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Normative Values for Obstacles and Curb Tests and Analysis of their Psychometric Properties for Children with Cerebral Palsy

A Thesis Submitted in Partial Fulfillment of the Requirements for a Master's Degree in Physical Therapy at the Department of Rehabilitation Sciences at the College of Applied Medical Sciences at King Saud University

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بسم الله الرحمن الرحيم

In the name of Allah, Most merciful and Most beneficent

Dedicated to My Parents

Whom gave me everlasting support and encouragement

My Father Ahmad Mohammad Almass

My Mother Nadia Abdulaziz Alhezam

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Abstract

Background: The Obstacles and Curb Tests are timed walking tests used to measure physical functioning, gait speed, and functional balance for adults. They have recently been modified for pediatrics; however, their normative values, validity, and reliability have not yet been studied.

Objectives: The study aimed to determine the normative values and prediction equations of Obstacles and Curb Tests for typical developing (TD) children and to assess their validity and reliability for children with Cerebral Palsy (CP).

Methods: This cross-sectional study consisted of two phases. In phase one, the normative values of the two tests were investigated by administering the tests on 240 TD children from age 6 to 12 years. The factors affecting walking speed in each test were studied and their predicted equations were established. In phase two, 44 walking children with CP participated in the Obstacles and Curb Tests with ages from 6 to 12 years old. After excluding children who were not able to complete the tests, 41 children completed the Obstacles Test, and 29 children of the 41completed the Curb Test. To examine convergent construct validity, children with CP completed the Obstacles and Curb Tests in addition to 10-Meter Walk Test (10MWT), Modified Time Up and Go (MTUG), and Pediatric Balance Scale (PBS). For assessing discriminative validity, children with CP were compared to a similar matching age and sex group of TD children. To assess the test-retest reliability, children performed the Obstacles and Curb Tests twice on the same day.

Results: The mean speed and standard deviation for TD children in the Obstacles Test was 5.4 ± 1 seconds whereas for the Curb Test it was 2.9 ± 0.6 seconds. Age, height, and weight were factors affecting the score of both tests. The highest predictor of score in both tests was height. For children with CP, the Obstacles Test had a very strong correlation with the MTUG and PBS, and a strong correlation with the 10MWT. The Curb Test had a strong correlation with the 10MWT, MTUG, and PBS. TD children appeared to be faster than children with CP. Test-retest reliability appeared to be excellent for the Obstacles and Curb Tests with ICC = 0.98 and ICC = 0.99 respectively.

Conclusion: Obstacles and Curb Tests are used to challenge children with greater walking abilities. Normative values and the prediction equations for the Obstacles and Curb Tests in TD children have been reported for the first time in this study. The tests are valid and reliable to be used for children with CP. Using the Obstacles and Curb Tests as measurement tools prior to and after a clinical treatment can show the improvement in physical functioning, gait speed, and functional balance.

Keywords: Normative values, typically developing children, Obstacles and Curb Tests, Timed walking tests, Cerebral palsy.

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List of Abbreviations

Phrase	Abbreviation
Cerebral Palsy	CP
Typical Developing	TD
10 Meter Walk Test	10MWT
Modified Timed Up and Go Test	MTUG
Pediatric Balance Scale	PBS
Gross Motor Functional Classification System	GMFCS
Spinal Cord Injury	SCI
International Classification of Functioning, Disability and Health	ICF
Spinal Cord Injury Functional Ambulation Profile	SCI-FAP
Body Mass Index in Percentile	BMI%
Gross Motor Function Measure-88	GMFM-88
Gross Motor Function Measure-66	GMFM-66
Pediatric Evaluation of Disability Inventory	PEDI
Pediatric Functional Independence Measure	WeeFIM
6 Minute Walk Test	6MWT
1 Minute Walk Test	1MWT
Minimal Detectable Change	MDC
Ankle–Foot Orthoses	AFO
Knee-Ankle–Foot Orthoses	KAFO
Confidence Interval	CI
Interquartile Ranges	IQR
Standard Deviation	SD

CHAPTER I

INTRODUCTION

Chapter I. Introduction

Walking is a multifaceted construct that involves several key components such as stepping ability, gait speed, dynamic balance, postural equilibrium, functional mobility, cardiovascular and muscular endurance, and the ability to adjust walking to meet behavioral goals and environmental demands (Ammann-Reiffer et al., 2014; Balasubramanian et al., 2014). Walking requires the engagement of the musculoskeletal, cardiopulmonary, and nervous systems (Balasubramanian et al., 2014). It is a complex task when being evaluated since it requires tools that measure different aspects of walking and reflect the walking ability in the community.

For the ability to objectively evaluate walking, clinicians require tools to distinguish between the walking abilities of children. This gives clinicians and researchers the opportunity to evaluate development, check for treatment response, and provide an overview of the functional ability of a child (Bisaro et al., 2015). Tools that measure walking exist, but few show response in high functional children or represent walking in the community (Ammann-Reiffer et al., 2014; Bisaro et al., 2015; Zanudin et al., 2017). One of the approaches of walking assessment is the timed walking tests. Timed walking tests are global indicators of physical functioning, gait speed, and functional balance needed for walking (Ammann-Reiffer et al., 2014). The results of these tests provide a glimpse of the ability to ambulate in the community. Timed walking tests require postural control and balance to functionally move through walking and negotiating obstacles and curbs (Ammann-Reiffer et al., 2014; Bisaro et al., 2015). Therefore, we require tools that evaluate the complexity of walking, challenge children with higher walking abilities, and reflect walking in the community.

The Obstacles and Curb Tests are timed walking tests that measure walking ability, physical functioning, gait speed and functional balance for people with high walking abilities. They emerged from the Spinal Cord Injury Functional Ambulation Profile (SCI-FAP) that is used for adults with Spinal Cord Injury (SCI) to evaluate performance on common functional walking tasks (Musselman et al., 2011). The tests measure a unique aspect of walking, offer a more appropriate challenge, and an ecologically valid assessment than level-ground walking measures. They give insight on functional ability since negotiating obstacles and ascending and descending a curb require walking ability, gait speed, postural control, and stability (Ammann-Reiffer et al., 2014). Being able to negotiate obstacles and curbs are two essential aspects of community ambulation and functional independence. Hence, a person's daily life involves more complex types of walking than walking on a ground-level surface, the need for a test that assesses walking in a similar to the real-life situation was needed.

The Obstacles and Curb Tests were modified by Kane et al. (2016) for children and they were confirmed to be feasible for children with Cerebral Palsy (CP). The Obstacles Test requires walking over obstacles and navigating around others. The Curb Test requires stepping onto and off a platform that mimics a curb that is found in the community (Kane et al., 2016). Researchers and clinicians can benefit from these tests when dealing with typical developing (TD) children and children with disabilities such as CP.

CP is the most common physical disability among children (Aravamuthan et al., 2021). It is defined as an umbrella term for a non-progressive motor disorder that affects movement and posture, causing activity limitations since infancy (Papavasiliou et al., 2021). With the presence of CP, children are usually challenged with participating in walking functions. Stimulating an active lifestyle and having the ability to walk is extremely important for children with CP, therefore; many children with CP and their parents prioritize walking above all other activities (Graser et al., 2016) since it is a mean of independence and participation in physical, recreational, and social activities (Begnoche et al., 2016). The International Classification of Functioning, Disability and Health (ICF) considers walking an item on the activity and participation domain (WHO, 2013).

The limitation in mobility for children with CP depends on the type of CP and the severity of the condition. The Gross Motor Functional Classification System (GMFCS) is a tool used for children with CP to represent their abilities and limitations in gross motor function (Palisano et al., 2003). According to this tool, children who are classified to fit in the first three levels can walk with or without limitations or the use of an assistive device (Palisano et al., 2003). Ambulatory children with CP are considered when they are classified within the first three levels of GMFCS (Palisano et al., 2003). The Obstacles and Curb Tests are two tests that are suitable for children with all walking abilities when classified according to GMFCS levels (Kane et al., 2016).

Timed walking tests play a high role in exploring walking abilities in children with CP. These tests include the 10 Meter Walk Test (10MWT) and Modified Timed Up and Go Test (MTUG). The 10MWT is a valid and reliable tool for children with CP (Chrysagis et al., 2014; Graser et al., 2016; Thompson et al., 2008). The MTUG is a valid and reliable tool for children (Carey et al., 2016; Dhote et al., 2012; Gan et al., 2008; Nicolini-Panisson & Donadio, 2014; Williams et al., 2005; Y et al., 2017; Zaino et al., 2004). Both the 10MWT and MTUG tests are tested on level grounds.

Balance is a fundamental component of walking, therefore, knowledge about the correlation between balance and the Obstacles and Curb Tests could provide a useful guide in the clinical use of the Obstacles and Curb Tests. The Pediatric Balance Scale (PBS) is the most widely used tool to assess balance for children with CP (Chen et al., 2013; Duarte et al., 2014). It has been proven to be a valid and reliable tool (Chen et al., 2013; Duarte et al., 2014; Franjoine et al., 2003; Her et al., 2012; Ko & Kim, 2010; Yi et al., 2012). PBS can distinguish between different GMFCS levels in children with CP (Yi et al., 2012).

The Obstacles and Curb Tests required establishing their normative values for TD children and studying their psychometric properties for children with CP. Studying these two eras in separate phases was to highlight their importance in detail and to clarify each part independently. This allows readers to comprehend and make use of each part separately when used with TD children or children with CP. Since the Obstacles and Curb Tests are new tools in pediatrics, their normative values have not been collected before. Having normative values allowed appropriate quantifications for obstacles and curb walking scores. The establishment of normative values acted as a mean to reference walking scores to these timed walking test scores in future studies either for TD children or children with CP or study the associated factors of walking in Obstacles and Curb Tests. Joining the application of the Obstacles and Curb Tests on both TD children and children with CP in one study was intended to find the discrimination between the scores of TD children and children with CP. Knowledge of the psychometric properties for the Obstacles and Curb Tests for children with CP makes using the tests suitable in clinical environments. Applying the Obstacles and Curb Tests on children with CP showed the challenges and limitations of the two tests. These findings indicate the need for further studies of the tests. The Obstacles and Curb Tests are simple to apply, cost-effective, require limited equipment, safe and time-efficient tools to evaluate walking ability. These characteristics make these tests useful in clinics and the community.

1.1 Research Questions

1. What are the normative values and prediction equations of Obstacles and Curb Tests?
2. Are the Obstacles and Curb Tests valid to be used for children with CP?

3. Are the Obstacles and Curb Tests reliable to be used for children with CP?

1.2 Significance of the Study

A child's daily activity involves more than walking on ground level, it involves more complex walking demands such as walking over obstacles, ascending, and descending curbs and stairs and walking on bumpy or soft grounds. The Obstacles and Curb Tests aid in the testing of challenging walking abilities in similar settings. The presence of normative values of the tests is ideally of importance to act as the base of comparison for children. Establishing normative values can also aid in distinguishing normal scores of TD children from children with slower scores caused by any physical injury. This will set a reference for future studies involving the Obstacles and Curb Tests. Since the Obstacles and Curb Tests are new tools in pediatrics, normative values and psychometric properties have not yet been studied.

Moreover, with having a valid and reliable tool that assesses walking in challenging environments a more vivid picture will appear around the walking ability of children with CP. A more challenging walking tool should be available to measure walking ability for children with CP. Therefore, when a child's performance is enhanced after rehabilitation a clinical responsive tool will show improvement.

1.3 Aims of the Study

1. To determine the normative values and prediction equations of Obstacles and Curb Tests.
2. To assess the Convergent Construct and Discriminative Validity of Obstacles and Curb Tests for children with CP.
3. To assess the Test-retest Reliability of Obstacles and Curb Tests for children with CP.

1.4 Hypothesis

1. The Obstacles and Curb Tests will demonstrate very good Convergent Construct Validity as an outcome measure of functional mobility, gait speed and balance ability for children with CP.
2. The Obstacles and Curb Tests will demonstrate very good to excellent Test-retest reliability.

1.5 Variables

Phase One

- Independent variables: Sex, age, height, weight, and BMI%
- Dependent variables: Time needed in each of the Obstacles and Curb Tests.

Phase Two

- Independent variables: Sex, age, height, weight, BMI%, type of CP, GMFCS, use and type of orthosis or assistive device.
- Dependent variables: Time needed for each test.

1.6 Operational Definition

- Typical Developing Children: are children who achieve developmental milestones that are age appropriate and appear physically and mentally healthy.

CHAPTER II

LITERATURE REVIEW

Chapter II. Literature Review

This chapter included a review about walking ability and the assessment tools used for measuring walking ability such as timed walking tests. Additionally, it included a detailed review of the SCI-FAP and Obstacles and Curb Tests and the need for implementing the modified tests on children with CP. It explained the walking abilities of children with CP and the speed adjustment when assessing walking. By the end of this chapter, it incorporated important information about the relative tests to this study such as 10MWT, MTUG and PBS used in measuring the psychometric properties of the Obstacles and Curb Tests for children with CP. At last, it covered the importance of normative values for the Obstacles and Curb Tests.

2.1 Walking Ability

Walking is a complex task that requires the contribution of many body systems and functions (Balasubramanian et al., 2014). Walking ability on its own is not enough, therefore functional walking is considered when referring to walking ability. Functional walking includes not only the ability to walk but also the ability to use walking as a mood for ambulation in the community and this involves the ability to walk on different surfaces and ground levels as well as negotiate obstacles and ascend and descend curbs and stairs (Musselman et al., 2011). The measuring of walking ability is extremely important for quantifying the ability to walk in the community.

2.2 Walking Assessment

Many approaches to walking assessment exist, ranging from mobility classifications, laboratory-based measures, objective scales, and timed walking tests. Mobility classifications set an overview on the ability and degree of walking but do not detect minimal changes in gait or walking ability (Palisano et al., 2008). Laboratory-based measures are objective and accurate and, in most cases, provide a clear and detailed assessment of the walking ability and gait pattern, yet they are timely to administer and require the presence of a gait lab and a skilled examiner. (Feng et al., 2016) Objective scales and timed walking tests require knowledge on the proper use of the scale/test according to established guidelines, require affordable tools, provide an objective assessment of walking ability and they are more applicable for walking assessment in multiple settings (Brussel & Helders, 2009; Graser et al., 2016; Held et al., 2006; McDowell et al., 2005; Nicolini-Panisson & Donadio, 2013; Vardhan, 2015; Zaino et al., 2004).

2.3 Timed Walking Tests

With the importance of optimizing walking functions, researchers established tests to help objectively measure functional ability using timed walking tests. Timed walking tests allow researchers to measure the change in walking, assess response to treatment, and show change when a change in walking ability has occurred (Bisaro et al., 2015). Timed walking tests are used with multiple conditions and cover a wide age group. For children, the search for timed walking tests yielded seven outcome measures such as: 10-meter Walk Test (10MWT) (Graser et al., 2016), Timed Up and Go Test (MTUG) (Nicolini-Panisson & Donadio, 2013), 6-minute Walk Test (6MWT) (Vardhan, 2015), 1-minute Walk Test (1MWT) (McDowell et al., 2005), 30-Second Walk Test (Brussel & Helders, 2009), Standardized Walking Obstacle Course (Held et al., 2006) and Timed Up and Down Stairs Test. (Zaino et al., 2004) Most commonly used for children are the 10MWT and MTUG (Y et al., 2017) All the above-mentioned tests are implemented on the ground level floor except the Standardized Walking Obstacle Course and Timed Up and Down Stairs Test. The Standardized Walking Obstacle Course involves walking through a long curved standardized obstacle course while stabilizing a tray in both hands. With this situation, the Standardized Walking Obstacle Course challenges balance and stability and it's used for children who can walk independently with no assistive device (Held et al., 2006). The pathway is long, needs large space and requires multiple tools. The Timed Up and Down Stairs Test include ascending and descending 14-step flight of stairs and has no walking path.

2.4 Obstacles and Curb Tests

The Obstacles and Curb Tests are timed walking tests that merged from the SCI-FAP (Kane et al., 2016; Musselman et al., 2011). The SCI-FAP was adapted in 2011 to objectively measure functional walking through a variety of timed walking tasks for individuals with SCI. The SCI-FAP is a valid, reliable, and responsive measure of walking skills for adults with SCI (Musselman et al., 2011; Musselman & Yang, 2014). It was used in research to validate multiple assessment tools (Gordon et al., 2016; Shah et al., 2017) and to measure walking capacity during or after interventions (Dijsseldonk et al., 2018; Fang et al., 2020; Fox et al., 2017; Lam et al., 2015; Malik et al., 2019). The SCI-FAP is composed of 7 tasks originally and has been modified to 4 tasks in the Modified SCI-FAP (Musselman et al., 2011; Musselman & Yang, 2014). The 7 tasks are: (1) walking on a carpet, (2) the up and go task, (3) walking above and around obstacles, (4) walking up and down stairs, (5) walking a specific distance while carrying a bag, (6) curb/step task, (7) and navigating through a door (Musselman et al., 2011). A specific calculation of these 7 tasks' scores makes up the total score of the SCI-FAP. Two of the tasks in SCI-FAP were taken separately to establish the Obstacles and Curb Tests.

The Obstacles and Curb Tests were modified by Kane et al. (2016) for children. They were developed to evaluate functional walking in TD children, children with CP and Spina Bifida. The Obstacles Test requires walking over obstacles and navigating around others. The

Curb Test requires stepping onto and off a platform that mimics a curb that is found in the community. The tests require no calculations of a score, the time needed for walking in each test is recorded to specify walking ability (Kane et al., 2016). Such measures of walking tasks are useful for children's assessment, especially those with greater walking function (Kane et al., 2016). Children with higher functional abilities need suitable challenging tasks to show discrimination in walking ability.

In the preliminary study of the Obstacles and Curb Tests, the participants were either diagnosed with CP or Spina Bifida. The study had a low number of participants (n=16) included in the analysis, with the majority diagnosed with Spina Bifida. Six children with CP were included, five out of six were on GMFCS level I and one child was on GMFCS level III (Kane et al., 2016). Although the study showed promising results, the sample is not representative of children with CP. Researchers of the study validated the Obstacles and Curb Tests to the 10MWT and MTUG test and recommended the implementation of the Obstacles and Curb Tests on a larger sample that included a variety of GMFCS levels (Kane et al., 2016). Even though the Obstacles and Curb Tests are deemed to be challenging for children with CP, they are still feasible and impose a motor challenge that is reflected in measurements (Kane et al., 2016).

2.5 Cerebral Palsy

Among the variety of physical disorders that affect children's mobility, CP is the most prevalent. It is a chronic disorder that has a prevalence of 1 to 2.5 per 1000 births (Aravamuthan et al., 2021). The definition of CP is an umbrella term for a non-progressive motor disorder that affects movement and posture, causing activity limitations since infancy (Papavasiliou et al., 2021). The majority of cases of CP are spastic; and other types include dyskinetic (dystonia, athetosis and chorea) and ataxic characteristics. CP could affect the four limbs of the body causing quadriplegia, or the two lower limbs causing diplegia or half the body including either the right or left side of the body causing hemiplegia (Aravamuthan et al., 2021). With this representation, CP usually has an impact on walking ability.

2.6 Walking for Children with Cerebral Palsy

With the presence of CP, children are usually challenged with participating in walking functions. They experience increased muscle stiffness, reduced joint range of motion, altered coordination and postural control, loss of selective motor control and muscle weakness (Noorkoiv et al., 2019). This leads to an abnormal gait pattern that increases the energy cost of walking and therefore reduces participation in physical activity (Noorkoiv et al., 2019). Children with CP show less participation in daily activities since walking is energy consuming compared with TD children (Noorkoiv et al., 2019). Studies done in Laboratory settings show that children with CP approach and cross obstacles slower than TD children (Law & Webb, 2007). Several factors contribute to the variability of walking in children with CP including age, distance, (Chrysagis et al., 2014; Thompson et al., 2008) environment, level of GMFCS, distractibility or mood (Kane et al., 2016). Stimulating an active lifestyle and having the ability to walk are extremely important for children with CP. The attainment of walking is a vital goal for families and children with CP and subsequently, a major goal of physical therapy to reach optimal independence (Palisano et al., 2003; Rosenbaum et al., 2007; Rosenbaum et al., 2003). Walking ability may change with the alteration of walking speed, the difference in walking path, changing the underlying walking surface, the presence of obstacles or change in the level of walking (Malone et al., 2015).

2.7 Walking Speed

Walking speed is an important factor when assessing walking ability in children with disabilities. It affects the gait patterns of children with CP (Gross et al., 2013; Tirosh et al., 2013; Van der Krogt et al., 2009). Researchers suggest that timed walking tests that include functional tasks and performed at fast walking speed are more appropriate for high ambulatory children with CP (Zaino et al., 2004). This produces a wider range of scores across the levels of GMFCS in children with CP (Zaino et al., 2004) and therefore helps to discriminate between children with different walking abilities. Researchers who modified the Obstacles and Curb Tests proved that walking at fast speeds in Obstacles and Curb Tests showed a more suitable challenge and a greater correlation with fast speed walking in 10MWT and MTUG making it preferable in implementation of the tests (Kane et al., 2016). Following the test protocol, the walking tests of Obstacles and Curb Tests, 10MWT, MTUG were administered at fast speed.

2.8 10-Meter Walk Test

The 10MWT is a performance measure that indicates walking ability and gait speed (Ammann-Reiffer et al., 2014). It is a widely used tool for all age groups from 2 to 65+ years. It has been validated and its reliability has been studied for many conditions including CP (Chrysagis et al., 2014; Graser et al., 2016; Thompson et al., 2008). The 10MWT has a moderate to high correlation with the 1-minute Walk Test, MTUG Test, Timed Up and Down Stair Test, Sit-to-Stand Test and Lateral Step-up Test (Chrysagis et al., 2014). Researchers reported excellent inter-rater, intra-rater (Chrysagis et al., 2014; Graser et al., 2016) and test-retest reliabilities at GMFCS II and III (Thompson et al., 2008). However, one study showed adequate test-retest reliability for GMFCS III and challenged its clinical usefulness for children with higher functional levels (GMFCS I and II) (Chrysagis et al., 2014).

With response to its psychometric properties, the 10MWT will be used to validate the Obstacles and Curb Tests in this study. The 10MWT tests walking on a flat surface and this serves as a limitation since walking is not only a form of ambulating on level-ground but also requires a change in terrain, navigating around or over objects that cross the walking path and other skills needed in daily walking. Moreover, children with high GMFCS levels will not be challenged when measured by the 10MWT which means they will most likely not show improvement in scores when an increase in walking ability has been reached. This is because of the insensitivity of the test to improvement of children or adults with high walking abilities due to a ‘ceiling effect’ (Graham et al., 2008). A tool that serves the purpose of challenge and shows response is needed to cover this gap in timed walking assessment tools.

