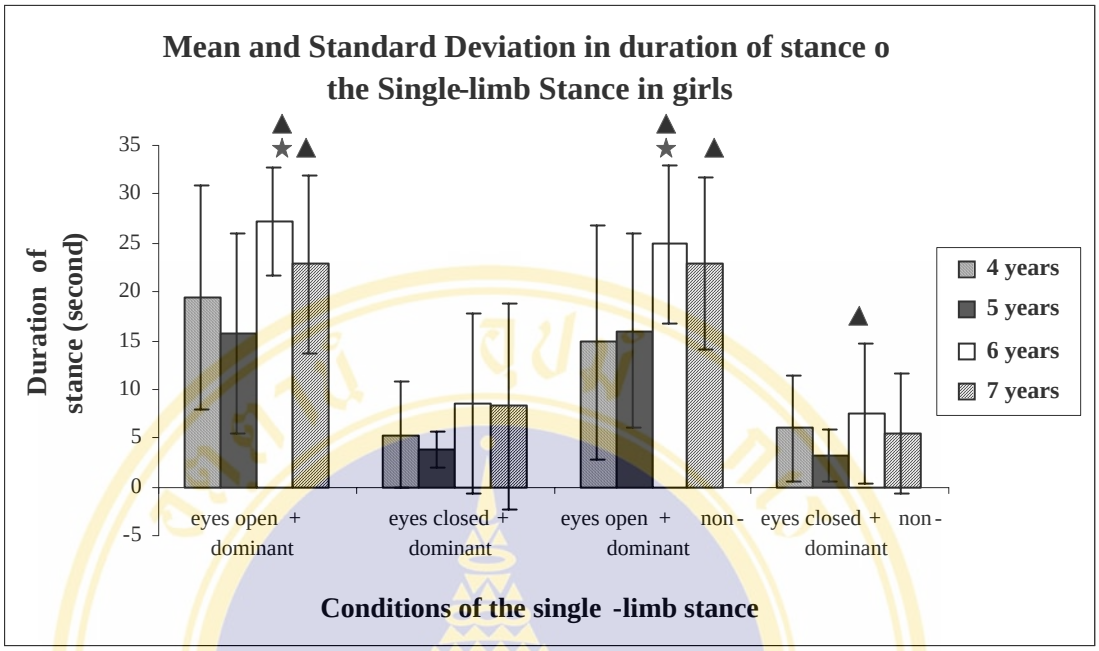

Figure 4.18. Mean and Standard Deviation (SD) of duration obtained from 4 conditions of the Single-limb Stance in 4 age groups of girls.

★ = $p < 0.05$ significant difference from 4 years to 4 years 11 months

▲ = $p < 0.05$ significant difference from 5 years to 5 years 11 months

4.2.3 Tandem walk test

1) Comparison of number of error step between age groups

Table 4.17 shows the number of error steps in 4 age groups. From Table 4.17, the minimum number of error steps in each age groups were similar. However, no difference in the maximum number of error steps obtained from tandem walk test between any aged groups were revealed. The median of error step number tended to decrease in children aged 7 years to 7 years 11 months when compare with other age groups.

Table 4.17. Number of error steps in Tandem Walk Test between 4 age groups (n=30 in each age groups)

Parameters	Number of error steps (step)			
	Minimum	Maximum	Range	Median
4 years – 4 years 11 months	0	16	16	5.00
5 years – 5 years 11 months	0	15	15	2.00
6 years – 6 years 11 months	0	14	14	2.00
7 years – 7 years 11 months	0	15	15	1.50

4.3 Correlations among balance performances obtained from The P-CTSIB, Single-limb Stance and Tandem Walk Test

4.3.1 Correlation of balance performances between the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) with Single-limb Stance

Table 4.18 shows correlation between degree of sway in 6 conditions obtained from P-CTSIB and stance duration of the single-limb stance. The correlation between degree of sway of the P-CTSIB in the conditions of eyes open, eyes closed and wearing visual conflict dome while standing on floor with duration of stance obtained from single-limb stance in the conditions of eyes open and eyes closed while standing on dominant leg and eyes open while standing on non-dominant leg was shown in negative direction and low level correlation. Moreover, the relationship between degree of sway of the P-CTSIB and duration of stance obtained from the single-limb stance were shown that in the conditions of eyes closed and wearing visual conflict dome while standing on density foam were correlated with eyes open and eyes closed while standing on dominant leg in negative direction and correlation between 2 parameters were presented in low level.

In addition, there was relationship between the conditions of eyes open and wearing visual conflict dome while standing on density foam and the condition of eyes

open while standing on non-dominant leg. It was found that the correlation between 2 parameters were shown in negative direction and low level.

The relationship of degree of sway obtained from the P-CTSIB in the condition of eyes closed while standing on density foam was correlated with the duration of stance in the condition of eyes closed while standing on non-dominant leg obtained from the single-limb stance in negative direction and low level.

Table 4.19 shows the relationship between degree of sway of 6 conditions obtained from the P-CTSIB and degree of sway of the single-limb stance. The degree of sway of the P-CTSIB in the condition of wearing visual conflict dome while standing on either floor or foam correlated with degree of sway obtained from single-limb stance in the condition of eyes closed while standing on dominant leg, however, the correlation was found in low level and in negative direction. In addition, the condition of eyes open while standing on density foam of the P-CTSIB was correlated with the condition of eyes open while standing on non-dominant leg obtained from single-limb stance in positive direction and level of correlation was low.

Table 4.18. Correlation between degree of sway in 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) and duration of the Single–limb Stance

P-CTSIB / Single-limb stance	Correlation#					
	Eyes Open + Floor	EyesClosed + Floor	Dome + Floor	Eyes open + foam	Eyes closed + foam	Dome + foam
Eyes open + dominant leg	- 0.312*	- 0.258*	- 0.272*	- 0.133	- 0.231*	- 0.311*
Eyes closed + dominant leg	- 0.210*	- 0.263*	- 0.201*	- 0.092	- 0.241*	- 0.244*
Eyes open + non -dominant leg	- 0.233*	- 0.198*	- 0.216*	- 0.215*	- 0.168	- 0.222*
Eyes closed + non -dominant leg	0.159	- 0.180	-0.111	- 0.085	- 0.204*	- 0.157

= Spearman Correlation
* = Statistical significant at $p < 0.05$

Table 4.19. Value of correlation between degrees of sway in 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) and degrees of sway of Single – limb Stance

P-CTSIB / Single-limb stance	Correlation#					
	Eyes Open + Floor	EyesClosed + Floor	Dome + Floor	Eyes open + foam	Eyes closed + foam	Dome + foam
Eyes open + dominant leg	0.111	0.021	0.006	0.095	0.077	0.027
Eyes closed + dominant leg	- 0.083	- 0.080	- 0.202*	- 0.119	- 0.157	- 0.242*
Eyes open + non -dominant leg	0.061	- 0.048	- 0.068	0.209*	0.063	0.130
Eyes closed + non -dominant leg	0.018	0.028	0.148	0.087	- 0.024	- 0.010

= Spearman Correlation
* = Statistical significant at $p < 0.05$

4.3.2 Correlation of balance performances between the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) with Tandem Walk Test

Table 4.20 presents the relationship between degree of sway of the P-CTSIB and number of error step obtained from tandem walk test. It was found that relationship between degree of sway of the P-CTSIB in the conditions of eyes open while standing on density foam and wearing visual conflict dome while standing on either floor or foam correlated with number of error steps obtained from tandem walk test in positive direction. The correlation's level was in low level.

Table 4.20. Correlation between degree of sway of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) and number of error step of Tandem Walk Test

P-CTSIB / Tandem walk test	Correlation#					
	Eyes Open + Floor	Eyes Closed + Floor	Dome + Floor	Eyes open + foam	Eyes closed + foam	Dome + foam
number of error steps	0.107	0.108	0.283*	0.184*	0.155	0.359*

= Spearman Correlation
* = Statistical significant at $p < 0.05$

4.3.3 Correlation of balance performances between the Single-limb Stance and Tandem Walk Test

Table 4.21 presents the relationship between duration of stance of the Single-limb Stance and number of error step obtained from tandem walk test.

It was found that relationship between duration of single-limb stance in the conditions of eyes open while standing on either dominant or non-dominant legs and number of error steps obtained from tandem walk test was in negative direction. The correlation's level was in low level.

Table 4.22 presents the relationship between degree of sway of the Single-limb Stance and number of error step obtained from tandem walk test. The result showed no relationship between degree of sway obtained from the single-limb stance and number of error steps of tandem walk test.

Table 4.21. Correlation between duration of stance of the Single-limb Stance and number of error step of Tandem Walk Test

Single-limb stance / **Tandem walk test**	**Correlation#**			
	Eyes Open + Dominant leg	Eyes Closed + Dominant leg	Eyes open + non-dominant leg	Eyes closed + non-dominant leg
number of error steps	-0.247*	-0.096	-0.357*	-0.012

= Spearman Correlation
* = Statistical significant at $p < 0.05$

Table 4.22. Correlation between degree of sway of the Single-limb Stance and number of error step of Tandem Walk Test

Single-limb stance / **Tandem walk test**	**Correlation#**			
	Eyes Open + dominant leg	Eyes Closed + dominant leg	Eyes open + non-dominant leg	Eyes closed + non-dominant leg
number of error steps	0.054	-0.058	0.017	0.079

= Spearman Correlation
* = Statistical significant at $p < 0.05$

CHAPTER 5
DISCUSSION

The present study determined balance performances in healthy children aged 4 to 7 years 11 months using the P-CTSIB. In addition, simple clinical tests were investigated in the present study including the Single-Limb Stance and Tandem Walk Test. Comparison of the measured variables obtained from these 3 tests were determined between genders and age groups. Additionally, relationships among these tests were also examined in this study.

5.1 Comparison of age between genders

One hundred and twenty children aged between 4 years to 7 years 11 months were included in this study. The children were divided into 4 groups; 4 years to 4 years 11 months, 5 years to 5 years 11 months, 6 years to 6 years 11 months and 7 years to 7 years 11 months. Each group was composed of 30 children: 15 boys and 15 girls. The age of subjects in each group are shown in Table 4.1. There were no significant differences in mean age between genders in each age groups. Therefore, the similarity of the subjects' ages were assumed.

5.2 Comparison between genders

5.2.1 Comparison of measured variables obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)

In this study, the parameters obtained from the P-CTSIB were degree of sway (degree), duration (second) and strategy of movement (2,4,11,13,26-27). Results of the present study revealed significant differences in degree of sway between boys and girls aged 4 years to 4 years 11 months in the following conditions: eyes closed, wearing visual conflict dome while standing on floor and eyes open and wearing visual conflict dome while standing on density foam. Children aged 5 years to 5 years

11 months showed significant differences in degree of sway between genders in condition wearing visual conflict dome while standing on floor. In addition, there was significant difference in degree of sway in the condition of eyes open while standing on floor in children aged 6 years to 6 years 11 months.

