RELIABILITY AND VALIDITY OF A PEDIATRIC FUNCTIONAL OBSTACLE COURSE IN THAI CHILDREN

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RELIABILITY AND VALIDITY OF A PEDIATRIC FUNCTIONAL OBSTACLE COURSE IN THAI CHILDREN

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ABSTRACT

The pediatric functional obstacle course (PFOC) is an assessment of the functional balance and mobility in simulated daily activities. The purpose of the study was to determine the reliability and validity of the PFOC test. Subjects were 30 Thai children with typical development (15 boys and 15 girls), aged between 4-9 years. Two physical therapists timed the gait performance on the PFOC separately (Inter-tester reliability). One tester repeated timing of the gait performance one week after the original tests (Test-retest reliability). Additionally, the validity of PFOC was determined by correlating the test with timed up and go (TUG) and fast gait speed (FGS).

Results revealed that the inter-tester reliability of the PFOC was high [ICC(2,k)=0.97] and test-retest reliability was high [ICC(3,k)=0.83]. Regarding validity, good correlations were found for the PFOC and TUG (r=0.85) and for the PFOC and FGS (r=0.82)(p<0.01).

In this study, the PFOC that was modified for functional tasks for testing Thai children appropriately demonstrated high reliability and validity. As a result, the PFOC is useful for assessing functional balance and mobility in children.

KEY WORDS : FUNCTIONAL OBSTACLE COURSE/ FUNCTIONAL BALANCE/ MOBILITY

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ความเชื่อถือได้และความเที่ยงตรงของการทดสอบการเดินผ่านสิ่งกีดขวางในเด็กไทย
(RELIABILITY AND VALIDITY OF A PEDIATRIC FUNCTIONAL OBSTACLE COURSE IN THAI CHILDREN)

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บทคัดย่อ

การทดสอบความสามารถในการเดินผ่านสิ่งกีดขวางในเด็ก (PFOC) เป็นการประเมินการทรงตัวขณะเคลื่อนไหวในรูปแบบของกิจกรรมและการเคลื่อนที่ในสิ่งแวดล้อมเสมือนจริง การศึกษานี้มีวัตถุประสงค์เพื่อหาค่าความเชื่อถือได้และค่าความเที่ยงตรงของการทดสอบความสามารถในการเดินผ่านสิ่งกีดขวาง กลุ่มตัวอย่างเป็นเด็กไทยที่มีพัฒนาการปกติ จำนวน 30 คน (ชาย 15 คน, หญิง 15 คน) ในช่วงอายุ 4-9 ปี โดยทำการทดสอบหาค่าความเชื่อถือได้ของการจับเวลาในการทดสอบระหว่างนักกายภาพบำบัด 2 คน (inter-tester reliability) และค่าความเชื่อถือได้ของการทดสอบซ้ำ (test-retest reliability) ซึ่งทำห่างกัน 1 สัปดาห์ นอกจากนี้ ความเที่ยงตรงของการทดสอบการเดินผ่านสิ่งกีดขวางทำได้โดยหาค่าความสัมพันธ์ของเวลาในการทดสอบการเดินผ่านสิ่งกีดขวาง (PFOC) กับเวลาที่ใช้ในการลุกยืนและเดินตรงไปข้างหน้า (TUG) และการจับเวลาขณะเดินเร็ว (FGS)

ผลการศึกษาพบว่า ความเชื่อถือได้ระหว่างผู้ทำการทดสอบ PFOC ทั้ง 2 คน อยู่ในระดับสูง [ICC(2,k)=0.97] และความเชื่อถือได้ของการทดสอบซ้ำ อยู่ในระดับสูงเช่นเดียวกัน [ICC(3,k)=0.83] ส่วนความเที่ยงตรงของการทดสอบการเดินผ่านสิ่งกีดขวาง พบว่า มีความสัมพันธ์กับการทดสอบ TUG (r=0.85)และ FGS (r=0.82) ในระดับดี

จากการวิจัยครั้งนี้ จะเห็นได้ว่า การทดสอบการเดินผ่านสิ่งกีดขวางที่ประยุกต์ลักษณะกิจกรรมให้เหมาะสมกับเด็กไทย มีความเชื่อถือได้และมีความเที่ยงตรง ดังนั้นการทดสอบนี้มีประโยชน์ในการนำมาใช้ตรวจประเมินความสามารถในการทรงตัวขณะเดินผ่านสิ่งกีดขวางในเด็กได้

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LIST OF ABBREVIATIONS

PFOC	=	Pediatric functional obstacle course
TUG	=	Timed up and go
FGS	=	Fast gait speed
FRT	=	Functional reach test
BBS	=	Berg balance test
POMA	=	Tinetti performance-oriented mobility assessment
TOAT	=	Timed obstacle ambulatory test
COMPS	=	Clinical observations of motor and postural skills
PDMS	=	Peabody developmental motor scales
BOTMP	=	Bruininks-Oseretsky test of motor proficiency
TUDS	=	Time up and down stair
COM	=	Center of mass
COG	=	Center of gravity
COP	=	Center of pressure
CNS	=	Central nervous system
ICIDH	=	The international classification of impairments, disability and handicaps
WHO	=	World health organization
NCMRR	=	National center for medical rehabilitation research
N	=	number
SD	=	standard deviation
CI	=	confidence internal
ICC	=	intraclass correlation coefficients
ID	=	identification

LIST OF ABBREVIATIONS

(Continued)

m.	=	meter(s)
cm.	=	centimeter(s)
yr.	=	year(s)
kg.	=	kilogram(s)
wt.	=	weight(s)
e.g.	=	exempli gratia
i.e.	=	id est
etc.	=	et cetera

CHAPTER I
INTRODUCTION

Balance is required for moving from one place to another. A person maintains his body in equilibrium during moving for daily activities (1). The ability of the person to perform maximal independent walking and move from one place to another in the least time under various environmental surroundings is defined as functional ambulation. A successful ambulation consists of balance, strength, speed, cognition, endurance, coordination and adaptability to environmental demands (2).

Children with physical disabilities often have problems in balance and gait leading to decreased ability to ambulate (3). The most common disability problems is a difficulty in adapting to environmental surroundings such as stepping over an obstacle or ascending stairs (2). These problems can lead to activity and social limitations that affect the quality of life (3). Additionally, the children with impairment of balance and mobility have restricted to perform a task or individual role.

There are different methods to measure balance and mobility in both children and adults. Common methods for evaluating a balance and a mobility are the "timed up and go test" (TUG)(4-7), and the "timed balance test" (8, 9). These tests usually measure the performance time (10). In addition, function related questionnaires are also used to screen gait, balance, or activity. However, only the questionnaires are insensitive to changes of the balance and mobility and unable to measure velocity and postural sway (11).

Many sophisticated methods in assessing balance and mobility include computerized motion analysis systems, force platforms and posturography (8, 11, 12). These methods are very sensitive to change of gait and postural sway. However, they require high technology, specific equipment and adequate training (8, 11). Researchers have developed testing tools for assessing functional balance and mobility in persons with impairments (8, 11, 13-15) especially gait and balance problems in various environments (8, 11, 13). However, many assessments of balance and mobility only emphasize physiological impairment. These assessments do not measure the balance and mobility in environment and task contexts (8). Some researchers have assessed mobility and balance by constructing functional obstacle course (FOC) (8, 11, 13, 16-18). These tests evaluate patients' mobility and balance within tasks and environments that are similar to daily environment (8). The PFOC is simple and easy-to-use.

Many researches examined balance and mobility in adults and elders with functional limitations (8, 11, 13, 15-21). The FOC consisted of a series of common functional tasks including different types of floor textures, ramps, stairs and discrete functional tasks (e.g., walking around cones, walking in narrow pathway, stepping over obstacle, and bending under a mini-blind) (13). Originally, the FOC was set in rehabilitation centers. At present, the FOC has been modified for using in the community that is set up easier to store than the original course (20).

Benedetto et al (22) studied the reliability and validity of timed obstacle ambulatory test (TOAT) that measured functional mobility in typical children. However, some tasks of this FOC were not commonly found in Thai children's daily activities. Therefore, it is interesting to develop the FOC that is appropriate for children and to examine its reliability and validity.

Purposes of the Study

General Objective

To determine reliability and validity of a pediatric functional obstacle course (PFOC) test specifically designed for Thai children.

Specific Objectives

1. To examine the inter-tester reliability of the PFOC test.
2. To examine the test-retest reliability of the PFOC test
3. To examine the concurrent validity of the PFOC test using TUG and FGS as gold standard test.

Hypotheses of the Study

1. There is an acceptable inter-tester reliability of the PFOC.
2. There is an acceptable test-retest reliability of the PFOC.
3. There is a good relationship between the PFOC and the TUG.
4. There is a good relationship between the PFOC and the FGS.

Parameters of the Study

1. The time (seconds) to complete in the PFOC.
2. The time (seconds) to complete in the TUG.
3. The time (seconds) to complete in the FGS.

Scope of the Study

This study constructed a new assessment tool for measuring functional mobility through obstacles specifically designed for Thai children. The reliability and validity of the PFOC test were examined.

Advantages of the Study

1. To obtain a new assessment tool for measuring functional mobility simulated in natural environments.
2. To be a guideline for assessing mobility and balance in children with disabilities based on daily activities.

CHAPTER II
LITERATURE REVIEW

2.1 Balance and Postural Control

2.1.1 Descriptions of balance, postural control and related variables.

2.1.1.1 Balance and postural control

Shumway-Cook and Woolacott (23) defined balance as the ability to control the center of mass (COM) within the base of support or to maintain the body in equilibrium which is either static equilibrium or dynamic equilibrium. Balance or postural stability is also defined as the ability to maintain or control the center of mass (COM) in relation to the base of support to complete desired movements (3, 24, 25). The ability to maintain a posture when stationary or without changing the base of support is defined as static balance. The ability to maintain postural control while in motion such as walking defined as dynamic balance (3, 23). Cherng et al (26) defined static standing balance is the state, in a quiet stance, of maintaining or controlling the position and the momentum of the whole body's center of mass within the base of support without falling. Some researchers (27, 28) described that balance is accomplished by keeping or returning the center of body mass over its base of support under varied types of external disturbance. Balance can be evaluated at the physiological, functional or disability levels. The physiological level includes sensory, motor and effector components. The functional level can be assessed by physical performance tests of mobility. The disability level can be measured by using instruments such as the Falls efficacy scale (12).

Postural control is necessary to the performance of skilled movement (29) which cannot be separated from the action or from the environment in performance (30). All tasks require postural control for adapt to varying task and environment demands (3). Horak in 1987 (24) described postural control is the ability to maintain equilibrium in a gravitational field by keeping the center of mass over the base of support. In addition, postural control must be done by responding quickly and accurately to all internal and external environmental changes (29). Many researchers have suggested that balance is not a general motor ability but rather is specific to the task which is performed (23). Controlling the body's position in space requires the generation and coordination of forces that produce movements effective in postural control (23). An individual's postural control required interaction that include the vestibular, visual, proprioceptive, musculoskeletal and cognitive systems(31, 32). Additionally, postural and equilibrium components of balance control ensure stability of the body during various activities (3, 30).

2.1.1.2 Center of mass (COM), center of gravity (COG) and center of pressure (COP)

The COM is defined as a point that is at the center of the total body mass, determined by finding the weighted average of the COM of each body segment. Any movement of the body can displace the location of the COM relative to the base of support that many systems within the body that work to keep the COM within the base of support when maintain static position and to move the COM in relation to the BOS in a controlled manner when maintain in dynamic tasks (3).

The vertical projection of the COM is often defined as the center of gravity (COG) (23). The center of gravity (COG) of the body is the position of mass center of each body segment (33). The COG must be kept vertically over the base of support to maintain stability that varies with the positions and movements of the body(34). To achieve balance, the body's position of gravity must be kept perpendicular over the center of the base of support (24).

The center of pressure (COP) of the body is the center of distribution of total force intersects with the base of support. During the stable stance there is a separate COP point under each foot. To maintain a quite stance position, one can either relocate the COM through movement of the different body segments or adjust the size of base of support. Winter et al in 1995 (33) referred the COP as the point location of the vertical ground reaction force vector, which represents a weighted average of all the pressure over the surface of the area in contact with the ground. Cherng et al suggested the COP is differs from the COM because the COP is the location of the vertical ground reaction at the surface of support. The COM is the location of the net mass of all the body segments in space (26). Balance can be estimated from the COG or the COP displacements and can be maintained when the horizontal COG projection is far from the COP or COG lies outside the base of support (31).

2.1.2 Systems relate balance and postural control

Postural control results from a complex interaction among many body systems that work cooperatively to control both orientation and stability of the body. The primary systems involved for the process of balancing are 1) sensory system 2) motor system 3) biomechanical system (23).

2.1.2.1 Sensory system

The control of postural orientation is derived from the integration of three major sensory inputs : somatosensory, visual and vestibular systems with all three providing spatial orientation input (27, 35) . To achieve balance, the body organized multiple sensory inputs for maintain stability in a variety of environments (23).

2.1.2.1.1 Somatosensory system

The somatosensory system provides information about the position of the body include body parts relative to each other and motion with reference to supporting surfaces (23, 36). Somatosensory information consists of muscle spindles and golgi tendon organs, joint receptors, cutaneous and pressure receptors (23, 25, 32, 37). It helps to determine characteristics and the relation of the individual to the support surface (32). Somatosensory inputs appear to dominate postural control in response to transient surface perturbations or when the body is standing still on a fixed, firm surface (23, 38). Horak and Shupert (39) demonstrated inflexible use of somatosensory inputs for postural control became unstable when surface inputs do not allow patients to maintain a vertical orientation. Under difference surface, somatosensory receptors provide information about position and movement of body with respect to a horizontal surface (23). The somatosensory system provides the CNS with position and motion information about the body with reference to supporting surfaces (23). To control balance, the CNS must be assessed the state of the body and its environment to judge when movements are important to maintain postural control because the CNS integrates information from various sensory systems (40). Under normal circumstances, somatosensory receptors provide information about the position and movement of body with respect to a horizontal surface example firm and flat surface. However, on a surface that is not horizontal (i.e., a ramp) is not appropriate to establish a vertical orientation with reference to the surface. Input informations about body's position with respect to the surface become less helpful in establishing a vertical orientation (23).

2.1.2.1.2 Visual system

Visual inputs provide sensory information references for upright orientation of the body relative to the environment (23). Visual inputs are an important source of information for postural control include both peripheral visual information and focus information (41). Vision provides information about the environmental and the location, direction and speed of movement of the individual. Visual information from the environment combines with memory in a process called cognitive-spatial mapping to enable us to plan a route to places out of sight (42) and to report information regarding the position and the motion of the head with respect to surrounding objects. Visual inputs appear to primarily influence later stabilizing reactions to the initial balance correlations (43-45). Enborm (46) suggested that the pressure receptors of the feet and the proprioception were of major importance for postural compensation in children with congenital or early acquired bilateral vestibular loss.

2.1.2.1.3 Vestibular system

Vestibular system is also a powerful source of information for postural control (47). Vestibular apparatus is comprised of semi-circular canals, saccule and utricle which located in the inner ear (48). The semi-circular canals are in a position to sense movement directions or particular rotation. Saccule and utricle provide signal information about the orientation of head to the gravity (48). The vestibular system provides the CNS with information about the position and movement of the head with respect to gravity and inertial forces. The vestibular system has two types of receptors that sense difference aspects of head position and motion. It sends information to the brain about the position and movements of the head-data necessary to control postural sway and dynamic balance. The vestibular system is independent of visual cues (23). Vestibular information related with vertical and proprioceptive and somatosensory messages detailing the relative positions of body parts and support surface make up the sensory input to the balance control mechanism (30).