2.9 Modified Timed Up and Go

MTUG is an assessment tool for functional mobility and dynamic balance (Habib et al., 1999). It is a widely used tool for all age groups from 4 to 65+ years. A modified version of the test was established to simplify orders for children. The modified version is similar to the TUG with the difference in the endpoint. In the modified version the child is asked to touch a picture on the wall instead of walk around a cone placed on the ground. In research, the two tests are used interchangeably. The MTUG has good psychometric properties in children with CP (Carey et al., 2016; Gan et al., 2008; Nicolini-Panisson & Donadio, 2014; Williams et al., 2005; Zaino et al., 2004). It has a moderate negative correlation with PBS and Star Excursion Balance Test (Y et al., 2017) and a moderate to strong correlation with Gross Motor Function Measure-88 (GMFM-88), (Gan et al., 2008; Nicolini-Panisson & Donadio, 2014; Williams et al., 2005) 10MWT, (Gan et al., 2008) and Timed Up and Down Stairs Test (Zaino et al., 2004). The MTUG has excellent test-retest, inter-rater and intra-rater reliabilities (Carey et al., 2016; Dhote et al., 2012; Gan et al., 2008; Nicolini-Panisson & Donadio, 2014; Williams et al., 2005; Zaino et al., 2004). The MTUG tests walking on level-ground and requires the ability to stand, walk, turn around and sit without more challenging tasks that are important in ambulating in the community. Despite this, the strength and relativeness of the MTUG test make it useful to validate the Obstacles and Curb Tests in this study.

2.10 Pediatric Balance Scale

PBS is the most widely used tool to assess balance for children with CP (Chen et al., 2013; Duarte et al., 2014). It is a valid and reliable tool that has been correlated to many pediatric tools of many domains for children age 5 to 15 years (Chen et al., 2013; Duarte et al., 2014; Franjoine et al., 2003; Her et al., 2012; Ko & Kim, 2010; Yi et al., 2012). PBS showed excellent correlation with GMFM-88, (Yi et al., 2012) a moderate correlation with the Pediatric Evaluation of Disability Inventory (PEDI) mobility domain (Duarte et al., 2014; Yi et al., 2012) and a fair-to-excellent correlation with Gross Motor Function Measure-66 (GMFM-66) and Pediatric Functional Independence Measure (WeeFIM) (Chen et al., 2013). It proves to have excellent intra-rater, inter-rater and test-retest reliabilities (Her et al., 2012; Ko & Kim, 2010). The PBS will be correlated with the Obstacles and Curb Tests.

2.11 Normative Values

The measurement and establishing of normative values are crucial in providing an accurate interpretation of a test in clinical practice and scientific fields (Cacau et al., 2016). Having reference values for Obstacles and Curb Tests lend great value to the tests. This could act as a base for further researchers who aim to study functional mobility, gait speed or dynamic balance in children. Since this study is new in the field no normative values of the Obstacles and Curb Tests have been collected for children. Normative values for adults have shown to be 11.4 + 1.3 seconds for the Obstacles Test and 3.7 + 0.5 seconds for the Curb/Step Test (Musselman et al., 2011).

Normative values could differentiate between TD children and children with CP. Previous studies have studied the differences in spatiotemporal gait parameters of TD children and children with CP (Kim & Son, 2014). They have found a widening gap when mobility problems increase (Bjornson et al., 2007; Kim & Son, 2014). With this in mind, an assumption of the widely variable score will discriminate TD children from children with CP. This highlights the importance of determining normative values to help quantify scores to a normal range, which helps in establishing further research about the Obstacles and Curb Tests for children and finding the associated factors of walking in Obstacles and Curb Tests.

2.12 Summary

The previous review concludes that measuring walking ability in children is crucial. This shows the need for a valid and reliable assessment tool that can measure functional walking across more complex walking challenges and can be used for children with walking aids. The Obstacles and Curb Tests are promising tools that aim to assess functional walking, body mobility, balance, stability, and gait speed. Furthermore, the normative values of the Obstacles and Curb Tests were not established which limits the interpretation of the test. Further studies are needed to establish the Obstacles and Curb Tests normative values and study their psychometric properties for children with CP.

CHAPTER III

SUBJECTS AND METHOD

Chapter III. Subjects and Method

The method in this cross-sectional study was divided into two phases. The first included measuring normative values of the Obstacles and Curb Tests in TD children and the second included assessment of the psychometric properties of Obstacles and Curb Tests for children with CP.

3.1 Participants and Sample Size Estimation

Phase One

Participants. A sample of 240 TD children of both genders participated in this study. Children were included if they: (1) Age 6 to 12 years, and (2) Were born full-term. Children were excluded if they: (1) Had trauma that affected walking or balance, (2) Were uncooperative, (3) Were unable to understand commands in Arabic (Kane et al., 2016). The children were divided into 6 age groups (6 to < 7), (7 to < 8), (8 to < 9), (9 to < 10), (10 to < 11), (11 to < 12). Each group had a similar number of children from each gender.

Sample Size Estimation. The "Rule of Thumb" was used to estimate the sample size of TD children; $N>104+m$, where N was the sample size and m was the number of independent variables including "sex, age, height, weight, and Body Mass Index Percentile (BMI%)". Therefore $104+5=109$ (Green, 1991). Furthermore, for regression analysis, the appropriate sample size for statistical analysis needed to be ≥ 200 children (Israel, 1992). To ensure having normally distributed data each group had at least 40 children with an equal number of girls and boys. With calculation, 6x40 the final sample was 240 children.

Phase Two

Participants. This phase was conducted with a sample of 44 children with CP who met the inclusion criteria: (1) Age 6 to 12 years, (2) Able to walk for 14 meters with or without walking aids or orthosis, (3) Had a GMFCS level of I, II or III, (4) Had no other condition that affected walking. Children were excluded if they: (1) Were unable to understand commands in Arabic, (2) Were uncooperative or unable to complete the test (Kane et al., 2016).

Sample Size Estimation. The sample size in this phase was calculated using the sample size calculator for reliability studies (Arifin, 2018) with a desired significance level of 0.05, a power of 0.80 and a 20% dropout rate. After the calculation, the estimated sample size was 23 children.

3.2 Ethical Considerations

For both phases an ethical approval (IRB) (Appendix A) was obtained from the College of Medicine, King Saud University (Reference Number 20/0802/IRB). Also, permission from a Children Recreational Center was obtained to apply phase one of the study. For phase two, an ethical approval from Sultan Bin Abdulaziz Humanitarian City (Reference Number 34-2020-IRB) was gained. Consent forms (Appendix B) which provided information about the researchers, the objectives and aims of the study as well as the voluntary participation in the study were available for children's parents/caregivers to sign. An appropriate assent was also taken from children according to their age.

Procedure of the study

3.3 Study Design

A cross-sectional study assessed the normative values for Obstacles and Curb Tests and analyzed their psychometric properties for children with CP.

3.4 Recruitment

Phase One

A convenient sampling method was used to recruit children in this phase. Next children were stratified according to age to provide a representative sample with an equal number of children in each age group. The recruitment of TD children took place from December 2020 to February 2021 in five Recreational Centers for Children in different areas around Riyadh city. As children and their families arrived at the recreational centers they were greeted and invited with a flyer to participate in the study and all their questions were answered. As soon as they accepted the invitation, they were asked to come to a private test room and sign the consent form and participate in the study.

Phase Two

A convenient sampling method was used to recruit children in this phase. The recruitment of children with CP took place from November 2020 to February 2021 from the pediatric housing departments and from the clinics of Sultan bin Abdulaziz Humanitarian City. After gaining access to the patient's files, the file of each child being currently treated at Sultan bin Abdulaziz Humanitarian City was reviewed. An excel table was formed including all the children who might be suitable to participate in the study. Children who were admitted in the housing departments were visited in their rooms with their parents and they were greeted and invited with a flyer to participate in the study. Children who were being treated in the clinics were contacted through a phone call to their parents and invited to participate in the study verbally. After accepting the invitation, an appointment for screening was scheduled for both children who were in the housing departments and in the clinics. When the child was fit for the study, they were asked to sign the consent form and participate in the study.

3.5 Instrumentations and Measurements

Phase One

This phase included the following instrumentations and measurements: (1) the demographic and anthropometric datasheet, (2) the recording sheet, (3) the tape measure, (4) the weight scale, (5) the BMI, (6) the stopwatch, (7) the assessment of Obstacles Test, (8) and the assessment of the Curb Test.

Phase Two

This phase included the use of all the instrumentations and measurements mentioned in phase one in addition to: (1) the Gross Motor Function Classification Scale, (2) the 10-Meter Walk Test, (3) the Modified Timed Up and Go Test, (4) and the Pediatric Balance Scale.

3.5.1. Demographic and Anthropometric Data Sheet

Phase One. For TD children data about sex, age, height, weight, and BMI% were collected. Appendix C)

Phase Two. For children with CP data about sex, age, height, weight, BMI%, type of CP, GMFCS level, use and type of orthosis or assistive device needed while walking were collected. Appendix C)

3.5.2. Recording Sheet

A recording sheet for both TD children and children with CP (Appendix D) was used to record test results.

3.5.3. Tape Measure

The height of TD children and children with CP with no skeletal deformities was measured from standing against a tape measure secured to a wall (Louer et al., 2017). For those with major skeletal deformities, such as scoliosis, kyphosis or flexion deformities in the lower limbs, (Araujo & Silva, 2013) height was estimated using segmental measuring through the Knee Height Equation, where: Height = (2.69 x knee height) + 24.2 (Stevenson, 1995). Segmental measuring is accurate (95% CI (Confidence Interval) = 0.98-0.9) (Stevenson, 1995) in measuring height for children with CP (Lamounier et al., 2020). The tape measure was also used to measure the height of the lower limbs of all children to customize the obstacles heights in the Obstacles Test.

3.5.4. Weight Scale

The weight of children was measured by kilograms using a digital weight scale (Louer et al., 2017).

3.5.5. Body Mass Index

BMI is an anthropometric index for height/weight defined as body weight in kilograms divided by height in meters squared (Nuttall, 2015).

$$BMI = weight\ (kg) / height\ (m^2)$$

In this study, for the measurement of BMI%, the children and teen version named BMI-for-age was used. BMI% values were measured and categorized using reference growth charts from the Centers for Disease Control and Prevention. BMI% is represented in percentages (Centers for Disease Control and Prevention, 2020). It is a valid tool to be used for children from ages 2 to 20 years (Kuczmarski et al., 2002). BMI% of children were computed by excel using a formula to calculate the BMI% after data extraction.

3.5.6. Gross Motor Function Classification Scale (GMFCS)

The GMFCS was used to indicate a motor function in children with CP. It is a five-point ordinal scale that rates a child’s motor function from level I (least severe) to level V (most severe). Children who were classified as level I, II or III were fit in this study as follows: Level I included children who walk without limitations, level II included children who walk with limitations, and level III included children who walk using a hand-held mobility device (Palisano et al., 2007, 2008).

3.5.7. Stopwatch

A digital stopwatch that measures the time in seconds was used to measure time.

3.5.8. 10-Meter Walk Test (10MWT)

The 10MWT is a timed walking test used to determine functional mobility, gait, and vestibular function for individuals from age 2 to 65+ years. It is valid to be used for children with CP (Chrysagis et al., 2014; Graser et al., 2016; Pirpiris et al., 2003; Thompson et al., 2008). The test requires the use of a stopwatch, a 14-meter path marked at 2 meters and 12 meters. Time was measured for the ten intermediate meters. The less time required to complete the test showed better performance (Figure 1).

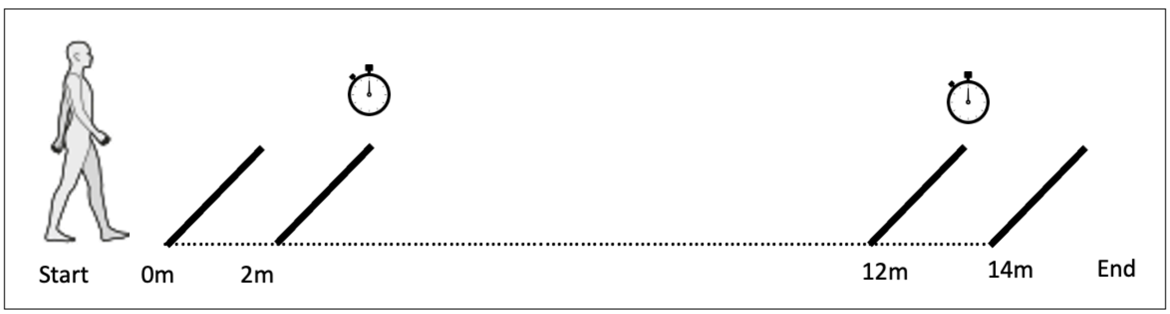


Figure 1.10-Meter Walk Test Illustration

3.5.9. Modified Timed Up and Go Test (MTUG)

The MTUG is a test used to assess functional mobility and dynamic balance in children age 4 to 12 years (Dhote et al., 2012). To administer this test a stable chair with a back and no arm-rests were used. The test required a chair that keeps 90° more or less 10° of the knee and hip flexion with feet flat on the ground. Near the child's feet, a start line was set on the floor and a photo was hung on the wall three meters away from the start line for the child to touch and walk back to the chair and sit down (Nicolini-Panisson & Donadio, 2014;

Williams et al., 2005). The less time required to complete the test showed better performance (Figure 2).

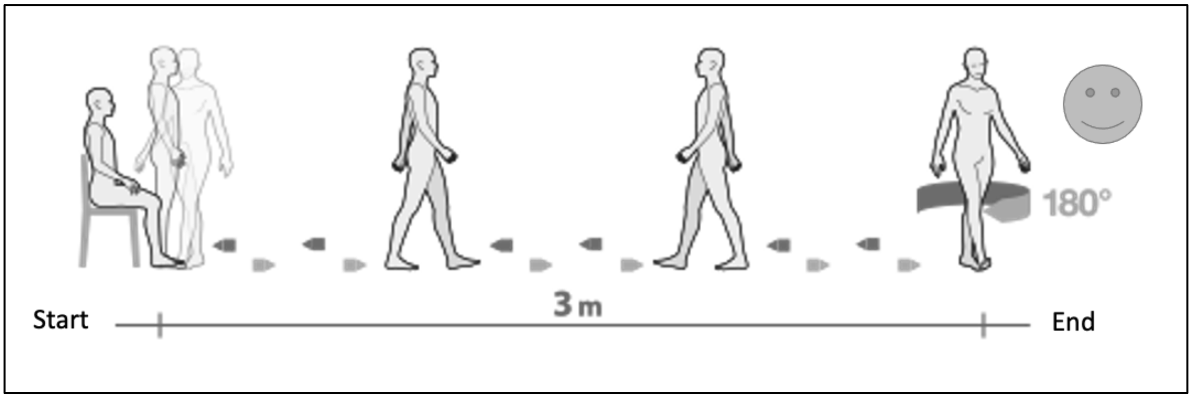


Figure 2. Modified Timed Up and Go Test Illustration

Obstacles Test

The Obstacles Test (Appendix E) is a walking test that involves stepping over two obstacles and walking around one basket (Kane et al., 2016; Musselman et al., 2011). The Obstacles Test pathway is approximately 8.5-meters in length and set as shown in Figure 3 and Figure 4. The start and end lines were marked by green tape at 6-meters before the basket (indicating the start line) and 2-meters after the basket (indicating the end line). In addition to the start and end lines marked in green, the path was marked at 1-meter after the start line and 1-meter before the end line with blue tape. Time was measured for the area between the blue lines, allowing 1-meter for acceleration and deceleration (Kane et al., 2016). As illustrated in Figure 3, two obstacles were set at 2.5-meters and 4-meters from the start line. The two obstacles were set carefully so that they are of width and height of 10%–15% and 20%–25% of the child's leg length, respectively. The obstacles were stackable foam blocks that form 0.5-meters in length. The basket was around 56 centimeters in width and 69.5 centimeters in length. The child should stand behind the start line and walk in a straight line then step over the obstacles, walk around one side of the basket then pass the end line (Kane et al., 2016). The less time required to complete the test showed better performance.

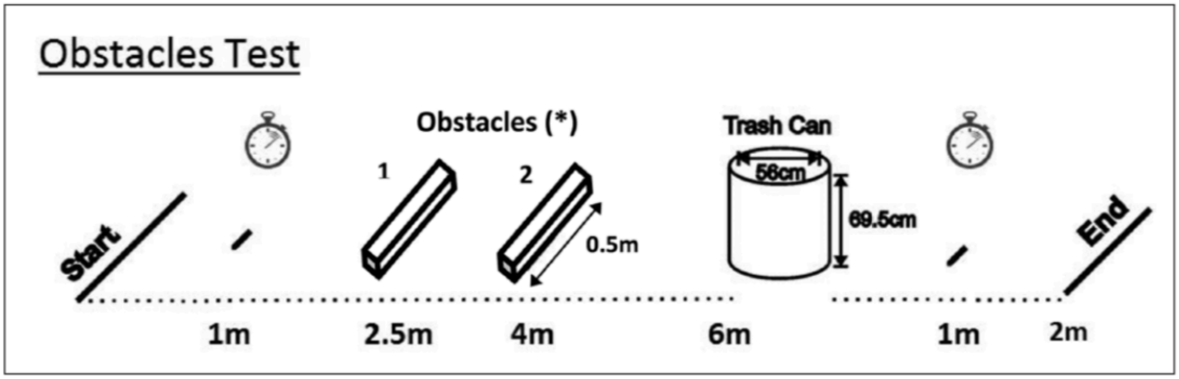


Figure 3. Obstacles Test Illustration (Kane et al., 2016)

Figure 4. Obstacles Test Pathway

3.5.10. Curb Test

The Curb Test (Appendix F) is a walking test that involves stepping onto and off a wooden platform that is meant to mimic a curb (Kane et al., 2016; Musselman et al., 2011). The Curb Test pathway is approximately 5.5-meters in length and set with a wooden platform as structured in Figure 5 and Figure 6. The start and end lines were marked by green tape at 2-meters before and after the wooden platform. The path was marked at 1-meter after the start line and 1-meter before the end line with blue tape. Time was measured for the area between the blue lines, allowing 1-meter for acceleration and deceleration. The wooden platform was approximately 21 centimeters in height, 122 centimeters in length and 81 centimeters in width. The child should stand behind the start line and walk in a straight line toward the wooden platform, step onto it, walk across, step down to the ground then cross the end line (Kane et al., 2016). The less time required to complete the test showed better performance.

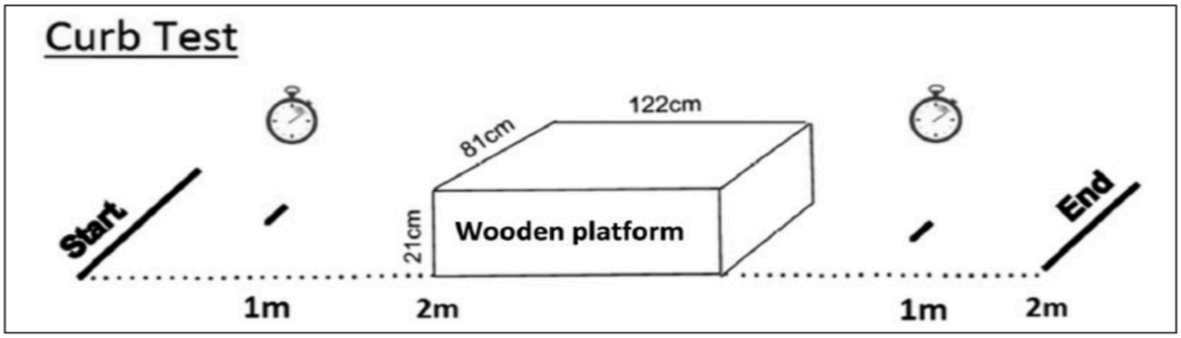


Figure 5. Curb Test Illustration (Kane et al., 2016)

Figure 6. Curb Test Pathway

3.5.11. Pediatric Balance Scale (PBS)

The PBS is a valid tool used for assessing balance from age 5 to 15 years (Franjoine et al., 2003). It consists of 14 items that measure balance. Each item is scored from 0 to 4. The scores for all items are added to generate a total score. Higher total scores showed better balance and low total scores showed decreased balance and a risk of fall. The administration of the test required the instruments as following: (1) two chairs; one with an armrest that keeps 90° of the knee and hip flexion with feet flat on the ground and the other of standard adult size without armrest, (2) two footprint photos; one parallel and the other heel to toe, (3) a stopwatch, (4) a colored flashcard, (5) a chalkboard eraser, (6) a four-inch step, and (7) a tape measure/yardstick on the wall (Franjoine et al., 2003).

3.6 Study Settings

For both phases, the study was set in a wide quiet room that was at least 7 x 11 meters, had solid and ground-level floors, and was well ventilated and private. In addition to the previous settings, phase two required a long corridor that was at least 3 x 20 meters with the same settings. During the examination, the area included only the child participating now and the examiner.

3.7 Data Collection Procedure

Phase One

3.7.1.1. Demographic and Anthropometric Data

The demographic and anthropometric data for each child were collected before starting the tests. The child was asked to remove their shoes and socks before measuring the height and weight. The height was measured with a tape measure that was fixed on a hard, flat wall. The child was asked to stand straight and look straight ahead with the feet, knees, mid-thighs, or legs making contact and heels against the wall. The examiner made sure that the child was not weight-shifting to one side or the other. A flat ruler was positioned on top of the child's head drawing a line to the tape measure. The height of the child was marked using a pencil on the tape measure. The tape measure was then used to measure the height of the lower limbs while standing. To measure the weight the child was asked to stand straight and with light clothing on the weight scale (Louer et al., 2017).

3.7.1.2. Obstacles Test

The child stood behind the start line and was instructed as following: "When I say go, walk in fast speed without running, step over the blocks, go around the basket from either right or left side then walk till you reach the green line. Don't touch the blocks or basket and if you do, or they fall do not stop, continue walking till you reach the green line". The test was demonstrated once to the child and they were given one practice trial to try the path without recording the time, after that the child had one trial to complete the test. The child was instructed to walk at a fast speed (Musselman et al., 2011). A 10% time penalty was added to the recorded time if the child touches one or more obstacles with their body (Kane et al., 2016).

3.7.1.3. Curb Test

The child stood behind the start line and was instructed as following: "When I say go, walk in fast speed, step on the curb, walk across then step off and walk till you reach the green line". The test was demonstrated once to the child and they were given one practice trial to try the path without recording the time, after that the child had one trial to complete the test. The child was instructed to walk at a fast speed (Musselman et al., 2011). The Curb Test guidelines offered the child a choice of using stepping or crawling as a mood for getting on and off the platform.

Phase Two

3.7.2.1. Demographic and Anthropometric Data

Similar to phase one, the demographic and anthropometric data were collected in the same way with the difference in height measurement for children with major skeletal deformities that altered the child's height (Araujo & Silva, 2013). For those with deformities, height was estimated using segmental measuring through the Knee Height Equation (Stevenson, 1995). Knee height was measured with the knee and ankle flexed to 90 degrees from the heel to the anterior surface of the thigh over the femoral condyle using a tape measure (Figure 7) (Stevenson, 1995).

