CORRELATION OF FUNCTIONAL ABILITY OF UPPER EXTREMITY AND SCOLIOSIS AMONG UNIVERSITY STUDENTS

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By

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A Research project submitted to the Department of Physiotherapy,
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CORRELATION OF FUNCTIONAL ABILITY OF UPPER EXTREMITY AND SCOLIOSIS AMONG UNIVERISTY STUDENTS

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ABSTRACT

Background and Objective: Scoliosis is a spinal deformity that is said to be having multifactorial epidemiology. School Scoliosis Screening (SSS) has not been offered in Malaysia and this might lead to occurrence of scoliosis in all age groups, including college students. Upper extremity functions are significant in our activities of daily living and is found to be affected by scoliosis. Therefore, this study aims to assess the influence of different scoliotic curve patterns and levels to the functions of upper extremity among college students.

Methods: Scoliosis screening and upper extremity assessment was done among UTAR students in both Sungai Long and Kampar campus. Scoliometer was used in scoliosis screening while upper extremity assessment include handgrip strength, pinch strength, Nine Hole Peg test, Nelson Hand Reaction test and CKCUES test. A total of 40 university students were included for this study and the sampling method used was convenience sampling. The data collected were analyzed using Spearman's Correlation and Mann-Whitney test in IBM SPSS software statistics version 26.

Results: The data for all 40 subjects were analyzed. 20 were males and 20 were females. The upper extremity functions are found to be better in dominant hands among all 40 right-handed subjects. Lumbar curve is correlated with all three types of pinch strength and handgrip strength while thoracic curve only correlated with the right pinch strength and handgrip strength. Both left and right convexity of scoliotic curve is found to be significantly correlated with all three types of pinch strength and also handgrip strength. Lumbar scoliotic curvature group had a significantly weaker lateral pinch strength and handgrip strength than thoracic scoliotic curvature group. Right upper extremity performs better at convex side while left upper extremity performs better at concave side.

Conclusion: Upper extremity function is found to be correlated with scoliotic curve pattern and level of curve. Individuals with lumbar curvatures were found to be having weaker upper extremity functions, particularly in strength assessments.

Keywords: Functional Ability, Upper Extremity, Scoliosis, College Students

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APPROVAL SHEET

This Research project entitled "**CORRELATION OF FUNCTIONAL ABILITY OF UPPER EXTREMITY AND SCOLIOSIS AMONG UNIVERSITY STUDENTS**" was prepared by SAMMI LEONG SING YEE and submitted as partial fulfilment of the requirements for the degree of Bachelor of Physiotherapy (HONOURS) at Universiti Tunku Abdul Rahman.

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PERMISSION SHEET

It is hereby certified that **SAMMI LEONG SING YEE** (ID No: **20UMB06323**) has completed this Research project entitled "CORRELATION OF FUNCTIONAL ABILITY OF UPPER EXTREMITY AND SCOLIOSIS AMONG UNIVERISTY STUDENTS under the supervision of MR. DEEPAK THAZHAKKATTU VASU (Supervisor) from the Department of Physiotherapy, M. Kandiah Faculty of Medicine and Health sciences.

Yours truly,

SAMMI LEONG

(SAMMI LEONG SING YEE)

DECLARATION

I hereby declare that the Research project is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

Name: SAMMI LEONG SING YEE

Date: 22/12/2022

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LIST OF ABBREVIATIONS

UE	Upper Extremity
UTAR	Universiti Tunku Abdul Rahman
SSS	Scoliosis Screening in Schools
SRS	Scoliosis Research Society
UL	Upper Limb
BMI	Body Mass Index
T	Intricate Action
RS	Specific Rotation
C	Cobb Angle
T	Torsion Angle
NHPT	Nine Hole Peg Test
CKCUES	Closed Kinetic Chain Upper Extremity Stability
COM	Centre of Body Mass
ADLs	Activities of Daily Living
AAOS	American Academy of Orthopaedic Surgeons
POSNA	Pediatric Orthopaedic Society of North America
AAP	American Academy of Pediatrics
EMG	Electromyography
M	Mean
SD	Standard Deviation
p	P value (Significance)