In general, the mean values of degree of sway in the girls tended to be less than boys in most age groups for all 6 conditions of P-CTSIB. These finding implied that the abilities to maintain balance in various conditions in girls were generally better than boys, especially children aged 4 years to 6 years 11 months. From the results, it might be that children aged 4 years to 6 years 11 months were in the process of balance development, whereas in children 7 years to 7 years 11 months might be in the transition to adult-liked performances. It could be that development of sensory system occurs gradually in which the visual system is the first to develop completely. Therefore, gender associated difference in balance performance was evident in healthy Thai children which were similar to previous reports (13,19,36). Richardson et al (19) proposed that eventhough there was no statistically significant gender difference in all P-CTSIB conditions, girls tended to perform better than boys. In addition, the result found that girls also enter the developmental maturation to adult-like pattern earlier than boys. The study of Seller (36) found significant gender difference in static balance. In addition, Deitz et al (13) examined performances in normal children, both boys and girls, and found little but significant gender differences in condition feet together. On the other hand, Riach et al (39) found that boys tended to perform better than girls, but at an earlier age, boys had poorer stability than girls.

For stance duration of the P-CTSIB, the present results found that all children could similarly perform stance duration for all conditions of the P-CTSIB. Therefore, the result showed no significant duration differences for all conditions of the P-CTSIB between genders. Result from this study is similar to a previous study (19). Richardson et al (19) found no statistically significant difference in duration for all conditions of the P-CTSIB between genders in the same age.

The pattern of movement strategy in the present study showed that boys tended to select the strategies similar to girls in the same age for all conditions of the P-CTSIB. However, girls aged 4 years to 4 years 11 months tended to choose suspensory strategy more frequently than boys of the same age. From this result, girls used suspensory strategy than boys because girls aged 4 years to 4 years 11 months try to maintain standing balance, thus it might be involved in degree of sway obtained from the P-CTSIB. For the other age groups, both boys and girls showed similar movement strategies. Moreover, suspensory strategy was frequently used in more difficult conditions, that the children had to rely on vestibular system (15-16,19,39). From the results, younger girls tended to use suspensory strategy more than boys in the same age. It might be that girls were rely on visual system to maintain standing balance and might be that muscular strength and properties in girls perform worse than boys in same age. The movement strategy in girls aged 4 years to 4 years 11 months should be effect less degree of sway of the P-CTSIB.

5.2.2 Comparison of measured variables obtained from the Single–limb Stance

The parameters obtained from the Single-limb Stance were degree of sway (degree) and duration of stance (second) (9,22,31). For degree of sway, results of the present study revealed significant gender differences only in children aged 7 years to 7 years 11 months in the condition of eyes closed while standing on dominant leg. In this condition, the mean degree of sway for boys was greater than girls. From the present study, the tendency of degree of sway between the condition of eyes closed while standing on either dominant or non-dominant leg presented less than condition eyes open while standing on either dominant or non-dominant legs (Table 4.7). The result from this study was controversy in the theory of postural balance. However, it might be that stance duration of the single-limb stance in the conditions of eyes closed in this study were present very short, degree of sway in these conditions were show less than in the conditions eyes open.

From the results of study, balance performances in boys did not differ from girls for all conditions of the single-limb stance in each age group. It might be that the single-limb stance was depended on the strengthening of lower extremity. However, Usui et al (31) proposed that there was significant difference in total sway area while standing on one foot between genders. Moreover, the Usui's study revealed that boys tended to sway greater than girls.

For, duration of single-limb stance, it was shown that girls could stand on single-leg longer than boys in the same age group. However, statistically significant gender differences were found in the 4 years group in the conditions of eyes open while standing on dominant leg, eyes closed while standing on non-dominant leg and 6 years group in the conditions of eyes open while standing on either dominant or non-dominant legs. In general, duration of stance in all conditions in girls were longer than boys in each age group. It might be that balance performances in girls developed earlier than boys. Additionally, duration of single-limb stance during eyes open tended to be longer than eyes closed. Visual system was firstly completed in developmental process (15,34), thus, duration of stance obtained from condition eyes open was longer than condition eyes closed.

5.2.3 Comparison of measured variable obtained from the Tandem Walk Test

Parameter obtained from tandem walk test was number of error steps (step). The result of this study revealed that median number of error steps for boys group was higher than girls in all age groups. This finding was in accordance with greater degree of sway and shorter duration of single-limb stance found in boys when compared with girls in the present study.

5.3 Comparison between age groups

5.3.1 Comparison of measured variables obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)

Therefore, it could be concluded that children aged 4 years to 4 years 11 months showed greater postural sway than children aged 7 years to 7 years 11 months both boys and girls. In addition, postural balance obtained from girls in each age group was better than boys in the same age. This finding might be that postural sway was generally reduced with age and the child improved stability. Sensory organization system in younger child is more incompleted than the older child (15). This result was similar to previous reports (13,39). The study of Riach et al (39) found significant differences in postural sway between age groups: that older children were more stable than younger children. Deitz et al (13) found little significant differences in degree of sway between age groups. However, Richardson et al (19) proposed controversial report that no significant differences between aged groups.

For duration of stance in the P-CTSIB, there was no significant difference in duration for all conditions between age groups. The P-CTSIB was the static balance and wide base of support during altered sensory inputs, therefore, all children could perform for all conditions. This result was similar to previous studies (13,19). Richardson et al (19) found no significant differences in duration of stance between age groups. The result from Deitz et al (13) also revealed no significant differences between age groups.

Patterns of movement strategy in children aged 4 years to 4 years 11 months tended to be suspensory strategy more frequently than other age groups. Result of the present study demonstrated statistically significant differences in movement strategy between age groups. In addition, children aged 5 years to 5 years 11 months showed variability in movement strategy which differed from other age groups. This result was similar to previous study. Rine et al (3) found significant differences in strategy of movement between age groups and variability of strategy between age groups.

Younger children frequently selected suspensory strategy because the muscular system is gradually developed to reach maturation patterns (15,34). Additionally, the contribution of sensory systems are important factors to select strategy to control balance (15,34).

5.3.2 Comparison of measured variables obtained from the Single-limb Stance

There were significant differences in degree of sway between boys aged 4 years to 4 years 11 months and 7 years to 7 years 11 months in the following conditions : eyes closed while standing on dominant leg and eyes opened while standing on non-dominant leg.

Additionally, there were significant differences in degree of sway in the following conditions: eyes closed while standing on dominant leg between boys aged 5 years to 5 years 11 months with boys aged 6 years to 6 years 11 months and between boys aged 7 years to 7 years 11 months. The significant difference in degree of sway obtained from the P-CTSIB, between boys aged 6 years to 6 years 11 months and 7 years to 7 years 11 months were in accordance with the finding of a significant difference in the condition of eyes open while standing on non-dominant leg.

In girls, comparison of degree of sway obtained from the P-CTSIB between age groups showed significant differences in degree of sway in the condition of eyes open while standing on non-dominant leg between 5 years to 5 years 11 months and 7 years to 7 years 11 months. Additionally, other comparison of mean values between age groups demonstrated no statistically significant differences for all conditions.

The present study found that degree of sway for all conditions obtained from the single-limb stance in children aged 4 years to 4 years 11 months showed no difference when compared between other age groups. It might be due to the frequent use of suspensory strategy to maintain balance in children aged 4 years to 4 years 11 months. In addition, balance performance obtained from the single-limb stance is

depended on any factors, for instance, strengthening of lower extremity muscle (15,21,34,38), coordination of lower extremity (15,21,34,38), narrowing of base of support (19,32,39).

Duration of the single-limb stance in boy group demonstrated a significant difference between 4 years to 4 years 11 months and 6 years to 6 years 11 months in the conditions of eyes opened while standing on dominant leg and eyes closed while standing on non-dominant leg. In addition, boys age 4 years to 4 years 11 months compared with boys aged 7 years to 7 years 11 months revealed significant differences in the condition of eyes closed while standing on non-dominant leg. For girls, comparison of duration of stance between age 4 years to 4 years 11 months and 6 years to 6 years 11 months found significant differences in the conditions of eyes open while standing on either dominant or non-dominant legs. Girls aged 5 years to 5 years 11 months compared with 6 years to 6 years 11 months showed significant duration differences in the following conditions: eyes opened while standing on either dominant and non-dominant legs and eyes closed standing on non-dominant leg. Moreover, girls aged 5 years to 5 years 11 months compared with girls aged 7 years to 7 years 11 months showed significant duration differences in the conditions of eyes opened while standing on either dominant or non-dominant both surfaces. Tendency of duration obtained from single-limb stance revealed that younger children could perform worse than older children. It might be the strength of lower extremity in younger children are lower than older children (12), therefore, younger children are more difficult in maintaining balance than the older.

5.3.3 Comparison of measured variable obtained from the Tandem Walk Test

The result of the present study demonstrated that the minimum number of error steps obtained from tandem walk test was similar among 4 age groups. However, median values of the number of error steps tended to decrease as the children grew older. It might be that younger children were in the process of gradual development of postural control. Also, this simple clinical test might be difficult to detect

developmental changes of postural control in children at these age groups. Result in this study was similar to previous study (12). Figura et al (12) showed statistically significant differences in the tandem walk test between age groups. Older children performed better than younger children (12).

5.4 Correlation among balance performances obtained from the P-CTSIB, the Single-limb Stance and Tandem Walk Test

Result of the present study revealed that correlation analysis among various balance parameters obtained from the P-CTSIB, Single-limb Stance and Tandem Walk Test was in low correlations. From the result, the characteristic of pattern and assessment dimention obtained from the P-CTSIB differed from the Single-limb Stance and Tandem Walk Test. In addition, difficulty of these tests are difference when standing on both legs of the P-CTSIB. It was showed wide base of support, thus balance assessment showed more stable than single-limb stance and tandem walk test. The Single-limb Stance was static balance but base of support was narrow. Therefore, strength of lower extremity and the coordination between muscles and joints involve the standing balance. However, Tandem Walk Test was dynamic balance that involves strengthening of lower extremities obtained from both legs and coordination of between muscles and joint to control balance. Therefore, tandem walk test was mostly difficult when compare in other tests.

The P-CTSIB is static balance and appropriates to assess standing balance in term of sensory organization. It could be determined the contribution of sensory systems that following visual, somatosensory and vestibular system. Additionally, the Single-limb Stance assessed focus on strength and coordinate of muscles obtained from lower extremity.

From the present study, it is suggested that balance performances examination in younger children should be use various test because each test examines different aspect of balance control.

5.5 Clinical Implication and further study

The present study provided a guidance for standing balance assessment in Thai children using the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) and some other simple clinical tests. The comparison of balance performances between genders are associated in postural control among these tests. Balance performances in girls tended to better than boys at the same age. These finding may be resulted from the difference in the level of developmental process, that girls show earlier entering to adult pattern than boys.

Balance performances obtained from the P-CTSIB, Single-limb Stance and Tandem Walk Test between 4 age groups show significant differences in various variables. Performances between 4 age groups revealed that elder children could maintain balance better than younger children. It may be that elder children enter to mature developmental process in balance performance while younger children are still in the developmental process.