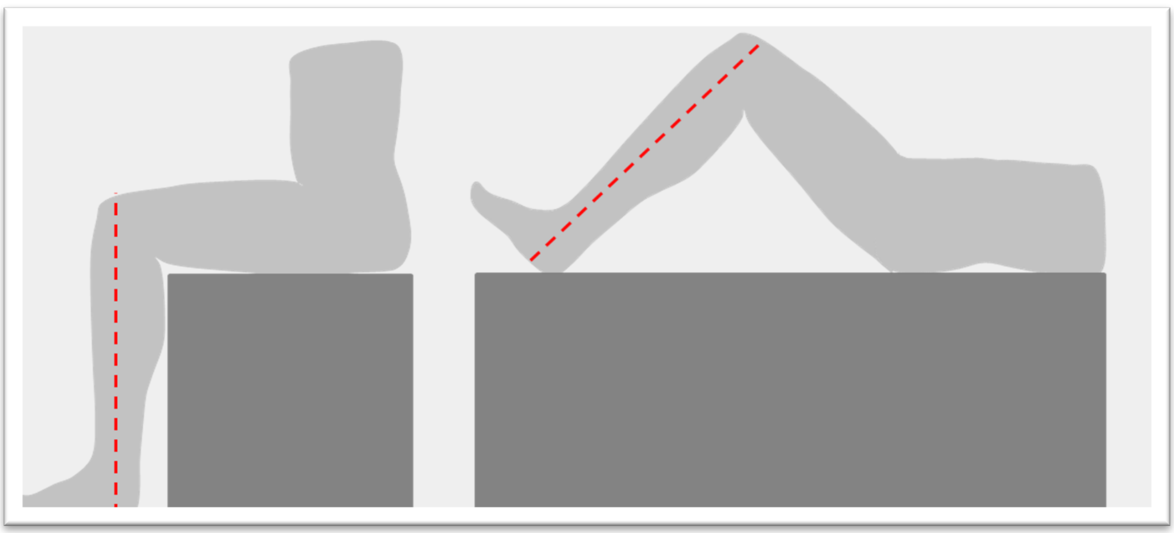


Figure 7. Knee Height Measurement

The data collected for the main five tests were performed in the following order: 10MWT, MTUG, Obstacles Test, Curb Test then PBS (Kane et al., 2016). This order was guided by the practice of Kane et al. (2016) to ensure consistency of the data collected. In case of limiting the presence of any fatigue, each child had the time to rest in between tests while the next test instructions were provided. Children who habitually used an orthosis and/or a walking aid were asked to utilize them for all the tests (Bahrami et al., 2017; Dhote et al., 2012; Duarte et al., 2014; Kane et al., 2016). To evaluate the test-retest reliability, the Obstacles and Curb Tests were repeated in the same order after the child took a 15-minute break (Kane et al., 2016).

3.7.2.2. 10-Meter Walk Test (10MWT)

A visible 14-meter walking path was marked at the beginning and end with green tape on the floor. In addition to the start and finish mark in green, the path was marked at 2 and 12-meters with blue tape. The child was given instructions to start fast walking at the first green line by hearing the word "Go" and stop after the green end line when hearing the word "Stop". As soon as the child's foot passed the first blue mark the time started and as soon as the child's foot passed the last blue mark the time stopped. Time was recorded for the intermediate 10-meters. The untimed 2 meters at the beginning and end were considered to remove acceleration or deceleration (Bahrami et al., 2017). The test was repeated three times and the mean for the trials was recorded (De Baptista et al., 2020). The administration of this test took approximately 2 to 3 minutes.

3.7.2.3. Modified Timed Up and Go Test (MTUG)

The examiner demonstrated the test to the child and clarified the instructions before beginning the test. Once the child was ready and seated on the chair with both feet on the ground, the examiner gave the child instructions to start by saying "GO". The child stood and walked to the wall, touched the photo on the wall and came back to the chair and sat down. The time started as soon as the child's bottom was off the chair and stopped as soon as the child's bottom touched the chair again. The examiner gave guidance as needed within the test and encouraged the child to walk at a fast speed. The test was repeated for three trials and the score of the shortest trial was considered as the final result (Nicolini-Panisson & Donadio, 2013). The administration of this test took approximately 2 to 3 minutes.

3.7.2.4. Obstacles Test

The Obstacles Test was set following the guidelines of Kane et al. (2016). The procedure was similar to the one identified in phase one, with the alteration of the obstacles that measured 0.5-meters in length for children who walk with no assistive device to obstacles that measure 0.25-meters for children who use walkers. The 10% time penalty added included the touch of the child's body or assistive device (Kane et al., 2016). The administration of this test took approximately 2 minutes.

3.7.2.5. Curb Test

The Curb Test was set following the guidelines of Kane et al. (2016). The procedure was similar to the one identified in phase one. The child had the option of ascending and descending the wooden platform in any manner including stepping or crawling (Kane et al., 2016). The administration of this test took approximately 2 minutes.

3.7.2.6. Pediatric Balance Scale (PBS)

Each item on this test was administered following the protocol and scoring method as described by Franjoine et al. (2003). The child received a practice trial before each performance of an item. If multiple trials were given as prescribed in the protocol, the best result was recorded (Franjoine et al., 2003). The administration of this test took approximately 10 to 20 minutes.

Figure 8. Child with CP (GMFCS II) performing Obstacles Test

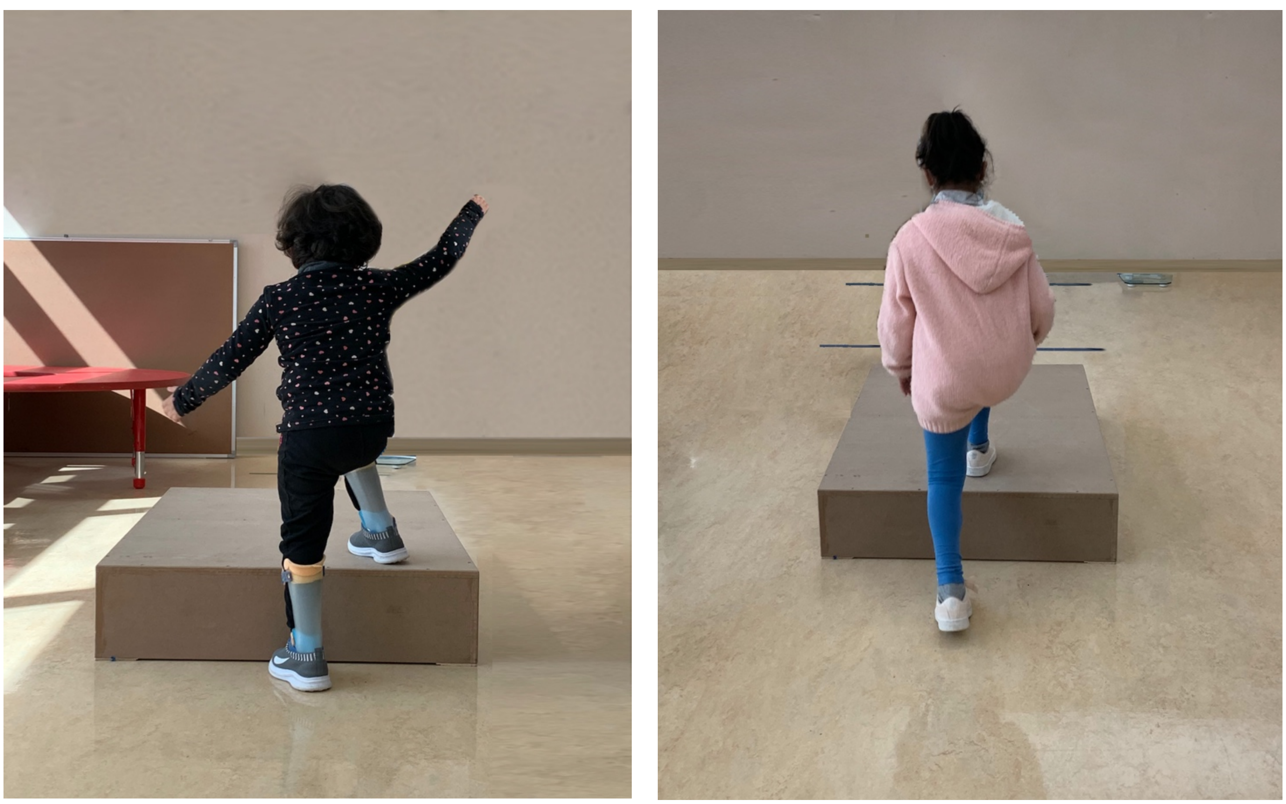


Figure 9. Children with CP (GMFCS level I and II) performing Curb Test

Figure 10. Child with CP (GMFCS Level II) preforming 10MWT and MTUG

3.8 Data Management

The data from the tests were extracted into Microsoft Excel and SPSS datasheets for further analysis of the findings.

3.8.1. Confidentiality.

To ensure confidentiality the data extracted was kept confidential with allowing access only to researchers who worked on this study.

3.8.2. Archiving and Access.

All data was stored in an excel or SPSS sheet on a secure computer accessed by researchers only. The entire data will be archived for two years following this study and deleted afterward.

3.9 Psychometric Properties

The convergent construct validity was used to evaluate the correlation between the Obstacles and Curb Tests with the 10MWT, MTUG and PBS for children with CP. The discriminative validity was done for each test with a randomly matching age and sex group of TD children. The within-session test-retest reliability was done in the same day after a 15-minute break for both tests (Kane et al., 2016).

3.10 Statistical Analysis

SPSS, version 25.0, was used for data analysis. Normal distribution of data was examined before the analysis by Shapiro-Wilk Test for both phases to determine the proper statistical analysis.

Phase One

For normative data, descriptive statistics in the form of mean and standard deviation (SD) were done for height, weight, BMI%, Obstacles and Curb Test scores. An independent t-test was performed to measure the effect of sex on test scores. A two-way ANOVA was used to assess the main effect of the interaction between age and sex on Obstacles and Curb Tests. Correlations were assessed by Pearson's correlation coefficient between the Obstacles and Curb Tests score and the related variables (age, height, weight, and BMI%). The ETA test was used to study the association between Obstacles and Curb Test scores and sex. A Stepwise regression was used to predict the Obstacles and Curb Tests' factors and their order of importance. The variance inflation factor was tested and the collinear between the multivariate was reported. Pearson's Correlation was used to find the correlation between Obstacles and Curb Tests' scores. Guidelines developed by Cohen (2013) will be used to interpret Pearson's Correlation scores, where 0.1 – 0.29 means small significance, 0.3 – 0.49 means medium significance, and 0.5 – 1 means large significance.

Phase Two

Descriptive statistics in the form of mean and SD were done for height, weight, and BMI%, while median and interquartile ranges (IQR) were done for Obstacles and Curb Test scores. Frequencies and percentages were used for sex, age groups, type of CP, GMFCS levels, use of orthosis and/or an assistive device. For convergent construct validity, the correlation was examined using the Spearman's Rank Correlation. Spearman's rho values were interpreted as follows: ⩽0.35 = low/weak, 0.36–0.67 = moderate/modest, 0.68– 0.89 = strong/high, and ⩾0.9 = very strong (Taylor, 1990). For discriminative validity, the Mann-Whitney Test used to compare the performance of children in both tests per group. The test-retest reliability was calculated using the Intra-class Correlation Coefficient (ICC) and Spearman's Rank Correlation to discern the strength of the association between the test scores. Guidelines developed by Cicchetti (1994) were used to interpret ICC scores, where 0.40 and less mean poor correlation, 0.40 – 0.59 mean fair correlation, 0.60 – 0.574 mean good correlation and 0.75 – 1.00 mean excellent correlation. Alpha was set to $P < 0.05$.

CHAPTER IV

RESULTS

Chapter IV. Results

The results in this study were displayed into two sections depending on the phase. The first phase included results of normative values of the Obstacles and Curb Tests in TD children and the second phase included results of psychometric properties of Obstacles and Curb Tests for children with CP.

Phase One

A Shapiro-Wilk Test showed that all the data were normally distributed and hemogenic for phase one ($P < 0.05$).

4.1.1. Participants' Characteristics

Three-hundred and forty consent forms were distributed to invite children to participate in the study and 282 TD children were recruited with a response rate of 82.9%. Forty-two children were excluded for various reasons while 240 (120 girls and 120 boys) were eligible and completed the study. Six age groups were included, in each age group, there were 40 children with an equal number of 20 girls and 20 boys (Figure 11). The anthropometric characteristics of the children are demonstrated in Table 1. The total means and SD were: 130.5 ± 14.1 cm for height, 31.4 ± 10.8 kg for weight, and 60.9 ± 34.2 percent for BMI%. Boys in the entire group of participants and in the age group of 10 to < 11 weigh more and have a higher BMI% than girls ($P<0.05$). Moreover, boys in the age group of 9 to < 10 were significantly taller and weighed more than girls in the same age group ($P<0.05$). According to BMI% children were classified as 10.4% underweight, 51.6% healthy weight, 20.8% overweight, and 17% obese.

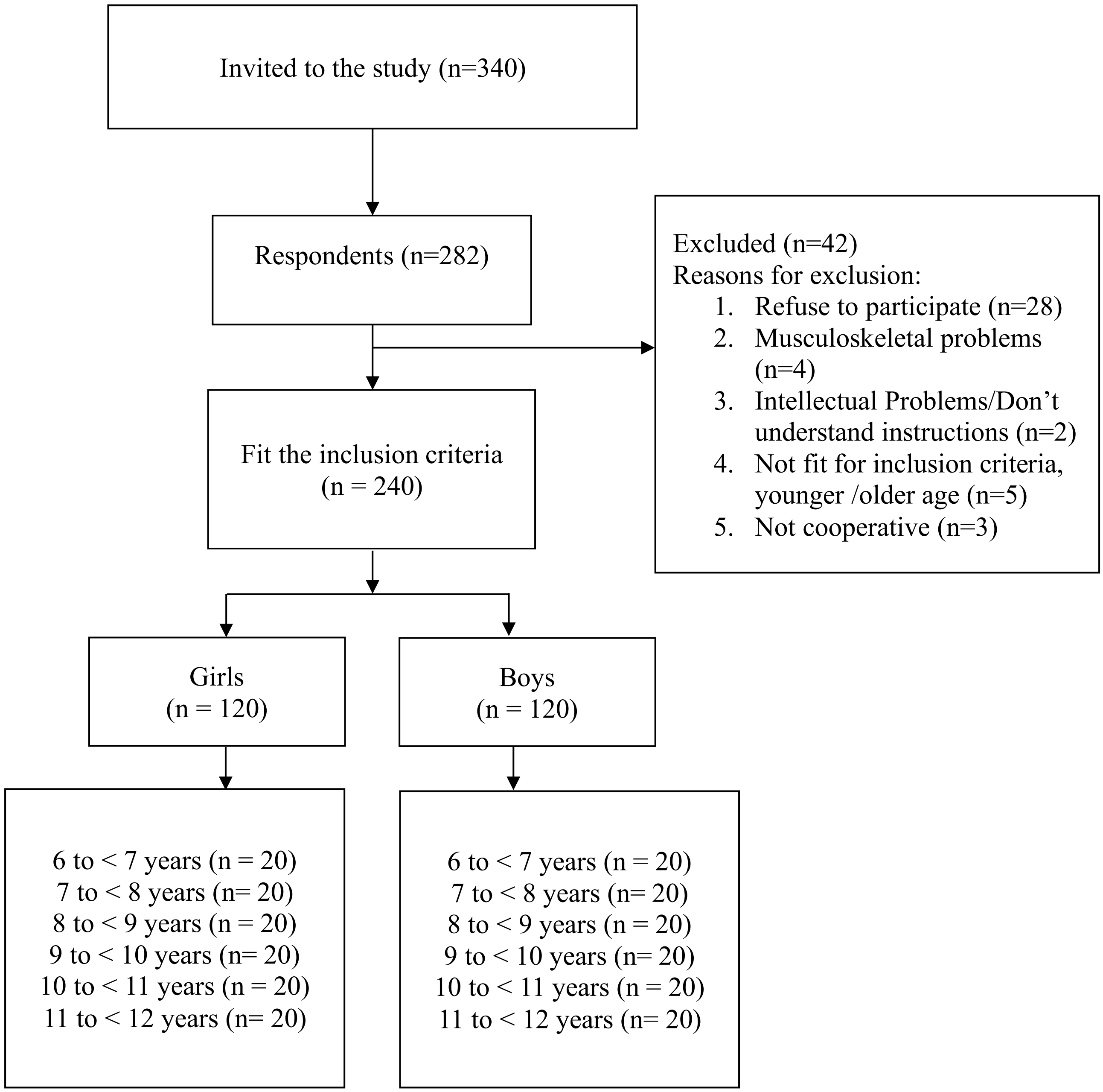


Figure 11. Flow Chart of Selection Process for TD Children

Table 1. Anthropometric Characteristics for Normative Data

	Girls								Boys							
					BMI% categories								BMI% categories			
Age (years)	**N**	**Height (cm)**	**Weight (kg)**	**BMI% (%)**	**UW**	**HW**	**OW**	**O**	**N**	**Height (cm)**	**Weight (kg)**	**BMI% (%)**	**UW**	**HW**	**OW**	**O**
6 to < 7	20	112.7 ± 6.1	20.8 ± 5.2	56.1 ± 38.4	3 (15%)	11 (55%)	3 (15%)	3 (15%)	20	111.2 ± 7.6	21.1 ± 6.1	51.6 ± 37	2 (10%)	12 (60%)	1 (5%)	5 (25%)
7 to < 8	20	122.4 ± 6.5	24.4 ± 6	50.7 ± 33.7	3 (15%)	13 (%)	2 (10%)	2 (10%)	20	120 ± 8.3	23.3 ± 5.5	51.9 ± 37.2	4 (20%)	10 (50%)	4 (20%)	2 (10%)
8 to < 9	20	125.9 ± 6.4	27.7 ± 7	55.9 ± 39.4	2 (10%)	8 (40%)	7 (35%)	3 (15%)	20	128.4 ± 5.8	30.1 ± 5.9	72.5 ± 27.4	0 (0%)	10 (50%)	6 (30%)	4 (20%)
9 to < 10	20	130 ± 5.7	30.5 ± 6.5	59.5 ± 34.6	1 (5%)	11 (55%)	5 (25%)	3 (15%)	20	135.4 ± 5.6*	36.3 ± 7.1*	78.7 ± 28	2 (10%)	5 (25%)	7 (35%)	6 (30%)
10 to < 11	20	140.6 ± 11.7	35 ± 9.7	52 ± 30.9	3 (15%)	14 (70%)	2 (10%)	1 (5%)	20	142.8 ± 6.6	41 ± 8.5*	72.1 ± 27.5*	0 (0%)	11 (55%)	2 (10%)	7 (35%)
11 to < 12	20	145.6 ± 8.4	41.6 ± 12.5	57.9 ± 38.1	5 (25%)	8 (40%)	4 (20%)	3 (15%)	20	149.9 ± 6.4	44.6 ± 7.2	72 ± 26.7	0 (0%)	11 (55%)	7 (35%)	2 (10%)
Total	120	129.6 ± 13.4	30 ± 10.6	55.4 ± 35.4	17 (14.1%)	65 (54.1%)	23 (19.1%)	15 (12.5%)	120	131.3 ± 14.7	32.7 ± 11*	66.5 ± 32.2*	8 (6.6%)	59 (49.1%)	27 (22.5%)	26 (21.6%)

Variables presented as mean ± SD. BMI% categories presented as frequency and percentage. N: Number of participants, Cm: centimeter, Kg: kilogram, BMI%: body mass index percentile, UW: Underweight, HW: Healthy weight, OW: Overweight, O: Obese
*Significant between girls and boys, $P < 0.05$

4.1.2. Obstacles and Curb Tests

The mean and SD of time for the Obstacles Test across all children was 5.4 ± 1 seconds whereas for the Curb Test it was 2.9 ± 0.6 seconds. When grouped into two groups of girls and boys, girls had a mean of 5.5 ± 0.9 seconds in the Obstacles Test and a mean of 3.0 ± 0.6 seconds in the Curb Test. On the other hand, boys had a mean of 5.3 ± 1.0 seconds in the Obstacles Test and a mean of 2.8 ± 0.6 seconds in the Curb Test. Across all age groups boys appeared to be faster than girls.

4.1.3. The influence of Age and Sex on Obstacles and Curb Tests

A two-way ANOVA showed a statistically high significant effect of age on both the Obstacles and Curb Tests, respectively ($F_{(1,228)}$=4.78, P<0.001) ($F_{(1,228)}$=4.95, P<0.001). Sex had a statistically significant effect on the Curb Test ($F_{(1,228)}$= 4.87, P<0.05) and no statistically significant effect on Obstacles Test ($F_{(1,228)}$= 3.33, P>0.05). The interaction of sex x age showed no significance with the Obstacles Test ($F_{(1,228)}$= 1.23, P>0.05) and a significance with the Curb Test ($F_{(1,228)}$= 2.59, P<0.05). Age had a higher association and contributed more to both the Obstacles and Curb Tests than sex. A Tukey Post Hoc test revealed that generally there were no statistically significant differences between most age groups. For the Obstacles test, a significant mean difference appeared between the age group of 6 to < 7 and 10 to < 11 with a mean average difference of 1.03, (P<0.001) and between the age group of 6 to < 7 and 11 to < 12 with a mean average difference of 0.65 (P<0.05) in favor to the older age group. Whereas for the Curb Test, the Tukey Post Hoc test revealed that there were significant mean differences between the age groups of 6 to < 7 and 10 to < 11 with a mean average difference of 0.56 (P<0.001) and between the age group of 6 to < 7 and 11 to < 12 with a mean average difference of 0.45 (P<0.05) and between the age group of 8 to < 9 and 10 to < 11 with a mean average difference of 0.55 ($P<0.001$) and between the age group of 8 to < 9 and 11 to < 12 with a mean average difference of 0.44 ($P<0.05$) in favor to the older age groups. These results display that as age increases the mean score of the Obstacles and Curb Tests decrease, which means that older children are faster than younger ones. The Partial η Squared showed a small effect size of sex ($\eta^2 = 0.02$) and sex x age ($\eta^2 = 0.05$) on Curb Test, and a medium effect size of age on Obstacles Test ($\eta^2 = 0.09$) and Curb Test ($\eta^2 = 0.09$) (Table 2 and Figure 12). Generally, the results of an independent-samples t-test revealed that there were no significant differences in the Obstacles Test scores in respect to sex through all age groups ($P>0.05$) and a significant difference in the Curb Test scores in respect to sex through all age groups ($P<0.05$) in favor to boys and specifically in the age group of 9 to <10 ($P<0.001$). In early childhood, girls appeared to be faster than boys but as they reached age 8 to < 9 and age 9 to < 10 boys became faster than girls till age 12 (Table 3). All children in this phase completed the tests with no need of assistance and did not touch the obstacles and they all used stepping in ascending/descending the curb.