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The epidemiology of scoliosis varies by area, and genetic factors may contribute to this heterogeneity (Du et al., 2016). Adolescent idiopathic scoliosis prevalence varies according to Cobb angle, ranging from 0.1% in curvature more than 40° Cobb angle to 2% to 3% in curvature greater than 10° Cobb angle (Sabirin et al., 2010). Many studies have shown that the prevalence rate is higher in females compared to males. A study that involves 4 cross-sectional studies and 1 cohort study has shown that females were more likely than men to have scoliosis, with prevalence rates of 41.2 percent vs 27.5 percent, respectively (McAviney et al., 2020). A study in China found that the male and female ratio was 1:1.5, which the researchers also agreed with the findings found in previous studies in different countries (Du et al., 2016; Ugras et al., 2010; Suh et al., 2011; Ueno et al., 2011). According to Du et al., 2016, the prevalence rate of scoliosis is found to be variable in different countries due to multi-factorial such as ages, races, type of curves in scoliosis. Overall prevalence showed that thoracic curve are the most common curve found in scoliosis (Suh et al., 2011). There is a higher risk of progression in the main thoracic right convex curve (Wang et al., 2012).

Curves are a normal element of the formation of the spine. When viewed from the side, it resembles a soft 'S' shape (laterally). Four anterior to posterior curves form the human spine. Lordosis (cervical and lumbar spine) and Kyphosis (Sacral and thoracic spine) are the names given to these natural curves. According to Cramer & Darby, 2017, lordosis are curves that are concave posteriorly (convex anteriorly) while kyphosis are curves that are concave anteriorly (convex posteriorly). These organic shapes have function to disperse mechanical stress whilst at rest movement. When viewed from behind (posteriorly), it looks to be vertically straight (Glassman et al., 2005). A particular spinal disease is defined as any increase or reduction in the angulations of the normal curve or any deviation from it (White III, 1971).

In the view of biomechanics, the biomechanical, biological, and clinical evidence all point to the problem being one of front-back asymmetry rather than right-left asymmetry. The significance of biological factors is based on their capacity to bring the spinal column to and above its buckling point. As a result, a taller and more spindly spine is more prone to bending and, because it is stiffer in the sagittal plane, it endorses movement into other planes (Millner & Dickson, 1996). Scoliosis is characterised by an abnormal deviation between or within the vertebrae, causing an exaggerated curvature in the frontal plane. In some cases, there will be secondary compensatory balancing curves form on top of the initial curve or beneath it. It is found that the most significant vertebral change occurs at the curve’s apex, where shortening and thickening on the concave side of the curve by pedicles and laminae is observed. Moreover, the vertebral canal becomes asymmetrical and narrower on the convex side (Shakil et al., 2014). The prognosis and progression of curves in thoracic and thoracolumbar scoliosis are frequently linked to vertebral motions in the axial planes. In the normal vertebral column, all of the vertebrae are in the same anatomic plane, which is in the centre of the sagittal plane. However, in the scoliotic spine, it is difficult to place all of the vertebrae in the same plane; there is a torsion movement, and it is thus imperative to investigate the placement of each vertebra in relation to the adjacent vertebra and also to the individual's anatomic planes. There are two types of vertebral motions based on the level of the vertebrae. First, the primary thoracic and thoracolumbar curves rotate in the two vertebrae closest to the upper end vertebra, and exclusively in these two vertebrae. This rotatory movement happens in the intervertebral articulations of these vertebrae and occurs solely in one plane, the axial plane of the vertebrae; we refer to this as the specific rotation (RS). Second, a combination of an intervertebral extension in the sagittal plane, a lateral intervertebral inclination in the frontal plane, and an axial plane rotatory component cause the movement in three planes in all of the curve's other vertebrae. Torsion is the name given to this intricate action (T). The specific rotation (RS), Cobb angle (C), and torsion angle (T) measurements will be used to determine the prognosis for each curve and its pattern of advancement. These measures will be connected to the patient's age, pubertal growth stage and iliac crest apophyse ossification (Perdriolle&Vidal, 1985). Pelvic incidence does not appear to be a factor of the location of scoliotic collapse within the spine in the formation of thoracic vs thoracolumbar curves. The discovery of thoracic hypokyphosis in individuals with thoracic scoliosis, despite an elevated pelvic incidence and lumbar lordosis, may support the idea of anterior spinal overgrowth as a "driver" for the development of thoracic scoliosis. This sagittal plane study provides a less clear picture of the role of anterior overgrowth in the development of thoracolumbar scoliosis (Upasani et al., 2007).