The results of the present study suggested that the P-CTSIB could be used for assessing balance performances in boys and girls aged 4 years to 7 years 11 months in aspect of both sensory and motor systems of balance. However, using this test alone in clinic might not be efficient enough since there were low correlations among the three tests. For this reason the Single-limb stance and tandem walk test should be included in the test battery to provide enough evidence to clarify balance performance in children. Further study should examine the effect that influenced postural control in children. An increase in number of sample in each age group should be encouraged.

CHAPTER 6
CONCLUSION

The present study determined balance performances between genders and between age groups using 3 balance tests including the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB), the Single-limb stance and Tandem walk test and relationships among these 3 tests in Thai children both boys and girls aged 4 years to 7 years 11 months.

From the results of this study, comparison of balance performances revealed significant differences in degree of sway obtained from the P-CTSIB between boys and girls especially in children aged 4 years to 4 years 11 months. This result implied that girls tended to control balance better than boys.

For single-limb stance, there was significant difference in degree of sway between genders in children aged 7 years to 7 years 11 months in the condition of eyes closed while standing on dominant leg. In addition, there were significant differences in duration of Single-limb Stance between genders in children aged 4 years to 4 years 11 months and aged 6 years to 6 years 11 months similar to the results of the P-CTSIB, girls tended to control balance better than boys in the same age group.

From the results of Tandem Walk Test, it was found that boys tended to have less median number of error steps than girls. This may implied that boys seemed to be better than girls in performing dynamic balance.

Comparison of balance performances between age groups revealed significant differences in degree of sway obtained from the P-CTSIB, especially in boys aged 4 years to 4 years 11 months and 5 years to 5 years 11 months when compared with other age groups. Additionally, there were significant differences in degree of sway obtained from the P-CTSIB between 4 age groups of girls, especially aged 4 years to 4

years 11 months. There was a tendency of degree of sway to be decreased in older children both boys and girls. It could be explained that developmental progression in older children became matured like adult pattern. For movement strategy between age groups, it was found that young children tended to frequently used suspensory strategy more than other age groups.

For single-limb stance, significant differences were found in degree of sway and duration of stance between age groups both boys and girls. Performances between age groups revealed that older children both boys and girls tended to control balance better than younger children.

There were low correlations between degree of sway obtained from the P-CTSIB with variables obtained from the single-limb stance. In addition, number of error step of tandem walk test was poorly correlated with degree of sway obtained from the P-CTSIB and duration of stance obtained from the single-limb stance. Moreover, number of error steps did not correlated with degree of sway obtained from the single-limb stance for all conditions. Further studies in variables influencing postural control are recommended.

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APPENDIX

APPENDIX A
CONSENT FORM

แบบยินยอมเข้าร่วมการศึกษา

วันที่.....เดือน……..……พ.ศ……..

ข้าพเจ้า ..... อายุ ..... ปี เป็นผู้ปกครองของ .....
อายุ ..... ปี อาศัยอยู่บ้านเลขที่ ..... ถนน..... ตำบล/แขวง.....
อำเภอ/เขต..... จังหวัด..... โทรศัพท์..... โทรสาร.....
ขอแสดงเจตนายินยอมให้เด็กในปกครองเข้าร่วมโครงการวิจัยเรื่อง " ความสามารถในการยืนทรงตัวของเด็กไทยเมื่อทดสอบโดยการทดสอบ P-CTSIB, การยืนขาเดียวและการเดินต่อเท้าแบบแทนเด็ม "

โดยข้าพเจ้ารับทราบเกี่ยวกับรายละเอียดของโครงการ ดังต่อไปนี้

วัตถุประสงค์ของการวิจัย คือ ศึกษาความสามารถในการยืนทรงตัวในเด็กไทยสุขภาพดี อายุ 4 – 7 ปี 11 เดือน เมื่อทดสอบการทรงตัวโดยวิธี P-CTSIB, การยืนขาและการเดินต่อเท้าแบบแทนเด็ม โดยเปรียบเทียบระหว่างกลุ่มอายุและระหว่างเพศ

ประโยชน์ที่คาดว่าจะได้รับจากการวิจัย คือ การทดสอบทั้ง 3 การทดสอบใช้ทดสอบความสามารถในการทรงตัวในท่ายืน และผลที่ได้จากการวิจัยอาจทดสอบเพื่อดูความเสี่ยงว่าเด็กมีปัญหาเรื่องการทรงตัวในท่ายืน

ความเสี่ยงหรือผลข้างเคียงที่อาจเกิดขึ้นนั้นไม่มีแต่อย่างใด

รายละเอียดและขั้นตอนที่ผู้เข้าร่วมโครงการวิจัยจะได้รับการปฏิบัติเริ่มจากการทดสอบความสมรรถภาพทางกายเบื้องต้น เมื่อผ่านการทดสอบแล้วลำดับการทดสอบจะมีลักษณะดังนี้คือ เริ่มจากการทดสอบการยืนทรงตัวโดยวิธี P-CTSIB ซึ่งประกอบด้วย 6 ขั้นตอน หลังจากนั้นทดสอบการเดินต่อเท้าแบบแทนเด็ม ซึ่งเดินในระยะทาง 10 เมตร และการทดสอบสุดท้ายคือการยืนขาเดียวทั้งขาข้างถนัดและไม่ถนัดในขณะลืมตาและหลับตา ระหว่างทำการทดสอบโดยการทดสอบแรกและสุดท้าย จะบันทึกวิดีโอเทป เพื่อนำภาพจากวิดีโอวิเคราะห์องศาการเซและรูปแบบที่เด็กใช้เพื่อให้ทรงตัวได้โดยไม่ล้ม

หากเด็กในปกครองของข้าพเจ้าได้รับผลข้างเคียงหรือฤทธิ์ไม่พึงประสงค์หรือภยันตรายจากการวิจัย เด็กในปกครองของข้าพเจ้าจะได้รับการปฏิบัติ/การชดเชยดังนี้ คือ ได้รับการดูแลและการช่วยเหลือจนกว่าจะปกติหรือหายจากความผิดปกติต่างๆ ที่เกิดขึ้น

หากผู้วิจัยมีข้อมูลเพิ่มเติมทั้งด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ผู้วิจัยจะแจ้งให้ข้าพเจ้าทราบอย่างรวดเร็วโดยไม่ปิดบัง

ข้าพเจ้ามีสิทธิ์ของดให้เด็กในปกครองของข้าพเจ้าเข้าร่วมโครงการวิจัยโดยไม่ต้องแจ้งให้ทราบล่วงหน้า โดยการงดการเข้าร่วมการวิจัยนี้จะไม่มีผลกระทบต่อการได้รับบริการหรือการรักษาที่เด็กในปกครองของข้าพเจ้าจะได้รับแต่ประการใด

ข้าพเจ้าได้รับทราบข้อมูลของโครงการข้างต้นตลอดจนข้อดี ข้อเสีย ที่จะได้รับจากการเข้าร่วมโครงการในครั้งนี้และข้าพเจ้ายินยอมที่จะให้เด็กในปกครองเข้าร่วมในโครงการดังกล่าว โดยขอให้ผู้วิจัยงดเปิดเผยชื่อประวัติ ตลอดจนข้อมูลที่เกี่ยวข้องกับเด็กในปกครองของข้าพเจ้าแก่ผู้อื่นได้รับทราบ

ลงชื่อ.....บิดา/มารดา/ผู้ปกครอง

(.....)

ลงชื่อ.....หัวหน้าโครงการ

(.....)

ลงชื่อ.....พยาน

(.....)

ลงชื่อ.....พยาน

(.....)

APPENDIX B
QUESTIONNAIRE FORM

ข้าพเจ้า (นาย / นาง / นางสาว) ..... อายุ.....ปี เป็นผู้ปกครองของ
(ด.ช. / ด.ญ.) .....มีความเกี่ยวข้องเป็น.....ของเด็ก
ที่อยู่.....โทรศัพท์..... อาชีพ.....
ที่อยู่สถานที่ทำงาน.....โทรศัพท์ที่ทำงาน.....
โทรศัพท์มือถือ .....
1) ท่านมีโรคประจำตัวหรือไม่ ☐ มี ☐ ไม่มี ถ้ามี (ระบุ) .....
ได้รับการรักษา (ระบุ) .....
2) ท่านคุ้นเคยกับเด็กในระดับ ☐ น้อยที่สุด ☐ น้อย ☐ ปานกลาง ☐ มาก ☐ มากที่สุด

คำถามต่อไปนี้จะเป็นคำถามเกี่ยวกับเด็ก กรุณาตอบคำถามเหล่านี้ตามความจริง
เด็กเกิดวันที่.....เดือน.....พ.ศ..... ขณะนี้อายุ.....ปี.....เดือน
น้ำหนัก.....กก. ส่วนสูง.....ซม.
1) เด็กมีโรคประจำตัวหรือไม่ ☐ มี ☐ ไม่มี ถ้ามี (ระบุ).....
ได้รับการรักษา (ระบุ).....
2) สายตาของเด็ก ☐ ปกติ ☐ สายตาสั้น =..... ☐ สายตายาว = ...
ถ้าสายตาผิดปกติ ☐ ใส่แว่นตา ☐ ไม่ใส่แว่นตา
3) ตั้งแต่แรกเกิดถึงปัจจุบัน เด็กมีปัญหาเรื่องดังต่อไปนี้หรือไม่
1. พัฒนาการ
มี ไม่มี ถ้ามี (ระบุ).....
2. การเคลื่อนไหวต่างๆ เช่น นั่ง,เดิน เป็นต้น
มี ไม่มี ถ้ามี (ระบุ).....
3. การทรงตัวในท่าต่างๆ เช่น ท่านั่ง,ท่ายืน เป็นต้น
มี ไม่มี ถ้ามี (ระบุ).....
4. การเรียน
☐ มี ☐ ไม่มี ถ้ามี (ระบุ).....
5. โรคของหู ☐ มี ☐ ไม่มี ถ้ามี (ระบุ).....
6. เคยมีอาการชักหรือไม่ ☐ มี ☐ ไม่มี ถ้ามี (ระบุ ระยะเวลาที่ชัก,มีอาการบ่อยหรือไม่ เป็นต้น)
.....

APPENDIX C
DETAILS OF THE STUDY

A. Subjects can be divided into 8 groups, as follows ;

Group 1 is boys aged 4 years 0 month - 4 years 11 months : Gr1
Group 2 is girls aged 4 years 0 month - 4 years 11 months : Gr2
Group 3 is boys aged 5 years 0 month - 5 years 11 months : Gr3
Group 4 is girls aged 5 years 0 month - 5 years 11 months : Gr4
Group 5 is boys aged 6 years 0 month - 6 years 11 months : Gr5
Group 6 is girls aged 6 years 0 month - 6 years 11 months : Gr6
Group 7 is boys aged 7 years 0 month - 7 years 11 months : Gr7
Group 8 is girls aged 7 years 0 month - 7 years 11 months : Gr8

B. Physical ability screening test is composes of

1.Strength of abdominal muscle - the child will be lied on the floor with both arms placed on hips, then the examiner constructs the children are lifted their body's up.