Table 2. A two-way ANOVA for Age and Sex on Obstacles and Curb Tests

Source	Obstacles Test						Curb Test					
	Type III Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**	**Partial η Squared**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial η Squared**
Corrected Model	30.75[a]	11	2.79	3.04	0.00	0.12	18.07[b]	11	1.64	3.87	0.00	0.15
Intercept	7119.44	1	7119.44	7741.74	0.00	0.97	2138.03	1	2138.03	5042.00	0.00	0.95
Sex	3.06	1	3.06	3.33	0.06	0.01	2.06	1	2.06	4.87	0.02*	0.02
Age	22	5	4.4	4.78	0.00**	0.09	10.5	5	2.1	4.95	0.00**	0.09
Sex x Age	5.67	5	1.13	1.23	0.29	0.02	5.5	5	1.10	2.59	0.02*	0.05
Error	209.67	228	0.92				96.68	228	0.42			
Total	7359.87	240					2252.78	240				
Corrected Total	240.42	239					114.75	239				

Df: Degrees of freedom, F: F-value, Sig: Significance level ($P < 0.05$).
*Significant where $P < 0.05$, **Significant where $P < 0.001$
a. R squared = 0.12 (Adjusted R squared = 0.08)
b. R squared = 0.15 (Adjusted R squared = 0.11)

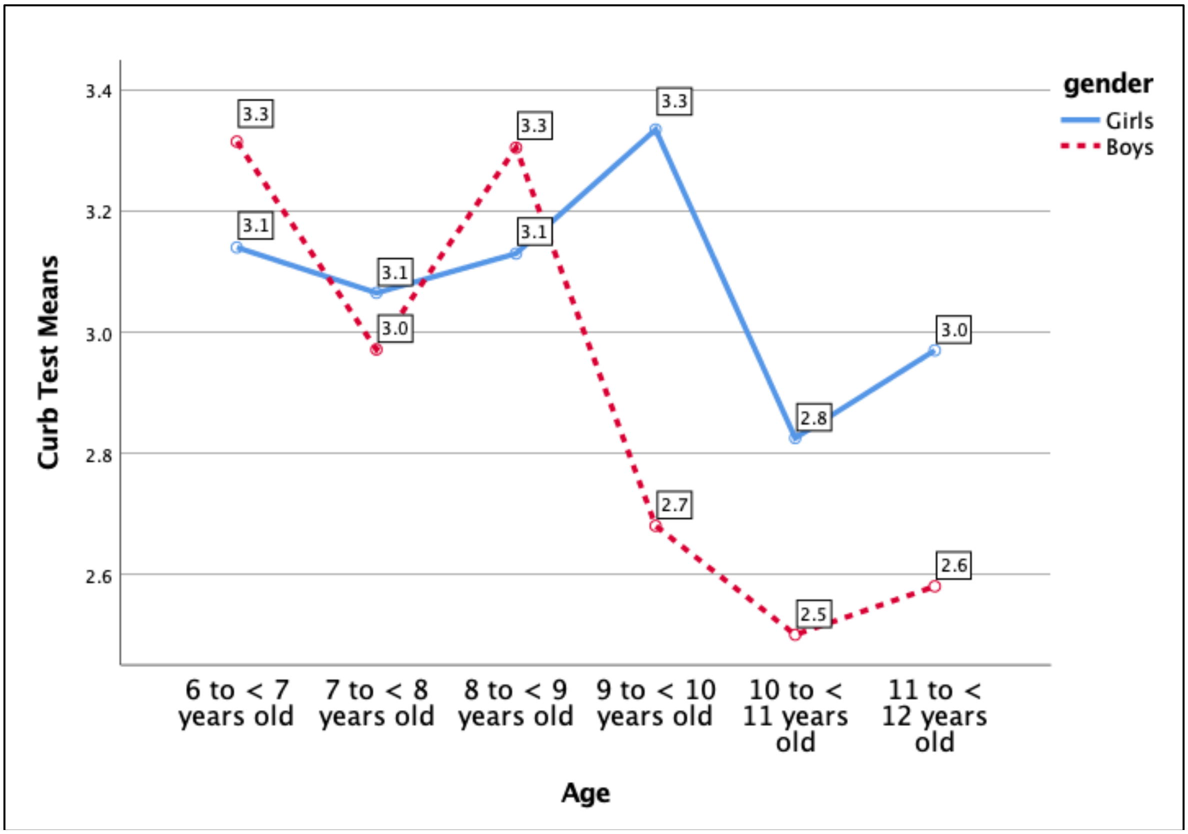


Figure 12. Gender x Age Interaction Effect on Curb Test

Table 3. Mean, SD and t-test Significance of Sex on Obstacles and Curb Tests

Age (years)	Obstacles Test						Curb Test					
	Girls		Boys		t-test		Girls		Boys		t-test	
	N	**Mean ± SD**	**N**	**Mean ± SD**	**t**	**P-value**	**N**	**Mean ± SD**	**N**	**Mean ± SD**	**t**	**P-value**
6 to < 7	20	5.8 ± 0.7	20	6.1 ± 1.4	-0.90	0.37	20	3.1 ± 0.6	20	3.3 ± 0.8	-0.75	0.45
7 to < 8	20	5.5 ± 1.0	20	5.5 ± 0.6	0.08	0.93	20	3.0 ± 0.5	20	2.9 ± 0.5	0.51	0.61
8 to < 9	20	5.6 ± 1.0	20	5.2 ± 0.8	1.46	0.15	20	3.1 ± 0.5	20	3.3 ± 0.8	-0.79	0.43
9 to < 10	20	5.7 ± 1.0	20	5.1 ± 1.0	1.85	0.07	20	3.1 ± 0.8	20	2.6 ± 0.3	3.05	0.00*
10 to < 11	20	5.0 ± 0.9	20	4.8 ± 0.8	0.88	0.38	20	2.8 ± 0.6	20	2.5 ± 0.4	1.81	0.07
11 to < 12	20	5.5 ± 0.9	20	5.1 ± 0.5	1.51	0.13	20	2.9 ± 0.7	20	2.5 ± 0.4	1.92	0.06
Total	120	5.5 ± 0.9	120	5.3 ± 1.0	1.75	0.08	120	3.0 ± 0.6	120	2.8 ± 0.6	2.08	0.03*

Mean and ± SD represented in seconds, N: Number of participants, P-value: significant level
*Significant between girls and boys, P < 0.05

4.1.4. Factors Affecting Obstacles and Curb Tests

The Pearson's correlation results for the Obstacles and Curb Tests and the related variables: sex, age, height, weight, and BMI% are presented in Table 4. The results showed that the Obstacles Test had a significant negative medium correlation with height (r=-0.32, P<0.001), a significant negative small correlation with weight (r=-0.18, P<0.05) and age (r=-0.24, P<0.001), and an insignificant negative small correlation with BMI% (r=-0.04, P>0.05). Furthermore, the Pearson's correlation results showed that the Curb Test had a significant negative small correlation with age (r=-0.25, P<0.001), height (r=-0.29, P<0.001) and weight (r=-0.17, P<0.05), and an insignificant correlation with BMI% (r=0.01, P>0.05). The η test showed a weak association between Obstacles and Curb Tests with sex, in favor to boys (η = 0.11) (η = 0.13) respectively (Figure 13 to Figure 20).

Table 4. Factors Affecting Obstacles and Curb Tests

		Related Variables				
		Sex	**Age**	**Height**	**Weight**	**BMI%**
Obstacles Test	Pearson Correlation		-0.24**	-0.32**	-0.18*	-0.04
	η Value	0.11				
Curb Test	Pearson Correlation		-0.25**	-0.29**	-0.17*	0.01
	η Value	0.13				