These three systems work as a unit to sense changes in posture and balance. Additionally, if one system is impaired, the other two must take up the slack to prevent a fall.

2.1.2.2 Motor system

This system create the movement to maintain posture (3). Postural control requires the generation and coordination of forces that produce movements effectively in controlling the body’s position in space (23). Factors of stability are the first, body alignment is the effect from gravitational forces. The second, muscle tone keeps the body from the force of gravity. Muscle tone is the force of muscle resistance being lengthened (49). The use of a particular strategy depends on the configuration of the support surface and on the size of the perturbation. The ankle strategy is used for small perturbations on a firm and wide surface. The hip strategy is used in response to larger perturbations such as standing on a narrow support (39).

2.1.2.3 Biomechanical system

Postural and equilibrium control of the body are necessary to maintain the stability of the body against the forces of gravity and acceleration (30). Postural control is important to counterbalance any movement which alters the COM to move closer to the boundaries of the base of support (50). Equilibrium control relates to maintain the part of body during activity by external force (51). The restriction of joint range of motion, muscle strength and endurance can affect the maintenance of equilibrium positions and the available movement strategies example range of motion limitations at the ankle joint may result in compensatory hip and trunk movements to correct disequilibrium in standing (39). Force activity such as linear and angular accelerations affect to the moment before and during the movement (52) or horizontal acceleration forces at the hip during walking. The equilibrium control necessary is determined by the speed of the focal movement and by the mass of the body part being moved. The normal control system manages appropriately energy expenditure during intersegmental movement such the requirement to clear an obstacle is reduced at the hip and ankle by active knee flexing. Biomechanical parameters are changed depending on tasks or activities that are determined by the magnitude, direction and combination of the forces of gravity and acceleration. The environmental context of a task can influence the biomechanical parameters including both kinematics and kinetics. The biomechanical demands on balance related to the motor task itself and to aspects of its environmental context (30).

2.1.3 Factors influencing the functional balance

2.1.3.1 Cognitive and perceptual

Cognition is defined as the ability to process, sort, retrieve and manipulate information (53). Cognitive evaluation is the first crucial step in evaluating a patient's ability to interact with other individuals and the environment (54). Perception is the integration of sensory impressions into psychologically meaningful information (55). Sensation is a necessary prerequisite for perception. Therefore, patients with primary sensory impairments have some cognitive or perceptual problems. These problems affect an ability of patients during ambulating within the environment. Cognitive impairments include deficits memory, attention and executive functions (23). In addition, it affects a decrease of problem-solving ability, lack of initiation and decreased short-term memory etc. Thus, cognition depends on many factors involve that attention, orientation, memory, problem solving.

2.1.3.1.1 Attention

Attention is the ability to focus on a specific stimulus without being distracted. Attention has multiple factors composed of a) focus attention b) sustained attention c) selective attention d) alternating attention and e) divided attention (23).

2.1.3.1.2 Orientation

Orientation refers to the ability to maintain a position in space with reference to a specific sensory reference. Orientation determines person, place and time such as where are you ?, How old are you ? (23).

2.1.3.1.3 Memory

Memory can be defined as the retention of information over time. For humans, memory can be defined as changes in behavior caused by events in the remembers' past. Memory is the ability to process, store and retrieve information. Memory provides short term goal and long term goal (23).

2.1.3.1.5 Problem solving

Problem solving is the ability to manipulate new or unfamiliar situations (23, 56). Problem solving has been dived into three steps: preparation, production and judgment (57). It require the integration of attention, memory and perception (58).

2.1.3.2 Gender

The difference of balance between men and women is mainly due to their different anthropometrics. The different body heights of men and women have been assumed to contribute to the poorer balance of men compared to of women (50).

Riach and Hayes (59) studied the body sway between boys and girls. The results showed the boys had a greater rate improvement in postural stability than the girls had. The gender differences in sway amplitudes or velocities were controversial. Ekhdahl et al (60) studied the balance performance of women and men with some traditional functional balance tests and force platforms. The study found that the balance of woman were more stable than men were. However, Overstall et al (61) found that women were less stable than men. Therefore, the comparisons of results concerning the effects of gender should be made with caution.

2.1.3.3 Age

The transition in sensory selection strategies occurred from age 4-6 years, with some improvement up to age 9 years (62). It indicated that children who were younger than 7.5 years old did not have a process for weighting the appropriate sensory inputs (63). The study supported the idea that maturation of somatosensory function in postural control was presented at six years but maturation of the function of visual and vestibular process for postural control was inadequate at seven and a half years of age. Adults presented with a greater percentage of ankle strategy use than young children on the support surface perturbations (64). Age was found to have a significant effect on sway area, movement time, path length and functional reach normalized to body height (65). However, researchers suggested that difference of muscle strength and anthropometric variables may affect postural stability either static or dynamic conditions (66). Foudriat et al (67) measured postural stability during early stages (i.e., 3-6 years). The results showed body sway decreased with advancing age in both males and females. The postural stability in children with six years old was greater than then on children with three, four, and five years old. Children even three years were able to maintain stance under all sensory conditions. In 4-6 years of age, presented the ability to resolve sensory conflict, although the skill to ignore misleading sensory inputs and integrate multiple sensory did not reach adult level until approximately 7-10 years.

2.2 Development of Postural Control

During the early years of life, children develop many functional skills, including crawling, independent walking, running, climbing, and manipulating (23). The emergence of these skills requires the development of postural activity to support the basic movement. Development of sensory and motor aspects of postural control involved the capacity to build up appropriately internal postural representations that reflect the rules organizing sensory inputs and coordinating them with motor actions. For example, the children gain the experience by moving in a gravity environment and sensory-motor maps development. The maps involve to incoming sensory inputs from somatosensory, vision and vestibular systems (23).

Infants (i.e., birth to 2 years old) gradually develop the ability to align body segments with respect to each other and with respect to the environment. They develop locomotor skills beginning at rolling, then crawling and creeping, next walking with support. Finally, the infants achieve the important milestone of independent locomotion (i.e. independent walking) (68).

In early children (2 to 6 years old), development of postural control involves the attainment of new skills but not necessarily new patterns of movement. Walking is refined and modified to many high functional skills such as running, hopping, jumping and skipping (68). Children at 1.5 to 3 years are immature of sensory systems in postural control (69) who depends on the visual system to maintain balance (3, 23). Assaiante studied the effects of visual factors on the angular oscillations of the head and trunk during various locomotor tasks in 3 to 8 years old children and adults. The study showed that narrow supports, the lateral oscillations of the trunk increased trunk between the ages of 3 and 6 years. The oscillations with a maximum amplitude were shown at the latter age and decreased in adult (70).

At 4-6 years of age, children begin to maintain balance using primary vestibular information for postural control (23). The change of postural strategy represents developmental changes in the nervous systems itself. Some children can walk on narrow pathway (10cm.×3m.) by placing heel of one foot directly in front of toes of the other (71). Accordingly to previous studies, the coordination of the postural response went through a transitional stage at 4 to 6 years of age and reached adult-like maturity by 7-10 years of age. Postural responses in children 4 to 6 years of age are in general slower and more variable than those found in the 1.5 to 3 years old, 7 to 10 years old or adults (23, 72).

At 7 years old, children are able to walk completely on balance beam placing heel of foot directly in front of toes of other foot (71). By 7 to 10 years of age, the children are able to resolve a sensory conflict and appropriately utilize the vestibular system as a reference. The postural response is essentially like those of the adult. None of the children lost balance (23). McFadyen et al (73) explored the anticipatory locomotor adjustments during obstacle avoidance by aged 7-9 years that analyzed kinematic, kinetic and muscle mechanical power patterns. The children demonstrated adult-like limb displacements and anticipatory locomotor adjustments for obstacle clearance that is still maturing during mid-childhood. Walking development may be determined by the dynamic cooperation of physiological, neural and musculoskeletal systems with respect to the environment context (74).

2.3. Model of Disablement

Disablement is a global term that refers to impacts of chronic and acute conditions on the functions of specific body systems, on basic human performance and on the functioning of people (23). The term of disablement reflects all the diverse consequences that diseases, injuries or congenital abnormalities have on human functioning at different levels (75). Major conceptual schemes or models of physical disablement. These models are 1) World health organization model (WHO) 2) Nagi model and 3) National center for medical rehabilitation research (NCMRR) (23, 75, 76).

2.3.1 World health organization model

The international classification of impairments, disabilities and handicaps (ICIDH) is a model of disablement developed by Philip Wood for the world health organization (WHO). The ICIDH model is divided into 4 levels of dysfunction: pathology, impairment, disability and handicap. The first level is a "disease" level that refers to a description of the pathology or injury process at the organ level. The second level is "impairment" that refers to a physiological abnormality, loss anatomical structure or functional mobility at organ level. The third level is a "disability" level that describes any restricted abilities to perform a task or an activity in the manner. Disability is a disturbance in task-oriented. Finally, the fourth level is "handicaps" level that defines the effect of disease, impairment or disability for the individual. Handicap is a social and environmental consequences for the individual from impairments and disabilities (23, 75, 76).

Disease → Impairment → Disability → Handicaps

Figure 2.1. Diagram of disablement model based on WHO or ICIDH model.

2.3.2 Nagi model

This model contains 4 levels of dysfunction. The first level is an "active pathology" level that involves the interruption or interference with normal processes and efforts of the organism to regain normal. The second level is the "impairment" level that is similar to this level referred in the ICIDH. Impairments can occur both in the primary underlying pathology and in secondary pathology. The next level of dysfunction is a "functional limitation" level, which is an inability of an individual to perform a task or activity within the range considered normal for human beings. Functional limitations describe a patient's problems with respect to independent tasks such as standing, walking or climbing. Functional limitations can in turn lead to a disability. The forth level is a "disability" level that is reserved for social rather than individual functioning. This concept represents an inability to perform roles and tasks of an individual within sociocultural and physical environment. Disability affects the quality of life of the individual (23, 75).

Active Pathology → Impairment → Functional Limitation → Disability

Figure 2.2 Diagram of disablement model based on Nagi model.

2.3.3 The national center for medical rehabilitation research (NCMRR model)

This NCMRR model of disablement is modified by the national center for medical rehabilitation research (NCMRR). The model presents 5 levels of dysfunction that the first four levels of disablement are similar to the levels described in Nagi model. An addition level is a level of societal limitation. Societal limitations are restrictions that increase from social policies or barriers that limit individuals' abilities within the environment (23, 75).

Patho-Physiology → Impairment → Functional Limitation → Disability → Societal Limitation

Figure 2.3 Diagram of disablement model based on NCMRR model

These models are necessary to assess the level of disablement in the individual person. Understanding these models can prevent and maintain impairments that result from disease or pathology.

The impaired mobility is a critical determinant of independence and a major contributor to physical disability. Mobility defines as an ability to independently and safely move oneself from one place to another. The mobility incorporates many types of tasks, including the ability to stand up from a bed or chair, to walk or run, and to navigate through complex environments. All mobility tasks consist of 3 essential task requirements: (a) motion in a desired direction (progression), (b) postural control (stability) and (c) the ability to adapt to changing task and environmental conditions (adaptations) (23). By the way, many mobility demands on the systems that control posture and balance. The term posture is used to describe biomechanical alignment of the body as well as the orientation of the body to the environment. Balance or postural stability (23), is the ability to maintain the body in equilibrium both static and dynamic postural control (3).

2.4. Assessments of Postural Balance

2.4.1 Impairment level

Assessments of postural balance in the impairment level usually involve three systems (i.e., sensory systems, motor systems, and biomechanical systems) (3). Most children who have postural balance problems usually have defects in these systems.

2.4.1.1 Assessment of the sensory systems

Three primary sensory systems that involve the postural balance are visual, somatosensory, and vestibular systems. The assessment of sensory system can identify sensory deficits that affect the ability to execute postural response (3). These measurements of postural sway are used to evaluate deficits in a sensory organization. The sensory organization is the ability of an individual to select from sensory input to identify the sensory system appropriately for maintaining postural balance (3).

Clinical test of sensory systems that have been widely used by physical therapist such as Romberg test, tandem walking test, tiltboard test (3, 29). The romberg test and tandam walking test are used to measure interaction of the vestibular system with other sensory systems (3). The tiltboard test is measured the balance ability of the children in various sensory conditions (3, 29, 77).

2.4.1.2 Assessment of the motor systems

Assessment of motor coordination during balancing is a method of evaluating the motor system. The clinical observations of motor and postural skills (COMPS) are based on Ayres' original non-standardized clinical observations used in conjunction with the Southern California sensory integration tests. The COMPS provides a feed forward motor coordination during activities that involve the maintenance of the postural stability during dynamic movements as well as static movements (3). Additionally, Fisher and Bundy (78) developed a flat-board and tilt board reach test for measuring motor coordination during balancing. This test can be useful for screening balance problems. However, test-retest reliability has not been done therefore it should be used to evaluate a progress with cautions.

2.4.1.3 Assessment of the biomechanical systems

Biomechanical factors (e.g. force output and range of motion) have been shown to relate to postural balance in children (3). A force output is related to functional measures of movement that require postural balance, such as running speed (79), the timed up and go test. The force output is evaluated by using manual muscle testing. One of the advantages is can be performed in any locations. However, an individual testers have different judges on the amount of resistance required for rating "normal" (80). The range of motion is evaluated by standard goniometric techniques. Inter-tester and test-retest reliabilities of goniometric measurements are problematic because many factors can be influenced to the reliabilities such as illness, medication and speed of movement (81).

2.4.2 Functional limitation level

Postural balance is necessary for children to perform gross motor skills or functional activity. Assessment of gross motor skill provides information regarding children's balance at the level of functional limitations (3). The functional limitation is defined as a restriction in the ability to performance the mobility in person (82).

Several assessment instruments for young children are developmental examination for examples the Barley scales of infants development, the Peabody developmental motor scales (PDMS). These tests have specific sections related to postural balance such as the PDMS consists of many balance items (one-foot balance, walking on a balance beam) (3, 23, 29, 71). For older children, the gross motor section of the Bruininks-Oseretsky test of motor proficiency (BOTMP) can be used. However, the BOTMP is designed for children with mild motor impairment but is very difficult for children with severe impairments (3, 23, 71, 83, 84).

Many several functional tests that were developed from the frail elderly have been studied in pediatric population. For example, the functional reach test (FRT) (31, 85), the timed up and go test (TUG) (5, 6), the berg balance scale (BBS) etc (2-7, 12, 23).

2.4.2.1 Functional reach test (FRT)

The functional reach test is a screening test for balance problems. The FRT examines the limits of stability in the forward direction. An individual stands with the feet are apart at the shoulder width and with one arm raises at 90 degrees of flexion. The subject reaches for forward as far as they can while maintaining a fixed base of support. The distance of reaching is measured (2, 3, 12, 23, 86). Schoppen (4) suggested the FRT may not be a valid indicator of the dynamic balance during gait. The correlation between the FRT and gait velocity was poor(r=0.08) (31).