2.Strength of lower extremities - the examiner is constructed the child that perform the movements of lower extremities, for example jump

3.Range of motion of lower extremities - the examiner is observed child's ROM from active movement and passive movement (compare of both legs).

C. The dominant leg test is consisted of 3 categories, that is following :-

Test 1 : kick a ball	right leg	left leg
Test 2 : step up test	right leg	left leg
Test 3 : step on the doll	right leg	left leg

(Note : when subject uses which side of leg in 2 categories of the dominant leg test that leg is preferred to the dominant leg)

D. Qualities of movement for maintained standing balance can be judged into 5 point- scales as follows :-

Score 1= Ankle strategy is scored if the subject maintained his/her balance through movement at the ankles.

Score 2= Hip strategy is recorded when the subject used flexion/extension or lateral flexion at the hip even if subject also used an ankle strategy.

Score 3= Stepping strategy is scored when the perturbation is large, thus subject acted to step in order to the Center of Gravity (COG) within the Base of Support (BOS).

Score 4= Suspensory strategy is recorded when the subject combined 2 movement strategies to decrease COG within the original BOS. Thus, subject will be dropped the body.

Score 5= Undetermined is scored when subject maintained balance is 3 seconds or less that balance strategy can't be observed.

APPENDIX D
RECORDING FORM

1. P-CTSIB

ลำดับที่……...…….

ชื่อ (ด.ช.,ด.ญ.)……..……นามสกุล……อายุ……....ปี…....เดือน

โรงเรียน……....ชั้น ..... วันที่ทดสอบ……..……

Sensory condition	Condition1		Condition2		Condition3		Condition4		Condition5		Condition6	
Vision	Eyes open		Eyes closed		Dome		Eyes open		Eyes closed		Dome	
Surface	floor		floor		floor		foam		foam		foam	
trial	1	2	1	2	1	2	1	2	1	2	1	2
Duration of stance												
Movement strategy												
Degree of sway												

ข้อมูลเพิ่มเติม ……..……

……

……

……

……

2. Tandem walk test

Test 1 : kick a ball right leg left leg

Test 2 : step up test right leg left leg

Test 3 : step on the doll right leg left leg

Dominant foot right leg left leg

Number of error = ... steps

3. Single-limb stance position

2.1 Dominant leg		Right side	Left side
2.1.1	Eyes opened	= ……. sec.	
	Degrees of sway	= ……. degrees	
2.1.2	Eyes closed	= …….. sec.	
	Degrees of sway	= ……. degrees	

2.2 Non-dominant leg		Right side	Left side
2.2.1	Eyes opened	= ……. sec.	
	Degrees of sway	= ……. degrees	
2.2.2	Eyes closed	= …….. sec.	
	Degrees of sway	= ……. degrees	

APPENDIX E
RESULTS OF INTRA – TESTER RELIABILITY

The intra–tester reliability study aimed to prove the consistency of the examiner in measuring degree of sway for the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) and the Single – limb Stance or scoring strategy of movement of the P-CTSIB. Ten children aged between 4 years – 7 years to 7 years 11 months were included in the study. All the tests were performed for 2 trials. The data of all tests were analyzed by SPSS for Window Release 10.0.0. Intraclass Correlation Coefficients (ICC 3,1) was determined the intra–tester reliability of the examiner. The value of Intra - tester Reliability were shown in the table E1 and E2.

Table E1. Intra-tester Reliability of degree of sway for all conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)

Conditions / ICC	Degree of sway of the P-CTSIB					
	Eyes open+floor	Eyes closed+floor	Dome +floor	Eyes open+foam	Eyes closed+foam	Dome + foam
Trial 1	0.9184	0.9382	0.9721	0.9777	0.9917	0.9817
Trial 2	0.8038	0.9324	1.0000	0.9780	1.0000	0.9846

Table E2. Intra-tester Reliability of degrees of sway for all conditions of the Single-limb stance

Conditions / ICC	Degree of sway of Single-limb Stance			
	Eyes open + dominant	Eyes closed + dominant	Eyes open + non-dominant	Eyes closed + non-dominant
Trial 1	0.9514	0.9740	0.9811	1.0000

The value of Intra – tester Reliability obtained from degree of sway of the P-CTSIB and the Single – limb Stance showed good level of reliability

APPENDIX F
RESULTS OF PILOT STUDY

Twenty – two children, both boys and girls, aged between 4 to 7 years months, were included in the pilot study. They were divided into four age groups including 4 to 4 years 11 months, 5 to 5 years 11 months, 6 to 6 years 11 months and 7 to 7 years 11 months. The first group was composed of 4 children; 2 boys and 2 girls. The other groups consisted of 6 children; 3 boys and 3 girls in each group.

Table F1. Comparison of degree of sway obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) between boys (n=11) and girls (n=11)

Conditions	**Degrees of sway (°)**		**P- value** [a]
	Boys (Mean ± SD)	**Girls** (Mean ± SD)	
Eyes open + floor	2.27 ± 0.79	2.27 ± 0.90	0.811
Eyes closed + floor	2.91 ± 0.70	2.91 ± 0.94	0.802
Dome + floor	3.45 ± 1.37	3.00 ± 1.00	0.471
Eyes open + foam	2.82 ± 0.87	2.64 ± 1.03	0.491
Eyes closed + foam	4.36 ± 1.50	3.55 ± 0.82	0.194
Dome + foam	4.18 ± 1.17	3.82 ± 0.98	0.562

[a] = Mann – Whitney U test

The result was shown no significant differences in degree of sway for all conditions obtained from the P-CTSIB between boys and girls.

Table F2. Strategy of movement obtained from 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) between boys and girls

Conditions	Strategy of movement (%)							
	Boys				Girls			
	A	H	ST	SU	A	H	ST	SU
Eyes open + floor	100.00	-	-	-	100.00	-	-	-
Eye closed + floor	90.90	9.10	-	-	100.00	-	-	-
Dome + floor	90.90	9.10	-	-	100.00	-	-	-
Eyes open + foam	90.90	9.10	-	-	100.00	-	-	-
Eye closed + foam	9.10	81.80	-	9.10	27.30	54.50	-	18.20
Dome + foam	18.20	63.60	9.10	9.10	27.30	45.50	-	27.20

A = Ankle strategy , H = Hip strategy , ST = Stepping strategy , SU = Suspensory strategy

Table F3. Comparison of stance duration for all conditions of the Single–limb Stance between boys (n=11) and girls (n=11)

Conditions	Duration of Single – limb Stance (sec.)		P- value
	Boys (Mean ± SD)	Girls (Mean ± SD)	
Eye open + Dominant leg	23.18 ± 16.27	29.64 ± 11.85	0.316[a]
Eyes closed + Dominant leg	8.82 ± 13.11	10.64 ± 10.38	0.274[b]
Eyes open + Non-dominant leg	5.54 ± 7.81	8.36 ± 7.26	0.526[b]
Eyes closed + Non-dominant leg	19.45 ± 17.85	24.27 ± 18.66	0.297[b]

a = Independent Sample t – test

b = Mann – Whitney U test

Calculation of this parameter found no significant difference in stance duration of the Single–limb Stance for all conditions between boys and girls.

Table F4. Comparison of degree of sway for all conditions obtained from the Single-limb Stance between boys (n=11) and girls (n=11)

Conditions	Degrees of sway (°)		P- value [a]
	Boys (Mean ± SD)	Girls (Mean ± SD)	
Eyes open + dominant	4.00 ± 1.26	3.45 ± 0.69	0.303
Eyes closed + dominant	2.45 ± 1.04	2.91 ± 1.58	0.588
Eyes open + non-dominant	3.91 ± 1.76	3.45 ± 1.63	0.567
Eyes closed + non-dominant	2.00 ± 1.10	2.73 ± 1.42	0.208

a = Mann - Whitney U Test

The result of table F4 showed no significant differences of degree of sway for all conditions obtained from the Single - limb Stance between boys and girls.

Table F5. The number of error steps obtained from Tandem Walk Test between boys and girls (n=11 in each group)

Gender	Number of error step			
	minimum	maximum	range	median
Boys	0	9	9	3.00
Girls	0	8	8	2.00

Variables obtained from the number of error step of Tandem Walk Test were shown in Table F5. Median's error steps in boys was higher than girls.

Table F6. Comparison of degree of sway obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) between 4 age groups

Conditions	Degree of sway (°)			
	4-4 years 11 months (Mean ± SD)	**5-5 years 11 months (Mean ± SD)**	**6-6 years 11 months (Mean ± SD)**	**7-7 years 11 months (Mean ± SD)**
Eyes open+ floor	2.25 ± 0.50	2.83 ± 0.98	2.17 ± 0.98	1.83 ± 0.41
Eyes closed+ floor	3.00 ± 0.82	3.00 ± 0.63	3.33 ±1.03	2.33 ± 0.52
Dome + floor	4.25 ± 1.71	3.50 ± 1.22	3.33 ± 0.52	2.17 ± 0.41
Eyes open + foam	3.50 ± 1.00	2.50 ± 0.55	3.17 ± 1.17	2.00 ± 0.00
Eyes closed + foam	4.75 ± 2.22	4.00 ± 1.10	4.17 ± 0.75	3.17 ± 0.75
Dome + foam	4.75 ±1.26	4.50 ± 0.84	4.17 ± 0.75	2.83 ± 0.41

Table F6 presents that means value and standard deviation of degree of sway in each age group obtained from 6 conditions of the P-CTSIB.

Table F7. The percentage of each aged group from the strategy of movement of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)

Conditions	Percentage of movement strategy (%)															
	4 – 4 years 11months				5 – 5 years 11months				6 – 6 years 11months				7 – 7 years 11 months			
	A	H	ST	SU	A	H	ST	SU	A	H	ST	SU	A	H	ST	SU
Eyes open + floor	100.00	-	-	-	100.00	-	-	-	100.00	-	-	-	100.00	-	-	-
Eyes closed+ floor	75.00	25.00	-	-	100.00	-	-	-	100.00	-	-	-	100.00	-	-	-
Dome + floor	100.00	-	-	-	83.30	16.70	-	-	100.00	-	-	-	100.00	-	-	-
Eyes open + foam	100.00	-	-	-	100.00	-	-	-	83.30	16.70	-	-	100.00	-	-	-
Eyes closed + foam	25.00	50.00	-	25.00	-	83.30	-	16.70	33.50	50.00	-	16.70	16.70	83.30	-	-
Dome + foam	25.00	50.00	25.00	-	-	66.70	-	33.300	16.70	50.00	-	33.30	50.00	50.00	-	-

Table F8. Mean and Standard Deviation (SD) of stance duration obtained from the Single – limb Stance of all aged groups

Age group	Duration of stance (sec.)			
	Eyes open + dominant	**Eyes closed + dominant**	**Eyes open + non-dominant**	**Eyes closed + non-dominant**
4-4 years 11 months	15.00 ± 8.29	3.25 ± 2.63	3.75 ± 2.75	6.75 ± 8.34
5-5 years 11 months	20.83 ± 3.11	4.17 ± 1.47	22.50 ± 6.04	4.00 ± 3.52
6-6 years 11 months	27.83 ± 6.83	7.33 ± 8.04	24.33 ± 3.82	8.17 ± 6.91
7-7 years 11 months	29.17 ± 0.23	22.00 ± 5.28	25.83 ± 4.03	9.00 ± 10.79

Table F8 presents means value and standard deviation of stance duration in each age group obtained from the Single-limb Stance.