*Significant where P < 0.05, **Significant where P < 0.001

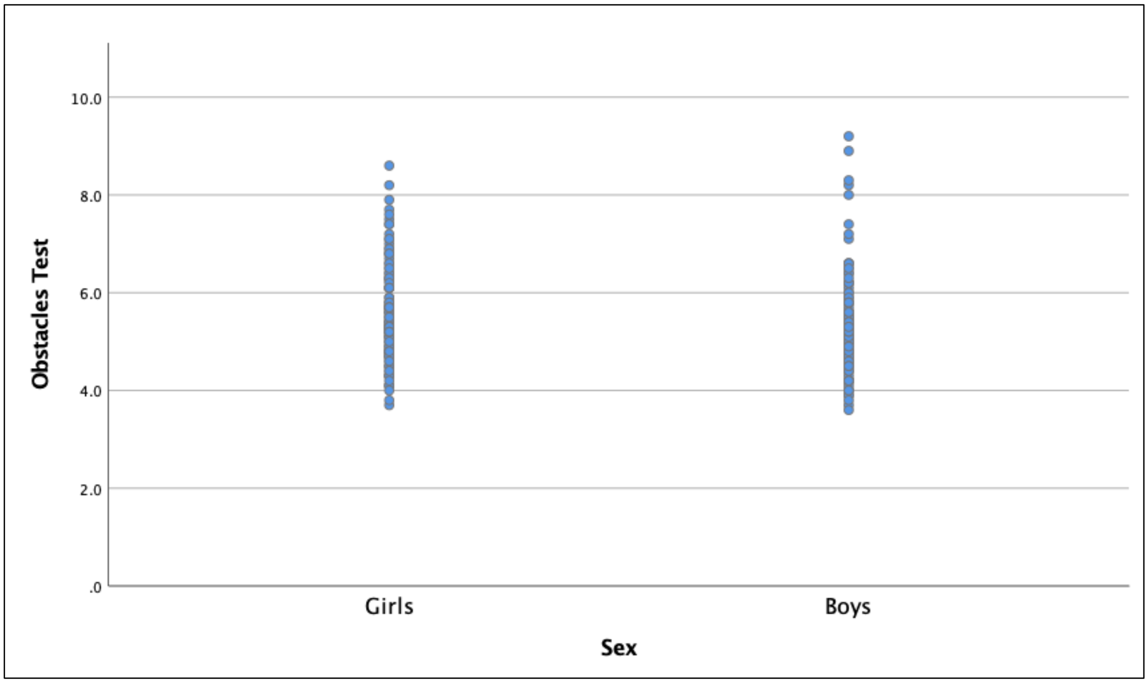


Figure 13. Correlation between Obstacles Test and Sex

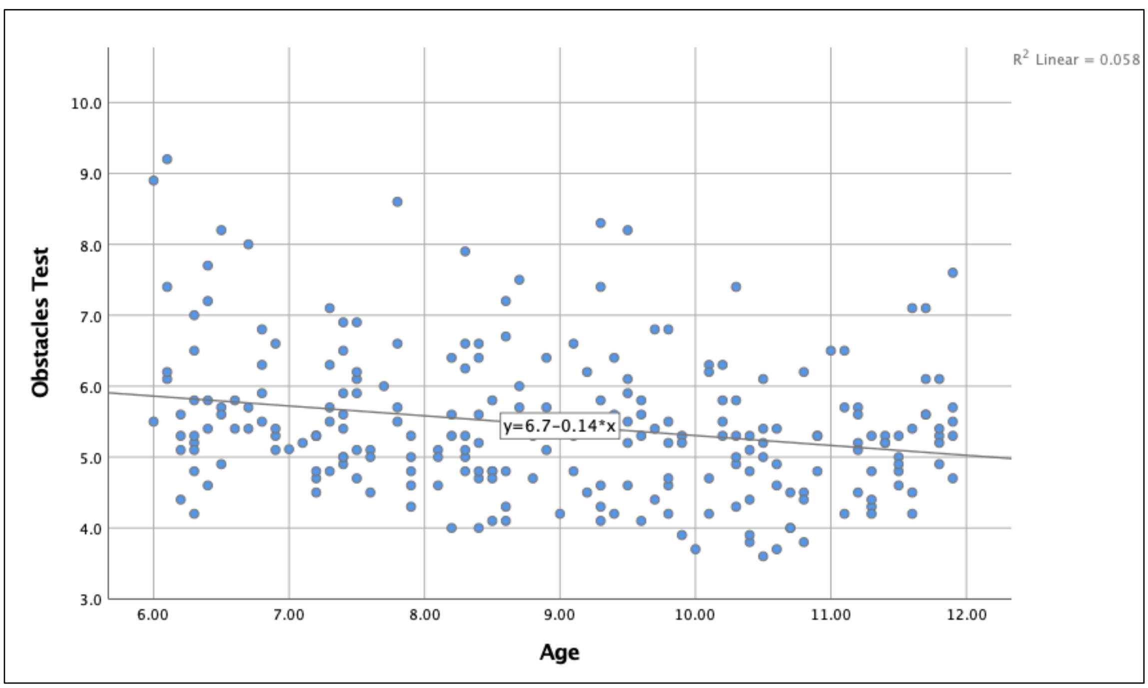


Figure 14. Correlation between Obstacles Test and Age

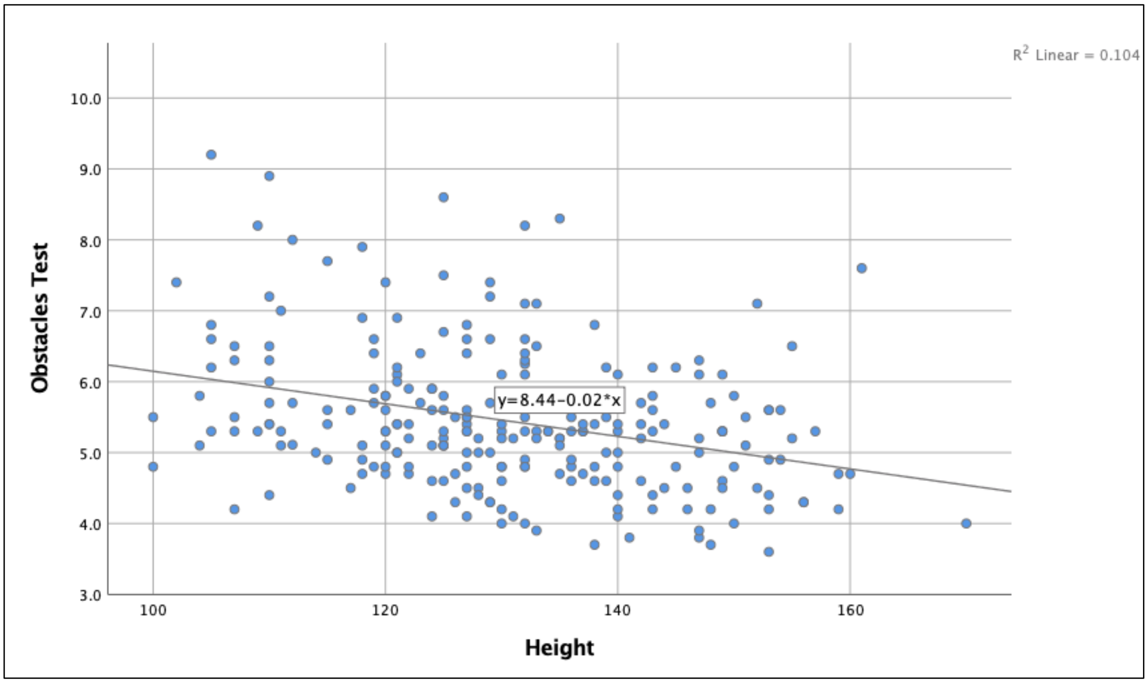


Figure 15. Correlation between Obstacles Test and Height

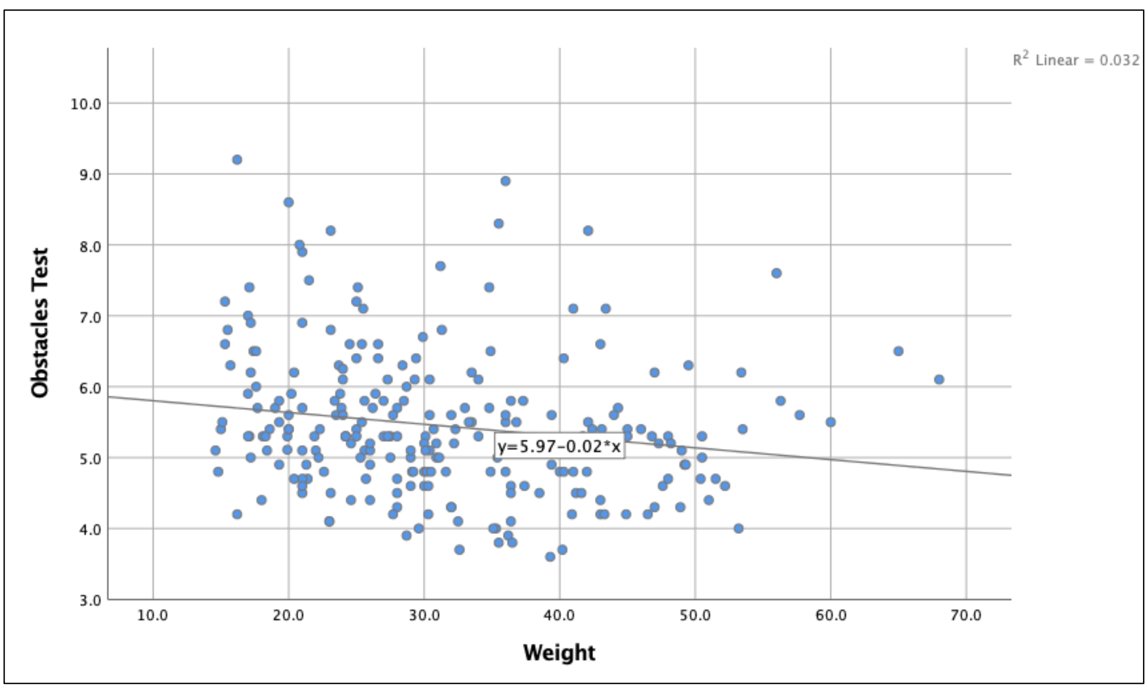


Figure 16. Correlation between Obstacles Test and Weight

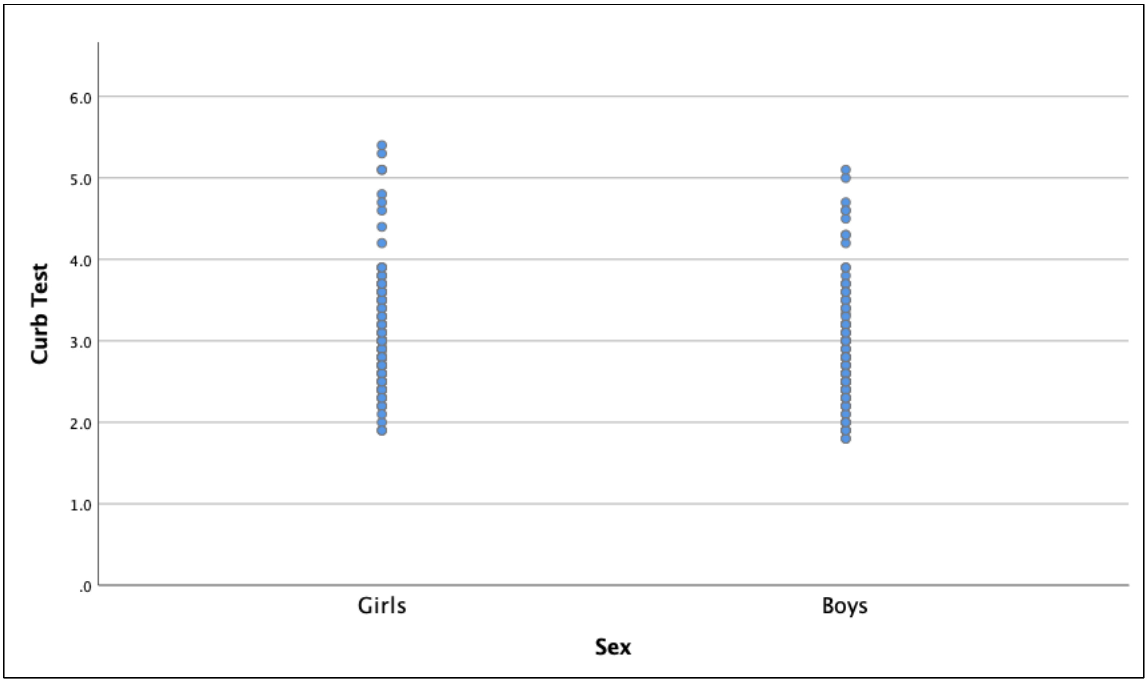


Figure 17. Correlation between Curb Test and Sex

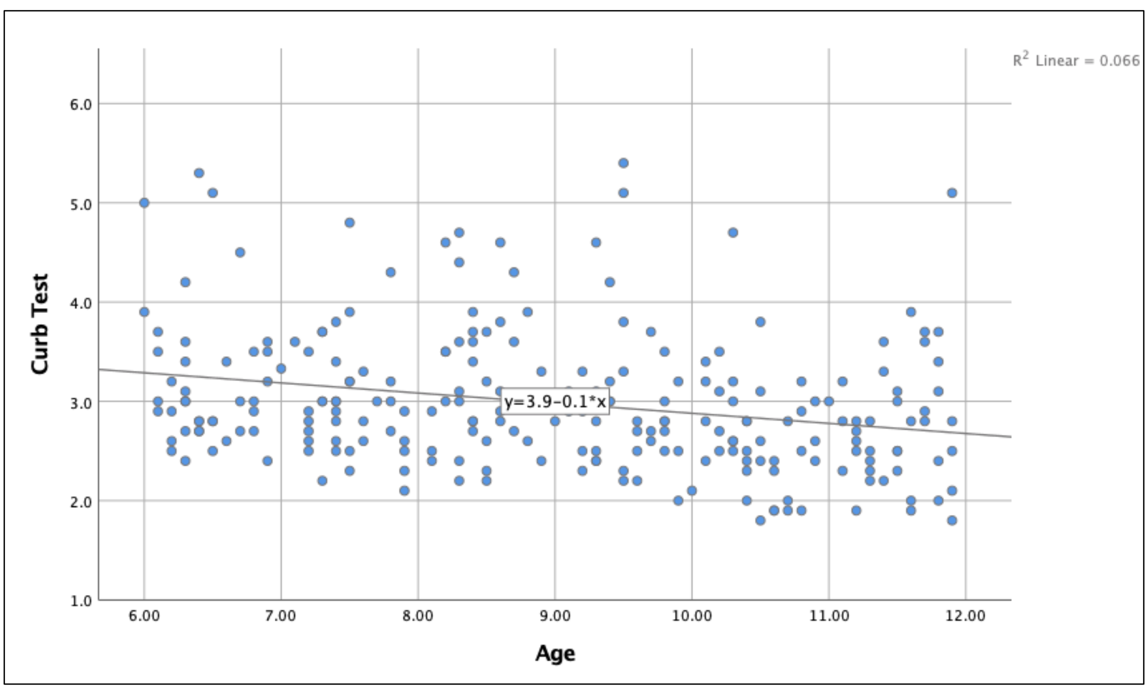


Figure 18. Correlation between Curb Test and Age

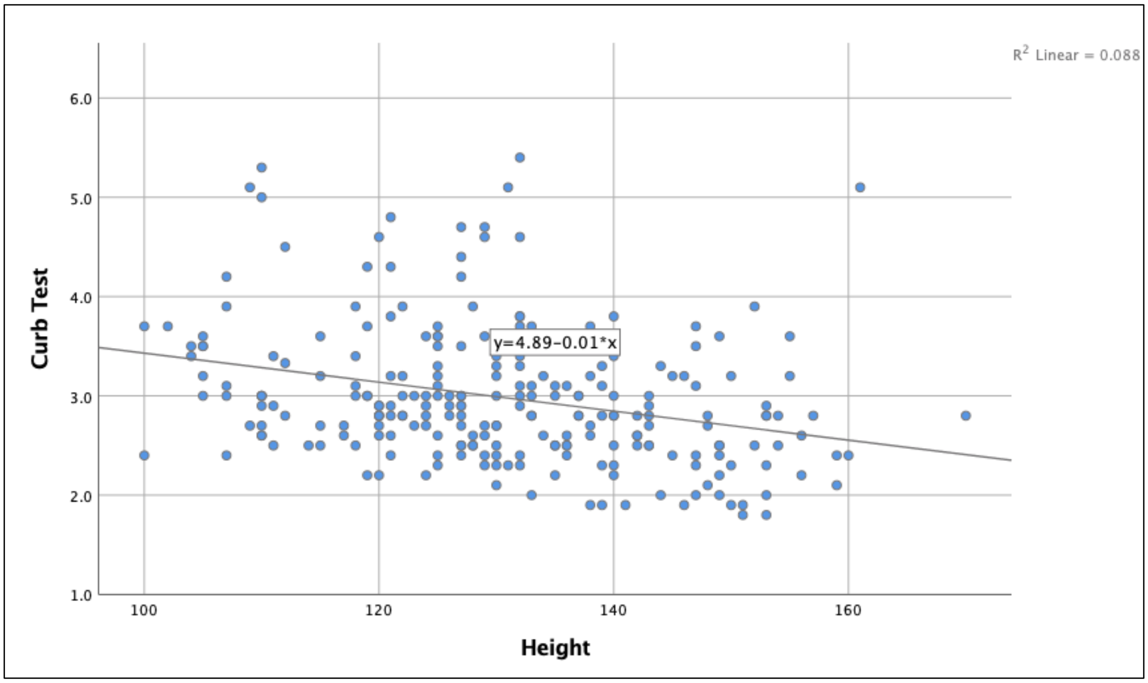


Figure 19. Correlation between Curb Test and Height

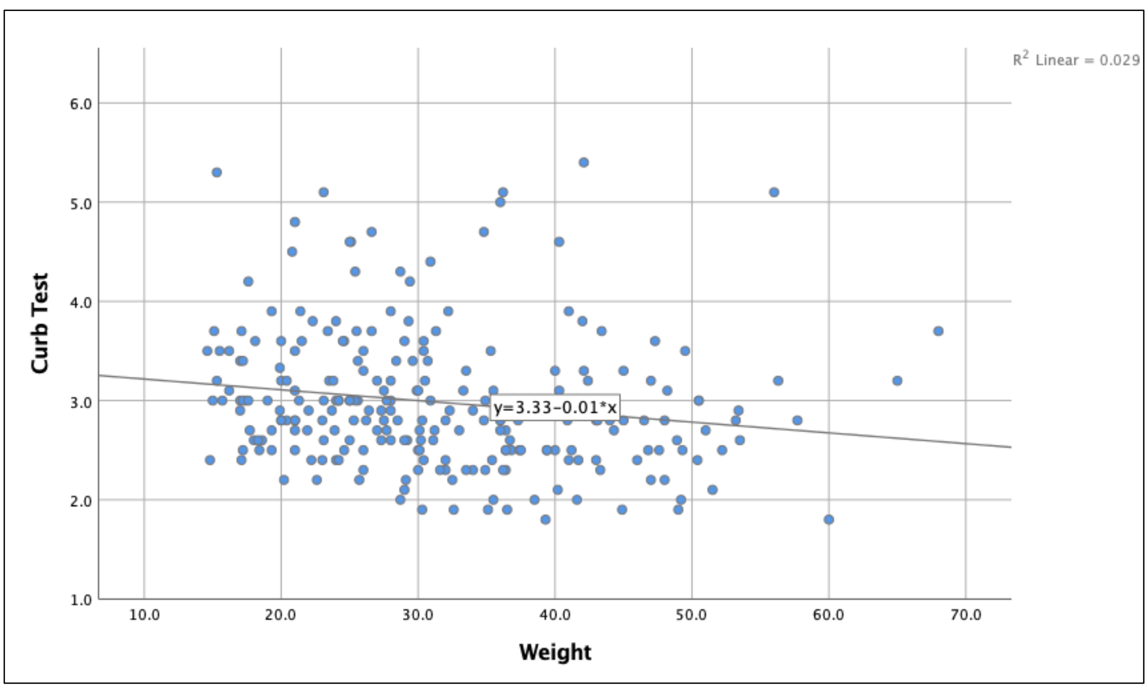


Figure 20. Correlation between Curb Test and Weight

4.1.5. Predictors of Obstacles and Curb Tests

Sex, age, height, and weight have shown to be the most associated factors with Obstacles and Curb Tests. After running a standard stepwise regression with including these factors it appeared that the significant predictors for the Obstacles Test were height and weight and they explained 12.7% of the total variance, and the significant predictors for the Curb Test were height, weight and sex and they explained 12.4% of the total variance (Table 5). The order of importance of each variable in determining the Obstacles Test appeared to be height, weight, age then sex, and for the Curb Test they were height, weight, sex then age. When testing the variance inflation factor it was found that there was no multicollinearity between the variables predicting the Obstacles and Curb Tests when the multicollinearity cut point was from 1 to 10.

The predicted Equation for Obstacles Test when using both height and weight as predictors was:

Obstacles Test (seconds) = 9.70 – 0.03 × (height in cm) + 0.02 × (weight in kg)

The predicted Equation for Curb Test when using height, weight, and sex as predictors was:

Curb Test (seconds) = 5.98 – 0.02 × (height in cm) + 0.01 × (weight in kg) + 0.19 × (sex, where boys = 0 and girls = 1)

Table 5. Stepwise Regression Analysis for Predicting Obstacles and Curb Tests

		Model	R	R^2	Unstandardized Coefficients		Standardized Coefficients	Sig.
					B	Std. Error	Beta	
Obstacles Test	**1**	**(Constant)**	0.32	0.10	8.44	0.57		0.00
		Height			-0.02	0.00	-0.32	0.00
	2	**(Constant)**	0.35	0.12	9.70	0.76		0.00
		Height			-0.03	0.00	-0.54	0.00
		Weight			0.02	0.01	0.26	0.01
Curb Test	**1**	**(Constant)**	0.29	0.08	4.89	0.39		0.00
		Height			-0.01	0.00	-0.29	0.00
	2	**(Constant)**	0.32	0.10	5.64	0.53		0.00
		Height			-0.02	0.00	-0.48	0.00
		Weight			0.01	0.00	0.23	0.03
	3	**(Constant)**	0.35	0.12	5.98	0.54		0.00
		Height			-0.02	0.00	-0.50	0.00
		Weight			0.01	0.00	0.26	0.01
		Sex			-0.19	0.08	-0.13	0.02

R and R^2: A measure of strength between model and dependent variable
Sig: Significance level ($P < 0.05$), B: Standardized coefficient

4.1.6. Relationship Between Obstacles and Curb Tests

The Pearson's correlation coefficient between Obstacles and Curb Tests was found to be a positive large correlation and statistically significant (r = 0.61, P < 001). Children who scored less in Obstacles Test relatively scored less in Curb Test and vice versa (Figure 21).

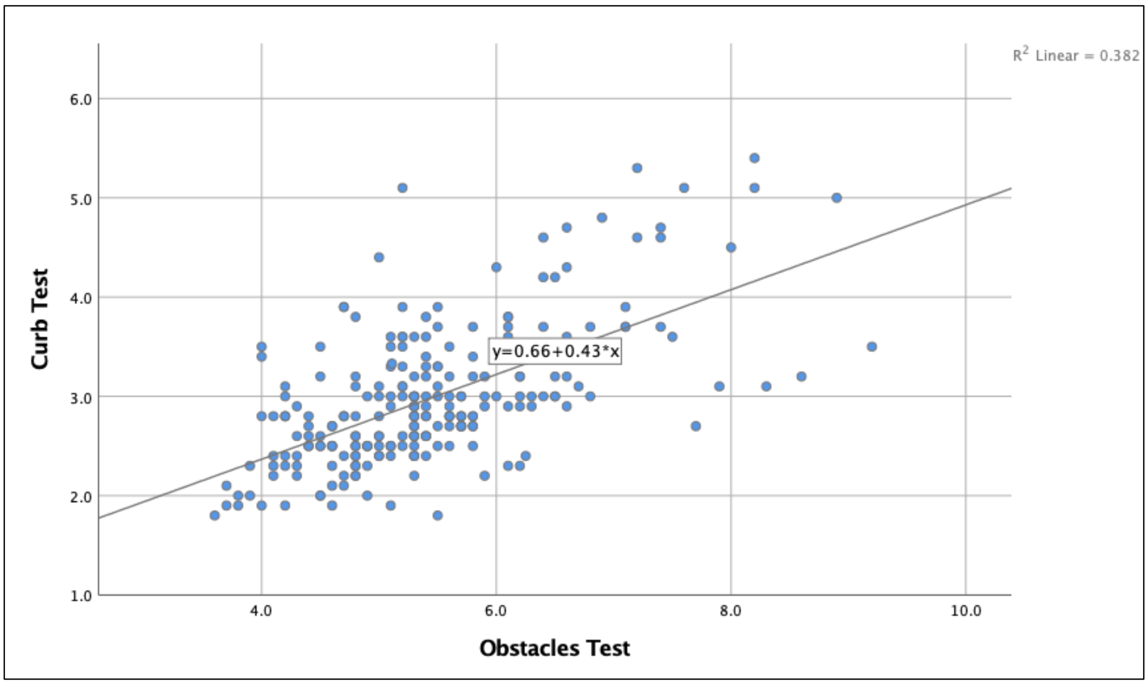


Figure 21. Correlation between Obstacles and Curb Tests

Phase Two

A Shapiro-Wilk Test showed that all the data were not normally distributed and heterogenic for phase two (P>0.05).

4.2.1. Participants' Characteristics

In general, forty-four children participated in the study. Forty-one children were included in the analysis of the Obstacles Test and Twenty-nine were included in the analysis of the Curb Test. The remaining children were excluded because they were unable to complete the tests (Figure 22).

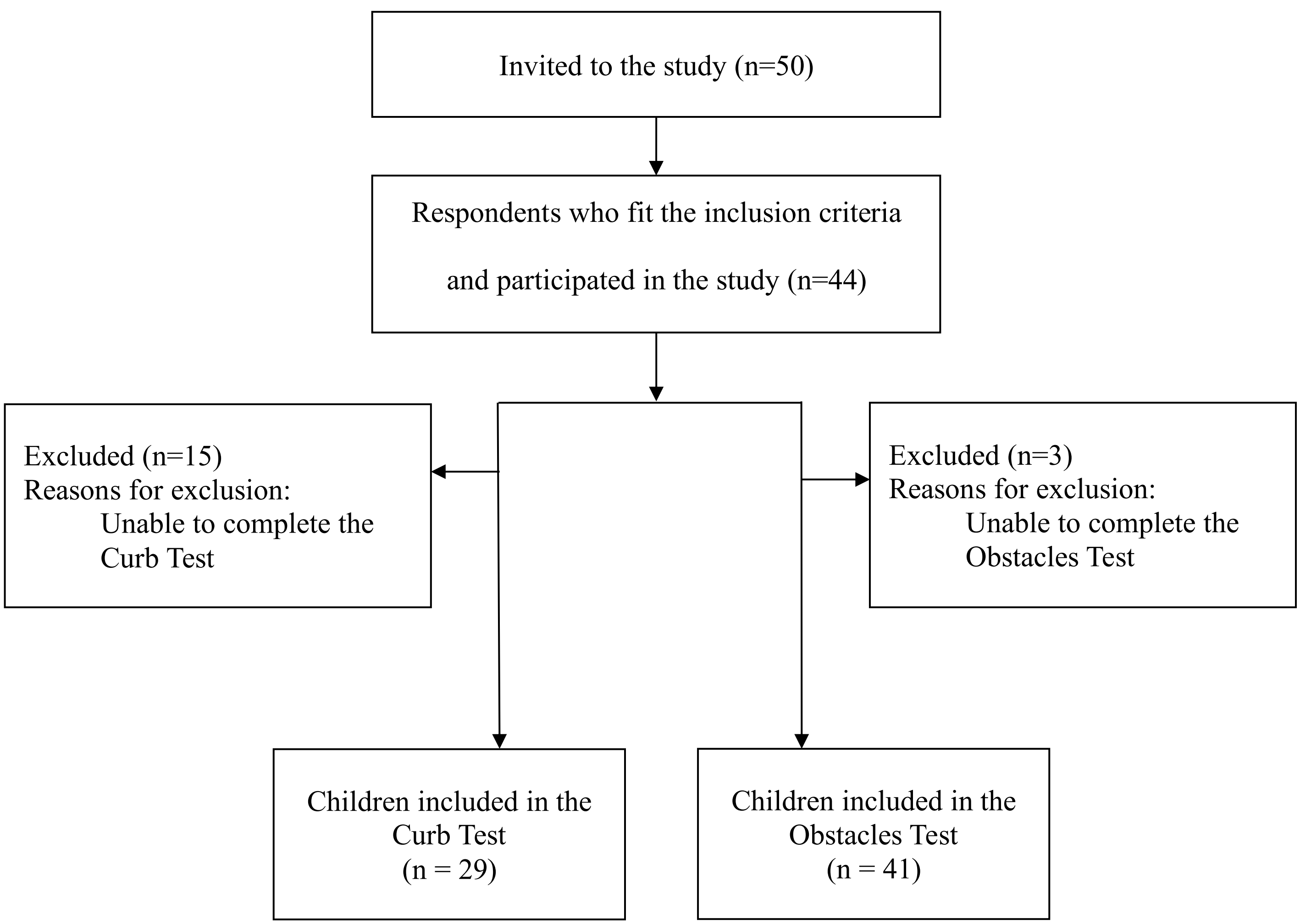


Figure 22. Flow Chart of Selection Process for Children with CP

Children in Obstacles Test comprised of 21 girls (51.2%) and 20 boys (48.8%) with a total mean and SD of: 122.6 ± 8.3 cm for height, 24.7 ± 6.2 kg for weight, 47.4 ± 33.1 percent for BMI%. They had a GMFCS level of: Level I 16 (39%), Level II 13 (31.7%) and Level III 12 (29.3%). Children in Curb Test comprised of 17 girls (58.6%) and 12 boys (41.4%) with a total mean and SD of: 122.9 ± 8.8 cm for height, 24.5 ± 6.4 kg for weight, 44 ± 33.9 percent for BMI%. They had a GMFCS level of: Level I 16 (55.2%) and Level II 13 (44.8%). No children from GMFCS level III were able to complete the Curb Test. The demographical and clinical characteristics of the children are shown in Table 6.

Table 6. Frequencies and Percentages of Demographic Data for Children with CP

		Obstacles Test	**Curb Test**
		N = 41	**N = 29**
Sex	**Girls**	21 (51.2%)	17 (58.6%)
	Boys	20 (48.8%)	12 (41.4%)
Type of CP	**Diplegic**	19 (46.3%)	14 (48.3%)
	Hemiplegic	9 (22.0%)	9 (31.0%)
	Ataxic	7 (17.1%)	5 (17.2%)
	Quadriplegic	6 (14.6%)	1 (3.4%)
GMFCS	**Level I**	16 (39.0%)	16 (55.2%)
	Level II	13 (31.7%)	13 (44.8%)
	Level III	12 (29.3%)	
Use Orthosis	**Yes**	18 (43.9%)	7 (24.1%)
	No	23 (56.1%)	22 (75.9%)
Use Assistive Device	**Yes**	12 (29.3%)	0 (0%)
	No	29 (70.7%)	29 (100%)

Numbers presented as frequency and percentage. N: number of children.

4.2.2. Obstacles and Curb Tests with Cerebral Palsy

In total, the median (IQR) for the Obstacles Test was 13.2 (9.6) and for the Curb Test was 6.1 (9.0). The median for each GMFCS level was presented in Table 7. Median scores grew higher as the GMFCS level increased showing that children took more time in completing the tests. Children in GMFCS level I completed the Obstacles Test without touching the obstacles, which was opposite to the majority of children in GMFCS level II and III who touched the obstacles. Furthermore, all children in GMFCS level I and II could step onto and walk across the curb, although with GMFCS level I they found no challenge in the stepping process while some children with GMFCS level II found a challenge when stepping onto/off the curb. Children with GMFCS level III were all excluded from the Curb Test because they were unable to step onto/off the curb.

Table 7. Median and IQR for Obstacles and Curb Tests according to GMFCS Levels

	Obstacles Test				**Curb Test**			
	Median	**IQR**	**Q1**	**Q3**	**Median**	**IQR**	**Q1**	**Q3**
GMFCS I	8.0	4.0	5.4	9.4	4.6	1.8	4.0	5.7
GMFCS II	13.8	3.7	12.3	16.0	13.8	2.3	12.0	14.3
GMFCS III	19.6	1.9	18.9	20.8				
Total	13.2	9.6	9.0	18.6	6.1	9.0	4.5	13.5

Numbers in table presented in seconds. IQR: Interquartile range, Q1: Lower bound of the interquartile range, Q3: Upper bound of the interquartile range.

4.2.3. Convergent Construct Validity

Analysis of convergent construct validity revealed a statistically positive strong correlation between the Obstacles Tests and the 10MWT and between the Curb Test and 10MWT and MTUG. A statistically positive very strong correlation appeared between the Obstacles Tests and the MTUG. The convergent construct validity showed a statistically significant negative correlation that was very strong with the Obstacles Test and strong with the Curb Test (Table 8).

Table 8. Convergent Construct Validity

		10MWT	MTUG	PBS
Obstacles Test	Spearman's rho	0.88**	0.93**	-0.90**
Curb Test	Spearman's rho	0.76**	0.83**	-0.81**

*Significant where $P < 0.05$, **Significant where $P < 0.001$

4.2.4. Discriminative Validity

Discriminative validity was done for both tests with an equal number of TD children and children with CP who participated in each test. TD children were chosen randomly and had similar characteristics of age and sex with each child with CP. The Obstacles Test had 41 TD children (21 girls, 20 boys, mean age = 8.8 ± 1.8 years, height = 128.6 ± 12.8 cm, weight = 30.6 ± 10.9 kg, and BMI% = 62.4 ± 33.2 percent) and the Curb Test had 29 TD children (17 girls, 12 boys, mean age = 8.8 ± 1.8 years, height = 127.8 ± 12.8 cm, weight = 29.3 ± 9.1 kg, and BMI% = 59.8 ± 35.8 percent). The Median scores for TD children appeared to be lower in both tests in comparison with children with CP. In the Obstacles Test TD children had a median (IQR) of 5.4 (0.9) while children with CP scored 13.2 (9.6). Whereas, in the Curb Test TD children had a median of 3 (0.7) which was less than children with CP who scored 6.1 (9.0). This showed that TD children required less time in completing both tests. A significant difference was found between the groups in Obstacles Test (Mann–Whitney U = 141.50, TD children rank = 24.45, children with CP rank = 58.55, z score = - 6.485, P < 0.001) and Curb Test (Mann–Whitney U = 49, TD children rank = 16.69, children with CP rank = 42.31, z score = - 5.781, P < 0.001) in favor to TD children (Figure 23 and Figure 24). With observation, some children with CP obtained penalties for touching the obstacles in Obstacles Test while all TD children completed the test without touching the obstacles.

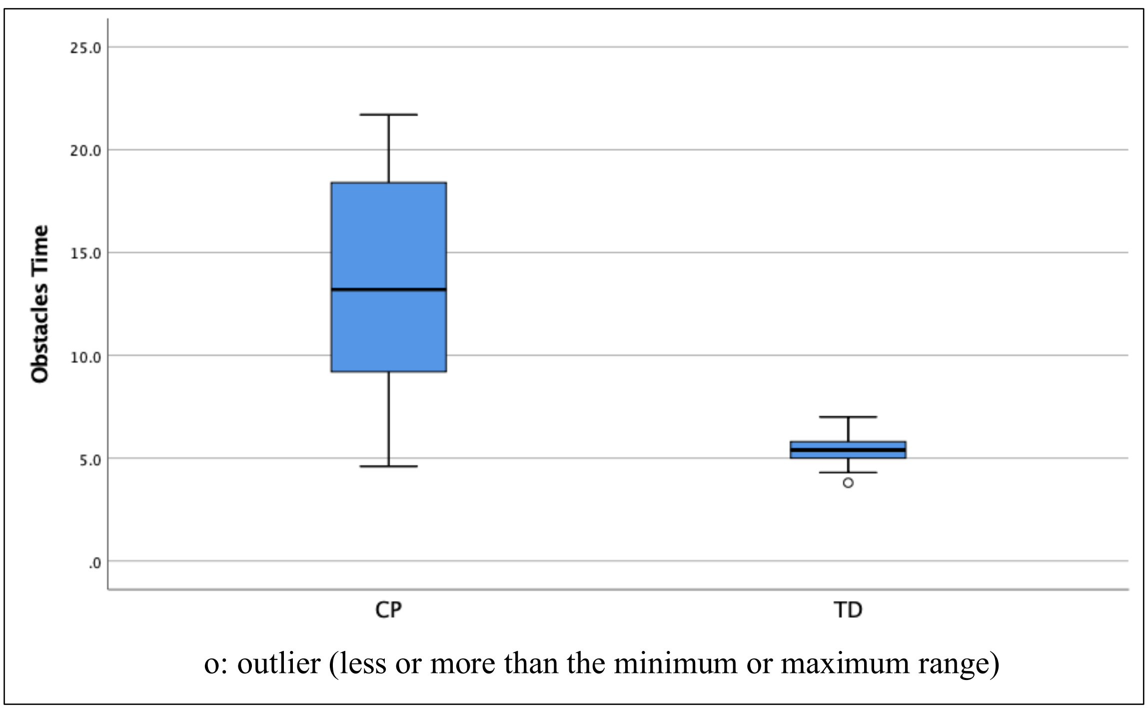
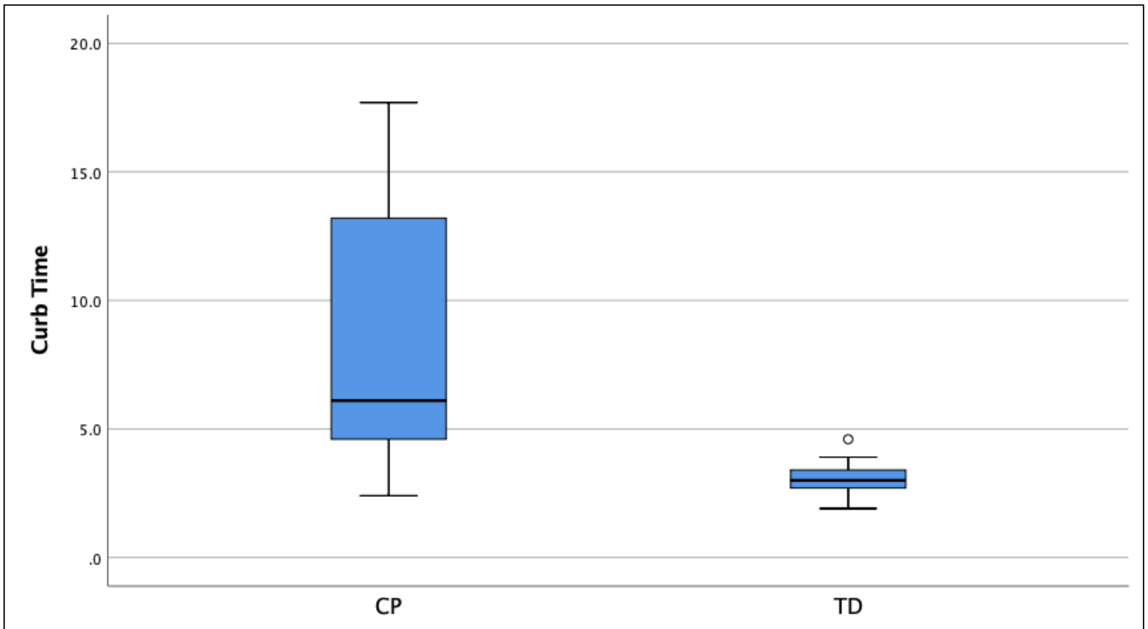


Figure 23. Difference between TD children and children with CP in Obstacles Test



o: outlier (less or more than the minimum or maximum range)

Figure 24. Difference between TD children and children with CP in Curb Test

4.2.5. Test-Retest Reliability

Test-Retest reliability was high for Obstacles and Curb Tests. They both had a statistically significant and very strong correlation. The Interclass Correlation showed an excellent correlation (ICC=0.98 (95% CI=0.97-0.99)) and (ICC=0.99 (95% CI=0.97-0.99)) respectively (Table 9).