2.4.2.2 Timed "up & go" test (TUG)

The timed up and go test consists of rising from a chair, walking 3 meters in a distance, turning around, returning to the chair, and sitting down the chair (3, 5-7, 23, 87). The end of test is defined when the patient's buttocks first touch the seat surface. A stopwatch is used to time the performance (seconds) (4). The TUG has been advocated as a useful tool for quantifying locomotor performance that gives information regarding functional and dynamic gait speed. This test was developed as a clinical measure of balance in elderly people. The TUG is a test of balance that is commonly used to examine the basic functional mobility. Time to complete the test is strongly correlated to level of functional mobility (88). This test is a popular test because it is quick, easy to administer, good inter-tester, and intra-tester reliabilities (i.e., 0.96, and 0.93 respectively) (3, 4, 7). Additionally, the TUG relates to the other postural stability the assessment such as the FRT and the BOTMP (3). It also correlates with the gait speed (r=0.75) (7), and berg balance scale (r=-0.72) (5). The sensitivity and specificity in elderly populations are high (87%) (87).

2.4.2.3 Berg balance scale (BBS)

The berg balance scale is developed as a performance-oriented measure that provided three dimensions: maintenance of a position, postural adjustment to voluntary movements, and reaction to external disturbances (89-91). The BBS, which measure functional balance, consists of 14 tasks including simple mobility tasks (e.g., transfer, sit to stand) and difficult tasks (e.g., tandem standing, turning 360°). Each task is scored on a scale from 0 to 4. A score of 0 is given if the participant is unable to do the task, and a score of 4 is given if the participant is able to complete the task The total score are 56 points in the completion of the tasks (2, 3, 7, 23, 86). . Declining BBS were associated with increased fall risk. The BBS has been shown to have excellent inter-tester and test-retest reliability (ICC=0.98). The sensitivity of the scale is 53% (92).

2.4.2.4 Gait velocity test

The gait velocity or fast gait speed (FGS) test is measured over a relatively short distance and thus does not include endurance as a factor. This test is measured in hundredth of a second with a stopwatch that is easy and inexpensive (93). The velocity is calculated by divided middle 6 m. on walkway (2). Each subject is instructed to walk on 10 meters. The test was strongly associated with the level of mobility, correlated with muscle strength (93). The gait velocity demonstrated high inter-tester and intra-tester reliabilities. The gait velocity correlated with the TUG (r=-0.75) and showed high sensitivity of 80% and specificity of 89% (7).

2.4.3 Disability and societal limitation level

Disability is the lack of ability to take part in the movement or mobility within the child's environment such as home, school, and community (82). Children with disabilities usually limit their mobility within the environments. Therefore, an assessment of functional mobility within the natural or simulated environments is essential. Many researchers have developed the assessments of the functional balance and the mobility based on various environments. This kind of assessment is usually a called functional obstacle course (FOC).

2.4.3.1 The functional obstacle course (FOC)

A functional ambulation is an ability of a person to walk with maximal independence and in the least time under various environment circumstances. Many researchers have been studied postural balance by using the functional obstacle course (FOC) (8, 13, 19-22). These FOC were designed to assess functional activities based on an interaction of an individual, a task and an environment to around. The FOC simulates activities for the daily life. Locomotor behaviors include initiating and terminating the locomotion, adapting gait to avoid obstacles, and changing speed and directions as needed (8, 13, 19-22, 73, 94, 95).

2.4.3.1.1 Characteristics of FOC

Means (8, 13-15, 21) described an obstacle course consisted of a series of functional tasks in common conditions as follows: 1) different types of floor surfaces (i.e., artificial turf, carpet, pine bark, sand) : The order of these surfaces are represented by increasing difficulty of an ambulation. The artificial turf, carpet and sand decrease a firmness for the weight-bearing limb. 2) ramps (i.e., up and down ramps): these tasks require motor coordination, strength ,and compensatory adjustments in center of mass. 3) two sets of stairs (low steps and high steps): The most critical element is an ability to use visual and kinesthetic information to detect the location of the edge of each step including an accuracy of the foot placement during going up or down stairs. 4) discrete functional tasks (i.e., opening the door, walking around the cones, rising from a chair and stepping over bolsters): these tasks challenge the ability to incorporate visual input formation and performance of the motor tasks. In addition, the coordination of limbs and trunk motion integrated into one motor task.

The total distance was 106 meters (8, 13, 14). The walkway was placed between parallel bars for safety (8, 11, 13-15, 19, 21). Performances on the obstacle course in the elderly were recorded by elapsed time and quality scores (8, 11, 13-15, 19-21). Means (20) also modified the FOC to use in the community by using walls instead of parallel bars. This FOC was modified six obstacles. These were artificial turf, carpet, pine bark, sand, up and down ramp. The modified FOC was less costly, less time in setting and easier to breakdown and store than the original course. Rubenstein et. al. (11) was set up the FOC that consisted of six different tasks in total distance 31 meters. The functional tasks were tandem walking, walking balance ladder with foam, stepping ramp and stairs, picking up box, walking mini-blind through, and stepping over a block. This course was developed to represent the mobility in daily life and was based on preliminary reports of the FOC by previous researchers (8, 13).

In addition, Benedetto and colleagues (22) developed a new function obstacle course specified for children. This FOC consisted of the functional ambulatory tasks on a basis of natural environments that children usually performed their activities. The template mat is 4m.× 4m. and made from artificial leather. These were 1) change to direction and base of support. 2) different walking surfaces. 3) ability to walk over, around and under obstacles. 4) discrete functional task. The purpose of this assessment test is measuring changes over time in pediatric populations.

2.4.3.1.2 Advantages of the FOC

The FOC is a good and inexpensive assessment of the postural stability within the environmental contexts (8, 13-15, 19-21). The FOC has been used for diagnosing and evaluating the balance and mobility in adults and children with disability (8, 13, 14, 19, 21, 73, 94, 95). Thompson et al (16) used an obstacle course to test the functional balance in the elderly with physical impairments after participating an exercise program. This obstacle course consisted of walking on a plank, walking over objects, picking up objects and turning in a chair. It can be used to evaluate the functional balance for pre and post exercise program. Means et al (14)used the FOC to evaluate the participation in a rehabilitation exercise program intended to improve the balance and mobility.

Additionally, Imms and Eldholm (17) suggested the relationship of the balance related velocity of walking and the performance on the obstacle course. The velocity of walking was positively correlated with the performance score of the FOC but was not related to age and falling history. Brown et al (18) used the FOC to evaluate the relation between muscle strength and physical performance in the elderly by timing the performance on functional activities (i.e., walking and rising from a chair). They found that the performance scores were correlated with muscle strength. Means (21) compared the balance and mobility between African American women and white women by the FOC. The results found that African women had less muscle strength and poorer balance and mobility than white woman did. The researcher suggested that the differences of the balance and mobility between racial groups were influenced by flexibility, muscle strength and daily activities.

2.4.3.1.3 Standardization of the FOC

Reliability of the PFOC

Means (13) studied the reliability of the FOC in elderly faller and non-faller (n=44). The results were found that the inter-tester agreement among three testers for the time score was 0.999 and the intra-tester agreement was 0.984. Rubenstein et al (11) studied the reliability of the obstacle course for the time in completing the tasks in elderly men (n=58). Inter-tester reliability was assessed by comparing different two testers and test-retest reliability was assessed by comparing the first and second sessions. The study found high inter-tester reliability (0.96) and test-retest reliability (0.93). Benedetto et al (22) studied reliability of a type of the FOC, called the timed obstacle ambulatory test (TOAT) in children. The inter-tester reliability for this FOC was very high (ICC=0.99).

Validity of the PFOC

Means et al (8) studied concurrent validity of the FOC by correlating with clinical indicators of balance and functional mobility. These were functional status, activity levels muscle strength, balance dysfunction symptoms and joint range of motion. The researcher suggested the FOC correlated with physical and functional ability in elderly exceptions include blood pressure and body mass index. Rubenstein et. al. (11) found that the FOC moderately to highly correlated with gait velocity (r=0.66), six-minute walk test (r=0.55) and Tinetti performance-oriented mobility assessment (POMA) gait score (r=0.60) (11). Means et al (15) examined the concurrent validity of the FOC by correlating Tinetti index scores (TI) and postural sway measured on a force platform. The TI included 14 balance subscale items (sitting balance, standing up, turning and extending the neck, trunk backward, standing one leg, turning in a circle and reaching up, etc.) and 10 gait subscale items (i.e., step length, step width, deviation of path, trunk sway, ability to turn around, etc.). The results were found that the FOC correlated with the TI but did not correlate with postural sway. Postural sway measurement was static balance with visual feedback however the FOC emphasized dynamic balance based on common functional tasks and simulated environmental conditions. Imms and Edholm (17) reported a significant correlation between the performance on an obstacle course and gait velocity, postural sway and self-reported activity level. Interestingly, the validity of timed obstacle ambulatory test (TOAT) in typical children was reportedly high (22). The concurrent validity of the TOAT was highly correlated with the BOTMP (run subtest) (r=0.96), the timed up and go test (TUG) (r=0.85), and modified time up and down stair (TUDS) (r=0.92).

2.5. Criteria for Measurement Tools (68).

A guideline for evaluating a test is required. The criteria for evaluating an assessment test (68).

2.5.1 Scalability: This is an attempt to quantify individuals’ response to a determined set of tasks. It is an easy evaluation.

2.5.2 Standardization: This is a set of measures with explicitly stated procedures, information regarding measurement properties. Assessment instruments that are used for one patient to another or from one facility to another require standardized measures (96).

2.5.3 Reliability: The reliability refers to extent to which a measurement procedure yields the extent of consistency of results on different trial, sessions, or even different testers; accuracy or precision of measurement (96, 97).

Types of reliability (98).

1) Test-retest reliability is used to reliable instrument will obtain the same results with repeated tester of the test. One sample of individuals is subjected to the identical test or two separate occasions, keeping all testing conditions as constant as possible. This estimate can be obtained for a variety of testing tools, and is generally indicative of reliability in situations when testers are not involved.

2) Rater reliability

2.1) Inter-rater reliability concerns between two or more testers who measure the same group of subjects. Inter-rater reliability is best assessed when all testers are able to measure a response during a single trial that can observe a subject independently

2.2) Intra-rater reliability refers to the stability of data recorded by one rater across 2 or more trials. Each subject is assessed by the same raters. Intra-rater is usually assessed using trials that follow each other with short intervals. Intra-rater reliability is achieved simply by having one experienced individual perform all measurements.

2.3) Alternate form reliability is established by administering two alternate forms of a test to the same group. The idea of alternate forms has been applied mostly to educational and psychological testing. For example, clinicians use parallel forms of gait evaluations, tests of motor development, strength tests, functional evaluations and range of motion test.

2.4) Internal consistency or homogeneity reflects the extent to which items measure various aspects of the same characteristic. The most common approach to testing internal consistency involves looking at the correlation among all items in a scale. For most instruments, it is desirable to see some relationship among items especially if the scale score is summed.

2.5.4 Validity: The validity refers to the extent to which an instrument measures what it is intended to measure. The validity emphasizes on the objectives of a test and the ability to make inferences from tests or measurements (96, 97). Validity implies that a measurement is relatively free from error (23).

Types of validity (98).

1) Face validity is used to test what it is supposed to test. Face validity is easily established because the instrument measures the property of interest through some forms of direct observation.

2) Content validity concerns with how well the measure samples the domains of interest. It is most useful for questionnaires and inventories.

3) Construct validity concerns with relating a measure to a network of measures that form a coherent group with some theoretical assumptions behind it.

4) Criterion-related validity concerns with the outcomes of an instrument or a target test that can be used as a substitute measure for an established gold standard criterion test.

4.1) Concurrent validity is taken at relatively the same time. Mostly, often used when a new or untested tool is more efficient, easier to administer, more practical or safer than another method.

4.2) Predictive validity measures an ability to predict a future criterion score or outcome.

CHAPTER III
MATERIALS AND METHODS

3.1 The Pediatric Functional Obstacle Course Test (PFOC)

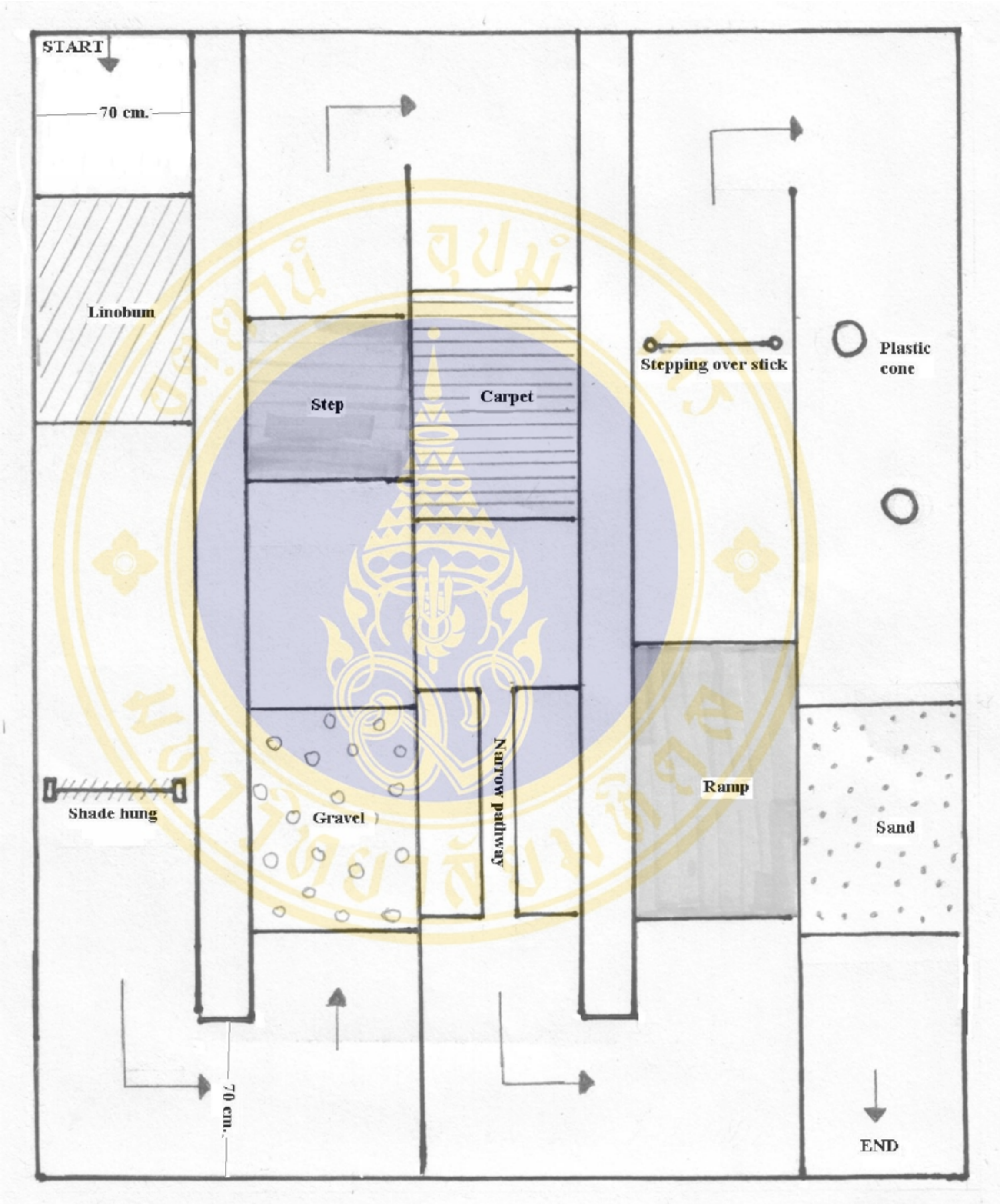
The pediatric functional obstacle course was designed for children to assess their balance and mobility while walking over different surfaces, through different turns, different function tasks and different bases of support. This PFOC was modified from the timed obstacle ambulatory test (TOAT) that was designed by Benedetto and colleagues (22). The obstacles that are commonly found in Thailand were primarily considered.