Table F9. Degrees of sway for all conditions obtained from the Single – limb Stance in each age groups

Age group	Degree of sway (°)			
	Eyes open + dominant	**Eyes closed + dominant**	**Eyes open + non-dominant**	**Eyes closed + non-dominant**
4-4 years 11 months	4.00 ± 0.82	2.50 ± 1.73	3.25 ± 1.71	2.75 ± 2.06
5-5 years 11 months	3.33 ± 1.21	2.33 ± 1.86	5.00 ± 2.19	1.83 ± 0.98
6-6 years 11 months	3.83 ± 0.75	2.83 ± 0.75	3.50 ± 1.22	2.83 ± 0.98
7-7 years 11 months	3.83 ± 1.33	3.00 ± 1.10	2.83 ± 0.75	2.17 ± 1.33

Table F9 shows means value and standard deviation of degree of sway in each age group obtained from the Single-limb Stance.

Table F10. The number of error steps obtained from Tandem Walk Test in each age groups

Age group	Number of error step			
	minimum	maximum	range	median
4-4 years 11 months	3	9	6	8.00
5-5 years 11 months	1	5	4	2.50
6-6 years 11 months	0	5	5	1.50
7-7 years 11 months	0	3	3	0.00

Variables obtained from the number of error step of Tandem Walk Test were shown in Table F10. Tendency of error steps was decrease with age.

Table F11. Value of correlation between degrees of sway of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) and degree of sway obtained from the Single-limb stance

Single-limb stance / P-CTSIB	Correlation [a]			
	Eyes open + dominant	**Eyes closed+ dominant**	**Eyes open + non-dominant**	**Eyes closed + non-dominant**
Eyes open+ floor	0.067	-0.404	0.317	0.162
Eyes closed+ floor	-0.014	-0.459*	-0.059	0.015
Dome + floor	-0.054	-0.601*	0.149	-0.010
Eyes open + foam	0.068	-0.095	-0.174	-0.068
Eyes closed + foam	0.007	-0.380	0.058	0.032
Dome + foam	-0.017	-0.456*	0.327	0.011

[a] = Spearman Correlation

* = Correlation is significant at the 0.05 level

Result of the table was shown that degree of sway of single – limb stance in the condition of standing on dominant leg while eyes closed correlated with degree of sway obtained from the P-CTSIB in the conditions of eye closed while standing on floor, visual conflict dome while standing on both surfaces.

Table F12. Value of correlation between degree of sway for all conditions of Single-limb stance with the number of error steps obtained from Tandem Walk Test

Single-limb / Tandem	Correlation [a]			
	Eyes open + dominant	**Eyes closed + dominant**	**Eyes open + non-dominant**	**Eyes closed + non-dominant**
Number of error step	0.256	-0.211	0.204	- 0.001

[a] = Spearman Correlation

No correlations between degree of sway of the Single-limb stance and the number of error step obtained from Tandem Walk test was shown (Table F12).

Table F13. Value of correlation between stance duration of the Single-limb stance and the number of error step obtained from Tandem Walk Test

Single-limb / Tandem	Correlation [a]			
	Eyes open + dominant	**Eyes closed + dominant**	**Eyes open + non-dominant**	**Eyes closed + non-dominant**
Number of error step	- 0.426 *	- 0.529*	- 0.531*	- 0.292

[a] = Spearman Correlation

* = Correlation is significant at the 0.05 level

Number of error steps of tandem walk test correlated with the single-limb stance in the condition of standing on dominant leg while eyes open and closed and standing on non-dominant leg while eyes open (Table F13).

Table F14. Correlations between degree of sway of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) and the error steps obtained from Tandem Walk Test

P-CTSIB / Tandem	Correlation [a]					
	Eyes open + floor	Eyes closed + floor	Dome + floor	Eyes open + foam	Eyes closed + foam	Dome + foam
Number of error step	0.449	0.456	0.033*	0.485	0.177	0.004*

[a] = Spearman Correlation

* = Correlation is significant at the 0.05 level

Correlations between degree of sway of the P-CTSIB in the conditions of visual conflict dome while standing on floor and foam with the number of error step obtained from Tandem Walk test was found (Table F14).

APPENDIX G
RAW DATA OF PILOT STUDY

Table G1. Characteristics of four children; aged between 4 years – 4 years 11 months

Subjects	Age (years)	Age(months)	Sex [a]	Group
1	4	7	1	1
2	4	1	1	1
3	4	10	2	2
4	4	9	2	2

[a] Sex : 1 = boy 2 = girl

Table G2. Characteristics of six children; aged between 5 years–5 years 11 months

Subjects	Age (years)	Age(months)	Sex [a]	Group
1	5	11	1	3
2	5	8	1	3
3	5	11	2	4
4	5	4	2	4
5	5	10	2	4
6	5	3	1	3

[a] Sex : 1 = boy 2 = girl

Table G3. Characteristics of six children; aged between 6 years–6 years 11 months

Subjects	Age (years)	Age(months)	Sex [a]	Group
1	6	10	2	6
2	6	4	2	6
3	6	5	2	6
4	6	11	1	5
5	6	4	1	5
6	6	2	1	5

[a] Sex : 1 = boy 2 = girl

Table G4. Characteristics of six children; aged between 7 year – 7 years 11 months

Subjects	Age (years)	Age(months)	Sex [a]	Group
1	7	8	1	7
2	7	11	2	8
3	7	10	1	7
4	7	10	2	8
5	7	8	1	7
6	7	4	2	8

[a] Sex : 1 = boy 2 = girl

Table G5. Stance duration obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of four children; aged between 4 years – 4 years 11 months

Subjects	Durations of stance (sec.)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	30	30	30	30	4	18
	2	30	30	30	30	30	30
2	1	30	30	30	30	30	13
	2	30	30	30	30	30	30
3	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
4	1	30	30	30	30	30	30
	2	30	30	30	30	30	30

Table G6. Stance duration obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of six children; aged between 5 years – 5 years 11 months

Subjects	Durations of stance (sec.)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+ foam	Dome+ foam
1	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
2	1	30	30	30	30	30	26
	2	30	30	30	30	30	30
3	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
4	1	30	30	30	30	30	30
	2	30	30	30	30	30	28

Subjects	Durations of stance (sec.)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+ foam	Dome+ foam
5	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
6	1	30	30	30	30	30	19
	2	30	30	30	30	30	30

Table G7. Stance duration obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of six children; aged between 6 years – 6 years 11 months

Subjects	Durations of stance (sec.)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
2	1	30	30	30	30	7	30
	2	30	30	30	30	30	30
3	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
4	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
5	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
6	1	30	30	30	30	30	30
	2	30	30	30	30	30	30

Table G8. Stance duration obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of six children; aged between 7 years – 7 years 11 months

Subjects	Durations of stance (sec.)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
2	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
3	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
4	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
5	1	30	30	30	30	30	30
	2	30	30	30	30	30	30
6	1	30	30	30	30	30	30
	2	30	30	30	30	30	30

Table G9. Degree of sway of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of four children; aged between 4 years – 4 years 11 months

Subjects	Degrees of sway (°)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	3	4	5	4	St	6
	2	4	4	5	4	8	7
2	1	2	3	6	5	4	St
	2	2	6	6	4	4	5

Subjects	Degrees of sway (°)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
3	1	2	3	4	8	7	8
	2	2	3	4	4	4	5
4	1	4	2	2	2	3	4
	2	2	3	2	2	3	3

Table G10. Degree of sway of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of six children; aged between 5 years – 5 years 11 months

Subjects	Degrees of sway (°)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	3	5	4	3	4	4
	2	3	4	3	3	6	4
2	1	4	3	4	2	3	St
	2	2	3	3	2	3	4
3	1	4	3	2	4	5	4
	2	2	2	5	3	3	5
4	1	2	3	4	2	4	5
	2	2	4	3	3	4	St
5	1	5	3	5	2	4	5
	2	4	5	5	2	5	4
6	1	5	4	5	4	7	St
	2	4	3	5	3	6	6

Table G11. Degree of sway obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of six children; aged between 6 years – 6 years 11 months

Subjects	Degrees of sway (°)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	2	3	3	3	3	4
	2	2	3	3	3	3	5
2	1	2	6	6	6	St	4
	2	2	5	4	5	5	6
3	1	4	4	5	2	5	5
	2	4	4	3	3	4	5
4	1	1	2	5	4	5	5
	2	3	3	4	5	5	6
5	1	2	3	3	2	4	7
	2	2	3	3	4	5	4
6	1	3	3	3	4	5	3
	2	2	4	3	3	4	5

Table G12. Degree of sway obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of six children; aged between 7 years – 7 years 11 months

Subjects	Degrees of sway (°)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	2	3	2	2	4	3
	2	2	2	2	2	3	3
2	1	2	2	2	2	4	2
	2	1	2	3	2	2	3

Subjects	Degrees of sway (°)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
3	1	2	2	2	2	3	4
	2	2	2	2	2	4	3
4	1	2	4	4	2	5	3
	2	4	3	3	2	4	4
5	1	2	3	5	4	4	3
	2	3	4	2	2	5	3
6	1	2	3	2	2	4	4
	2	2	2	3	2	3	3

Table G13. Movement strategy obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of four children; aged between 4 years – 4 years 11 months

Subjects	Strategy of movement						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	A	H	H	A	ST	ST
	2	A	H	A	A	SUS	SUS
2	1	A	A	A	A	H	ST
	2	A	A	A	A	H	H
3	1	A	A	A	A	H	ST
	2	A	A	A	A	H	H
4	1	A	A	A	A	A	A
	2	A	A	A	A	A	A

Table G14. Movement strategy obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of six children; aged between 5 years – 5 years 11 months

Subjects	Strategy of movement						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome + floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	A	A	A	A	H	H
	2	A	A	A	A	H	H
2	1	A	A	A	A	A	ST
	2	A	A	A	A	H	H
3	1	A	A	A	A	SUS	SUS
	2	A	A	A	A	SUS	SUS
4	1	A	A	A	A	H	SUS
	2	A	A	A	A	H	ST
5	1	A	A	A	A	H	H
	2	A	A	A	A	H	H
6	1	A	A	H	A	H	ST
	2	A	A	A	A	H	H

Table G15. Movement strategy obtained from the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of six children; aged between 6 years–6 years 11 months