The patients with adolescent idiopathic scoliosis who remain untreated into adulthood can experience a rate of advancement of 0.5 to 1 degree per year after they have attained a 50-degree coronal angle showed in a study (Menger & Sin, 2022). Moreover, in general, curves in adults are significantly stiffer and more inflexible than those in adolescence, necessitating more forceful and intrusive surgical methods. Asymmetric degeneration leads to increased asymmetric load and, as a result, degeneration and deformity progression as scoliosis and/or kyphosis. Osteoporosis, particularly in postmenopausal female patients, aids in the progression of a curve. Facet joint, joint capsule, disc, and ligament destruction can result in mono- or multisegmental instability and, eventually, spinal stenosis. These patients typically present with back pain, followed by leg pain and claudication symptoms. People with scoliosis have a greater prevalence of arthritis and a bad opinion of their body image, regardless of therapy. Scoliosis can change respiratory mechanics by altering the alignment of the respiratory system's muscles and joints, putting a patient at risk of severe respiratory morbidity or respiratory failure (Mayer, 2015). Furthermore, if the surgical repair includes chest wall invasion, discomfort and impaired lung function may occur. Deformity progression is one of the complications of untreated scoliosis. Back discomfort, lumbar radiculopathy, aesthetic issues, nerve damage, and even cardiac and pulmonary limitation might result from this. Untreated individuals with a coronal plane curve of greater than 80 degrees may have increasing shortness of breath (Weinstein et al., 2003). Scoliosis alters movement patterns by affecting spinal mobility and trunk balance. Because the trunk aids in the maintenance of balance, spinal deformation alters the centre of body mass (COM) during movement, resulting in gait disorders (Daryabor et al., 2017). Scoliosis has been linked to imbalance dysfunction. According to Nault et al, children with scoliosis exhibited a higher centre of pressure-center of movement difference in both the anteriorposterior and medial-lateral directions, according to the researchers. Greater sway in AIS patients standing in a range of poses was discovered (Chen et al., 2006). It is also found that those with scoliosis have reduced muscle strength and therefore affects gait (Kearon & Killian, 1993).

The observation of left convex curvature in left handed people lends support to the link between hand dominance and scoliosis (Orth, 2006). A few studies also indicate that scoliosis has impact on upper limb functions (Yagci et al., 2020; Lin et al., 2010). Impairment of the upper extremity (UE) as a result of sickness or injury causes major financial and functional disadvantages, many of which have long-term effects. Workers' compensation claims for injuries to the upper extremities surpass $500 million (Webster & Snook, 1994). Traumatic

UE injury functional impairments result in diminished independence in activities of daily living (ADLs) and lower quality of life (Pransky et al., 2000). Effective UE rehabilitation after impairment can enhance functional results, enable persons in returning to meaningful work, and lower expenditures. The fact the university students nowadays in the pandemic period were facing new learning style, which is online classes and exams. More activities and assignments are assigned to students in order to track their development. These proof that university students involve more upper limb functions in order to perform activities of daily life.