The PFOC consisted of a series of stations where functional tasks or simulations of common functional conditions encountering in and around the home environment. The PFOC stations were designed to challenge different functional strategies. These were four stations with different types of floor surfaces (i.e., sand, linobum, carpet, gravel), two ramps (i.e., up and down ramps), two steps (up and down steps) and four discrete functional tasks (i.e., bending under the shade, walking through narrow pathway, walking through the plastic cones, stepping over a stick). In addition to these obstacle stations, different directional changes (e.g., wide turns and sharp turns) were established.

3.2 Layout of the Pediatric Functional Obstacle Course Test (PFOC)

The PFOC test was set up over a template mat that was 4m.×5m. (width×length). This template mat was made of artificial leather (Figure 3.1). Each obstacle station was outlined setting on the template mat. The total distance was appropriately 20 meters (Figure 3.2).

Figure 3.1 Template mat of the pediatric functional obstacle course test (PFOC)



* 1 scale = 20 centimeters

Figure 3.2 Layout of the pediatric functional obstacle course test (PFOC)

3.3 Stations of PFOC Test

The PFOC test was modified from the timed obstacle ambulatory test (TOAT) (22) that was designed for children. Some obstacle stations of the TOAT were removed or modified based on the reviewed literature of the FOC and the appropriateness for Thai children's daily activities. The station of bending down to pick up a object was removed because it seemed to be a functional task, not a obstacle. Different types of u-turn (e.g., sharp, regular, wide, and 90º u-turn) were not emphasized because of the limitation of space. Two textured surfaces were changed. The surfaces of tilt and wood chips were modified to the surfaces of linobum and gravel because they were more commonly used in Thailand. The station of walking between the rails was modified to the station of walking through parallel lines. In addition to these, the textured surface of sand and the stations of walking up and down the ramp were added. These tasks are necessary to assess functional balance and mobility.

1. Four stations involved walking across different types of floor surfaces. These are
   (a) a linobum surface that represented shiny texture and hard support.
   (b) a carpet surface that represented uneven texture and medium support.
   (c) a gravel surface that represented coarse texture and loose support.
   (d) a sand surface that represented fine texture and loose support.

   Each flooring surface was 0.7m.×1.0m. The sand and gravel were inserted by a floor plank that was made of plywood. The edge of the floor plank was 4 cm. high.

2. Four stations included two different graded surfaces (up and down ramps) and two different stepping tasks (up and down step). The ramp and step were made of plywood.
   (a) a typical step was 15 cm. in high, 70 cm. wide, and 70 cm. long (99).
   (b) a standard ramp had a rise to length ratio equaling 1:12. The ramp was 10 cm. rise and 120 cm. long (13).

3. Four stations required discrete functional tasks and object negotiations:
   (a) bending under a shade hung at chin level each subject.
   (b) walking in narrow pathway with 15 cm. wide.
   (c) walking through a straight line of 2 plastic cones spaced 60 cm. apart.
   (d) stepping over a stick set at half shank level each subject.

The distance between tasks ranged from 60 to 100 meters (Figure 3.3, 3.4)

Figure 3.3 Total obstacle stations of the PFOC test

Figure 3.4 A diagonal view of the stations and directions of pathway of the PFOC test

3.4 Subjects

Children with typical development aged 4-9 years old were convenient sample for this study. They were recruited from Wat Dusidaram school in Bangkok. Before the study, their parents were requested to sign a consent form. This study was approved by the ethical committee on research involving human subject faculty of medicine Siriraj hospital.

Inclusion criteria

- standard weight and height were age-appropriate, based on the growth chart used in department of pediatrics, Siriraj hospital.
- no history of major injury or disorder.

Exclusion criteria

- inability to comprehend instructions.
- apparent musculoskeletal and neuromotor problems.
- apparent visual and auditory problems.

3.5 Testers

The testers in this study were two physical therapists who were practiced how to instruct and time the subjects' performance in all three tests (i.e., PFOC test, FGS test, and TUG test) before actually testing.

3.6 Procedure

Before testing, all subjects were screened the history of health by interviewing their parents and were measured height, weight and leg length (Appendix D). Subjects were randomized the order of three tests (i.e., PFOC test, FGS test, and TUG test). The subjects had a rest at least 2 minutes between the tests. For the PFOC test, the subjects were assessed by two testers by counter-balancing the order of the testers. One tester did the PFOC for 3 times and then took a rest at least 2 minutes. The other tester then did the PFOC for 3 times. In the following week, one of the testers repeated the PFOC for 3 trials, as she did in the first session.

3.6.1 The protocol for the pediatric functional obstacle course test (PFOC)

A tester explained and demonstrated how to walk through the course of the PFOC test. The tester gave the instructions according to the standard instructions (Appendix E) to the subject. The subject walked with barefoot. He/she was practiced for three times to get familiar with the tasks. The subject had to rest for at least two minutes between trials. The time (seconds) was recorded by a stopwatch. The time began when the tester said “ready….go”. The time was stopped when the subject crossed the line with both feet. The subject’s performance was recorded by two camcorders. The camcorders were positioned to get frontal and lateral views of the performance. The performance images were expected for discussion.

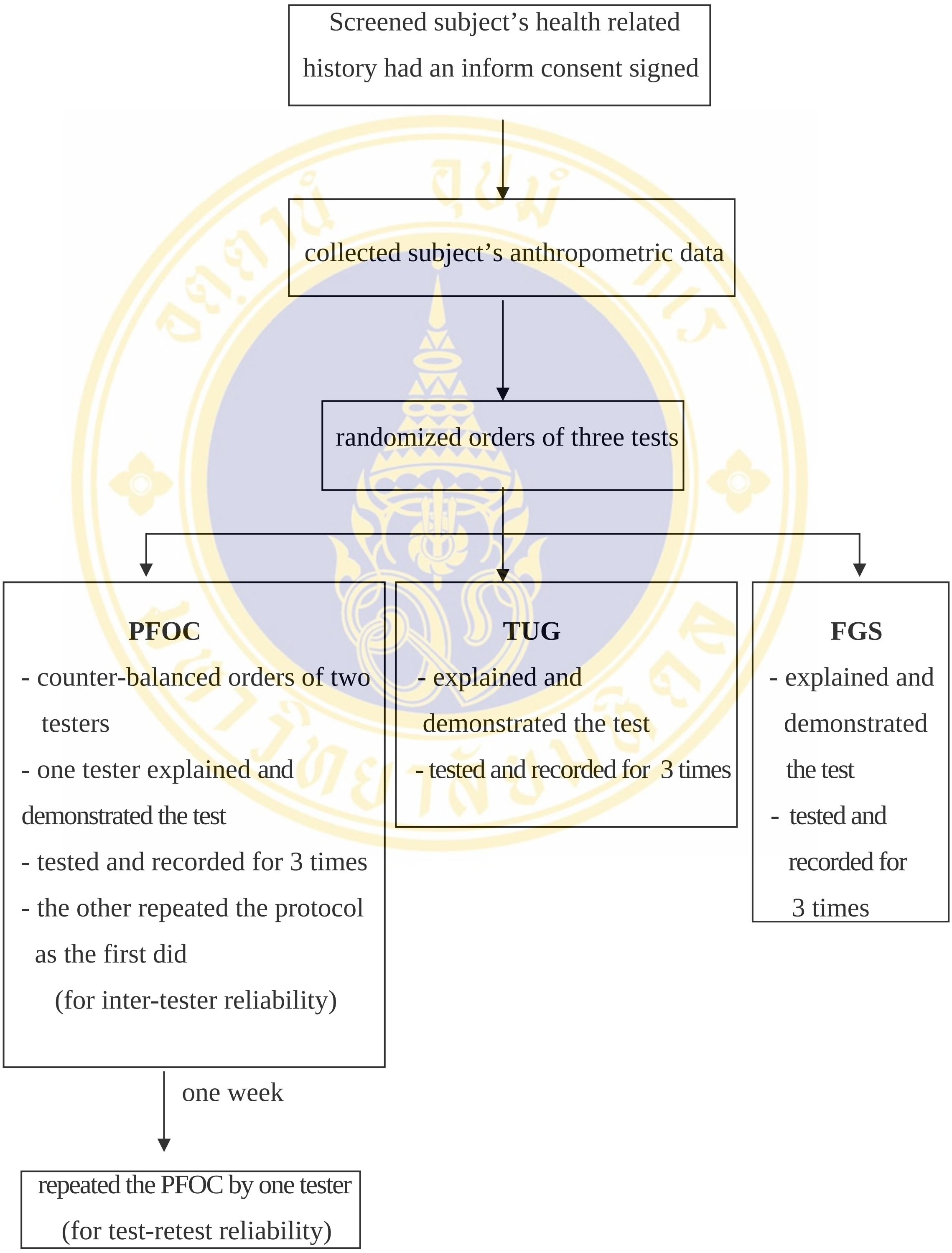
3.6.2 The protocol for fast gait speed test (FGS)

A tester instructed a subject according to the standard instruction (Appendix E). The tester explained and demonstrated how to perform the fast gait speed test. The subject practiced one time before the actual test. The subject walked on 10 meters walkway with barefoot. The tester recorded the time when the subject walked for the 6 meter distance in the middle of the walkway. The tester collected data for three trials (7, 11, 93, 100, 101).

3.6.3 The protocol for the timed “up and go” test (TUG)

A tester explained and instructed the subject according to the standard instructions (Appendix E). The subject sat on the chair that was adjusted to the height of the subject’s knees. The subject positioned hips, knees, and ankles in approximately 90 degrees. The subject practiced one time before the actual test to get familiar with the test. To complete the test, the subject stood up from a chair, walked through a distance of 3 meters, turned around a cone, walked back to the chair and sat down for each subject. The subject performed the test with barefoot. The tester started timing when tester said “ go” and stopped timing when the subject’s buttock touched the seat surface (3-7).

PROCEDURE


Screened subject's health related history had an inform consent signed
collected subject's anthropometric data
randomized orders of three tests
PFOC
- counter-balanced orders of two testers
- one tester explained and demonstrated the test
- tested and recorded for 3 times
- the other repeated the protocol as the first did
(for inter-tester reliability)
TUG
- explained and demonstrated the test
- tested and recorded for 3 times
FGS
- explained and demonstrated the test
- tested and recorded for 3 times
one week
repeated the PFOC by one tester
(for test-retest reliability)

3.7 Data Analysis

The data were calculated by using the SPSS for Microsoft Windows release 11.0 The level of significance was 0.05. The three recorded time on the three tests (i.e., PFOC, FGS and TUG) for each tester were descriptively analyzed. The average and standard deviation of the data were calculated.

For inter-tester reliability of the PFOC, the average time that was recorded by two testers were calculated by intraclass correlation coefficient, ICC (2,k)

For test-retest reliability of the PFOC, the average time that was recorded in two sessions, were calculated by intraclass correlation coefficient, ICC (3,k)

The intraclass correlation coefficients (ICC) ranges between 0.00 and 1.00, with values closer to 1.00 representing stronger reliability. The values above 0.75 are indicative of good reliability and those below 0.75 poor to moderate reliability (98).

The results of Kolmogorov Smirnov Goodness of fit test revealed that the data were normally distributed, then the concurrent validity was calculated by Pearson product-moment correlation analysis to examine relationships among the PFOC and two selected tests (i.e., FGS and TUG tests).

Strength of associations between two variables based on values of the correlation coefficients (r) (98) were as follows :

r = 0.00-0.25 little or no relation

r = 0.25-0.50 fair relation

r = 0.50-0.75 moderate to good relation

r = > 0.75 good to excellent relation

The results of pilot study are presented in Appendix H.

CHAPTER 4
RESULTS

The PFOC test is a new assessment tool for measuring functional mobility through obstacles for Thai children. The study determined the inter-tester reliability, test-retest reliability and concurrent validity of the PFOC test.

4.1 Characteristics of the Study Group

Subjects of this study were 30 Thai children with typical development (15 boys, 15 girls), aged between 4 and 9 years. The demographic data of the subjects are presented in Table 4.1

Table 4.1 The demographic data of the study groups (n=30)

Age (yr)	N	Weight (kg)	Height (cm)	Lower leg length (cm)
4	5	16.50±1.22	101.90±2.13	23.90±1.19
5	5	18.50±1.41	107.90±4.10	25.10±1.43
6	5	20.00±1.58	115.70±2.28	26.10±0.89
7	5	23.30±2.99	120.40±1.14	27.60±0.65
8	5	27.50±2.74	125.60±2.70	29.00±1.36
9	5	31.60±5.13	132.90±1.75	30.30±1.20

4.2 The Time to Complete on the PFOC, TUG, and FGS Tests by Age Groups

The time of the PFOC, TUG and FGS tests were recorded by two physical therapists that practiced to get familiar with the tests before administering. The elapsed time of the three tests are presented in Table 4.2 The results revealed that the time for completing the tests tended to decrease by increasing age in all three tests (Figure 4.1, 4.2 and 4.3).

4.3 Inter-Tester Reliability of the PFOC

This study demonstrated inter-tester reliability between two physical therapists of the PFOC test. The average time of the PFOC test for tester1 and tester2 was 20.43±4.42 and 20.13±4.40 seconds, respectively. Intraclass correlation coefficient (ICC 2,k) was used to determine inter-tester reliability of the PFOC (Table 4.3). The data was computed by two-way random effect model (absolute agreement definition). Inter-tester reliability for the recorded time was high (ICC=0.97). The result was shown in Table 4.3 The confidence interval at 95% for the ICC values for the PFOC was 0.94 to 0.99 (Table 4.3).

4.4 Test-Retest Reliability of the PFOC

The data from this study established test-retest reliability between the first session and the second session that was separated by one week. The recorded time for the first and second test were 20.43±4.42, 19.58±3.62 seconds, respectively. The data were computed by ICC (3,k) which used two-way mixed effect model (consistency definition). Test-retest reliability for the recorded time was a high (ICC=0.83). The result is shown in Table 4.3 The confidence interval at 95% was 0.65 to 0.92 (Table 4.3).