Table 9. Test-Retest Reliability

	Spearman's rho	Intraclass Correlation		
		Intraclass Correlation	95% Confidence Interval	
			Lower Bound	Upper Bound
Obstacles Test	0.98**	0.98	0.97	0.99
Curb Test	0.96**	0.99	0.97	0.99

*Significant where P < 0.05, **Significant where P < 0.001

CHAPTER V

DISCUSSION

Chapter V. Discussion

Measuring the walking ability of children is important. It provides useful knowledge in planning healthcare, measuring functional ability, and observing change before and after treatments. The Obstacles and Curb Tests are timed walking tests that have been modified for children, but their normative data, validity and reliability have not been collected or studied. This study was the first of its nature, and its purposes were to determine the normative values of Obstacles and Curb Tests on TD children and to assess their validity and reliability for children with CP.

The Obstacles and Curb Tests were performed at fast speed and had one scored trial after a practice trial as suggested by the test protocol done by Kane et al. (2016). This protocol of walking at fast speed agrees with studies on walking tests in laboratory settings, where they have found that when TD children walked at fast speeds a variation in walking appeared according to a child's age which makes it more suitable when testing the walking ability for TD children (Voss et al., 2020). Moreover, in timed walking tests researchers have established that walking speed affects the gait of children with CP which gives a more score range according to the levels of GMFCS and therefore helps show discrimination between children with CP (Zaino et al., 2004). Implementing walking at fast speeds in this study for both TD children and children with CP agrees with the fact that established timed walking tests such as the 10MWT, MTUG, Timed Up and Down Stairs were all proved to be more appropriate when performed at fast speeds (Bahrami et al., 2017; De Baptista et al., 2020; Habib et al., 1999; Nicolini-Panisson & Donadio, 2014; Thompson et al., 2008; Verbecque et al., 2019; Zaino et al., 2004). Additionally, fast walking in timed walking tests is supported by the fact that all studies of 10MWT recommend the use of fast speed (De Baptista et al., 2020; Graser et al., 2016).

According to our findings, the mean and SD for TD children in the Obstacles Test was 5.4 ± 1 seconds whereas for the Curb Test it was 2.9 ± 0.6 seconds. TD children can complete the Obstacles and Curb Tests with no difficulties. All TD children could perform the Obstacles Test without touching the obstacles. They also engaged in the Curb Test smoothly and could achieve both ascending and descending the curb without loss of balance or the need to use hands for stabilization. Our findings revealed that children who performed the Obstacles Test in less time were ultimately able to perform the Curb Test in a short period of time and vice versa. Therefore, we found that there was a positive large correlation between the two tests.

The anthropometric characteristics of TD children who participated in this study were 130.5 ± 14.1 cm for height and 31.4 ± 10.8 kg for weight. These findings are close to the measures reported by Al-Hazzaa et al. (2020) about the anthropometric characteristics of Saudi TD children from 6 to 13 years old (133.2 ± 11.4 cm for height, 32.8 ± 11.3 kg for weight). A slight increase in the mean of the height and weight appears between our study and the previous study and this could be explained by the age difference, where the previous study included children who are two years older than the age range in our study. Moreover, the findings of the BMI% of TD children in our study were nearly like the findings of the anthropometric characteristics of Saudi children where more than half of the participants had a healthy weight (Al-Hazzaa et al., 2020). Our findings showed that there were no significant differences between the height, weight, and BMI% of TD girls and boys in younger age groups from 6 to 8 years. However, boys increase in height, weigh more and have a higher BMI% than girls as they reach the age of 9 years, and this finding has been recorded in previous studies and referred to as the approach of puberty (Pereira et al., 2016). The study by Al-Hazzaa et al. (2020) differs from our findings where they found no significant differences between the anthropometric characteristics of TD girls and boys across all ages, and this could be due to the difference in age range and sample size where they included 1149 children. On the other hand, the study by Pereira et al. (2016) agreed with our findings and reported the effect of puberty in increasing the height, weight and BMI of boys at age 9 to 12 years.

Age showed an influence on the Obstacles and Curb Tests scores. Age had a statistically high significant effect on the scores of the two tests. Similarly, age appeared to be a factor affecting the scores of the 10MWT and MTUG (Itzkowitz et al., 2016; Nicolini-Panisson & Donadio, 2014; Pereira et al., 2016). As age increased the child required less time to finish the test, this occurred because motor tasks are better performed with the increase of age (Itzkowitz et al., 2016; Nicolini-Panisson & Donadio, 2014; Pereira et al., 2016). Studies have reported that maturation of body size and strength, as well as the improvement in balance with age, also relate to the fact that older children need less time in walking tests (Fukuchi et al., 2019). Moreover, children become faster in walking as they grow in age and subsequently increase in height and have a longer stride length (Voss et al., 2020). Furthermore, a walking test performed in a lab revealed that younger children demonstrated an increase in stance and double support times and a decrease in swing time in comparison to older children (Voss et al., 2020). Since this observation was concluded from a lab walking test performed when walking fast in a straight path, a more variation in the gait pattern may occur with the presence of the obstacles and the curb due to the adjustment of speed needed to accelerate and decelerate when approaching the obstacles and the curb. This could explain the influence of age on the score of the Obstacles and Curb Tests.

Sex showed no significance on the Obstacles Test, but the degree of significance was at borderline (P-value=0.08) in favor of boys. Sex had a statistically high significant effect on the Curb Test scores in favor of boys. Boys were faster than girls in the age group of 9 to <10 when performing the Curb Test where the results showed a significant difference. In the age groups of 10 to < 11 and 11 to < 12 there was no significance between boys and girls, but both age groups were at borderline (P-value=0.07 and 0.06, respectively) in favor of boys. This could relate to the increase in height for boys during this age as an effect of puberty which ultimately increases stride length (Pereira et al., 2016; Voss et al., 2020). Our results showed that in both tests, girls were nearly as fast as boys from early childhood till the age of 8 to < 9 and age 9 to < 10. Afterwards, boys exceeded girls in speed and achieved less walking test scores. These results are consistent with earlier studies related to walking tests. They have found that girls from the age of 7 to 14 years scored less in walking tests and had less aerobic capacity than boys (Castro-Pineiro et al., 2011). This was explained by the differences in physical development, the changes in lean body weight and body fat, the hemoglobin concentration and changes in hormones (Castro-Pineiro et al., 2011). Another factor that could explain this was that girls are less active than boys (Castro-Pineiro et al., 2011). Studies on the 10MWT found no significant influence of sex (De Baptista et al., 2020). And studies on the MTUG were in contrary where some found a significant influence of sex in favor to girls (Itzkowitz et al., 2016) and others found no significant influence of sex (Butz et al., 2015; Nicolini-Panisson & Donadio, 2014; Williams et al., 2005). This could show that whether there was a significant influence of sex or not, it does not have clinical importance since it did not exceed 2 seconds (Itzkowitz et al., 2016).

Other factors that affect the Obstacles and Curb Tests were found to be height and weight. They both had a significant negative correlation with the two tests. The BMI% showed an insignificant correlation with both tests. Our findings agreed with the results of the studies done on the 10MWT (De Baptista et al., 2020) and MTUG (Itzkowitz et al., 2016;

Nicolini-Panisson & Donadio, 2013, 2014) when studying the anthropometric variables that affect the scores of the tests.

After running a standard stepwise regression to generate a predictive equation for the Obstacles and Curb Tests, height and weight explained 12.7% of the total variance for the Obstacles Test and height, weight and sex explained 12.4% of the total variance for the Curb Test. Our predictive equations both considered different factors than the equation of the MTUG which used age only (Habib & Westcott, 1998; Itzkowitz et al., 2016) or age and weight (Nicolini-Panisson & Donadio, 2014) as the main predictive variables. An established equation for the 10MWT does not exist. Our predictive equation did not consider age as the main variable as previously mentioned walking tests, this could be because height showed more relevance and effect on the test scores of the Obstacles and Curb Tests.

For children with CP, our finding revealed that the median (IQR) for the Obstacles Test was 13.2 (9.6) and for the Curb Test was 6.1 (9.0). Children with a lower GMFCS level required more time to complete the two tests. Children with GMFCS level I were able to walk in the Obstacles Test pathway without touching the obstacles, while some children with GMFCS levels II and III touched the obstacles and received an increase of a 10% time penalty as presented in the Obstacle Test protocol. This showed that children with GMFCS levels II and III had difficulties with stepping over the blocks or adjusted their assistive device around them. This could be due to the higher impairments associated with the degree of disability which decreases the gait quality (Nelson & Boyer, 2021). In the Curb Test, children within GMFCS level I and II were able to ascend the curb, walk across it and descend from the other side. Children with GMFCS level 1 could perform the test with no challenge in ascending the curb while some children with GMFCS level II performed the test with a challenge in ascending/descending the curb. None of the children with GMFCS level III were able to complete the Curb Test therefore they were excluded. This was observed as a result of the inability to maneuver the assistive device to step onto the curb. Some children from GMFCS level II were hesitant to perform the stepping process due to fear of losing balance.

The curb in this study was 21 centimeters in height according to the modified version of the Curb Test (Kane et al., 2016). We believe that this mentioned height might be the reason behind the difficulty of this test for children with CP in GMFCS levels II and III. According to the Federal Highway Administration in the United States, the standard height of the curb in the community is 15.2 centimeters (Federal Highway Administration, 2021). The Federation of Canadian Municipalities in Canada established a standard curb height of 15 centimeters (Federation of Canadian Municipalities, 2021). In the United Kingdom, the standard curb height is from 10 to 12 centimeters (Doherty, 2015). After searching and contacting the Saudi Arabia Building and Roadway Administrations we found that in Saudi Arabia the minimum required curb height used in the community was 10 centimeters, but no standard curb height was established yet in Saudi Arabia (Saudi Arabia Building Administration, 2021). Moreover, the standard sidewalk depth in the United States, Canada, and Saudi Arabia was 1.5 meters. The sidewalk should never decrease this standard measure, but it increases in major roadways to 1.8 meters or more (Federal Highway Administration, 2021; Sidewalk Design, Construction, and Maintenance, 2004; Saudi Arabia Building Administration, 2021). In the United Kingdom, a depth of 2 meters is recommended unless there is a limit in space the minimum accepted depth is 1.5 meter (Department of Transportation, 2018).

In light of these findings, we suggest a new modification for the Curb Test. We recommend that the curb has a height of 15 centimeters to mimic the highest standard curb height found in the community. We also believe that increasing the depth of the curb to 1.5

meters to reflect the minimum depth in the community could give children who use an assistive device more space to maneuver the assistive device. Changing the curb height and depth could make the Curb Test feasible for children with CP with GMFCS level III.

The Obstacles and Curb Tests are both valid for children with CP. They showed a positive strong/very strong correlation between the 10MWT and MTUG, and a negative strong/very strong significant correlation with the PBS. This means that lower scores on the Obstacles and Curb Tests are associated with lower scores on the 10MWT and MTUG and higher scores on the PBS. Lower scores on the 10MWT and MTUG indicate better walking ability, higher gait speed and greater physical functioning ability, and likewise, higher scores on the PBS indicate better balance (Ammann-Reiffer et al., 2014; Duarte et al., 2014). Therefore, the assessment of walking using the Obstacles and Curb Tests can reflect the ability to walk in the community as well as show the overall degree of speed, physical functioning, and balance.

The Obstacles and Curb Tests' scores showed discrimination between children with CP and an age and sex matched group of TD children. The median scores of both tests were significantly lower in TD children when compared to children with CP. This discrimination appears because children with CP walk at slower speed and have a high energy cost (Rodby-Bousquet & Hagglund, 2012). This energy consumption increases with the use of an assistive device which increases the time needed to perform the tests (Rodby-Bousquet & Hagglund, 2012). In addition, a decrease of balance is a major result of motor impairments associated with CP. Balance and endurance are the greatest factors limiting walking abilities in children with CP (Nelson & Boyer, 2021). Balance was perceived to limit 8%, 22%, and 30% of walking ability in GMFCS levels I to III, respectively (Nelson & Boyer, 2021).

The Obstacles and Curb Tests are reliable timed walking tests for children with CP. They showed a very strong significant correlation when repeating the test on the same day after 15 minutes of rest. Re-applying the test on the same day was implemented following the tests protocol (Kane et al., 2016) and this protocol of implementing the retest on the same day agrees with the studying of MTUG and 6MWT's test-retest reliability on the same day (Lans et al., 2020; Mesquita et al., 2013). Since the results have shown excellent correlation, we can assume that the time of rest was appropriate, and that fatigue was not present to alter the test scores.

Study Strengths and Limitations

In this current study, there are strengths that need to be acknowledged. This study was the first to estimate the normative values of the Obstacles and Curb Tests and the first to establish the validity and reliability of the test for children with CP. The study of normative values was applied in Riyadh, where subjects were recruited by a convenience sampling method, and this can be representative of all children in the Kingdom of Saudi Arabia since Riyadh city is the capital and children from different ethnicities are living there.

The limitation in this study was that we were not able to apply a stratified sampling method according to location for the sample of TD children due to the limited access to children's schools through a year of pandemic. Therefore, we generated a convenience sample that was divided into equal age and sex groups and applied the study in different areas in the city of Riyadh. Furthermore, the ability of the Obstacles and Curb Tests to distinguish between GMFCS levels for children with CP was not studied due to the limited sample size of children in each GMFCS level. Despite these limitations, we believe our research provides important evidence and established information about the normative values of the Obstacles and Curb Tests, and determines the validity and reliability of these tests in children with CP.

Summary

In conclusion, this study established the Obstacles and Curb Tests' normative values for TD children from age 6 to 12 years. The results of this study also showed that the Obstacles and Curb Tests are valid and reliable timed walking tests for children with CP. The Curb Test was not applicable for children with CP in the GMFCS level III. The Obstacles and Curb Tests evaluate the ability to walk, the overall physical functioning of a child, the gait speed, and they reflect the degree of balance. Having simple and applicable timed walking tests that challenge the walking ability of children and represent walking in the community can help clinicians in the assessment of walking.

CHAPTER VI

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Chapter VI. Summary, Conclusion and Recommendations

6.1. Summary

Background: The Obstacles and Curb Tests are timed walking tests that have been recently modified for pediatrics; therefore, their normative values, validity and reliability have not yet been studied. Knowledge of their normative values is important to distinguish the normal speed of typical developing (TD) children from children with slower speed caused by any physical disability. Studying the validity and reliability of both tests for children with Cerebral Palsy (CP) provides us with a more challenging tool for children with higher functions that reflects walking in the community.

Objectives: The study aimed to determine the normative values of Obstacles and Curb Tests on TD children and to assess their validity and reliability for children with CP.

Method: This cross-sectional study consisted of two phases. Phase one was the study of normative data where 240 TD children (120 girls and 120 boys) participated in the study. They were grouped into six age groups with a one-year increment from age 6 to 12 years old. Children were recruited using a convenience sampling method from five recreational centers in Riyadh. Children completed both the Obstacles and Curb Tests after their height, weight, and BMI% were measured. The Obstacles Test required the child to step over two obstacles and walk around one basket, while the Curb Test required the child to step on, walk across and step off a wooden platform that mimics a curb. Data gathered from testing was statistically analyzed using SPSS. Means and standard deviations were measured for height, weight, BMI%, and Obstacles and Curb Tests for all children. An independent t-test was performed to measure the effect of sex on test scores. A two-way ANOVA was used to assess the interaction effect of age and sex on Obstacles and Curb Tests. The factors affecting walking speed in each test (age, height, weight, and BMI%) as well as the correlation between both tests were studied using Pearson Correlation. The η test was used to study the association between both test scores and sex. Stepwise regression was used to predict the Obstacles and Curb Tests' factors and their predicted equations were established.

Phase two was the study of psychometric properties of the Obstacles and Curb Tests on children with CP where 44 children with CP with ages from 6 to 12 years old participated in both tests. Children were recruited using a conventional method from Sultan bin Abdulaziz Humanitarian City. After excluding children who were unable to complete the tests, 41 children were included in the results of the Obstacles Test, and 29 children were included in the results of the Curb Test. Children with CP completed both the Obstacles and Curb Tests after their height, weight, and BMI% were measured and information about their physical ability and diagnosis were gathered. To examine convergent construct validity, they also participated in three other tests (10-Meter Walk Test (10MWT), Modified Time Up and Go (MTUG) and Pediatric Balance Scale (PBS)). For assessing discriminative validity, children with CP were compared to a similar matching age and sex group of TD children. For studying test-retest reliability, children with CP underwent the Obstacles and Curb Tests twice in the same day. Mean and SD was done for height, weight, and BMI%, while median and interquartile ranges (IQR) were done for Obstacles and Curb Test scores. The Spearman's Rank Correlation was used for convergent construct validity. The Mann-Whitney Test was used for discriminative validity. The test-retest reliability was calculated using the Intra-class Correlation Coefficient (ICC) and Spearman's Rank Correlation. Alpha was set to $P < 0.05$.

Findings:

In phase one:

- The mean speed for TD children in the Obstacles Test was 5.4 ± 1 seconds whereas for the Curb Test it was 2.9 ± 0.6 seconds.
- Sex had no effect on the speed of the Obstacles Test and an effect on the Curb Test.
- Age had a higher association and contributed more to both tests than sex.
- Age, height, and weight were factors affecting the speed of children in both the Obstacles and Curb Tests. Height had a negative medium correlation with the Obstacles Test but a negative small correlation with Curb Test. Age and weight both had a negative small correlation with both tests. And BMI% showed no correlation with both tests.
- Based on η, the effect size of sex on both Obstacles and Curb Tests was weak ($\eta = 0.11$) ($\eta = 0.13$) respectively.
- The highest predictor of speed in both Obstacles and Curb Tests was height with a 10% of the total variance in Obstacles Test and 8% of the total variance in Curb Test.
- A positive large correlation was found between Obstacles and Curb Tests ($r = 0.61$, $P < 001$).

In phase two:

- The median (IQR) for children with CP in Obstacles Test was 13.2 (9.6) and for the Curb Test was 6.1 (9.0).
- The Obstacles Test imposed less challenge on children with CP than the Curb Test.

- Children with GMFCS level I, II, and III were able to complete the Obstacles Test and only children with GMFCS level I and II were able to complete the Curb Test.
- The Curb Test is not suitable for children with CP in GMFCS level III.
- Both tests had strong or very strong correlations with 10MWT, MTUG positively and with PBS negatively.
- A significant difference was found between the speed of TD children and children with CP where TD children appeared to be faster. The median (IQR) of TD children vs. children with CP in Obstacles Test was 5.4 (0.9) vs. 13.2 (9.6) and in Curb Test was 3 (0.7) vs. 6.1 (9.0).
- Test-Retest reliability appeared to be excellent for Obstacles and Curb Tests with ICC = 0.98 and ICC = 0.99 respectively.

6.2. Conclusion and Clinical Implementation

The Obstacles and Curb Tests are timed walking tests that are applicable for children who walk independently with or without an assistive device. They challenge walking in children with high walking abilities. The study presents the normative values of the Obstacles and Curb Tests. The tests are valid and reliable to be used for children with CP. The Obstacles Test shows that it is less challenging than the Curb Test for children with CP.

The results of this study have clinical usefulness. A clinician can use the Obstacles and Curb Tests as an assessment tool for walking ability that reflects walking in the community and the results of these tests can show improvement in walking and balance after an intervention. The normative values can act as a reference of walking speeds in TD children from age 6 to 12 years. Moreover, the tests can be useful in the physical screening of a large population such as schools. And this is the advantage of the test, where it can be applied in a nonlaboratory setting making it applicable in different areas. In addition, the Obstacles and Curb Tests show similarity to walking in the community and they challenge walking of higher functional children with CP, and this makes it useful for clinicians to reflect the ability to walk outside a clinic and in a more realistic environment. On the other hand, the predicted equations of the two tests could be useful in estimating the walking speed of TD children in the community.

6.3. Recommendations

Further studies are recommended for the following:

- Normative Data for Obstacles and Curb Tests on a larger geographical area.
- Involve other factors that affect the walking speed in typically developing children such as psychological factors, leg length, joint mobility, lower muscle strength, sensory function, cognitive status, and energy levels.
- Calculate the sensitivity, specificity, receiver operating characteristic (ROC) curve, responsiveness, floor and ceiling effect of Obstacles and Curb Tests.
- Measure the validity of Obstacles and Curb Tests for different diagnoses that affect children.
- Study if the Obstacles and Curb Tests can discriminate between GMFCS levels.
- Study the adjustment of the curb height and depth for children with CP.

CHAPTER VII

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Chapter VII. References

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CHAPTER VIII

APPENDIX

Chapter VII. Appendix

Appendix A. Ethical Approvals

Appendix a1. King Saud University Ethical Approval

Kingdom of Saudi Arabia
King Saudi University (034)
P.O. Box 7805 Riyadh 11472
Tel: +966 11 467 00 11
Fax: +96611 467 19 92
http://medicalcity.ksu.edu.sa

المملكة العربية السعودية
جامعة الملك سعود (٠٣٤)
ص.ب ٧٨٠٥ الرياض ١١٤٧٢
هاتف: ٩٦٦١١٤٦٧٠٠١١+
فاكس: ٩٦٦١١٤٦٧١٩٩٢+

جامعة الملك سعود
King Saud University

المدينة الطبية الجامعية
Institutional Review Board

08.11.2020 (22.03.1442)
Ref. No. 20/0802/IRB

To:	**Ms. Banan Ahmad Almass** Master Student in Pediatric Physical Therapy Department of Rehabilitation Sciences King Saud University College of Applied Medical Sciences Email: 438203962@student.ksu.edu.sa, Banan.almass@hotmail.com Principal Investigator
Cc:	Dr. Maha Fahad AlGabbani – malgabbani@ksu.edu.sa Supervisor
Subject:	**IRB Approval on Research Project No. E-20-5352**
Study Title:	"Normative Values for Obstacles and Curb Tests and Analysis of their Psychometric Properties for Children with Cerebral Palsy"
Type of Review:	Full-Board
Date of Approval:	29 October 2020
Date of Expiry:	08 November 2021

Dear Ms. Banan Ahmad Almass,

I am pleased to inform you that your submitted proposal with the above-mentioned title was approved following a full-board review at the IRB Meeting 02 (Academic year 1442-1443) held on 29 October 2020 (12 Rabi-I 1442). You are now granted permission to conduct this study as approved by the IRB.