Subjects	Strategy of movement						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	A	A	A	A	A	A
	2	A	A	A	A	A	A
2	1	A	A	A	A	ST	H
	2	A	A	A	A	A	H
3	1	A	A	H	A	H	SUS
	2	A	A	A	A	SUS	SUS

Subjects	Degrees of sway (°)						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome + floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
4	1	A	A	H	H	H	SUS
	2	A	A	A	H	H	H
5	1	A	A	A	A	H	H
	2	A	A	A	A	H	H
6	1	A	A	A	A	H	H
	2	A	A	A	A	H	H

Table G16. Movement strategy of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of six children; aged between 7 years– 7 years 11 months

Subjects	Strategy of movement						
	Trial	Eyes open+floor	Eyes closed+ floor	Dome+ floor	Eyes open+foam	Eyes closed+foam	Dome+ foam
1	1	A	A	A	A	A	H
	2	A	A	A	A	A	A
2	1	A	A	A	A	H	H
	2	A	A	A	A	H	A
3	1	A	A	A	A	H	H
	2	A	A	A	A	H	A
4	1	A	A	A	A	H	H
	2	A	A	A	A	H	H
5	1	A	A	A	A	H	A
	2	A	A	A	A	H	H
6	1	A	A	A	A	H	H
	2	A	A	A	A	H	A

Table G17. Stance duration and degree of sway obtained from the Single – limb stance of four children; aged between 4 years – 4 years 11 months

Subjects	Dominant Leg	Single – limb stance				
		Leg side	Duration of stance (sec)		Degree of sway (°)	
			Eyes open	Eyes closed	Eyes open	Eyes closed
1	Rt	Rt	12	2	3	2
		Lt	2	1	3	1
2	Rt	Rt	19	3	5	2
		Lt	7	2	5	1
3	Lt	Rt	1	5	1	5
		Lt	5	1	4	1
4	Lt	Rt	5	19	4	4
		Lt	24	7	4	5

Table G18. **Stance duration and degree of sway obtained from the Single – limb stance of six children; aged between 5 years – 5 years 11 months**

Subjects	Dominant Leg	Single – limb stance				
		Leg side	Duration of stance (sec)		Degree of sway (°)	
			Eyes open	Eyes closed	Eyes open	Eyes closed
1	Lt	Rt	5	2	2	1
		Lt	41	5	5	2
2	Lt	Rt	45	2	5	1
		Lt	6	3	2	1
3	Rt	Rt	29	5	4	6
		Lt	8	1	7	2
4	Rt	Rt	21	6	2	2
		Lt	26	2	4	1
5	Lt	Rt	6	8	4	3
		Lt	20	4	4	2
6	Rt	Rt	8	2	3	1
		Lt	45	9	8	3

Table G19. Duration of stance and degree of sway obtained from the Single – limb stance of six children; aged between 6 years – 6 years 11 months

Subjects	Dominant Leg	Single – limb stance				
		Leg side	Duration of stance (sec)		Degree of sway (°)	
			Eyes open	Eyes closed	Eyes open	Eyes closed
1	Rt	Rt	27	20	4	3
		Lt	10	21	2	4
2	Lt	Rt	45	6	3	2
		Lt	45	15	3	4
3	Lt	Rt	45	10	5	4
		Lt	45	2	4	2
4	Rt	Rt	37	2	4	3
		Lt	2	7	3	2
5	Rt	Rt	13	2	5	3
		Lt	25	5	5	3
6	Rt	Rt	3	3	3	2
		Lt	19	3	3	2

Table G20. Duration of stance and degree of sway obtained from the Single – limb stance of six children; aged between 7 years – 7 years 11 months

Subjects	Dominant Leg	Single – limb stance				
		Leg side	Duration of stance (sec)		Degree of sway (°)	
			Eyes open	Eyes closed	Eyes open	Eyes closed
1	Lt	Rt	6	2	3	1
		Lt	26	19	3	3
2	Lt	Rt	45	2	2	1
		Lt	44	34	3	3
3	Rt	Rt	45	45	5	4
		Lt	45	28	4	4
4	Rt	Rt	24	3	3	1
		Lt	45	16	3	3
5	Rt	Rt	45	11	6	4
		Lt	13	4	2	3

Subjects	Dominant Leg	Single – limb stance				
		Leg side	Duration of stance (sec)		Degree of sway (°)	
			Eyes open	Eyes closed	Eyes open	Eyes closed
6	Rt	Rt	45	20	3	3
		Lt	31	2	3	1

Table G21. Tandem Walk Test: Number of error steps of four children aged between 4 years – 4 years 11 months

Subjects	Tandem (number of error steps)
1	8
2	9
3	8
4	3

Table G22. Tandem Walk Test: Number of error steps of six children aged between 5 years – 5 years 11 months

Subjects	Tandem (number of error steps)
1	1
2	3
3	2
4	4
5	5
6	1

Table G23. Tandem Walk Test : Number of error steps of six children aged between 6 years – 6 years 11 months

Subjects	Tandem (number of error steps)
1	1
2	0
3	2
4	3
5	5
6	0

Table G24. Tandem Walk Test : Number of error steps of six children aged between 7 years – 7 years 11 months

Subjects	Tandem (number of error steps)
1	0
2	0
3	0
4	0
5	3
6	2

APPENDIX H

RAW DATA OF THE STUDY

Table H1. Characteristic of thirty subjects (both boys and girls) aged between 4 years - 4 years 11 months

Number	Sex[a]	Group[b]	Age (years)	Age (months)
1	1	1	4	9
2	1	1	4	11
3	1	1	4	10
4	1	1	4	10
5	1	1	4	10
6	1	1	4	11
7	1	1	4	7
8	1	1	4	11
9	1	1	4	10
10	1	1	4	2
11	1	1	4	10
12	1	1	4	8
13	1	1	4	7
14	1	1	4	1
15	1	1	4	8
16	2	2	4	10
17	2	2	4	10
18	2	2	4	7
19	2	2	4	10
20	2	2	4	11
21	2	2	4	10
22	2	2	4	10
23	2	2	4	11
24	2	2	4	10
25	2	2	4	10
26	2	2	4	8
27	2	2	4	9
28	2	2	4	10
29	2	2	4	9
30	2	2	4	8

[a] 1 = boys 2 = girls
[b] 1 = boys aged between 4 - 4 years 11 months
2 = girls aged between 4 - 4 years 11months

Table H2. Characteristic of thirty subjects (both boys and girls) aged between 5 years to 5 years 11 months

Number	Sex[a]	Group[b]	Age (years)	Age (months)
1	1	3	5	8
2	1	3	5	6
3	1	3	5	8
4	1	3	5	6
5	1	3	5	6
6	1	3	5	11
7	1	3	5	7
8	1	3	5	9
9	1	3	5	9
10	1	3	5	6
11	1	3	5	10
12	1	3	5	7
13	1	3	5	11
14	1	3	5	8
15	1	3	5	3
16	2	4	5	8
17	2	4	5	8
18	2	4	5	8
19	2	4	5	4
20	2	4	5	8
21	2	4	5	10
22	2	4	5	8
23	2	4	5	9
24	2	4	5	9
25	2	4	5	9
26	2	4	5	9
27	2	4	5	9
28	2	4	5	11
29	2	4	5	4
30	2	4	5	10

[a] 1 = boys 2 = girls
[b] 3 = boys aged between 5 to 5 years 11 months
4 = girls aged between 5 to 5 years 11 months

Table H3. Characteristic of thirty subjects (both boys and girls) aged between 6 years to 6 years 11 months

Number	Sex[a]	Group[b]	Age (years)	Age (months)
1	1	5	6	2
2	1	5	6	2
3	1	5	6	3
4	1	5	6	4
5	1	5	6	1
6	1	5	6	11
7	1	5	6	11
8	1	5	6	3
9	1	5	6	2
10	1	5	6	11
11	1	5	6	6
12	1	5	6	11
13	1	5	6	11
14	1	5	6	4
15	1	5	6	2
16	2	6	6	11
17	2	6	6	4
18	2	6	6	2
19	2	6	6	2
20	2	6	6	8
21	2	6	6	10
22	2	6	6	7
23	2	6	6	8
24	2	6	6	5
25	2	6	6	5
26	2	6	6	11
27	2	6	6	3
28	2	6	6	10
29	2	6	6	4
30	2	6	6	5

[a] 1 = boys 2 = girls

[b] 5 = boys aged between 6 to 6 years 11 months
6 = girls aged between 6 to 6 years 11 months

Table H4. Characteristic of thirty subjects (both boys and girls) aged between 7 years to 7 years 11 months

Number	Sex[a]	Group[b]	Age (years)	Age(months)
1	1	7	7	6
2	1	7	7	6
3	1	7	7	3
4	1	7	7	3
5	1	7	7	8
6	1	7	7	1
7	1	7	7	1
8	1	7	7	5
9	1	7	7	3
10	1	7	7	4
11	1	7	7	3
12	1	7	7	3
13	1	7	7	8
14	1	7	7	10
15	1	7	7	8
16	2	8	7	4
17	2	8	7	5
18	2	8	7	8
19	2	8	7	3
20	2	8	7	1
21	2	8	7	3
22	2	8	7	3
23	2	8	7	7
24	2	8	7	5
25	2	8	7	3
26	2	8	7	1
27	2	8	7	7
28	2	8	7	11
29	2	8	7	10
30	2	8	7	4

[a] 1 = boys 2 = girls

[b] 7 = boys aged between 7 to 7 years 11 months
8 = girls aged between 7 to 7 years 11 months

Table H5. Degree of sway, duration of stance and strategy of movement obtained from 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of children aged 4 years to 4 years 11 months (n = 30)

No.	Group	Degree of sway (°)						Duration (sec.)						Strategy of movement					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	1	3	5	3	4	5	6	30	30	30	30	30	30	1	2	1	2	4	4
2	1	4	6	4	3	7	5	30	30	30	30	30	30	1	1	1	2	2	2
3	1	2	5	4	4	9	7	30	30	30	30	30	30	1	1	1	2	4	4
4	1	3	6	6	3	6	5	30	30	30	30	30	30	1	1	1	1	2	2
5	1	3	5	3	3	5	5	30	30	30	30	30	30	1	1	1	1	2	2
6	1	6	6	4	6	6	6	30	30	30	30	30	30	1	1	1	1	2	2
7	1	6	7	4	6	9	8	30	30	30	30	30	30	1	1	1	2	4	4
8	1	4	3	6	4	7	7	30	30	30	30	30	30	1	1	1	1	2	2
9	1	6	6	5	7	6	6	30	30	30	30	30	30	1	1	1	1	2	2
10	1	3	4	5	4	4	6	30	30	30	30	30	30	1	1	1	1	1	2
11	1	3	3	5	4	5	6	30	30	30	30	30	30	1	1	1	2	2	2
12	1	3	4	4	5	6	4	30	30	30	30	30	30	1	1	1	1	2	2
13	1	3	4	5	4	8	7	30	30	30	30	30	30	1	2	1	1	4	4
14	1	2	3	6	4	4	5	30	30	30	30	30	30	1	1	1	1	2	2
15	1	2	3	5	4	5	7	30	30	30	30	30	30	1	1	1	1	4	4
16	2	4	4	5	3	5	5	30	30	30	30	30	30	1	2	2	4	4	4
17	2	4	4	4	6	8	6	30	30	30	30	30	30	1	1	4	4	4	4
18	2	4	5	4	3	5	4	30	30	30	30	30	30	1	1	1	1	2	2
19	2	2	4	3	2	4	4	30	30	30	30	30	30	1	1	1	1	2	2
20	2	3	3	4	4	6	5	30	30	30	30	30	30	1	1	1	1	2	2
21	2	4	4	4	3	6	5	30	30	30	30	30	30	1	1	1	1	2	2
22	2	3	4	4	3	5	5	30	30	30	30	30	30	1	1	1	1	4	4