The treatment method for idiopathic scoliosis is mostly determined by the magnitude of the deformity and its propensity for development. If the deformity is acceptable upon presentation, then the goal is to keep it that way; here is where conservative care comes in. If the deformity is unsatisfactory, the goal of surgical care must be to make it acceptable and preserve it that way (Dickson, 1985). According to Negrini et al., 2011, stopping scoliotic curve progression and preventing future respiratory complications are the main goals in treating scoliosis. Furthermore, other benefits in treating scoliosis are to alleviate current or to prevent future back pain other than improving appearance. Physiotherapy and bracing are two main methods of non-operative management of scoliosis. Bracing which is used to slow down curve progression is indicated for skeletally immature patient with a Cobb angle greater than 25°. However, bracing is not enough to correct curve in long-term period. There are various type of intervention which is used to improve the condition of scoliosis, such as bracing, traction, exercises, surgery, etc. (Menger & Sin, 2022). Studies have proof that physiotherapy can help in improving posture, correcting musculoskeletal misalignments such as chest wall abnormalities and also respiratory control issues (Fusco et al., 2011; Weiss, 2012). When the curvature exceeds 45° to 50° or if the curves progress at an accelerated rate, surgery is suggested. Most orthopaedic surgeons utilise the Lenke classification to determine which curves require surgical correction and how many levels to fuse in patients requiring surgical care and those with numerous curves. The major objective of surgical treatment is to produce a permanent structure that decreases spinal deformity in all planes. Modern pedicle screws and rods enable surgeons to accomplish significant curvature correction previously impossible with laminar hooks and wires (Blevins et al., 2018).

Early detection is critical in assisting a youngster in reaching significant milestones. An individual should go for a medical check-up, especially taking X-ray if one has shown any symptoms for scoliosis or having family member who has scoliosis. Early discovery and diagnosis of idiopathic scoliosis allows for early conservative therapy, such as bracing, which can avoid unneeded surgery and retain a better health-related quality of life score. Late identification may result in a greater incidence of patients requiring surgery, and if this problem is left untreated, it can proceed to severe scoliosis, which has been proven to impact patients' pulmonary function. Furthermore, significant scoliotic deformity will impair patients' self-image, which may have an irreparable psychological influence on this group of patients (Deepak et al., 2017). The following are some of the reasons why scoliosis can proceed undiagnosed to severe deformity. It is found that almost of instances are painless and result in no additional symptoms. Detection of scoliosis in earlier stage is important as only episodic, problem-focused health care will be given way due to routine physical examinations of older children. Early detection is always overlooked by the parents as the teenagers at this age period like to have long hair and to wear baggy clothes which may readily disguise significant deformities. Moreover, idiopathic scoliosis is most common in preadolescence or early adolescence, however, the "bashful era" of teenage modesty that may prevent parents from seeing their children's unclad spines. Since scoliosis is complex, there is still a lack of professional attention to indicators of spinal malformation. In many geographic locations, public awareness of scoliosis is low, owing in part to the widely held belief that most adolescents have bad posture instead of having scoliosis (Renshaw, 1988).

Since the 1950s and 1960s, early identification of idiopathic scoliosis has been recommended, coinciding with the modern era's development of mobile spinal orthoses to treat scoliosis in teenagers. As a result, screening programmes for specific groups were developed, as indicated by school screening programmes in the United States and public health systems in Europe and Asia (Hresko et al., 2016). When public health screening programmes satisfy specific requirements, they are frequently formed and recognised. Most or all occurrences of an otherwise unidentified issue should be identified quickly, accurately, and at a minimal cost. The screening test should be easily repeatable and have a low rate of false positives and false negatives. The natural history of the disease should be thoroughly understood and drastically altered by early therapy in order to minimise unwanted consequences and obtain better long-term benefits (Renshaw, 1988). Early screening programmes often involve the use of a scoliometer during the Adams forward-bending test to assess rotational deformity as a sign of scoliosis. As the patient bends forward and tries to touch the floor, the practitioner stands behind him. The patient's back is next measured with a scoliometer, which is a sort of inclinometer. A scoliometer reading of 7° or above necessitates additional investigation with radiography (Blevins et al., 2018).