Please be informed that in conducting this study, you as the principal investigator, are required to abide by the rules and regulations of the Government of Saudi Arabia, the KSUMC IRB policies and procedures and the ICH-GCP Guidelines. This approval shall remain valid until the expiry date noted above assuming timely and acceptable responses from the IRB's periodic requests for surveillance and monitoring information, with the following terms and conditions:

1. **Modifications to Research/ Amendments to the approved project:** any modifications to the research (including changes to the informed consent document(s) must receive IRB approval prior to implementation of the changes. Substantial variations may require new submission.
2. **Annual Reports:** continued approval of this project is dependent on the submission of annual reports. If you wish to have your protocol approved for continuation, please submit a completed request for reapproval of an approved protocol form (KSU-IRB 017E) at least 30 days before the expiry date. Failure to receive approval for continuation before the expiration date will result in automatic suspension of the approval of this protocol on the expiration date. Information collected following suspension is unapproved research and can never be reported or published as research data.
3. All unforeseen events that might affect continued ethical acceptability of the project should be reported to the IRB as soon as possible.
4. Any serious unexpected adverse events should be reported within 48 hours (2 days).
5. Personal identifying data should only be collected when necessary for research.
6. Secondary disclosure of personal identifiable data is not allowed.

Appendix a1. King Saud University Ethical Approval

Kingdom of Saudi Arabia
King Saud University (034)
P.O. Box 7805 Riyadh 11472
Tel: +966 11 467 00 11
Fax: +96611 467 19 92
http://medicalcity.ksu.edu.sa

المملكة العربية السعودية
جامعة الملك سعود (٠٣٤)
ص.ب ٧٨٠٥ الرياض ١١٤٧٢
هاتف: ‎+٩٦٦١١٤٦٧٠٠١١
فاكس: ‎+٩٦٦١١٤٦٧١٩٩٢

جامعة الملك سعود
King Saud University

المدينة الطبية الجامعية
Institutional Review Board

7. **Monitoring:** projects may be subject to an audit or any other form of monitoring by the IRB at any time.
8. **Retention and storage of data:** the PI is responsible for the storage and retention of original data pertaining to the project for a minimum period of five (5) years. Data should be stored securely so that a few authorized users are permitted access to the database.
9. **Future correspondence:** please quote the project number and project title above in any further correspondence.

The IRB is registered with the Office for Human Research Protection (OHRP) with OHRP Institution Registration No.: IORG0006829, OHRP IRB Registration No.: IRB00008189 and IRB KACST Registration No.: H-01-R-002. It is authorized to conduct the ethical review of clinical studies and operates in accordance with ICH-GCP Guidelines and all applicable national/local and institutional regulations and guidelines which govern Good Clinical Practices.

We wish you success in your research and request you to keep the IRB informed about the progress of the study on a regular basis by submitting a *Study Progress Report* every 6 months and a *Final Report* when the study has been completed.

Thank you!

Sincerely yours,

Prof. Abdulrahman AlSultan
Chairman of IRB
Health Sciences Colleges Research on Human Subjects
King Saud University College of Medicine
P. O. B ox 7805 Riyadh 11472 K.S.A.
Email: aalsultan1@ksu.edu.sa

كلية الطب
لجنة أخلاقيات البحوث الطبية
College Medicine
Institutional Review Board (IRB)

/rubie

Appendix a2. Sultan bin Abdulaziz Humanitarian City Ethical Approval

مدينة سلطان بن عبد العزيز للخدمات الإنسانية
SULTAN BIN ABDULAZIZ HUMANITARIAN CITY

Date: 08/11/2020
IRB No.: 34-2020-IRB

To: **Ms. Banan Almass**
PI: "Normative Values for Obstacles and Curb Tests and Analysis of their Psychometric Properties for Children with Cerebral Palsy."
Sultan Bin Abdulaziz Humanitarian City
E-mail: Banan.almass@hotmail.com
Co-Investigator: Ms. Manal Abdularahman Al Sonbul
Sultan Bin Abdulaziz Humanitarian City
E-mail: msonbul@sbahc.org.sa

Subject:	Approval for Research No. 30/SBAHC/MSc/2020
Study Title:	"Normative Values for Obstacles and Curb Tests and Analysis of their Psychometric Properties for Children with Cerebral Palsy."
Study Code:	30/SBAHC/MSc/2020
Date of Approval:	05/11/2020
Date of Expiry:	06/01/2022
Board approval:	All members except Dr. Mohammed Ali Al Zaben

Dear Ms. Banan,

Your Project has been approved and you have the permission to conduct this study following your submitted documents as follow:

1. Curriculum Vitae for the PI researcher
2. Letter from the researcher requesting SBAHC participation in the clinical study
3. Research proposal according to SBAHC IRB Guidelines
4. Research Obligatory Agreement. Available upon the completion of the other requirements

You are required to obey by the rules and regulations of the Government of Saudi Arabia, the SBAHC IRB Policies and procedures and the ICH-GCP guidelines. You have to note that this approval mandate responding to IRB's periodic request and surveillance result. Drawing your attention to the following:

- Amendment of the project with the required modification to providing Periodical report for this project specially when study extension is required or expiry before study completion
- All unforeseen events that might affect continued ethical acceptability of the project should be reported to the IRB as soon as possible
- Any serious unexpected adverse events should be reported within 48 hours (2 days)

Page **1** of **2**

Appendix a2. Sultan bin Abdulaziz Humanitarian City Ethical Approval

- Personal identifying data should only be collected when necessary for research.
- Secondary disclosure of personal identifiable data is not allowed.
- Monitoring: projects may be subject to an audit by the IRB at any time.
- The PI is responsible for the storage and retention of original data pertaining to the project for a minimum period of five (5) years.
- Data should be stored securely so that a few authorized users are permitted access to the database.

The IRB registered with the IRB KACST Registration No. H-01-R-090. It is authorized to conduct the ethical review of clinic studies and operates in accordance with ICH-GCP Guidelines and all applicable national/local and institutional regulations and guidelines which govern Good Clinical Practices.

For Future Correspondence, please quote the project number and project title above and you are requested to keep IRB informed about your study progress and submit project progress report every six (6) months. A final report should be provided upon completion of the study.

Wish you a success in your research project.

Yours sincerely,

Prof. Khalid Al-Rubeaan
Chairman-IRB
Sultan Bin Abdulaziz Humanitarian City

Page **2** of **2**

Appendix B. Consent Forms

Appendix b1. Consent Form for Typical Developed Children

نموذج الموافقة على المشاركة في البحث

اسم الباحث: بنان أحمد الماص (طالبة ماجستير علاج طبيعي -أطفال- في جامعة الملك سعود)

عنوان البحث: القيم المعيارية لاختبارات العقبة والرصيف وتحليل خصائص صحتهما وموثوقيتهما عند الأطفال المصابين بالشلل الدماغي

طفلك مدعو للمشاركة في الدراسة البحثية المذكورة أعلاه. يرجى قراءة جميع جوانب الدراسة بعناية قبل التوقيع على هذا النموذج. يصف نموذج الموافقة هذا إجراءات الدراسة. بإمكانك طلب إيضاحات أو معلومات إضافية عن أي شيء مذكور في هذا النموذج أو عن البحث ككل من الباحث.

أولا: وصف البحث العلمي وهدفه وخطواته

الغرض من هذه الدراسة هو إيجاد القيم المعيارية لاختباري العقبة والرصيف اللذان يقيسان مقدرة الطفل على تخطي العقبات التي تكون في الطريق أثناء المشي والقدرة على الصعود والنزول من الرصيف. ستأخذ منك بعض المعلومات عن حالة طفلك للتأكد من إمكانية مشاركته في الدراسة وستؤخذ من طفلك بعض القياسات كالطول والوزن وبعدها سنجري اختبارى العقبة والرصيف. خطوات الاختبار سوف تُشرح لك بالتفصيل من قبل الباحث قبل القيام بها.

ثانيا: ما هي عينة البحث؟ وكم المدة التي سيمكثها طفلي في الدراسة؟

عينة البحث هي ٢٤٠ طفل/طفلة من عمر ٦ - ١٢ سنة . سيستغرق وقت تطبيق الاختبارين ١٠ دقائق .

رابعا: الأثار الجانبية

لا توجد أي تأثيرات جانبية على قبول أو رفض المشاركة في هذا البحث .

خامسا: السرية وخصوصية المشاركين

بيانات طفلك سوف تكون محفوظة بسرية تامة، وسوف تستخدم لغرض البحث العلمي فقط.

رابعا: موافقة أحد الوالدين

☐ لقد قرأت وفهمت مضمون النموذج، وتمت الإجابة على أسئلتي جميعها، وبناءً على ذلك فإنه برغبتي أوافق على مشاركة طفلي في هذا البحث. كما أن لي الحق من الانسحاب في أي مرحلة من مراحل البحث.

توقيع أحد الوالدين: ....

Appendix b2. Consent Form for Children with CP

نموذج الموافقة على المشاركة في البحث

اسم الباحث: بنان أحمد الماص (طالبة ماجستير علاج طبيعي -أطفال- في جامعة الملك سعود)

عنوان البحث: القيم المعيارية لاختبارات العقبة والرصيف وتحليل خصائص صحتهما وموثوقيتهما عند الأطفال المصابين بالشلل الدماغي

طفلك مدعو للمشاركة في الدراسة البحثية المذكورة أعلاه. يرجى قراءة جميع جوانب الدراسة بعناية قبل التوقيع على هذا النموذج. يصف نموذج الموافقة هذا إجراءات الدراسة. بإمكانك طلب إيضاحات أو معلومات إضافية عن أي شيء مذكور في هذا النموذج أو عن البحث ككل من الباحث.

أولا: وصف البحث العلمي وهدفه وخطواته

الغرض من هذه الدراسة هو إيجاد القيمة المعيارية لاختبارات العقبة والرصيف وتحليل خصائص صحتهما وموثوقيتهما عند الأطفال المصابين بالشلل الدماغي. سيتطلب منك الحضور لمقر الاختبار لمدة تقريبيه تصل إلى ٦٠ دقيقة. ستأخذ منك بعض المعلومات عن حالة طفلك للتأكد من إمكانية مشاركته في الدراسة وستؤخذ بعض القياسات كالطول والوزن وبعدها سنجري خمس اختبارات للمشي والتوازن لمرتين تفصل بينهما ١٥ دقيقة للراحة. خطوات الاختبارات سوف تُشرح لك بالتفصيل من قبل الباحث قبل القيام بها.

ثانيا: عينة البحث

مجموع عدد المشاركين ٤٤ طفل/طفلة من عمر ٦ - ١٢ سنة ممن لديهم القدرة على المشي.

ثانياً: الأثار الجانبية

لا توجد أي تأثيرات جانبية على قبول أو رفض المشاركة في هذا البحث.

ثالثاً: السرية وخصوصية المشاركين

بيانات طفلك سوف تكون محفوظة بسرية تامة، وسوف تستخدم لغرض البحث العلمي فقط.

رابعا: موافقة أحد الوالدين

☐ لقد قرأت وفهمت مضمون النموذج، وتمت الإجابة على أسئلتي جميعها، وبناءً على ذلك فإنه برغبتي أوافق على مشاركة طفلي في هذا البحث. كما أن لي الحق من الانسحاب في أي مرحلة من مراحل البحث.

توقيع أحد الوالدين: ....

Appendix C. Demographic and Anthropometric Data Forms

Appendix c1. Demographic and Anthropometric Data Form for Typical Developed Children

Sex:

- ☐ Girl
- ☐ Boy

Age: …………………….

- ☐ 6 to < 7 years old
- ☐ 7 to < 8 years old
- ☐ 8 to < 9 years old
- ☐ 9 to < 10 years old
- ☐ 10 to < 11 years old
- ☐ 11 to < 12 years old

Height: ………………………………..…….

Lower Limb Height: …………………….

Weight: ……………………………..……….

Home district:

- ☐ Center
- ☐ North
- ☐ South
- ☐ East
- ☐ West

Appendix c2. Demographic and Anthropometric Form for Children with Cerebral Palsy

Sex:

- ☐ Girl ☐ Boy

Age: ………………………..….

- ☐ 6 to < 7 years old ☐ 9 to < 10 years old
- ☐ 7 to < 8 years old ☐ 10 to < 11 years old
- ☐ 8 to < 9 years old ☐ 11 to < 12 years old

Height: By standing: ……………. Or segmental height (Knee Height): …………….

Lower Limb Height: ……………………. Weight: …………….………….…

Type of Cerebral Palsy:

- ☐ Spastic diplegic
- ☐ Spastic hemiplegic
- ☐ Spastic quadriplegic
- ☐ Ataxic
- ☐ Other: ……………….…….

Does the child use orthosis?

- ☐ Yes
- ☐ No

If yes, what is the type of orthosis:

- ☐ AFO
- ☐ KAFO
- ☐ Medical Shoes
- ☐ Other: ……………….…….

Does the child use a walking assistive device?

- ☐ Yes
- ☐ No

If yes, what is the type of walking assistive device:

- ☐ Reverse walker
- ☐ Front walker
- ☐ Other: ……….…………….

☐ One ☐ Two ☐ Three

GMFCS Level:

Appendix D. Recording Sheets

Appendix d1. Recording Sheet for Typical Developed Children

<u>Obstacles Test</u>

Obstacles Test's time in seconds:	
Did the child touch the obstacles?	☐ Yes ☐ No

<u>Curb Test</u>

Curb Test's time in seconds:	

Appendix d2. Recording Sheet for Children with Cerebral Palsy

10-Meter Walk Test

	Trial 1	Trial 2	Trial 3	Mean
10-Meter Walk Test's time in seconds:				

Modified Time Up and Go

	Trial 1	Trial 2	Trial 3	Best Trial
Modified Time Up and Go's time in seconds:				

Obstacles Test

Obstacles Test's time in seconds:	
Did the child touch the obstacles?	☐ Yes ☐ No
Did the child need assistance?	☐ Yes ☐ No

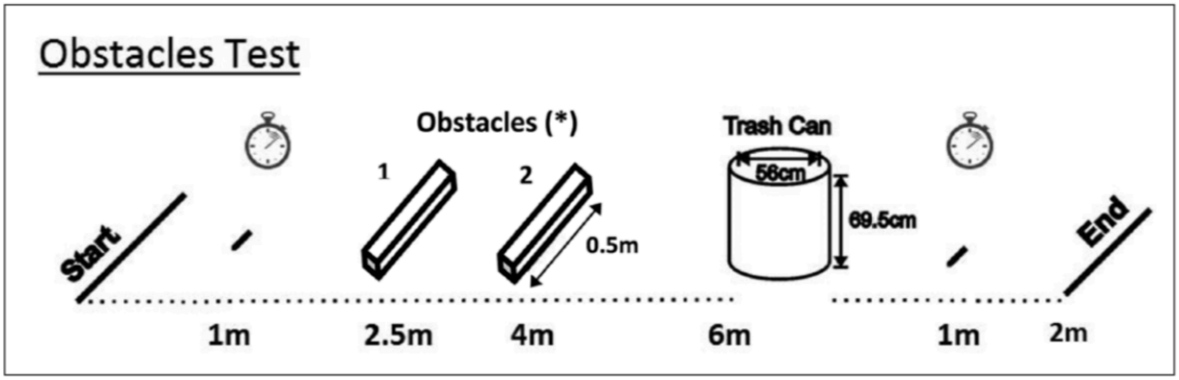
Curb Test

Curb Test's time in seconds:	
Did the child use stepping or crawling?	☐ Stepping ☐ Crawling
Did the child need assistance?	☐ Yes ☐ No

Pediatric Balance Scale

Pediatric Balance Scale's score:	

Appendix E. Obstacles Test Instruction



The Obstacles Test is a walking test that involves stepping over two obstacles and walking around one basket. Perform this test for children who are able to walk independently or while using an assistive device.

Time to complete the test: less than 5 minutes

Equipment needed: two obstacles that are of width and height of 10%–15% and 20%–25% of the child's leg length and obstacle length of 0.5-meters (or modified to length of 0.25-meters for children with assistive devices), a basket that is around 56 centimeters in width and 69.5 centimeters in length, a stopwatch, an 8.5-meters distance measured and marked by green and blue tape.

Obstacles Test Pathway:

The start and end lines are marked by green tape at 6-meters before the basket (indicating the start line) and 2-meters after the basket (indicating the end line). In addition to the start and end lines marked in green, the path is marked at 1-meter after the start line and 1-meter before the end line with blue tape. As illustrated in the above figure, two obstacles are set at 2.5-meters and 4-meters from the start line. The two obstacles are set carefully so that they are of width and height of 10%–15% and 20%–25% of the child's leg length, respectively. The obstacles are stackable foam blocks that form 0.5-meters in length (or shortened to 0.25-meters for children with assistive devices). The basket is set after 6-meters.

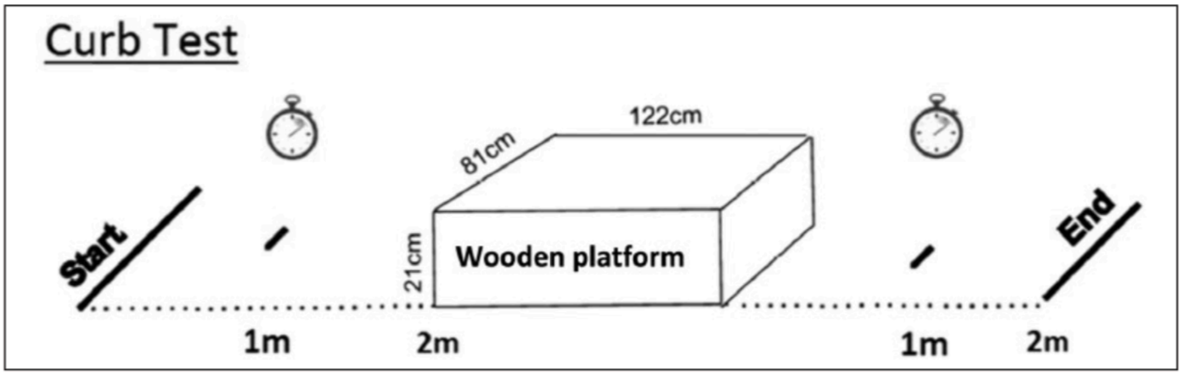
Tester Instructions:

- If a child uses orthosis or braces for walking in the community, they can use them while performing the test.
- The tester provides instructions and answers the child's questions as needed.
- The tester does not provide physical assistance but walks behind the patient for safety.
- The tester times the child's walking speed and gives no feedback/encouragement during the test.
- The tester demonstrates the test once to the child and then they give them one practice trial to try the path without recording the time, after that the child performs the test for one trial and the time is recorded.
- The child should stand behind the start line and walk in fast speed in a straight line then step over the obstacles, walk around one side of the basket then pass the end line.
- The time between the blue lines is recorded in seconds, allowing 1-meter for acceleration and deceleration. As one of the child's feet crosses over the first blue line the timer starts, and as one of their feet crosses the end blue line the timer stops.
- A 10% time penalty is added to the recorded time if the child touches one or more obstacles with their body or assistive device.

Child Instructions:

The instructions given to the child were as following: "When I say go, walk in fast speed without running, step over the blocks, go around the basket from either right or left side then walk till you reach the green line. Don't touch the blocks or basket and if you do, or they fall do not stop, continue walking till you reach the green line".

Appendix F. Curb Test



The Curb Test is a walking test that involves stepping onto and off a wooden platform that is meant to mimic a curb. Perform this test for children who are able to walk independently.

Time to complete the test: less than 5 minutes

Equipment needed: a wooden platform that is approximately 21 centimeters in height, 122 centimeters in length and 81 centimeters in width, a 5.5-meters distance measured and marked by green and blue tape.

Obstacles Test Pathway:

The start and end lines were marked by green tape at 2-meters before and after the wooden platform. The path was marked at 1-meter after the start line and 1-meter before the end line with blue tape.

Tester Instructions:

- If a child uses orthosis or braces for walking in the community, they can use them while performing the test.
- The tester provides instructions and answers the child's questions as needed.
- The tester does not provide physical assistance but walks behind the patient for safety.

- The tester times the child's walking speed and gives no feedback/encouragement during the test.
- The tester demonstrates the test once to the child and then they give them one practice trial to try the path without recording the time, after that the child performs the test for one trial and the time is recorded.
- The child should stand behind the start line and walk in a straight line toward the wooden platform, step onto it, walk across, step down to the ground then cross the end line.
- The time between the blue lines is recorded in seconds, allowing 1-meter for acceleration and deceleration. As one of the child's feet crosses over the first blue line the timer starts, and as one of their feet crosses the end blue line the timer stops.

Child Instructions:

The instructions given to the child were as following: "When I say go, walk in fast speed, step on the curb, walk across then step off and walk till you reach the green line".