Table 4.2 The time to complete on the tests in each groups

Age (yr)	N	PFOC (seconds) *		TUG (seconds)		FGS (seconds)	
		mean±SD	min-max	mean±SD	min-max	mean±SD	min-max
4	5	26.38±2.33	22.91-29.79	7.07±0.53	6.25-7.68	4.02±0.30	3.54-4.23
5	5	22.46±4.37	18.86-31.08	6.67±1.05	5.9-8.49	3.85±0.76	3.13-5.14
6	5	21.71±2.66	18.43-25.23	5.90±0.89	4.97-6.98	3.47±0.28	3.23-3.94
7	5	17.48±1.05	15.32-18.93	5.16±0.51	4.62-5.78	3.13±0.17	2.85-3.27
8	5	16.78±2.45	12.88-19.76	5.13±0.94	3.68-6.28	2.90±0.72	1.88-3.71
9	5	16.88±1.65	14.66-19.72	5.31±0.63	4.69-6.16	3.11±0.43	2.55-3.75

PFOC = pediatric functional obstacle course
TUG = timed up and go
FGS = fast gait speed
min = minimum of the elapsed time
max = maximum of the elapsed time
N = the number of subjects in age range

* average time of the PFOC between tester1 and tester2

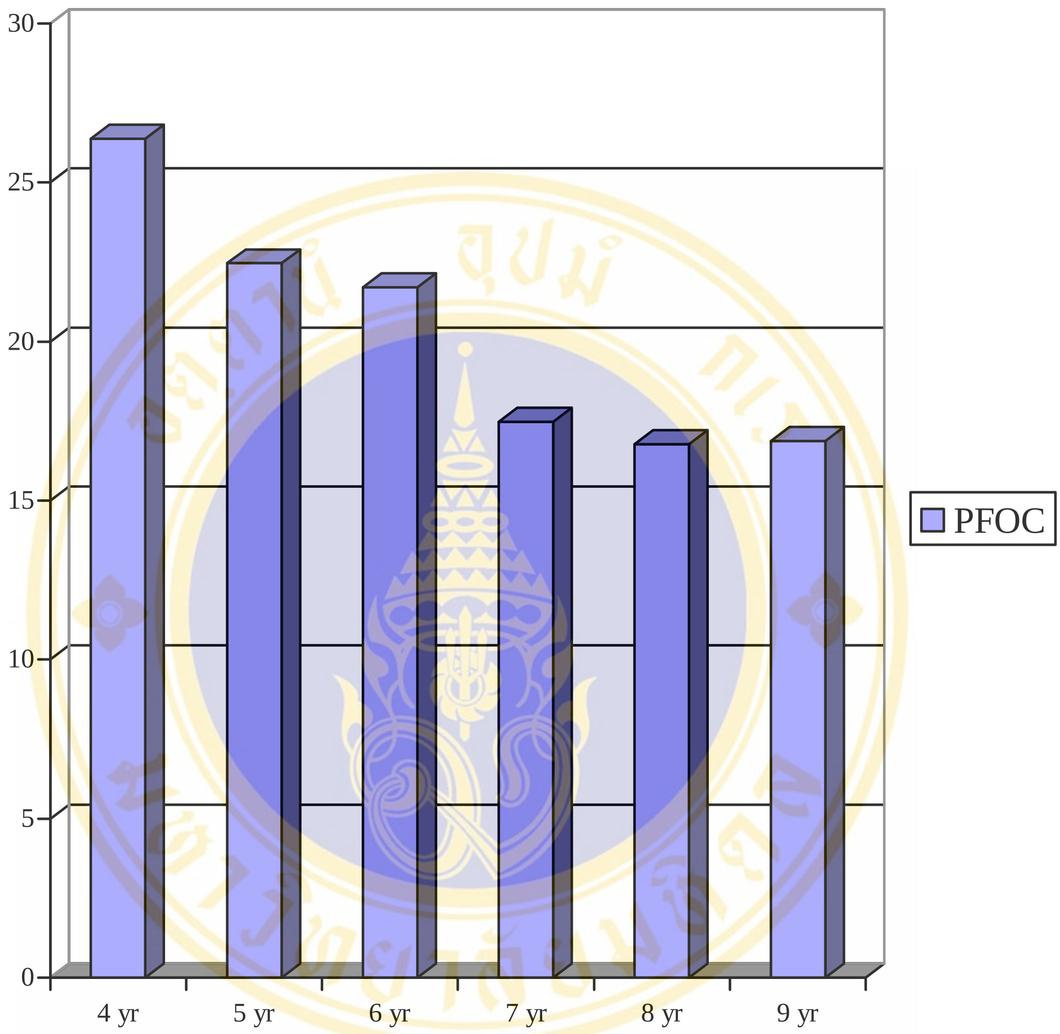


Figure 4.1 The time (seconds) to complete on the PFOC test by age groups.

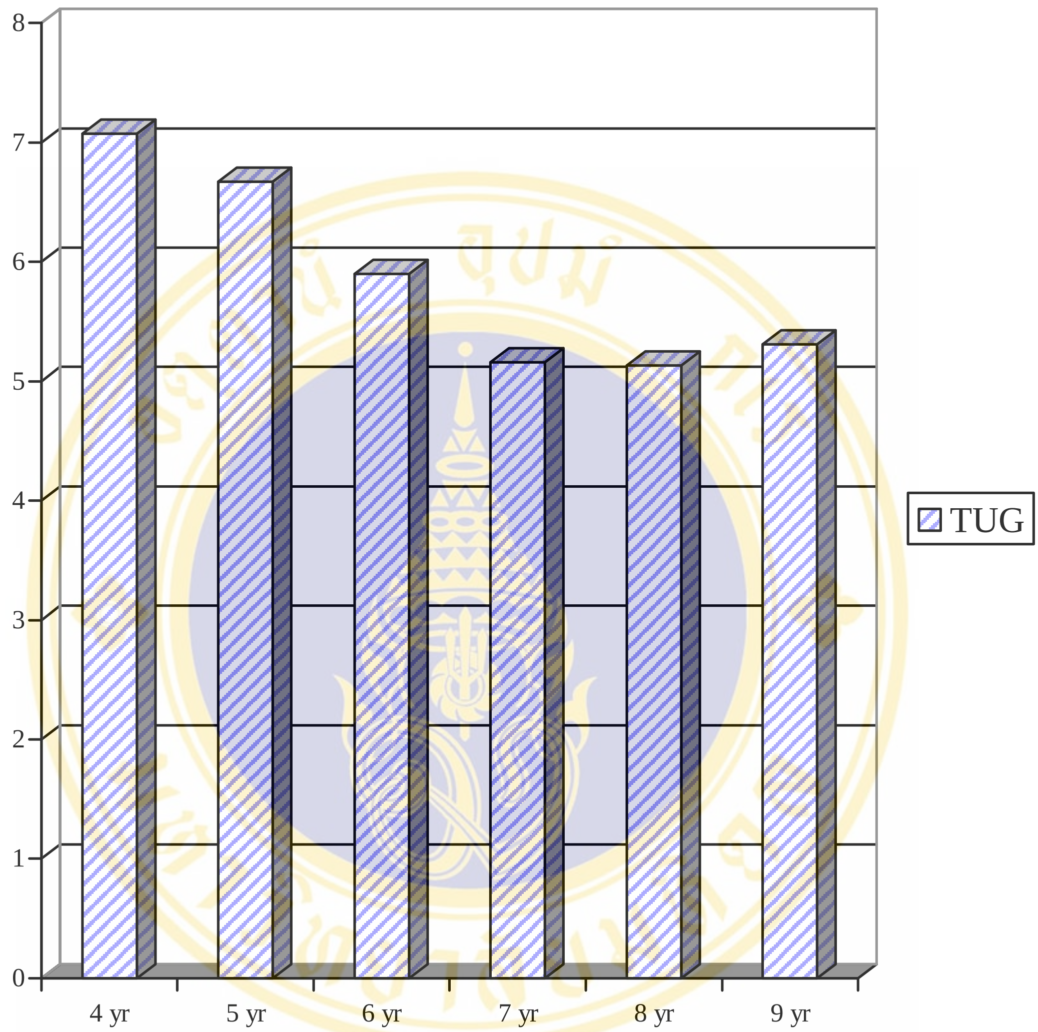


Figure 4.2 The time (seconds) to complete on the TUG test by age groups.

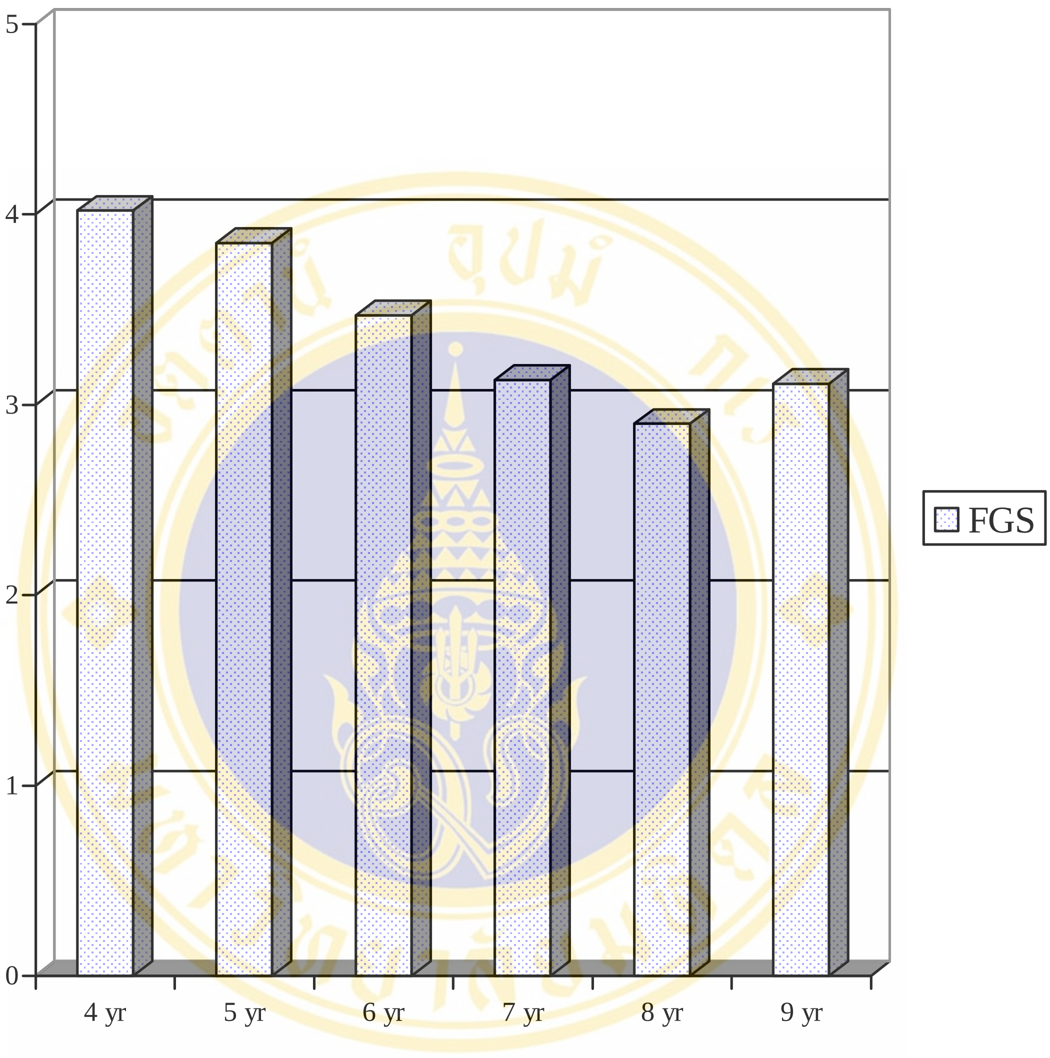


Figure 4.3 The time (seconds) to complete on the FGS test by age groups.

Table 4.3 Intraclass correlation coefficients (ICC) of the PFOC

	Inter-tester Reliability	Test-retest Reliability
ICC	0.97	0.83
95% CI	0.94-0.99	0.65-0.92

4.5 Concurrent Validity of the PFOC

The concurrent validity of the PFOC was determined by correlating the recorded time of the PFOC with the recorded of the TUG and the FGS. The distributions of all data were tested by Kolmogorov-Smirrov Goodness of Fit-test. These data were normally distributed; therefore they were analyzed by Pearson's product moment correlation coefficient. As shown in Table 4.5, the correlation between the PFOC and the TUG was 0.85. The relationship is shown as the scatter plot in Figure 4.2. The correlation between the PFOC and the FGS was 0.82. The relationship is shown as scatter plot in Figure 4.3. These correlations indicated highly acceptable concurrent validity ($p<0.01$).

Table 4.4 Correlation coefficient values of the PFOC, TUG and FGS tests

TEST		PFOC	TUG
PFOC	pearson correlation	1.000	0.85**
	Sig. (2-tailed)	.	0.008
FGS	pearson correlation	0.82**	0.85**
	Sig. (2-tailed)	0.009	0.001

** Correlation was significant at the 0.01 level (2-tailed)

PFOC = pediatric functional obstacle course

TUG = timed up and go

FGS = fast gait speed

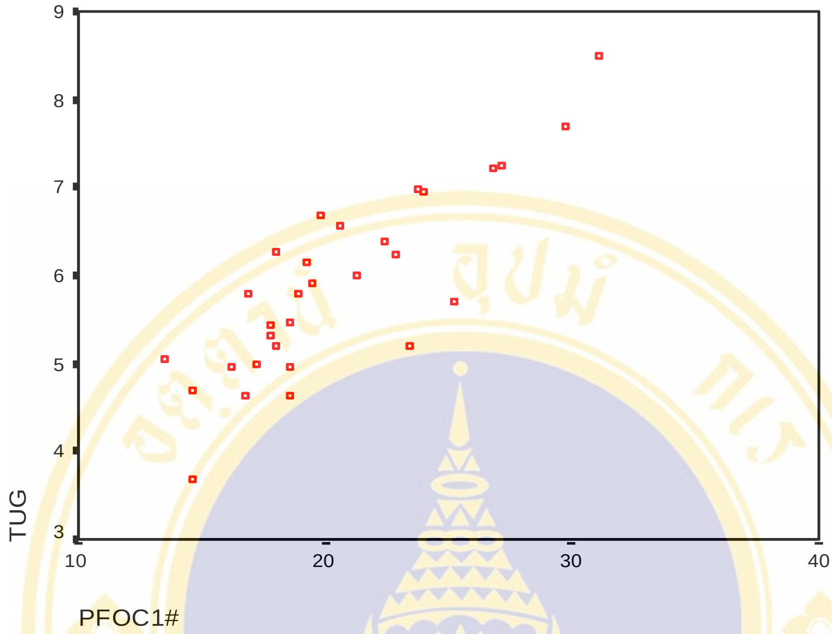


Figure 4.4 The scatter plot of the relationship between the pediatric functional obstacle course (PFOC) and the time up and go (TUG) (r=0.85)

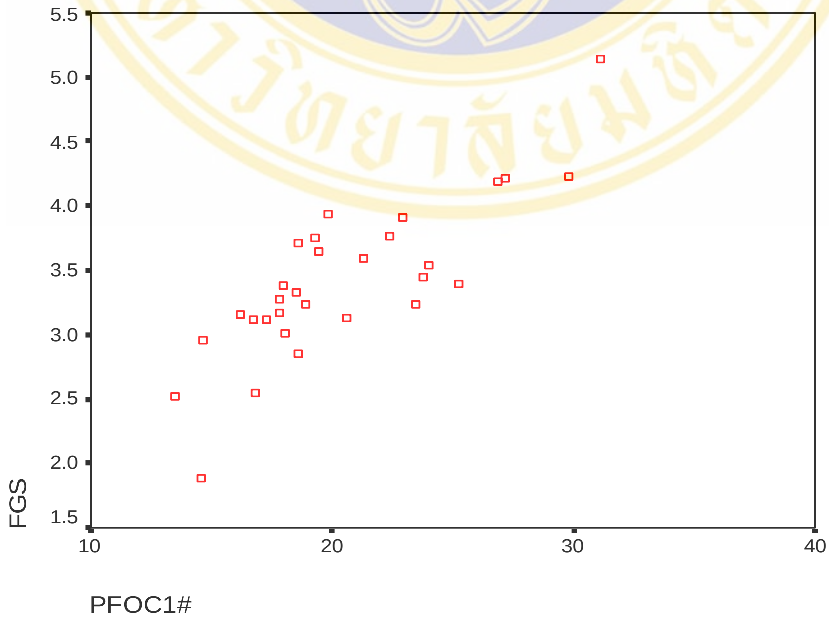


Figure 4.5 The scatter plot of the relationship between the pediatric functional obstacle course (PFOC) and fast gait speed (FGS) (r=0.82)

CHAPTER 5
DISCUSSION

5.1 The Time to Complete on the PFOC, TUG, and FGS Tests in Children.

The time to complete the PFOC, TUG, and FGS test tended to decrease when the subjects' age increased. This result indicates an influence of age on the time that was elapsed on these tests. One possible reason was the development of systems of postural control. In four to six years of age, children begin to maintain balance using primary vestibular information for postural control, rather than visual system. By seven to ten years, the children reach adult-like maturity. Therefore, they are able to resolve a sensory conflict and appropriately utilize the vestibular system as a reference (23). When comparing the time of the youngest groups (i.e., 4-year-old group) and the oldest group (i.e., 9-year-old group), the significant difference of the elapsed time was revealed. However, the sample size on each age group was small (n=5). This limitation probably affected an indifference of the time to complete the test among some age groups. These possible reasons with regards to the time of completion can also be explained on the TUG and FGS tests.