No.	Group	Degree of sway (°)						Duration (sec.)						Strategy of movement					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
23	2	3	3	4	4	6	5	30	30	30	30	30	30	1	1	1	2	4	2
24	2	2	3	4	4	5	6	30	30	30	30	30	30	1	1	1	2	2	2
25	2	2	3	3	4	5	6	30	30	30	30	30	30	1	1	1	2	4	2
26	2	3	3	4	3	5	5	30	30	30	30	30	30	1	1	1	2	4	2
27	2	3	4	3	4	6	6	30	30	30	30	30	30	1	1	1	2	2	2
28	2	2	3	4	4	4	5	30	30	30	30	30	30	1	1	1	1	2	2
29	2	2	2	2	2	3	3	30	30	30	30	30	30	1	1	1	1	1	1
30	2	2	3	4	4	5	6	30	30	30	30	30	30	1	1	1	1	2	4

Table H6. Degree of sway, duration of stance and strategy of movement obtained from 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of children aged 5 years to 5 years 11 months (n = 30)

No.	Group	Degree of sway (°)						Duration (sec.)						Strategy of movement					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	3	4	3	4	3	5	3	30	30	30	30	30	30	1	1	1	1	2	3
2	3	3	3	4	2	3	4	30	30	30	30	30	30	1	1	1	2	2	2
3	3	3	4	6	3	5	4	30	30	30	30	30	30	1	1	2	2	4	4
4	3	2	2	4	2	6	5	30	30	30	30	30	30	1	1	1	2	2	4
5	3	4	4	6	4	4	5	30	30	30	30	30	30	1	1	2	2	4	4
6	3	4	5	4	4	5	5	30	30	30	30	30	30	1	1	1	2	2	2
7	3	2	4	5	4	5	4	30	30	30	30	30	30	1	1	1	2	2	2
8	3	3	3	3	3	6	5	30	30	30	30	30	30	1	1	2	2	2	2
9	3	2	4	5	3	6	6	30	30	30	30	30	30	1	1	1	2	2	4
10	3	4	3	3	3	7	8	30	30	30	30	30	30	1	1	1	1	2	2

No.	Group	Degree of sway (°)						Duration (sec.)						Strategy of movement					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
11	3	3	3	5	3	5	6	30	30	30	30	30	30	1	1	1	2	2	4
12	3	4	7	6	6	6	7	30	30	30	30	30	30	1	2	1	1	2	4
13	3	3	4	3	3	4	4	30	30	30	30	30	30	1	1	1	1	2	2
14	3	2	3	3	2	3	4	30	30	30	30	30	30	1	1	1	1	1	2
15	3	4	3	5	3	6	6	30	30	30	30	30	30	1	1	1	1	2	2
16	4	3	3	3	3	2	3	30	30	30	30	30	30	1	1	1	2	2	2
17	4	2	2	2	2	3	4	30	30	30	30	30	30	1	1	1	1	2	2
18	4	3	3	3	3	4	4	30	30	30	30	30	30	1	1	1	1	2	2
19	4	4	4	5	5	3	4	30	30	30	30	30	30	1	1	1	2	2	2
20	4	1	2	3	4	4	3	30	30	30	30	30	30	1	1	1	2	2	2
21	4	2	3	4	3	6	5	30	30	30	30	30	30	1	1	2	2	2	2
22	4	3	3	5	4	7	4	30	30	30	30	30	30	1	1	2	2	4	2
23	4	1	3	3	4	5	4	30	30	30	30	30	30	1	1	1	2	2	2
24	4	3	5	4	5	6	6	30	30	30	30	30	30	1	1	1	2	4	4
25	4	3	3	4	4	8	5	30	30	30	30	30	30	1	1	1	2	2	4
26	4	5	4	4	4	5	4	30	30	30	30	30	30	1	1	1	1	2	2
27	4	2	5	3	3	4	7	30	30	30	30	30	30	1	1	1	2	2	2
28	4	2	2	2	3	3	4	30	30	30	30	30	30	1	1	1	1	4	4
29	4	2	3	3	2	4	5	30	30	30	30	30	30	1	1	1	1	2	4
30	4	4	3	5	2	4	4	30	30	30	30	30	30	1	1	1	1	2	2

Table H7. Degree of sway, duration of stance and strategy of movement obtained from 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of children aged 6 years to 6 years 11 months (n = 30)

No.	Group	Degree of sway (°)						Duration (sec.)						Strategy of movement					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	5	3	4	5	3	5	6	30	30	30	30	30	30	1	1	2	2	2	2
2	5	4	5	4	3	8	5	30	30	30	30	30	30	1	1	2	2	4	4
3	5	3	3	3	4	4	7	30	30	30	30	30	30	1	1	1	2	4	4
4	5	2	3	3	2	4	4	30	30	30	30	30	30	1	1	1	1	2	2
5	5	3	4	3	3	4	4	30	30	30	30	30	30	1	1	1	1	2	2
6	5	2	3	3	2	3	4	30	30	30	30	30	30	1	1	1	1	2	4
7	5	2	2	2	3	3	3	30	30	30	30	30	30	1	1	1	1	2	2
8	5	4	5	4	4	5	6	30	30	30	30	30	30	1	1	1	2	2	4
9	5	2	4	3	4	4	3	30	30	30	30	30	30	1	1	1	1	2	1
10	5	3	4	3	3	5	3	30	30	30	30	30	30	1	1	1	1	2	2
11	5	3	3	3	4	7	5	30	30	30	30	30	30	1	1	1	1	4	2
12	5	3	3	4	2	5	4	30	30	30	30	30	30	1	1	1	1	2	2
13	5	1	2	4	4	5	5	30	30	30	30	30	30	1	1	1	2	2	4
14	5	2	3	3	2	4	4	30	30	30	30	30	30	1	1	1	1	2	2
15	5	2	3	3	3	4	3	30	30	30	30	30	30	1	1	1	1	2	2
16	6	1	3	4	3	3	2	30	30	30	30	30	30	1	1	1	1	1	1
17	6	2	2	2	2	3	4	30	30	30	30	30	30	1	1	1	1	2	2
18	6	1	2	2	2	3	3	30	30	30	30	30	30	1	1	1	1	2	2
19	6	3	4	5	5	5	4	30	30	30	30	30	30	1	1	1	2	2	2
20	6	2	4	3	3	3	4	30	30	30	30	30	30	1	1	1	1	2	2
21	6	2	3	6	4	4	5	30	30	30	30	30	30	1	1	1	1	2	2
22	6	2	2	3	3	5	3	30	30	30	30	30	30	1	1	1	1	2	2

No.	Group	Degree of sway (°)						Duration (sec.)						Strategy of movement					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
23	6	2	4	5	3	4	5	30	30	30	30	30	30	1	1	2	1	2	2
24	6	2	3	3	2	4	3	30	30	30	30	30	30	1	1	1	1	2	1
25	6	2	2	3	4	5	4	30	30	30	30	30	30	1	1	1	1	2	2
26	6	2	3	4	4	5	3	30	30	30	30	30	30	1	1	1	1	2	2
27	6	2	3	4	4	4	4	30	30	30	30	30	30	1	1	1	1	2	1
28	6	2	3	3	3	3	4	30	30	30	30	30	30	1	1	1	1	1	1
29	6	2	5	4	5	5	4	30	30	30	30	30	30	1	1	1	1	1	2
30	6	4	4	3	2	5	4	30	30	30	30	30	30	1	1	1	1	4	4

Table H8. Degree of sway, duration of stance and strategy of movement obtained from 6 conditions of the Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB) of children aged 7 years to 7 years 11 months (n = 30)

No.	Group	Degree of sway (°)						Duration (sec.)						Strategy of movement					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	7	2	4	2	2	3	3	30	30	30	30	30	30	1	1	1	1	1	1
2	7	2	3	3	2	3	3	30	30	30	30	30	30	1	1	1	1	1	1
3	7	2	2	2	3	4	5	30	30	30	30	30	30	1	1	1	1	1	1
4	7	2	2	4	2	5	4	30	30	30	30	30	30	1	1	1	1	1	1
5	7	2	3	3	3	4	5	30	30	30	30	30	30	1	1	1	1	1	1
6	7	3	2	2	4	4	2	30	30	30	30	30	30	1	1	1	1	1	1
7	7	3	4	3	2	5	3	30	30	30	30	30	30	1	1	1	1	1	1
8	7	4	4	4	2	3	3	30	30	30	30	30	30	1	1	1	1	1	1
9	7	2	3	4	3	4	4	30	30	30	30	30	30	1	1	1	1	2	2
10	7	2	2	3	3	5	5	30	30	30	30	30	30	1	1	1	2	2	2

No.	Group	Degree of sway (°)						Duration (sec.)						Strategy of movement					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
11	7	3	3	4	4	5	5	30	30	30	30	30	30	1	1	1	1	2	3
12	7	4	6	5	3	6	3	30	30	30	30	30	30	1	1	1	2	4	4
13	7	2	2	2	2	3	3	30	30	30	30	30	30	1	1	1	1	1	1
14	7	2	2	2	2	3	3	30	30	30	30	30	30	1	1	1	1	2	1
15	7	2	3	2	2	4	3	30	30	30	30	30	30	1	1	1	1	2	1
16	8	3	4	3	2	3	5	30	30	30	30	30	30	1	1	1	1	1	1
17	8	3	4	6	3	4	6	30	30	30	30	30	30	1	1	1	2	4	4
18	8	1	4	3	2	6	4	30	30	30	30	30	30	1	1	1	1	2	2
19	8	1	2	2	1	3	3	30	30	30	30	30	30	1	1	1	1	1	2
20	8	2	4	4	2	3	4	30	30	30	30	30	30	1	1	1	1	2	2
21	8	2	3	6	2	4	4	30	30	30	30	30	30	1	1	1	1	2	2
22	8	2	2	4	2	4	2	30	30	30	30	30	30	1	1	1	1	1	1
23	8	2	3	3	2	3	3	30	30	30	30	30	30	1	1	1	1	2	2
24	8	3	3	6	4	5	6	30	30	30	30	30	30	1	1	1	2	2	2
25	8	2	3	4	3	4	5	30	30	30	30	30	30	1	1	1	2	3	2
26	8	4	4	4	3	3	3	30	30	30	30	30	30	1	1	1	2	2	2
27	8	2	2	3	4	3	4	30	30	30	30	30	30	1	1	1	1	2	2
28	8	1	2	2	2	2	2	30	30	30	30	30	30	1	1	1	1	2	2
29	8	2	3	3	2	4	3	30	30	30	30	30	30	1	1	1	1	2	2
30	8	2	2	2	2	3	3	30	30	30	30	30	30	1	1	1	1	2	1