In general, scoliosis is a condition which is quite common in population nowadays. Not only children, but also in teenagers, adults and elderly. Since there is different type of scoliosis and also different signs and symptoms, a lot of people might overlook this condition. Furthermore, some people did not show any symptom and did not realised about this. The scoliosis curve is possible to progress into more serious angle. Early detection of scoliosis is significant in terms of avoiding surgery treatment which might cause sequelae.

1.2 Problem Statement

Even though there are studies introducing what is scoliosis, but as scoliosis has no cure treatment and its severity varies, people in nowadays often have misconception when talk about scoliosis. Only a few studies done to find out the effect of scoliosis on the upper extremity function. The studies that compare different curve of scoliosis in affecting upper extremity function are rarely done too. Since there is no study to find out these effects among university students in Malaysia, this study aims to assess the upper extremity function in idiopathic scoliosis among Universiti Tunku Abdul Rahman (UTAR) students. As upper extremity involved a lot in our activities of daily life, it is said to be important to have normal upper extremity functions. With this study, the participants will be able to understand the severity of scoliosis. They will also have the chance to find out whether their upper limb functions are affected due to the presence of scoliotic curve.

1.3 Research Question

1. Does scoliosis have an impact on the functions of upper extremity?
2. Do different scoliotic curve patterns influence the functions of upper extremity?
3. Do different level of scoliosis influence the functions of upper extremity?

1.4 Aim

To assess the influence of different scoliotic curve patterns and levels to the functions of upper extremity among university students.

1.5 Research Objectives

1. To assess the influence of scoliosis on functions of upper extremity.
2. To determine the influence of different scoliotic curve pattern to the functions of upper extremity.
3. To determine the influence of different level of scoliosis to the functions of upper extremity.

1.6 Operational Definition

1. Functional ability is defined as the ability to execute everyday activities independently without undue discomfort or exhaustion.

2. Functional assessment is an ongoing process in which the entire set of procedures are used to determine the causes and effects of problem behaviour. In this study, the functional assessment include: handgrip strength, pinch strength, fingers dexterity,hand reaction, upper extremity performance.

3. Upper extremity is an anatomical term referring to the functional unit of upper part of a body, which consists of upper arm, forearm and hands.

4. Scoliosis is a three-dimensional spine deformity evidenced by a lateral curvature of greater than 10° in the coronal plane.

5. University students are all students whom are 18-26 years old that are currently pursuing any course in Sungai Long or Kampar campus of Universiti Tunku Abdul Rahman.

1.7 Rationale of Study

Local studies related to influence of scoliosis on upper extremity functions are lacked and only shoulder imbalance has been conducted. This research can help in providing information about different curve pattern and scoliosis level on upper extremity functions. The results from this study is also important to fill this gap and thus help in promoting the development of interventions in terms of more effective ways to improve the effects of upper extremity functions in scoliosis. Because handgrip strength is important for many daily activities, it is suggested as an evaluator in clinical settings to indicate an individual's overall physical strength and health (Nicolay & Walker, 2005). The deterioration of parameters such as finger dexterity and hand reaction time coincides to a greater impairment of the upper extremity (Butter et al., 2013). The CKCUES test is a cheap but sensitive clinical tool for assessing overall upper extremity functional stability, particularly for the shoulder segment in the closed kinetic chain (Tucci et al., 2014). These are the reasons for these parameters to be focused on in this study. As the severity varies, most people might not get to know that they are having scoliosis if no assessment or screening is done. The influence of different curve patterns and scoliosis level were not studied in Malaysia before this. Some people also have the misconception that a person without any symptom is not having scoliosis (Lee et al., 2014). The etiology of scoliosis is unknown. With the late diagnosis, the symptoms of scoliosis might become worse and not easy to be improved with different treatments. Scoliosis is also a disease which is often overlooked by primary healthcare professionals (Hengwei et al., 2016). Thus, this research is carried out to fill this knowledge gap and can be used as guidance for future researchers in conducting studies related to scoliosis. Furthermore, there are many types of treatment methods used to improve the condition of Adult Idiopathic Scoliosis patients, including physiotherapy. Scoliosis could not be cured but their condition can be improved (Kleinberg, 1992).