5.2 Inter-Tester Reliability of the PFOC

The inter-tester reliability of the PFOC test (n=30) was high [ICC (2,k) = 0.97]. High inter-tester reliability implies that multiple testers can use the PFOC with consistency. Additionally, the 95% confidence interval (0.94 to 0.99) confirmed the acceptable level of reliability. Some possible reasons of high reliability are as follows: (1) the testers (physical therapists) were trained how to appropriately record the time and to instruct the subjects before actually testing, (2) the testers instructed the subjects with the standardized statements of the PFOC at every testing trials, and (3) the testing tools were placed correctly on the template.

Similarly, previous studies reported high inter-tester reliability for timing the completion of the tasks on the functional obstacle courses. Mean et al in 1996 (13) showed excellent inter-tester reliability both time scores (ICC=0.98) and quality scores (ICC=0.99). Benedetto et al (22) studied the reliability of timed obstacle ambulatory course (TOAT) in typical children (n=9). Inter-tester reliability of the TOAT by two testers was high (ICC=0.99).

5.3 Test-Retest Reliability of the PFOC

The test-retest reliability of the PFOC was high [ICC (3,k)=0.83]. The confidence interval at 95% was in wide range (i.e., 0.65 to 0.92). Commonly, the test-retest reliability is higher than the inter-tester reliability. However, this study found the test-retest reliability was lesser than inter-tester reliability. Most subjects (66%) reduced their time in the second session. In the retest session, the average time to complete the course was shorter than the first test.

Possible reasons of the test-retest reliability in this study are as follows :

1. Subjects: In the first session, the children were recorded the performance by the camcorders as well as recording the time. The children were possibly very excited or distracted during testing. This concern probably involved an increase of the time of the PFOC. In the second session, the children were tested without the camcorders leading to a decrease of the external disturbance factor.

2. Tester: The tester sometimes did not follow every statement on the standardized instructions in the second session. This probably affected the difference of the performance speed.

3. Procedure: In the first session, all subjects had to perform the tasks on three tests within the same day. This probably made them so fatigue that they could not do the best. In the second session, the subjects were tested on the PFOC only.

Rubenstein et al in 1997 (11) studied test-retest reliability of an obstacle course. Test-retest reliability was high (ICC=0.93). Means (13) examined intra-tester agreement of the obstacle course by reviewing the videotapes. The result showed high intra-tester agreement for the time (ICC=0.98).

5.4 Concurrent Validity of the PFOC

The concurrent validity of the PFOC was supported by the correlation of the PFOC with the TUG and the FGS. The correlations between the PFOC and FGS (r=0.82), the PFOC and TUG (r=0.85) were good to excellent (p<0.01). Many previous studies supported the validity of the functional obstacle courses (8, 11, 15, 22).

Means (8) studied the concurrent validity of an obstacle course in elderly by correlating the obstacle course with various indicators of balance and functional mobility. These comprised number of medications, number of medical conditions, functional status, activity levels, number of falls in last years, balance dysfunction symptoms, neurologic abnormalities, muscle strength, and joint range of motion. The results revealed that the obstacle course correlated with activity level (r=0.54) and functional status (r=0.46).

Moreover, Means (15) found that the functional obstacle course had good correlation with the Tinetti index scores (r=-0.78) but weak correlation with the postural sway measurement during open-eyes (r=-0.24) or closed-eyes conditions (r=-0.15). Both Tinetti index and functional obstacle course tests measured the balance and mobility during dynamic activities. In contrast, postural sway measurement was the static balance test.

Rubenstein et al in 1997 (11) reported that the obstacle course was moderately correlated with Tinetti performance-oriented mobility assessment (POMA) balance scores (r=-0.44) and POMA gait score (r=-0.66). The obstacle course was moderately correlated with six-minute walk test (r=0.55) and gait velocity test (r=0.66). However, single leg stance time was poorly correlated with obstacle course (r=0.19). The reason could be the single stance was the static balance test whereas the functional obstacle course was dynamic balance test. Therefore, these studies support the PFOC as dynamic balance test.

Furthermore, the high correlation between the PFOC and the timed up and go (TUG) test in this study is supported by Benedetto and colleagues' study (22). Benedetto et al (22) reported that the timed obstacle ambulatory test (TOAT) highly correlated with Bruininks-Oseretsky test of motor proficiency in the sub-test of running (r=0.96), timed up and go (TUG) (r=0.85), modified time up and down stairs (TUDS) (r=0.92).

Additionally, this current study found that the PFOC highly correlated with age (r=-0.786) and height (r=-0.818), whereas, poorly to moderately correlated with weight (r=-0.649) and lower leg length (r=-0.692). Davis et al (102) stated that short body height was a possible reason for an increased risk of falling but weight and body mass index (BMI) were not found to be associated with falls in the elderly when examined with the time up and go, tandem balance test and walking speed test.

Limitation of the Studies

Small sample size in each age group (n=5) probably affected unclear answer regarding the time of the PFOC test by age. However, this concern did not affect the main purpose of the study. In this study, the reliability and validity of the PFOC was the study of interest. Additionally, the testers were not encouraged to seriously follow the standardized instructions. This probably affected the test-retest reliability. Therefore, the testers should be aware of standardized instructions every time for high reliability and validity.

Clinical Implications and Further Studies

The results of this study indicated that pediatric functional obstacle course (PFOC) test could be used to measure functional balance and mobility for typical Thai children reliably and validly. The PFOC is expected to be important to assess the ambulatory problems based on daily environments in children with disability. The reliability and validity of the PFOC for the time in typical children make physical therapists somewhat confident to use the PFOC in children with disabilities.

However, further study of reliability and validity of the PFOC in children with disabilities is suggested such as children with Down's syndrome, etc. Furthermore, the PFOC in this study measures the completion of the tasks by timing only. An examination of quality of movement is also essential for an evaluation of functional balance and mobility in children with disabilities. Therefore, a study of qualitative scores for the PFOC is suggested. Finally, the further studies with a larger sample size are suggested for discriminating the results of the PFOC by age.

CHAPTER 6
CONCLUSION

The pediatric functional obstacle course (PFOC) is a new tool for assessing functional balance and mobility in Thai children based on daily environments. This study showed that the PFOC test reached the acceptable levels of reliability and validity for timing the completion of the tasks. Therefore, the PFOC test would be a good choice for a measurement of functional balance and mobility in clinical settings. The PFOC may also enhance physical therapists to analyze problems, plan treatment, and re-evaluate the functional balance and mobility based on natural environments.

The PFOC can be used to measure functional balance and mobility for various age group. However, in this study, the sample size in each age group was small (n=5). This probably affected an unclear answer regarding the time of the PFOC test. In addition, the testers should be seriously following the standardized instructions in testing for high reliability and validity.

Further study of the PFOC is suggested to measure functional balance and mobility in children with disability or Down’s syndrome etc. Moreover, the PFOC should utilize both the time to completion and quality scores of the tasks as they are essential for an evaluation of functional balance and mobility in children with dynamic postural control and ambulation problems.

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APPENDIX A

INTERVIEW FORM (IN THAI)

APPENDIX A

INTERVIEW FORM

แบบสัมภาษณ์ข้อมูลของผู้เข้าร่วมการวิจัย

ชื่อ-สกุล.. **อายุ.........................ปี**

ประวัติความเจ็บป่วย

1.เคยมีประวัติเกี่ยวกับปัญหาการทรงตัวขณะเดินหรือไม่

❒ ไม่มี ❒ มี โปรดระบุ............

2. เคยมีประวัติเกี่ยวกับปัญหาทางระบบกระดูกและกล้ามเนื้อ

❒ ไม่มี ❒ มี โปรดระบุ............

3. เคยมีประวัติเกี่ยวกับปัญหาทางการได้ยินหรือไม่

❒ ไม่มี ❒ มี โปรดระบุ............

4. เคยมีประวัติเกี่ยวกับปัญหาทางการมองเห็นหรือไม่

❒ ไม่มี ❒ มี โปรดระบุ...........

5. มีโรคประจำตัวอื่นๆหรือไม่

❒ ไม่มี ❒ มี โปรดระบุ...........

APPENDIX B

PARTICIPATE INFORMATION FORM (IN THAI)

APPENDIX B
PARTICIPATE INFORMATION FORM

เอกสารแนะนำสำหรับอาสาสมัคร

ชื่อโครงการวิจัย การหาค่าความเชื่อถือได้และความเที่ยงตรงของการทดสอบเดินผ่านสิ่งกีดขวางในเด็กไทย

ชื่อผู้วิจัยหลัก นางสาวสุนทรี ทวีธนะลาภ

เรียนท่านผู้ปกครอง

การศึกษานี้มีวัตถุประสงค์ เพื่อศึกษาความเชื่อถือได้และความเที่ยงตรงของการทดสอบการเดินผ่านสิ่งกีดขวางของเด็ก โดยทำการศึกษาในเด็กไทย อายุ 4-9 ปี เนื่องจาก พัฒนาการด้านการทรงตัวของเด็กในวัยนี้ยังไม่มีประสิทธิภาพมากนักเมื่อเทียบกับวัยผู้ใหญ่ ดังนั้น การทดสอบโดยใช้การเดินผ่านสิ่งกีดขวางจะเป็นการทดสอบความสามารถในการทรงตัวขณะเดินของเด็กที่ภาวะแวดล้อมต่างๆที่พบในชีวิตประจำวัน ว่ามีศักยภาพมากน้อยเพียงใด ซึ่งการศึกษาครั้งนี้แบ่งเป็น 3 การทดสอบ ได้แก่

1. การทดสอบการเดินผ่านสิ่งกีดขวาง ประกอบด้วย 12 งาน ดังนี้ การเดินบนพื้นผิวต่างๆ 4 ลักษณะ(เสื่อน้ำมัน,พรม,กรวด,ทราย), การก้าวขึ้น-ลงพื้นต่างระดับ 1 ขั้น, การเดินขึ้น-ลงทางชัน, การทำกิจกรรมร่วมด้วยขณะเดิน 4 งาน(การก้ม,การอ้อม,การก้าวข้ามสิ่งกีดขวางและการเดินในที่แคบ)
2. การวัดความเร็วขณะเดินด้วยความเร็วสูงสุด โดยเดินให้เร็วที่สุดในระยะทาง 10 เมตร
3. เวลาที่ใช้ในการลุกขึ้นจากเก้าอี้และเดินไปข้างหน้า เป็นการจับเวลาตั้งแต่ลุกขึ้นยืนจากเก้าอี้และเดินตรงไปข้างหน้าเป็นระยะทาง 3 เมตร จากนั้นเดินกลับมานั่งที่เก้าอี้ตัวเดิม

ทั้ง 3 การทดสอบ เด็กที่เข้าร่วมวิจัยทุกคน จะได้รับการอธิบายอย่างละเอียด การสาธิตและฝึกซ้อมก่อนทุกครั้ง ผู้วิจัยจะดูแลเด็กอย่างใกล้ชิดตลอดทำการทดสอบ

ถ้าท่านมีข้อสงสัยประการใดกรุณาสอบถามและติดต่อผู้วิจัยได้ทุกเวลา และในการนี้ผู้วิจัยขอขอบคุณผู้ปกครองที่ให้ความร่วมมือในการอนุญาตให้เด็กเข้าร่วมการทดลองในการศึกษาครั้งนี้

....

(นางสาวสุนทรี ทวีธนะลาภ)

ผู้วิจัยหลัก

APPENDIX C

CONSENT FORM (IN THAI)

APPENDIX C
CONSENT FORM

หนังสือแสดงเจตนายินยอมเข้าร่วมโครงการการวิจัย

วันที่……..….เดือน……..………..พ.ศ……..…...

ข้าพเจ้า………………………………….....…...อายุ……….ปี อาศัยอยู่บ้านเลขที่…….
ถนน…………………แขวง…………………..เขต……………………..จังหวัด……………………
ได้รับทราบรายละเอียดของโครงการวิจัยเรื่อง "การหาค่าความเชื่อถือได้และความเที่ยงตรงของการทดสอบเดินผ่านสิ่งกีดขวางในเด็กไทย" ดังนี้

วัตถุประสงค์ของการศึกษา

เพื่อศึกษาถึงความเชื่อถือได้และความเที่ยงตรงของเครื่องมือที่ใช้ในการทดสอบการเดินผ่านสิ่งกีดขวางในเด็กไทย

ประโยชน์ของการศึกษา

1.ได้เครื่องมือที่มีความเชื่อถือได้และมีความเที่ยงตรงในการทดสอบความสามารถขณะเดินข้ามสิ่งกีดขวางที่เหมาะกับเด็กไทย

2.สามารถทดสอบความสามารถในการทรงตัวขณะเดินของเด็กที่สภาวะแวดล้อมต่างๆที่สามารถพบได้ในชีวิตประจำวัน

3.สามารถตรวจประเมินเบื้องต้นเกี่ยวกับความผิดปกติของการทรงตัวขณะเดินผ่านสิ่งกีดขวางหรือในสิ่งแวดล้อมต่างๆที่เปลี่ยนไป

4.สามารถนำข้อมูลที่ได้จากการวิจัยครั้งนี้ เป็นข้อมูลเบื้องต้นในการศึกษาถึงลักษณะการทรงท่าและการเคลื่อนไหวขณะเดินผ่านสิ่งกีดขวางของเด็ก

ขั้นตอนการศึกษา

เด็กของข้าพเจ้าจะได้รับการอธิบายถึงวิธีการทดสอบ การสาธิต รวมถึงการฝึกซ้อมก่อนที่จะทำการทดสอบเพื่อให้เกิดความคุ้นเคย โดยการศึกษาครั้งนี้ ประกอบด้วยการทดสอบ 3 อย่าง ได้แก่ การทดสอบการเดินผ่านสิ่งกีดขวาง, การเดินเร็ว, การลุกขึ้นจากเก้าอี้และเดินไปข้างหน้า โดยที่การเก็บข้อมูลครั้งนี้จะไม่มีอันตรายหรือผลเสียต่อสุขภาพแต่อย่างใด

ข้าพเจ้ามีสิทธิ์ที่จะให้เด็กงดการเข้าร่วมโครงการวิจัยโดยมิต้องแจ้งให้ทราบล่วงหน้า โดยการงดการเข้าร่วมการวิจัยครั้งนี้จะไม่มีผลกระทบต่อข้าพเจ้าและเด็กที่เข้าร่วมการวิจัย

ข้าพเจ้าได้รับทราบจากผู้วิจัยว่าจะไม่เปิดเผยข้อมูลหรือผลการวิจัยของเด็กที่เข้าร่วมวิจัยเป็นรายบุคคลต่อสาธารณชน หากผู้วิจัยมีข้อมูลเพิ่มเติมทั้งด้านประโยชน์ และโทษที่เกี่ยวข้องกับการวิจัยจะแจ้งให้ข้าพเจ้าทราบอย่างรวดเร็วโดยไม่ปิดบัง

ข้าพเจ้าได้รับทราบและซักถามจนหมดข้อสงสัยแล้วและยินดีให้เด็กของข้าพเจ้าเข้าร่วมในการวิจัย จึงได้ลงลายมือชื่อไว้เป็นหลักฐานต่อหน้าพยาน

ลงชื่อ…..……………………..ผู้ยินยอมหรือ
(………………………..)ผู้แทนโดยชอบธรรม

ลงชื่อ…..……………………..ผู้วิจัยหลัก
(…..……………...…..…)

ลงชื่อ…..……………………..พยาน
(.......................................)