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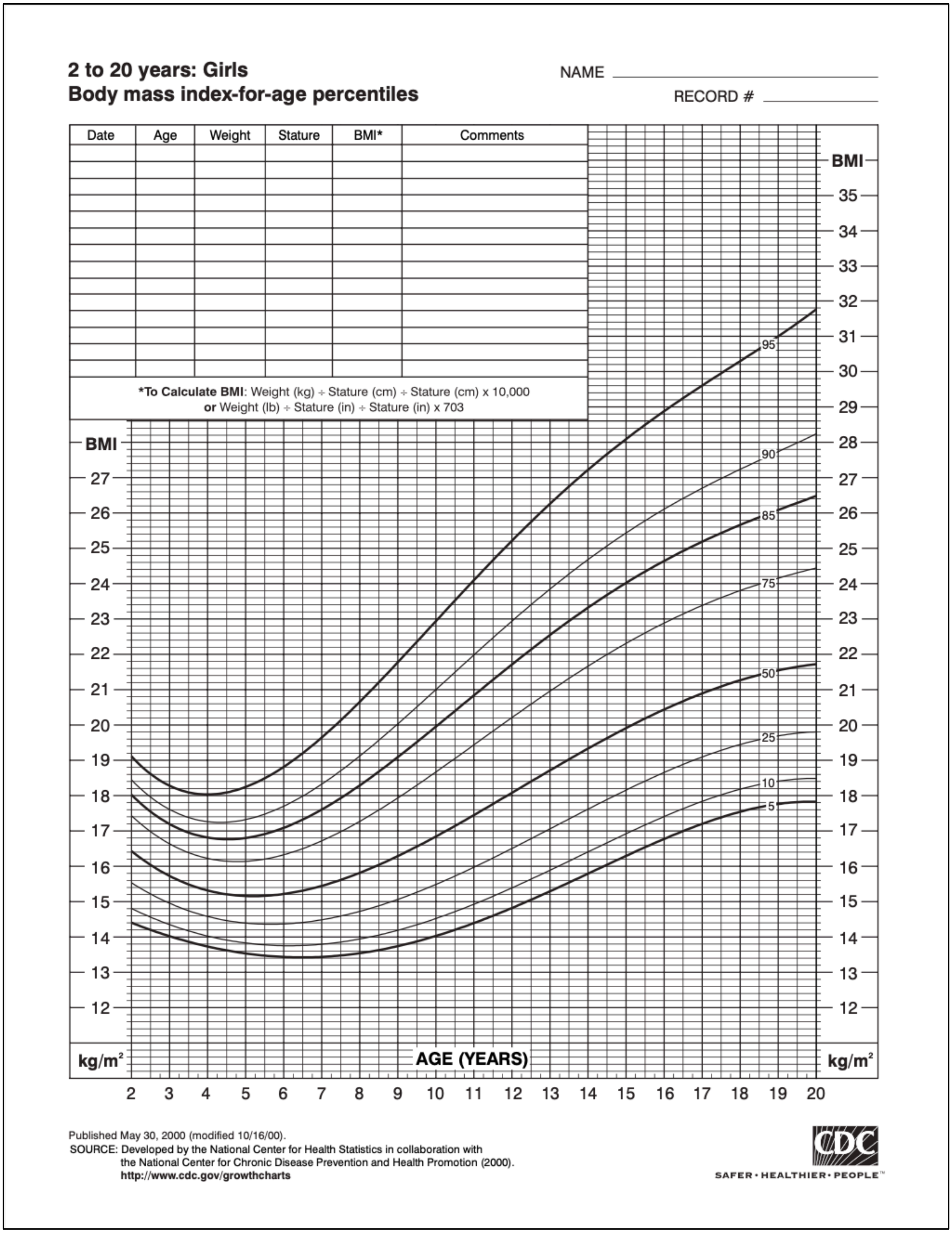
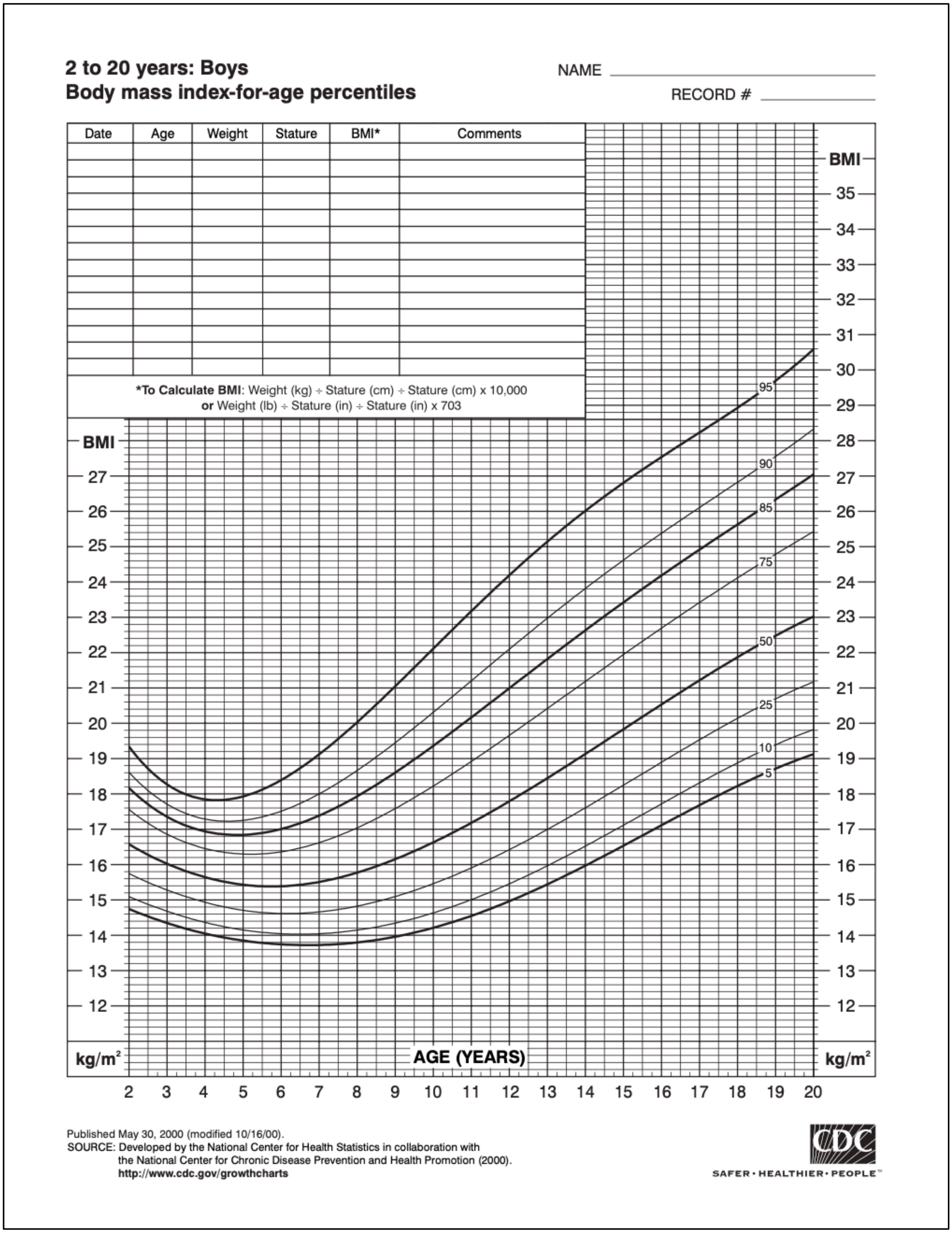
Appendix G. BMI Percentile Charts

Appendix g1. BMI Percentile Chart for Girls



Appendix g2. BMI Percentile Chart for Boys



CHAPTER IX

ARABIC SUMMARY AND ABSTRACT

Chapter IX. Arabic Summary and Abstract

الملخص

الخلفية: اختباري العقبة والرصيف هما اختباران من اختبارات المشي الذين تم تعديلهما حديثا لتناسب الأطفال، لذلك لم يتم بعد حساب القيم المعيارية لهما وكذلك تحليل خصائص صحتهما وموثوقيتهما. معرفة القيم المعيارية لهما ضرورية حتى نتمكن من معرفة الفرق بين سرعة الأطفال سليمو النمو وسرعة الأطفال المصابين بإصابات حركية. ان التحقق من صحة وموثوقية الاختبارين على الأطفال المصابين بالشلل الدماغي تمكننا من الحصول على اختبار يشكل تحدي في المشي للأطفال ممن لديهم قدرات حركية عالية ويعكس قدرة المشي في المجتمع.

الأهداف: هدفت هذه الدراسة إلى حساب القيم المعيارية لاختباري العقبة والرصيف للأطفال سليمو النمو وتحليل خصائص صحتهما وموثوقيتهما عند الأطفال المصابين بالشلل الدماغي.

الطريقة: تكونت هذة الدراسة المقطعية من مرحلتين: المرحلة الأولى تضمنت دراسة القيم المعيارية على ٢٤٠ طفلة/طفل (١٢٠ طفلة و١٢٠ طفل) من عمر ٦ - ١٢ عام مقسمين في ٦ مجموعات عمرية تزيد كل مجموعة عن الآخرى بسنة كاملة. جمعت العينة من خمس مراكز ترفيهية في الرياض باستخدام طريقة العينة العشوائية الطبقية. شارك الأطفال في كل من اختباري العقبة والرصيف بعد أخذ معلومات عنهم وقياس طولهم ووزنهم والمؤشر المئوي لكتلة جسمهم. يتطلب اختبار العقبة يتطلب من الطفل تخطي عقبتين توجد في طريق مشيه والدوران حول العقبة الثالثة بينما يتطلب اختبار الرصيف صعود ونزول الطفل من قطعة خشبية تشبه الرصيف وذلك بالمشي بسرعة عالية. عولجت البيانات باستخدام برنامج SPSS 25. تم حساب المتوسطات والانحرافات المعيارية لكل من الطول، والوزن والمؤشر المئوي لكتلة الجسم، واختباري العقبة والرصيف لكل الأطفال. اجري اختبار "ت" للعينات المستقلة لقياس تأثير الجنس على نتائج اختباري العقبة والرصيف. استخدم اختبار تحليل التباين الثلاثي المختلف (ANOVA) ثنائي الاتجاه لتحليل تأثير الجنس والعمر على كلا الاختبارين. استخدم معامل بيرسون لاختبار ارتباط العمر والوزن والطول والمؤشر المئوي لكتلة الجسم على كلا الاختبارين. كما استخدم مره اخرى لمعرفة الارتباط بين اختباري العقبة والرصيف. استخدمت η لدراسة تأثير الجنس على الاختبارين. استخدم نموذج الانحدار الخطي التدريجي لمعرفة المتغيرات التنبؤية المحتملة في كلا الاختبارين وتم تعيين معادلة تنبؤيه لكلا الاختبارين.

المرحلة الثانية كانت تحليل خصائص صحة وموثوقية اختباري العقبة والرصيف عند ٤٤ طفلة/طفل من الأطفال المصابين بالشلل الدماغي من عمر ٦ – ١٢ عام. جمعت العينة من مدينة سلطان بن عبد العزيز للخدمات الانسانية باستخدام طريقة العينة العشوائية الطبقية. بعد استبعاد الأطفال الذين لم يتمكنوا من اكمال الاختبارين، تم استخدام نتائج ٤١ طفلة/طفل من المصابين بالشلل الدماغي في اختبار العقبة و٢٩ طفلة/طفل من المصابين بالشلل الدماغي في اختبار الرصيف. شارك الأطفال المصابين بالشلل الدماغي في كلا من اختباري العقبة والرصيف بعد أخذ معلومات عن تشخيصهم وتعيين مستوى قدرتهم الحركية باستخدام نظام تصنف الوظيفة الحركية الاجمالية GMFCS وقياس طولهم ووزنهم والمؤشر المئوي لكتلة جسمهم. بعد استكمال اختباري العقبة والرصيف، قام الأطفال المصابين بالشلل الدماغي بالمشاركة أيضا في ثلاث اختبارات اخرى مختصة بالمشي والتوازن (اختبار المشي لعشرة أمتار، واختبار الوقوف والمشي، واختبار التوازن للأطفال) وذلك من أجل دراسة صحة الاختبارين باستخدام الصدق التقاربي. من أجل قياس لقياس صحة الاختبارين باستخدام الصدق التمايزي، تم مقارنة نتائج المشي لدى الأطفال المصابين بالشلل الدماغي ومجموعة عمرية مشابهه بالعمر والجنس من الأطفال سليمو النمو. قام الأطفال المصابين بالشلل الدماغي بخوض اختباري العقبة والرصيف مرتين في يوم واحد من أجل معرفة موثوقية الاختبارين باستخدام ثبات الاختبار. بعد جمع العينة، تم حساب المتوسطات والانحرافات المعيارية لكل من الطول، والوزن والمؤشر المئوي لكتلة الجسم، وحساب الوسيط (الانحراف الربعي) لنتائج اختباري العقبة والرصيف. استخدم ارتباط رتبة سبيرمان لقياس الصدق التقاربي بين اختباري العقبة والرصيف والاختبارات الثلاثة الاخرى. كما استخدم مقياس مان-وتني لقياس الصدق التمايزي. واستخدم معامل الارتباط ICC وارتباط رتبة سبيرمان لقياس موثوقية الاختبارين. حدد مستوى الدلالة عند $P < 0.05$.

النتائج:

في المرحلة الأولى:

- متوسط مشي الأطفال سليمو النمو كان ٥.٤ ± ١ ثانية في اختبار العقبة و٢.٩ ± ٠.٦ ثانية في اختبار الرصيف.
- الجنس ليس له تأثير على سرعة المشي في اختبار العقبة، ولكن له تأثير في اختبار الرصيف.
- كانت علاقة العمر مؤثرة أكثر من الجنس على سرعة مشي الأطفال في كلا الاختبارين.
- العمر، والطول والوزن كانوا المؤثرين على سرعة مشي الأطفال في كلا الاختبارين، حيث ارتبط الطول مع اختبار العقبة ارتباط متوسط سلبي ومع اختبار العقبة ارتباط ضعيف سلبي. العمر والوزن

ارتبطا مع كلا الاختبارين ارتباط ضعيف سلبي، بينما لم يظهر المؤشر المئوي لكتلة الجسم أي ترابط مع كلا الاختبارين.

- بناءا على η ظهر الارتباط بين الجنس واختباري العقبة ($\eta = 0.11$) والرصيف ($\eta = 0.13$) ضعيف.
- المتغير التنبئي الأكبر على كلا من اختباري العقبة والرصيف كان الطول.
- ظهر ارتباط قوي موجب بين اختباري العقبة والرصيف ($r = 0.61$, $P < 001$).

في المرحلة الثانية:

- الوسيط (الانحراف الربعي) لسرعة الأطفال المصابين بالشلل الدماغي كان ١٣.٢ (٩.٦) في اختبار العقبة و ٦.١ (٩.٠) في اختبار الرصيف.
- اختبار العقبة كان يشكل تحدي اقل للأطفال المصابين بالشلل الدماغي مقارنة باختبار الرصيف.
- الأطفال من مجموعة GMFCS الأولى والثانية والثالثة كان باستطاعتهم عمل اختبار العقبة بينما استطاع الأطفال من مجموعة GMFCS الأولى والثانية فقط عمل اختبار الرصيف.
- اختبار العقبة لا يناسب الأطفال من مجموعة GMFCS الثالثة.
- يوجد ارتباط قوي موجب بين الاختبارين واختبار المشي لعشرة أمتار، واختبار الوقوف والمشي وارتباط قوي سالب مع اختبار التوازن للأطفال.
- يوجد فرق بين سرعة الأطفال المصابين بالشلل الدماغي وبين الأطفال سليمو النمو حيث يظهر الأطفال سليمو بسرعة أكبر. الوسيط (الانحراف الربعي) للأطفال سليمو النمو مقابل الأطفال المصابين بالشلل الدماغي في اختبار العقبة كان ٥.٤ (٠.٩) مقابل ١٣.٢ (٩.٦) واختبار الرصيف كان ٣ (٠.٧) مقابل ٦.١ (٩.٠).
- ظهر وجود ارتباط قوي عند إعادة الاختبارين مما يدل على موثوقية اختبار العقبة ($ICC = 0.98$) والرصيف ($ICC = 0.99$).

خاتمة:

اختباري العقبة والرصيف هما اختباران من اختبارات المشي التي تناسب الأطفال الذين يتمكنون من المشي بشكل مستقل سواء باستخدام أدوات تساعد في المشي أو لا. اختباري العقبة والرصيف يشكلان تحدي للأطفال ممن لديهم قدرة عالية للمشي. الدراسة تعرض القيم المعيارية لاختباري العقبة والرصيف. هذه النتائج يمكن ان تستخدم اكلينيكيا

كمرجع في تقييم المشي عن الأطفال سليمو النمو. يساعد الاختبارين أيضا في تقييم الأطفال على نطاق واسع. اختباري العقبة والرصيف اختبارين صحيحين وموثوقين للاستخدام مع الأطفال المصابين بالشلل الدماغي. اختبار العقبة يظهر تحدي أقل من اختبار الرصيف مع الأطفال المصابين بالشلل الدماغي. يساعد كلا من اختباري العقبة والرصيف في تقييم المشي في أي مكان ولا يحتاج إلى مختبر وذلك يعكس المشي في المجتمع.

التوصيات:

يوصى بدراسات إضافية لكل من:

- معرفة القيم المعيارية لاختباري العقبة والرصيف على عينة جغرافية متوسعه.
- شمل عوامل أخرى تؤثر على المشي عن الأطفال سليمو النمو مثل: عوامل نفسية، وطول القدم، ومرونة المفاصل، وقوة عضلات الرجلين، وقوة الاحساس، والوعي الادراكي المعرفي ومستوي الطاقة.
- قياس الحساسية، التخصصية، الاستجابة، وتأثير الأرضية والسقف على اختباري العقبة والرصيف.
- قياس صحة اختبار العقبة والرصيف على تشخيصات أخرى تصيب الأطفال.
- دراسة قدرة اختباري العقبة والرصيف على التمييز بين الأطفال في كل مجموعة من مجموعات GMFCS.
- إعادة تعديل طول وعمق اختبار العقبة للأطفال المصابين بالشلل الدماغي.

المستخلص

الخلفية: اختباري العقبة والرصيف هما اختباران من اختبارات المشي اللذين يستخدمان لقياس الحركة الجسدية، سرعة المشي، ومستوى التوازن لدى الكبار. الاختباران تم تعديلهما حديثا لتناسب الأطفال، لذلك لم يتم بعد حساب القيم المعيارية لهما وكذلك تحليل خصائص صحتهما وموثوقيتهما.

الأهداف: هدفت هذه الدراسة إلى حساب القيم المعيارية لاختباري العقبة والرصيف للأطفال سليمو النمو وتحليل خصائص صحتهما وموثوقيتهما عند الأطفال المصابين بالشلل الدماغي.

الطريقة: هذه الدراسة المقطعية تكونت من مرحلتين: في المرحلة الأولى تم تطبيق اختباري العقبة والرصيف على عينة مكونة من ٢٤٠ طفل/طفلة من عمر ٦ - ١٢ عاما مقسمة في ٦ مجموعات عمرية تزيد كل مجموعة عن الآخرى بسنة كاملة (٢٠ طفل، ٢٠ طفلة في كل مجموعة عمرية). البيانات التي تم استنتاجها من المرحلة الأولى استخدمت في حساب القيم المعيارية لاختباري العقبة والرصيف. للتنبؤ بقيم اختباري العقبة والرصيف، تم بناء نموذج انحدار مبني على العمر والجنس. تمت معرفة العوامل المؤثرة على سرعة مشي الأطفال ووضع المعادلة التنبؤية لحساب نتيجة الاختبارين. تم وضع نموذج الانحدار الخطي التدريجي لمعرفة المتغيرات التنبؤية المحتملة في كلا الاختبارين. في المرحلة الثانية شارك ٤٤ طفل/طفلة من المصابين بالشلل الدماغي في اختبار العقبة والرصيف من عمر ٦ - ١٢ عاما. كان لديهم أنواع مختلفة من الشلل الدماغي وتم تصنيفهم في المستوي الأول والثاني والثالث من نظام تصنف الوظيفة الحركية الاجمالية GMFCS المستخدم في تصنيف حركة الأطفال المصابين بالشلل الدماغي. بعد استبعاد الأطفال الذين لم يتمكنوا من اكمال الاختبارين، شارك ٤١ طفل/طفلة في اختبار العقبة و٢٩ طفل/طفلة في اختبار الرصيف. تم استخدام نتائج هؤلاء الأطفال في استخراج نتائج الدراسة. لدراسة صحة الاختبارين باستخدام الصدق التقاربي، قام الأطفال المصابين بالشلل الدماغي باستكمال اختباري العقبة والرصيف بالإضافة لثلاث اختبارات اخرى مختصة بالمشي والتوازن (اختبار المشي لعشرة أمتار، واختبار الوقوف والمشي، واختبار التوازن للأطفال). لقياس صحة الاختبارين باستخدام الصدق التمايزي، تم مقارنة نتائج المشي لدى الأطفال المصابين بالشلل الدماغي ومجموعة عمرية مشابهه بالعمر والجنس من الأطفال سليمو النمو. لمعرفة موثوقية الاختبارين باستخدام ثبات الاختبار، شارك الأطفال المصابين بالشلل الدماغي مرتين في يوم واحد في اختباري العقبة والرصيف.

النتائج: متوسط مشي الأطفال سليمو النمو كان ٥.٤ ± ١ ثانية في اختبار العقبة و٢.٩ ± ٠.٦ ثانية في اختبار الرصيف. كانت علاقة العمر مؤثرة أكثر من الجنس على سرعة مشي الأطفال في كلا الاختبارين. العمر، والطول والوزن كانوا

المؤثرين على سرعة مشي الأطفال في كلا الاختبارين. المتغير التنبئي الأكبر على كلا الاختبارين كان الطول. في نموذج الانحدار الخطي التدريجي ظهر أن الطول يوضح ١٠٪ من نتيجة اختبار العقبة و٨٪ من نتيجة اختبار الرصيف. الوسيط (الانحراف الربعي) لسرعة الأطفال المصابين بالشلل الدماغي كان ١٣.٢ (٩.٦) في اختبار العقبة و ٦.١ (٩.٠) في اختبار الرصيف. أظهرت النتائج وجود ارتباط قوي بين الاختبارين واختبار المشي لعشرة أمتار، واختبار الوقوف والمشي، واختبار التوازن للأطفال مما يدل على صحة الاختبارين. أظهرت النتائج وجود فرق بين سرعة الأطفال المصابين بالشلل الدماغي وبين سرعة الأطفال سليمو النمو حيث يظهر الأطفال سليمو أسرع. أظهرت نتائج ثبات الاختبار وجود ارتباط قوي عند إعادة الاختبارين مما يدل على موثوقية الاختبارين (ICC=٠.٩٨ ، ICC=٠.٩٩ على التوالي)

الخلاصة:

اخباري العقبة والرصيف يستخدمان للأطفال الذين لديهم قدرة عالية في المشي. القيم المعيارية لاختباري العقبة والرصيف والمعادلة المتوقعة لحساب نتيجة الاختبارين للأطفال سليمو النمو من عمر ٦ – ١٢ عاما تم عرضها في هذه الدراسة لأول مره. اختباري العقبة والرصيف اختبارين صحيحين وموثوقين للاستخدام مع الأطفال المصابين بالشلل الدماغي. يستطيع الاختبار التفرقة بين الأطفال المصابين بالشلل الدماغي والأطفال سليمو النمو. استخدام اختباري العقبة والرصيف كأدوات لقياس المشي قبل وبعد علاج اكلينيكي يظهر التحسن في الحركة الجسدية، سرعة المشي، ومستوى التوازن.

الكلمات الدالة: القيم المعيارية، الأطفال سليمو النمو، اختباري العقبة والرصيف، اختبارات المشي، الشلل الدماغي.

القيم المعيارية لاختباري العقبة والرصيف وتحليل خصائص صحتهما وموثوقيتهما عند الأطفال المصابين بالشلل الدماغي

إعداد:

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نمت مناقشة الرسالة بتاريخ ٢٠٢١/١٢/٢١ م الموافق ١٦/٠٥/ ١٤٤٣هـ وتمت إجازتها من قبل

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المملكة العربية السعودية
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قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في العلاج الطبيعي لدى قسم علوم التأهيل الصحي في كلية العلوم الطبية التطبيقية في جامعة الملك سعود

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١٤٤٣ هـ - ٢٠٢١ م