1.8 Scope of Study

This study focuses on assessing upper extremity functions among scoliosis students. With the completion of this study, awareness of students towards scoliosis can be raised. The students diagnosed with scoliosis can have more understanding about their upper extremity functions and treatment could be done as early as possible to prevent deterioration. This study is useful in the future in health science aspect to plan a better protocol in order to help scoliosis patients. With the data collected in this study, the influence of scoliosis on the upper extremity functions can be determined and treatment can be given by focusing on the upper extremity. For instance, the curve pattern and level of scoliosis that affects the functions can be studied and management on improving the curve and upper extremity function can be determined.

CHAPTER 2

LITERATURE REVIEW

2.1 Prevalence of Scoliosis

2.1.1 Different Age and Gender

Scoliosis is a three-dimensional deformation of the spine that is said to be multifactorial, including genetic predisposition, an imbalance between anterior and posterior spinal growth, and connective tissue abnormalities. Overall prevalence of scoliosis is said to be 0.47% to 5.2% (Konieczny & Krauspe, 2013). In Asian countries, it was found a prevalence rate of about 0.4% to 7% among adolescents. In Malaysia, there are lack of studies in prevalence of scoliosis with the largest population with age 13 to 15 years old done in 8966 voluntary school students (Deepak et al., 2017). Another study with the population aged 11 to 12 years old done in total 42866 primary students in Malaysia. The prevalence rate found is 0.574%. According to Wong et al., 2005, a study in Singapore had found out that the prevalence rate in females 11 to 12 years old increased significantly when compared to the last prevalence research in 1982. By comparing individuals in different age range, their body structures are different. These body structures included body height and length of axial (Yamashita et al., 2019). Therefore, body functions are also different in different age range. A study has reported that muscle strength and movement speed are varies according to age groups (Larsson et al., 1979). Proprioceptive accuracy is found to be better with increasing age (Keessen et al., 1992). In Malaysia, there is no study about scoliosis done among university students. However, type and prevalence of scoliosis are also different in different age groups (Du et al., 2016). A study in Singapore proof that older children had larger proportions of larger curves (Wong et al., 2005). One study found out that the prevalence of scoliosis is not associated with gender (Kebaish et al., 2011). However, most of the studies found that the prevalence in females is higher than males. Komang-Agung et al., 2017 found with male to female ratio of 1:4.7. Inoue et al., 1977 found a male to female ratio of 1:3.7. A female-to-male prevalence ratio of 2:1, increasing to 3:1 in children aged 11-12 years id discovered by Daruwalla et al., 1985.

2.1.2 Different Ethnicity

Body structures in individuals with different ethnicity is obvious even with visual observation only. A study has done between residents in Europe and Asia and it has concluded that the body structures are almost very different (Crawfurd, 1867). The limbs in European are larger than those of Asiatic. It is found to be comparatively rigid of muscular fibres and joints of European while Asiatic's are found to be flexible and supple. The prevalence rate of scoliosis in different ethnicity or races are found to be different in some studies. Genetic factor could be one of the factors that influence body structures and thus functions. According to Du et al., 2016, the prevalence of scoliosis varies among races and curve severity is also varies among races. This is further support by a study, stating that prevalence is higher in whites (11.1%) compared with African Americans (6.5%) (Kebaish et al., 2011). Komang-Agung et al., 2017 found a 2.93% prevalence of scoliosis in school-age children aged 9 to 16 in Surabaya, which is higher than comparable Asian nation studies (1.09% in Nepal; 2.22% in Singapore). The prevalence of scoliosis in Chinese was found to be higher than in Malay and Indian (Daruwalla et al., 1985). A study in Singapore also further proof that there is a higher prevalence for Chinese females to have scoliosis as compared to Malay and Indian females (Wong et al., 2005).