APPENDIX D

DATA COLLECTION FORM

APPENDIX D
DATA COLLECTION FORM

แบบบันทึกข้อมูลผลการทดลอง

ลำดับที่..................

ชื่อ-สกุล...

วัน/เดือน/ปี เกิด.......................................

เรียนอยู่ชั้นปีที่..

น้ำหนัก.....................................กิโลกรัม

ส่วนสูง...................................เซนติเมตร

ความยาวขาท่อนล่าง(วัดจากtibial tubercleถึงmedial malleolus)..................................เซนติเมตร

วันที่ทำการทดสอบ ครั้งที่ 1 ....

วันที่ทำการทดสอบ ครั้งที่ 2 ....

ลำดับการทดลองที่ได้จากการสุ่ม

1) ....

2) ....

3) ....

ลำดับผู้ทดลองของการทดลองPFOC ....

ตารางบันทึกผลการทดลอง

ผู้ทดสอบ...

วันที่ทำการทดสอบ...

ลำดับผู้ถูกทดสอบ	เวลาที่ใช้ในการทดสอบ (วินาที)											
	PFOC				TUG				FGS			
	1	2	3	เฉลี่ย	1	2	3	เฉลี่ย	1	2	3	เฉลี่ย
1.												
2.												
3.												
4.												
5.												
6.												
7.												
8.												
9.												
10.												
11.												
12.												
13.												
14.												
15.												
16.												
17.												
18.												
19.												
20.												

ลำดับผู้ถูกทดสอบ	เวลาที่ใช้ในการทดสอบ (วินาที)											
	PFOC				**TUG**				**FGS**			
	1	**2**	**3**	**เฉลี่ย**	**1**	**2**	**3**	**เฉลี่ย**	**1**	**2**	**3**	**เฉลี่ย**
21.												
22.												
23.												
24.												
25.												
26.												
27.												
28.												
29.												
30.												

APPENDIX E

STANDARDIZED INSTRUCTIONS

APPENDIX E
STANDARDIZED INSTRUCTIONS
คำสั่งมาตรฐานของการทดสอบต่างๆ

คำสั่งมาตรฐานของ pediatric functional obstacle course test (PFOC)

ผู้ทดสอบให้คำชี้แจงมาตรฐานในครั้งแรกดังนี้

นี่เป็นการทดสอบว่า น้องเดินได้เร็วแค่ไหนเมื่อเดินผ่านสิ่งกีดขวางต่างๆ ให้พยายามทำตามที่บอกนะ และจะมีคนเดินตามน้องอยู่ตลอดทาง

ใช้เมื่อ : ก่อนให้คำสั่งและการสาธิตครั้งที่ 1

คำชี้แจงมาตรฐานทั่วไป

เริ่มแรก ต้องวางเท้าทั้ง 2 ข้างตรงขอบเสื่อ เมื่อได้ยินคำสั่งว่า “เตรียมตัว เริ่ม” ก็ให้เดินให้เร็วที่สุดเท่าที่จะทำได้ ห้ามวิ่ง ห้ามกระโดด

ใช้เมื่อ : ทุกครั้งที่ทำการฝึกซ้อมและทดสอบ

คำสั่งจำเพาะแต่ละสิ่งกีดขวาง

- เดินตรงมาผ่านเสื่อน้ำมัน
- ก้มตัวลอดผ่านผ้า อย่าให้ศีรษะชน
- เลี้ยวโค้ง เดินตรงมาผ่านกรวดหิน

- ก้าวขึ้นแท่นไม้
- ก้าวลงแท่นไม้
- เลี้ยวโค้ง เดินตรงมาผ่านพรม
- จากนั้น พยายามเดินให้เท้าอยู่ในเส้นสีแดง ห้ามเดินออกนอกเส้นหรือเหยียบเส้นสีแดง
- เลี้ยวโค้ง เดินขึ้นบนทางชันแล้วเดินลงมา
- เดินต่อมา ก้าวข้ามไม้ ระวังอย่าให้ขาแตะโดนไม้
- เลี้ยว แล้วเดินหลบโคน ห้ามแตะโดนโคนที่ตั้งไว้
- เดินต่อมา ผ่านทราย
- เดินตรงไปเรื่อยๆ จนเดินผ่านเส้นขอบของเสื่อ

ใช้เมื่อ : ทดสอบครั้งที่ 1 ให้คำสั่งตลอดการสาธิตโดยผู้ทดสอบ

ทดสอบครั้งที่ 2 ผู้ถูกทดสอบฝึกซ้อมโดยผู้ทดสอบให้คำชี้แจงมาตรฐานและแนะนำตลอดการทดสอบ

ทดสอบครั้งที่ 3 ผู้ถูกทดสอบฝึกซ้อมโดยผู้ทดสอบให้คำชี้แจงมาตรฐานและแนะนำเฉพาะงานที่ทำไม่ถูกต้อง

แต่ละการทดสอบผู้ทดสอบต้องใช้คำสั่งมาตรฐานดังนี้

เดินให้เร็วที่สุดเท่าที่จะทำได้ ห้ามวิ่ง ห้ามกระโดด

“เตรียมตัว เริ่ม”

คำสั่ง timed up and go (TUG)

การทดสอบนี้จะให้นั่งบนเก้าอี้ โดยที่เท้าทั้ง 2 ข้างให้วางราบบนพื้น พอได้ยินคำสั่ง “เตรียมตัว เริ่ม” ก็ให้ลุกขึ้นยืนแล้วเดินตรงไปข้างหน้าให้เร็วที่สุดเท่าที่จะทำได้ ห้ามวิ่ง ให้เดินเร็วๆ พอถึงเสาให้เลี้ยวอ้อมเสา แล้วเดินกลับมานั่งที่เก้าอี้เดิม

ผู้ทดสอบต้องบอกคำสั่งนี้ทุกครั้งในการทดสอบ

ให้เดินให้เร็วที่สุดเท่าที่จะทำได้ ห้ามวิ่ง “เตรียมตัว เริ่ม”

คำสั่ง fast gait speed (FGS)

การทดสอบนี้ จะให้เดินให้เร็วที่สุดบนทางเดิน โดยเริ่มต้นยืนที่จุดเริ่มต้น เมื่อได้ยินคำสั่ง “เตรียมตัว เริ่ม” ก็ให้เดินให้เร็วที่สุดตั้งแต่จุดเริ่มต้นไปจนสุดทางเดิน ห้ามวิ่ง

ผู้ทดสอบต้องบอกคำสั่งนี้ทุกครั้งในการทดสอบ

ให้เดินให้เร็วที่สุดเท่าที่จะทำได้ ห้ามวิ่ง “เตรียมตัว เริ่ม”

APPENDIX F

CURVES WEIGHT AND HEIGHT

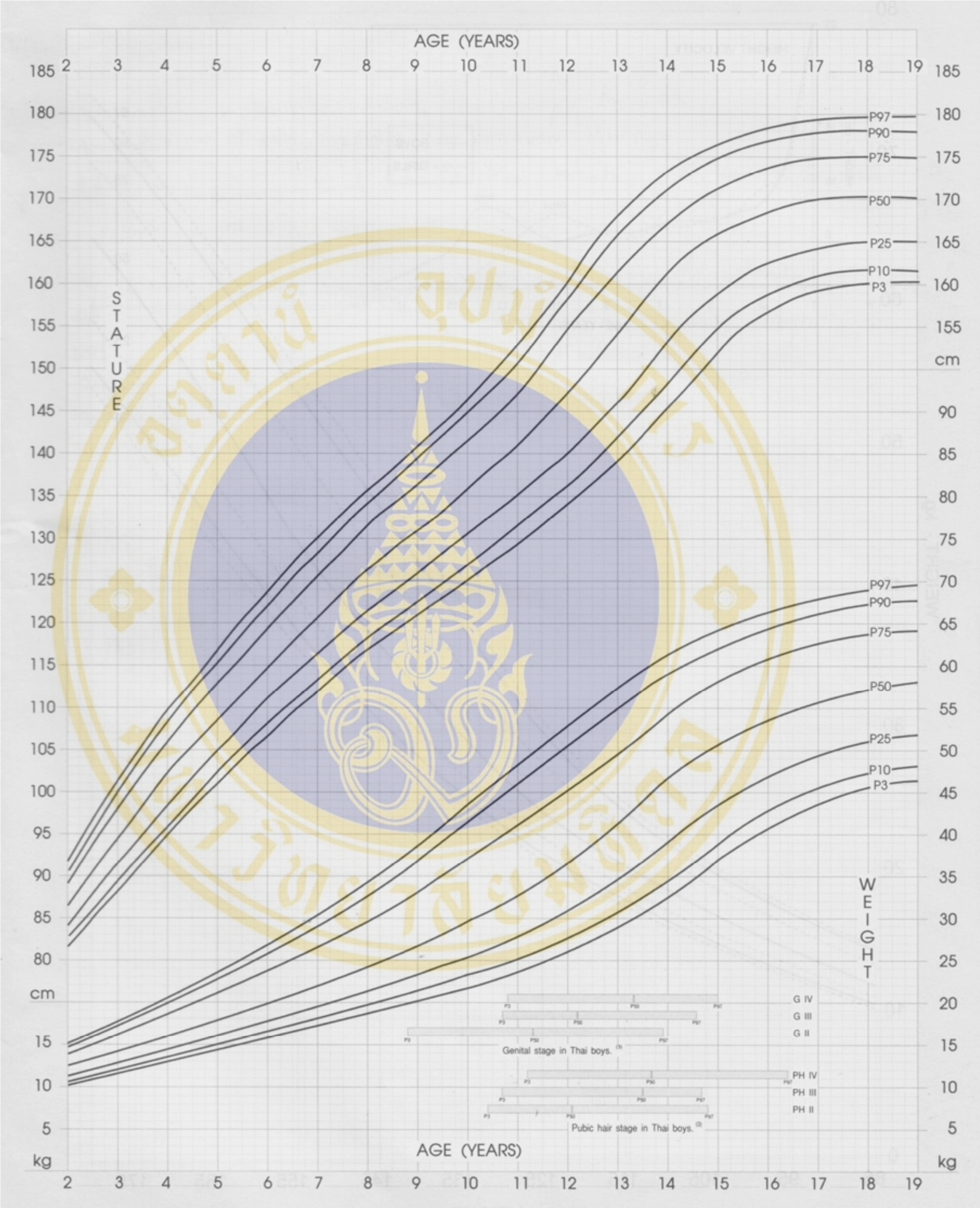

Figure F1. Curve of weight and height for Thai boys by age (from Siriraj hospital's growth chart)

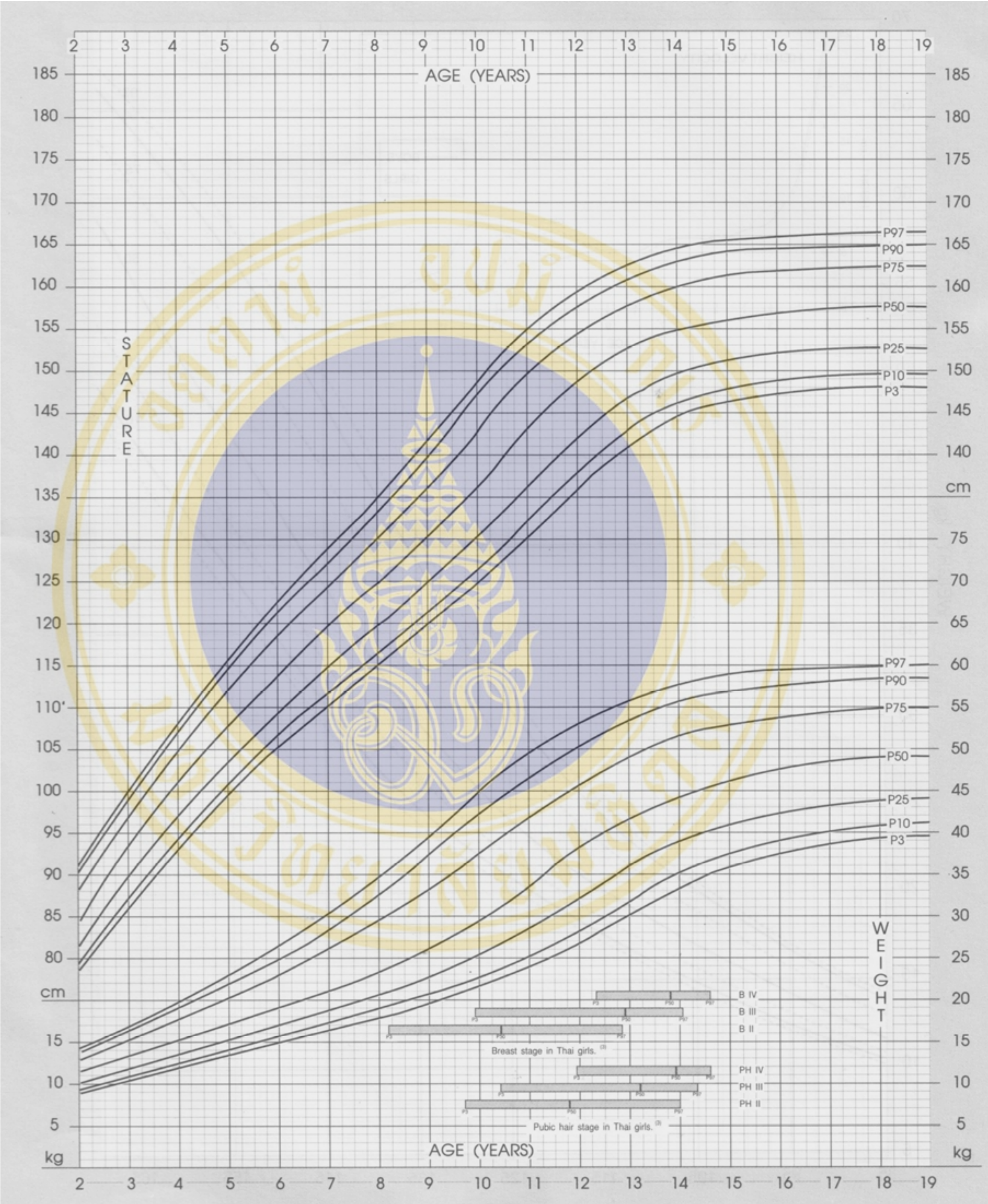

Figure F2. Curve of weight and height for Thai girls by age (from Siriraj hospital's growth chart)

APPENDIX G

RAW DATA OF PILOT STUDY

APPENDIX G
RAW DATA OF THE STUDY

Table G1. The demographic characteristics of subjects (n=30)