Table H9. Degree of sway and stance duration of the Single-limb Stance for all conditions in children aged 4 years to 4 years 11 months (n = 30)

No.	Group	Dominant leg				Non – dominant leg			
		Eyes Open		Eyes Closed		Eyes Open		Eyes Closed	
		degree	duration	degree	duration	degree	duration	degree	duration
1	1	5	27	1	1	4	30	2	3
2	1	4	16	2	1	2	2	2	1
3	1	2	4	2	1	3	6	1	1
4	1	4	16	3	2	2	17	2	2
5	1	4	3	4	9	5	12	2	2
6	1	4	8	3	7	4	12	3	1
7	1	6	9	2	1	5	10	1	1
8	1	1	1	1	2	2	16	4	1
9	1	5	14	2	1	3	10	2	1
10	1	6	16	2	1	3	1	2	1
11	1	1	1	3	10	4	19	2	2
12	1	2	4	1	1	4	13	1	1
13	1	3	12	2	2	3	2	1	1
14	1	5	19	2	3	5	7	1	2
15	1	3	20	3	9	5	10	3	6
16	2	6	30	1	1	3	13	3	4
17	2	3	30	2	2	6	12	2	2
18	2	4	24	4	3	2	1	4	6
19	2	2	30	3	18	3	30	3	10
20	2	6	30	1	1	1	2	2	4
21	2	2	2	2	2	5	30	2	4
22	2	4	21	1	1	2	4	1	2
23	2	3	18	1	2	3	11	2	2

No.	Group	Dominant leg				Non – dominant leg			
		Eyes Open		Eyes Closed		Eyes Open		Eyes Closed	
		degree	duration	degree	duration	degree	duration	degree	duration
24	2	1	1	2	5	6	30	3	5
25	2	6	30	3	16	5	30	1	1
26	2	4	18	2	3	5	25	1	2
27	2	1	1	3	9	5	24	3	7
28	2	4	5	1	1	1	1	5	5
29	2	4	24	5	7	4	5	4	19
30	2	4	27	4	9	4	4	4	17

Table H10. Degree of sway and stance duration of the Single-limb Stance for all conditions in children aged 5 years to 5 years 11 months (n = 30)

No.	Group	Dominant leg				Non – dominant leg			
		Eyes Open		Eyes Closed		Eyes Open		Eyes Closed	
		degree	duration	degree	duration	degree	duration	degree	duration
1	3	2	10	2	3	2	15	1	1
2	3	3	1	1	6	2	2	2	1
3	3	6	9	2	1	4	2	3	1
4	3	6	30	2	1	3	30	2	2
5	3	2	1	2	1	2	2	2	1
6	3	4	8	1	1	2	5	2	4
7	3	3	30	1	2	1	1	2	1
8	3	4	30	4	10	6	30	5	2
9	3	4	6	1	1	1	2	1	1
10	3	5	30	2	1	3	3	2	2

No.	Group	Dominant leg				Non – dominant leg			
		Eyes Open		Eyes Closed		Eyes Open		Eyes Closed	
		degree	duration	degree	duration	degree	duration	degree	duration
11	3	5	11	1	1	6	30	6	14
12	3	3	25	3	16	2	2	4	2
13	3	5	30	2	5	2	5	1	2
14	3	2	6	1	3	5	30	1	2
15	3	3	8	1	2	8	30	3	9
16	4	2	10	2	6	3	16	2	2
17	4	6	30	2	5	3	23	1	4
18	4	3	5	4	2	4	9	3	2
19	4	3	4	2	2	3	14	2	2
20	4	1	1	2	7	4	29	3	7
21	4	2	2	1	1	1	3	1	1
22	4	9	17	3	4	2	1	2	1
23	4	3	30	1	1	3	30	3	2
24	4	3	17	1	4	3	30	3	2
25	4	4	16	3	4	5	9	3	3
26	4	6	26	4	3	5	15	4	9
27	4	2	9	3	4	4	21	1	1
28	4	4	29	6	5	7	8	2	1
29	4	2	21	2	6	4	26	1	2
30	4	4	20	2	4	4	6	3	8

Table H11. Degree of sway and stance duration of the Single-limb Stance for all conditions in children aged 6 years to 6 years 11 months (n = 30)

No.	Group	Dominant leg				Non – dominant leg			
		Eyes Open		Eyes Closed		Eyes Open		Eyes Closed	
		degree	duration	degree	duration	degree	duration	degree	duration
1	5	4	19	3	5	2	1	2	7
2	5	3	3	2	2	4	30	2	2
3	5	4	20	2	1	4	3	1	1
4	5	4	24	2	1	3	13	1	1
5	5	3	16	1	1	3	3	3	13
6	5	3	30	4	8	4	3	4	3
7	5	5	30	2	3	4	28	6	9
8	5	2	20	3	4	2	3	2	5
9	5	4	15	3	2	4	2	3	2
10	5	4	30	5	6	2	1	4	5
11	5	3	3	1	1	5	12	2	2
12	5	4	23	2	1	4	30	1	1
13	5	4	30	3	2	3	2	2	7
14	5	5	13	3	2	5	25	3	5
15	5	3	3	2	3	3	19	2	3
16	6	1	30	2	30	3	27	4	26
17	6	2	9	1	1	2	10	1	5
18	6	4	30	2	2	3	25	1	2
19	6	3	30	2	2	3	9	4	4
20	6	4	30	5	16	4	30	3	7
21	6	3	30	2	5	3	28	4	6
22	6	1	24	2	12	2	25	3	11
23	6	4	24	3	2	5	30	2	4

No.	Group	Dominant leg				Non – dominant leg			
		Eyes Open		Eyes Closed		Eyes Open		Eyes Closed	
		degree	duration	degree	duration	degree	duration	degree	duration
24	6	3	30	2	1	2	30	2	1
25	6	6	30	1	1	5	30	2	2
26	6	5	24	4	17	5	30	1	1
27	6	6	30	1	1	5	30	2	6
28	6	4	27	3	20	2	10	4	21
29	6	3	30	4	15	3	30	2	6
30	6	4	30	2	2	5	30	4	10

Table H12. Degree of sway and stance duration of the Single-limb Stance for all conditions in children aged 7 years to 7 years 11 months (n = 30)

No.	Group	Dominant leg				Non – dominant leg			
		Eyes Open		Eyes Closed		Eyes Open		Eyes Closed	
		degree	duration	degree	duration	degree	duration	degree	duration
1	7	4	2	6	3	2	16	3	2
2	7	3	30	4	3	3	30	4	13
3	7	4	12	3	5	2	7	2	2
4	7	1	1	4	2	2	13	2	1
5	7	4	30	1	1	1	1	1	1
6	7	3	25	4	3	4	17	1	3
7	7	3	18	3	2	4	30	2	2
8	7	3	17	4	6	2	30	2	4
9	7	2	2	2	4	2	3	2	1

No.	Group	Dominant leg				Non – dominant leg			
		Eyes Open		Eyes Closed		Eyes Open		Eyes Closed	
		degree	duration	degree	duration	degree	duration	degree	duration
10	7	4	13	2	4	2	13	2	13
11	7	4	14	2	5	4	17	2	3
12	7	4	15	2	1	3	19	2	2
13	7	3	26	3	6	3	19	1	2
14	7	5	30	4	30	4	30	4	28
15	7	6	30	4	13	2	11	3	4
16	8	2	9	1	1	2	30	3	6
17	8	1	2	2	2	3	16	3	4
18	8	2	24	2	1	1	20	2	5
19	8	3	30	1	1	2	11	1	1
20	8	3	30	1	1	5	23	3	4
21	8	6	12	3	5	2	3	4	3
22	8	3	30	4	30	3	30	2	3
23	8	2	20	3	10	3	26	2	2
24	8	3	26	3	16	3	30	4	23
25	8	3	15	1	1	2	22	2	1
26	8	4	30	2	1	2	12	1	2
27	8	6	30	3	2	6	30	3	7
28	8	3	30	3	30	2	30	1	2
29	8	3	24	1	3	3	30	3	16
30	8	3	30	3	20	3	30	1	2

Table H13. The number of error steps obtained from Tandem Walk Test in children aged between 4 years to 4 years 11 months.

No.	Group	Number of error step (steps)
1	1	0
2	1	2
3	1	3
4	1	16
5	1	1
6	1	8
7	1	5
8	1	3
9	1	6
10	1	9
11	1	3
12	1	3
13	1	8
14	1	9
15	1	5
16	2	0
17	2	3
18	2	14
19	2	10
20	2	7
21	2	1
22	2	1
23	2	6
24	2	5
25	2	7
26	2	5
27	2	7
28	2	8
29	2	3
30	2	6

Table H14. The number of error steps obtained from Tandem Walk Test in children aged between 5 years to 5 years 11 months.

No.	Group	Number of error step (steps)
1	3	0
2	3	3
3	3	6
4	3	0
5	3	3
6	3	10
7	3	12
8	3	1
9	3	9
10	3	5
11	3	15
12	3	0
13	3	1
14	3	3
15	3	1
16	4	3
17	4	2
18	4	3
19	4	0
20	4	1
21	4	2
22	4	1
23	4	1
24	4	0
25	4	9
26	4	1
27	4	2
28	4	2
29	4	4
30	4	5

Table H15. The number of error steps obtained from Tandem Walk Test in children aged between 6 years to 6 years 11 months.

No.	Group	Number of error step (steps)
1	5	6
2	5	1
3	5	0
4	5	1
5	5	3
6	5	2
7	5	6
8	5	14
9	5	8
10	5	1
11	5	3
12	5	6
13	5	3
14	5	5
15	5	0
16	6	2
17	6	7
18	6	3
19	6	2
20	6	1
21	6	3
22	6	2
23	6	2
24	6	0
25	6	0
26	6	0
27	6	1
28	6	1
29	6	0
30	6	2

Table H16. The number of error steps obtained from Tandem Walk Test in children aged between 7 years to 7 years 11 months.

No.	Group	Number of error step (steps)
1	7	1
2	7	0
3	7	4
4	7	15
5	7	0
6	7	0
7	7	0
8	7	2
9	7	7
10	7	3
11	7	3
12	7	0
13	7	0
14	7	0
15	7	3
16	8	0
17	8	6
18	8	0
19	8	2
20	8	6
21	8	6
22	8	0
23	8	0
24	8	5
25	8	1
26	8	2
27	8	9
28	8	0
29	8	0
30	8	2

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