Subjects No.	Sex	Age (yr)	Weight (kg)	Height (cm)	Lower leg length (cm)
1.	Female	4	15.0	100.0	24.5
2.	Female	4	18.0	100.0	22.0
3.	Male	4	17.5	105.0	25.0
4.	Male	4	16.0	103.0	24.5
5.	Male	4	16.0	101.5	23.5
6.	Female	5	20.0	103.0	25.0
7.	Female	5	17.0	110.0	23.0
8.	Male	5	19.0	110.5	27.0
9.	Male	5	19.5	112.0	25.5
10.	Female	5	17.0	104.0	25.0
11.	Female	6	18.0	112.0	26.0
12.	Male	6	19.0	117.0	25.0
13.	Male	6	21.0	117.0	25.5
14.	Female	6	20.0	115.0	27.0
15.	Female	6	22.0	117.5	27.0
16.	Male	7	19.0	120.0	26.5
17.	Female	7	22.0	122.0	28.0
18.	Male	7	24.0	120.0	28.0
19.	Female	7	24.5	119.0	27.5
20.	Male	7	27.0	121.0	28.0

Table G1. The demographic characteristics of subjects (n=30) (continued)

Subjects No.	Sex	Age (yr)	Weight (kg)	Height (cm)	Lower leg length (cm)
21.	Female	8	25.0	123.0	29.0
22.	Female	8	28.0	126.0	29.5
23.	Male	8	32.0	130.0	31.0
24.	Male	8	26.0	125.0	28.0
25.	Female	8	26.5	124.0	27.5
26.	Male	9	32.0	134.0	30.0
27.	Male	9	25.0	132.0	29.0
28.	Female	9	28.0	130.5	31.0
29.	Male	9	37.0	135.0	32.0
30.	Female	9	36.0	133.0	29.5

Table G2. The time to completion of the PFOC between tester1 and tester2

Subjects No.	Age (yr)	Time to complete of the PFOC (seconds)					
		Tester 1			Tester 2		
		1	2	3	1	2	3
1.	4	31.47	28.31	28.60	29.22	29.81	30.16
2.	4	22.41	22.91	23.41	24.85	25.00	25.12
3.	4	26.42	27.13	26.97	27.29	26.84	26.78
4.	4	24.03	23.82	24.20	24.56	24.09	23.99
5.	4	27.07	27.34	27.10	26.97	27.43	27.04
6.	5	31.19	31.03	31.03	29.38	30.59	29.94
7.	5	23.38	23.50	20.22	20.66	19.57	19.62
8.	5	2038	20.28	21.05	19.5	20.71	20.06
9.	5	21.25	21.37	21.30	18.03	18.53	20.03
10.	5	19.31	19.16	19.79	20.81	21.00	21.02
11.	6	24.41	25.34	25.94	22.56	22.91	22.44
12.	6	22.87	23.66	23.87	19.15	21.09	19.78
13.	6	23.91	26.28	21.15	24.72	26.46	24.47
14.	6	18.68	20.72	19.96	19.85	20.01	20.06
15.	6	19.72	18.78	17.06	18.40	19.43	17.46
16.	7	18.12	19.06	18.54	17.00	16.58	16.37
17.	7	19.09	18.59	19.12	17.69	18.00	16.33
18.	7	18.13	15.28	16.78	17.88	17.91	18.50
19.	7	17.75	17.68	18.00	15.25	14.69	16.01
20.	7	17.83	17.41	18.09	18.06	17.10	17.63

Table G2. The time to completion of the PFOC between tester1 and tester2 (continued)

Subjects No.	Age (yr)	Time to complete of the PFOC (seconds)					
		Tester 1			Tester 2		
		1	2	3	1	2	3
21.	4	18.84	18.28	18.55	20.19	19.91	19.19
22.	4	18.00	17.75	18.25	18.16	17.60	17.78
23.	4	13.75	13.69	13.00	12.68	12.97	12.98
24.	4	14.75	14.25	14.78	18.19	14.50	13.98
25.	4	17.82	18.14	18.06	19.53	19.13	18.65
26.	5	16.75	16.00	17.75	16.19	14.66	15.13
27.	5	14.81	14.50	14.66	15.40	15.25	14.97
28.	5	19.20	19.44	19.08	18.44	19.31	21.40
29.	5	17.11	15.60	15.86	17.72	16.97	17.44
30.	5	17.10	17.28	17.30	19.00	16.09	15.85

Table G3. The time to completion of the TUG and FGS tests

Subjects No.	Age (yr)	Time to completion (seconds)					
		TUG			FGS		
		1	2	3	1	2	3
1.	4	6.90	7.02	9.11	4.30	4.25	4.15
2.	4	6.30	6.09	6.35	3.91	3.72	4.10
3.	4	7.07	7.61	7.02	4.25	3.96	4.37
4.	4	6.85	6.88	7.11	3.78	3.59	3.26
5.	4	7.74	6.90	7.12	4.39	4.12	4.14
6.	5	7.72	8.88	8.87	5.85	4.95	4.62
7.	5	6.19	6.60	6.40	4.28	3.50	3.50
8.	5	6.84	6.38	6.50	3.22	3.03	3.13
9.	5	6.03	6.00	6.01	3.72	3.37	3.69
10.	5	5.59	5.93	6.18	3.66	3.50	3.75
11.	6	5.34	5.97	5.78	3.47	3.22	3.50
12.	6	6.38	6.13	6.50	3.22	3.25	3.22
13.	6	6.18	7.00	7.75	3.45	3.37	3.52
14.	6	6.56	6.82	6.63	4.00	3.91	3.90
15.	6	4.53	5.25	5.13	3.37	3.56	3.06
16.	7	4.94	4.38	4.56	2.87	2.78	2.91
17.	7	5.31	5.93	6.10	3.16	3.19	3.34
18.	7	4.50	4.84	4.53	3.16	3.09	3.09
19.	7	5.34	5.62	5.35	3.40	3.00	3.12
20.	7	5.29	5.38	5.25	3.5	2.87	3.44

Table G3. The time to completion of the TUG and FGS tests (continued)

Subjects No.	Age (yr)	Time to completion (seconds)					
		TUG			FGS		
		1	2	3	1	2	3
21.	4	5.25	5.47	5.66	3.57	3.91	3.65
22.	4	4.81	6.25	6.37	3.16	3.50	3.47
23.	4	5.87	5.15	4.99	2.55	2.53	2.47
24.	4	5.06	3.60	3.76	1.85	1.88	1.90
25.	4	5.00	5.16	5.25	3.00	3.19	2.84
26.	5	5.78	5.91	5.66	2.44	2.60	2.62
27.	5	4.81	4.31	4.64	2.69	3.03	3.15
28.	5	5.87	6.22	6.40	3.68	3.59	3.97
29.	5	5.06	5.40	4.38	3.13	3.30	3.06
30.	5	5.00	4.88	5.07	3.25	2.97	3.13

Table G4. The time to completion of the first session and second session of the PFOC test

Subjects No.	Age (yr)	Time to completion of the PFOC (seconds)					
		First session			Second session		
		1	2	3	1	2	3
1.	4	31.47	28.31	28.60	31.25	31.90	29.97
2.	4	22.41	22.91	23.41	16.39	17.63	18.44
3.	4	26.42	27.13	26.97	20.08	19.79	19.67
4.	4	24.03	23.82	24.20	24.16	23.82	23.64
5.	4	27.07	27.34	27.10	24.34	23.75	22.29
6.	5	31.19	31.03	31.03	25.41	26.62	26.80
7.	5	23.38	23.50	20.22	20.38	19.75	19.90
8.	5	2038	20.28	21.05	25.69	24.72	25.11
9.	5	21.25	21.37	21.30	20.88	20.94	22.47
10.	5	19.31	19.16	19.79	18.15	17.78	17.56
11.	6	24.41	25.34	25.94	23.08	23.42	24.11
12.	6	22.87	23.66	23.87	19.25	20.72	19.12
13.	6	23.91	26.28	21.15	20.65	19.30	18.78
14.	6	18.68	20.72	19.96	17.50	17.44	17.22
15.	6	19.72	18.78	17.06	19.78	18.66	18.81
16.	7	18.12	19.06	18.54	19.83	18.42	18.84
17.	7	19.09	18.59	19.12	17.77	18.97	17.69
18.	7	18.13	15.28	16.78	16.16	15.92	17.50
19.	7	17.75	17.68	18.00	17.49	16.25	16.41
20.	7	17.83	17.41	18.09	16.06	17.94	17.69

Table G4. The time to completion of the first session and second session of the PFOC (continued)

Subjects No.	Age (yr)	Time to completion of the PFOC (seconds)					
		First session			Second session		
		1	2	3	1	2	3
21.	4	18.84	18.28	18.55	16.22	16.57	17.94
22.	4	18.00	17.75	18.25	17.93	16.64	17.38
23.	4	13.75	13.69	13.00	18.91	18.66	17.50
24.	4	14.75	14.25	14.78	20.06	22.19	17.28
25.	4	17.82	18.14	18.06	12.91	14.91	13.34
26.	5	16.75	16.00	17.75	14.22	14.13	15.65
27.	5	14.81	14.5	14.66	18.38	17.54	18.26
28.	5	19.20	19.44	19.08	17.72	17.60	17.15
29.	5	17.11	15.60	15.86	18.25	17.50	17.90
30.	5	17.10	17.28	17.30	20.27	20.06	19.14

APPENDIX H

RESULTS OF PILOT STUDY

APPENDIX H
RESULTS OF PILOT STUDY

The purpose of this pilot study was to determinate the reliability and validity of PFOC. Twelve typical children (male=5, female=7) who met inclusion criteria volunteered to participate in these study. The characteristics of twelve typical children are shown in Table H1.

Table H1. The demographic characteristics of pilot group (n=12)

Demographic Characteristics	Mean	SD	Range
Age (years)	7.42	1.44	4-9
Weight (kg)	18.58	3.47	14.8-28.8
Height (cm)	119.17	9.97	106.3-133.2
Leg length (shank) (cm)	24.83	2.64	21-31

The inter-tester reliability of PFOC is shown in Table H2.

Table H2. ANOVA table of inter-tester reliability analysis

Source of Variation	Sum of Square	D.F.	Mean Square	F	Prob.
Between People	264.4045	11	24.0368		
Within People	2.9761	12	0.2480		
Between Measures	0.0096	1	0.0096	0.0356	0.8538
Residual	2.9665	11	0.2697		
Total	267.3806	23	11.6252		
Grand Mean	18.5950				

$$ICC(2,1) = \frac{BMS - EMS}{BMS + (k-1)EMS + k(RMS-EMS)/n}$$

$$= \frac{24.0368-0.2697}{24.0368+0.2697+0.0096-0.2697/12}$$

$$= 0.9778$$

Results of inter-tester reliability of PFOC showed high reliability, which indicated there is a consistency of the PFOC between tester1 and tester2. The test-retest reliability of PFOC is shown in Table H3.

Table H3. ANOVA table of test-retest reliability analysis

Source of Variation	Sum of Square	D.F.	Mean Square	F	Prob.
Between People	186.0438	9	20.6715	5.3322	0.0463
Within People	16.1434	10	1.6143		
Between Measures	6.0061	1	6.0061		
Residual	10.1373	9	1.1264		
Total	202.1872	19	10.6414		
Grand Mean	18.3030				

$$ICC(3,1) = \frac{BMS - EMS}{BMS + (k-1)EMS}$$

$$= \frac{20.6715-1.12654}{20.6715+1.12654}$$

$$= 0.8967$$

There was high test-retest reliability of PFOC indicated there are no differences between test and retest for the PFOC. The correlation between the PFOC and the FGS,TUG are shown in Table H4.

Table H4. Correlation coefficient values of PFOC, TUG and FGS tests

TEST		PFOC	TUG	FGS
PFOC	Pearson Correlation	1.000	0.722**	0.717**
	Sig. (2-tailed)	.	0.008	0.009
TUG	Pearson Correlation	0.722**	1.000	0.819**
	Sig. (2-tailed)	0.008	.	0.001
FGS	Pearson Correlation	0.717**	0.819**	1.000
	Sig. (2-tailed)	0.009	0.001	.

** Correlation is significant at the 0.01 level (2-tailed)

As shown in Table H4 the correlations of the time of the PFOC and the time of the FGS were moderate (r=0.718), and the correlation of the TUG correlation with FGS were high. Time of the PFOC and the time of the TUG were also moderate (r=0.722). Nevertheless, the correlation of the time of the TUG and the time of the FGS was high (r=0.819).

APPENDIX I

RAW DATA OF THE STUDY

APPENDIX I
RAW DATA OF PILOT STUDY

Table I1. The demographic data of pilot group (n=12)

Subject No.	Sex	Age (yr)	Weight (kg.)	Height (cm.)	Lower leg length (cm.)
1.	Male	9	27.5	130.5	28.0
2.	Male	6	16.5	108.0	23.0
3.	Male	5	14.8	106.3	22.0
4.	Male	8	22.6	113.5	24.0
5.	Female	8	19.2	113.4	24.2
6.	Female	6	20.4	113.0	24.2
7.	Female	7	23.7	116.5	25.0
8.	Female	6	23.0	127.6	24.5
9.	Female	9	28.8	133.2	31.0
10.	Female	9	26.7	129.5	25.5
11.	Male	9	27.0	129.0	21.0
12.	Female	7	19.5	109.5	25.5

Table I2. Time of the PFOC by the tester1 and tester2

Subject No.	Time to completion of the PFOC (seconds)	
	Tester 1	Tester 2
1.	17.2	16.98
2.	23.58	23.13
3.	24.14	24.71
4.	17.29	18.20
5.	17.15	18.27
6.	24.33	23.91
7.	18.98	18.45
8.	18.81	17.93
9.	16.06	15.40
10.	14.53	15.54
11.	15.50	14.74
12.	15.81	15.64

Table I3. Time of the PFOC, FGS and TUG in the test session measured by tester1.

Subject No.	Time to completion (seconds)		
	PFOC	FGS	TUG
1.	17.2	3.16	5.41
2.	23.58	3.59	5.84
3.	24.14	3.69	6.44
4.	17.29	3.29	5.84
5.	17.15	3.28	5.58
6.	24.33	3.28	5.50
7.	18.98	3.13	5.50
8.	18.81	3.25	5.68
9.	16.06	2.97	5.25
10.	14.53	3.06	5.22
11.	15.50	2.81	5.00
12.	15.81	3.38	5.16

Table I4. Time of the PFOC in the test and retest sessions of PFOC measured by tester1.

Subject No.	Time to completion of the PFOC (seconds)	
	Test Session	Retest Session
1.	17.2	16.07
2.	23.58	20.46
3.	24.14	21.10
4.	17.29	17.81
5.	17.15	18.11
6.	24.33	22.23
7.	18.98	17.33
8.	18.81	*
9.	16.06	*
10.	14.53	15.46
11.	15.50	14.08
12.	15.81	14.90

* missing data because the subjects are absent.

APPENDIX J

ETHICAL COMMITTEE ON RESEARCH INVOLVING HUMAN SUBJECT

APPENDIX J
ETHICAL COMMITTEE ON RESEARCH INVOLVING HUMAN SUBJECT

๒ ถนนพรานนก บางกอกน้อย กรุงเทพฯ ๑๐๗๐๐
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Faculty of Medicine Siriraj Hospital
Mahidol University

The Ethical Committee on Research Involving Human Subject
Faculty of Medicine Siriraj Hospital, Mahidol University

No. 182/2003

Protocol Title	Reliability and Validity of a Pediatric Functional Obstacle Course in Thai Children
Protocol Number	-----------
Principal Investigator	Miss. Soontharee Taweetanalarp
Name of Department	Orthopedic Surgery

The aforementioned project and informed consent have been reviewed and approved by the Ethical Committee, Faculty of Medicine Siriraj Hospital, Mahidol University, based on the Declaration of Helsinki on November 6, 2003

Signature of Chairman ....
(Prof. Sumalee Nimmannit)

Signature of Dean P. Sakol ....
(Clin. Prof. Piyasakol Sakolsatayadorn)

BIOGRAPHY

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