2.1.3 Different Region

Various studies have been done to find out about different curves in scoliosis, mainly about thoracic curve and lumbar or thoracolumbar curve. A study from Greece states that thoracolumbar and lumbar curves were most common among others (Soucacos et al., 1997). In contrast, another study found out thoracic curves were more common, although bigger curves were more common in the thoracolumbar region (Shahcheragi & Hobbi, 1999). When compared with both gender in scoliosis patients, thoracic curve was also the most common type (Wang et al., 2012). Most of the studies proof that thoracolumbar and lumbar curves were to the left (Du et al, 2016; Shakil et al., 2014). According to Shakil et al., 2014, there are four basic types of curve patterns found in scoliosis: Thoracic (90 percent of curves on the right side), Lumbar (70 percent of bends on the left side), Thoracolumbar (80 percent of curves on the right side), and Double major (curves on both the right and left sides). In addition, Du et al., 2016 found that thoracic (60.3 percent on right), thoracolumbar (75.5 percent on left), lumbar (64.7 percent on left) and Double major (58.8 percent on right).

2.1.4 University students

According to Konieczny et al., 2013, the prevalence of scoliosis is found to be higher in the population with age after 15 years old (after puberty). College students are frequently barely past the peak stage of scoliosis pathogenesis and have appeared in the low-speed rise era of this pathogenesis. Biomechanical variables continue to be the most common cause of scoliosis in college students, and they are also one of the few ones that may be changed by active prevention. Poor posture in daily life contributes to the development of spinal health issues, notably scoliosis among college students (Yang et al., 2021). There is no study done to find out the prevalence rate of scoliosis in university students in Malaysia even though there are a few studies done among primary school students (Rahmat et al., 2021; Htwe et al., 2013). A study done in female physical therapy college students in Saudi Arabia found to be high prevalence in having scoliosis (31.5%). The female to male ratio is found to be 3:1 among these 152 college students (Walaa & Walaa, 2018). A study in Utah found a higher prevalence in college students as compared to a younger age (10-15 years old) group (Francis, 1988). Yang et al.m 2021 found a prevalence of 7.23%

scoliosis which is greater than seven degrees among 318 college students in China. This study also claims that sitting with crossed legs was the main factor that cause scoliosis in college students.

2.2 Classification of Scoliosis

Scoliosis is classified into two broad categories, that is Postural scoliosis (Grade I) and structural scoliosis (Grade II and III). Postural scoliosis defined by the absence of bony changes or muscular weakness. The impairment of the postural reflex mechanism or incorrect postural habits could be the underlying cause. Secondary soft tissue changes may cause this to organise into a structural one. Another type of scoliosis is structural scoliosis, which is a bone defect that causes soft tissue contractures on the concave side of the curve and reciprocal stretching on the convex side (Sarnadskiy, 2012). On top of that, scoliosis is also characterised as Idiopathic, Paralytic, or Congenital based on its cause. As the name implies, the pathophysiology of idiopathic scoliosis is unknown. The existence of genetic and hereditary causes is well established. It is further subdivided into Infantile (0–3 years), Juvenile (3–10 years), Adolescent (10–18 years), and Adult (above 18 years). Idiopathic scoliosis depends on the age of onset. Poliomyelitis, cerebral palsy, or spina bifida can all cause paralytic scoliosis. Congenital scoliosis can be discovered at birth if severe; in lesser types, it may develop during the teenage growth spurt (Shakil et al., 2014). Scoliosis has two curves: one primary and one secondary. Each curve has both convex and concave sides. Typically, the primary curvature is stiffer. The placement of the apical vertebra in the coronal plane determines whether the curve is cervical, thoracic, or lumbar. The apical vertebra is at the interface between these two locations in a junctional curve (cervicothoracic, thoracolumbar, or lumbosacral) (Nnadi & Fairbank, 2010).

2.3 Pathomechanics of Scoliosis

Stokes discusses the notion of mechanical modulation of vertebral body growth in the aetiology of progressive adolescent scoliosis, which is commonly linked to the Hueter-Volkmann or Delpech effect, in which continual pathologic high pressure limits endochondral longitudinal growth while lower compression promotes growth; pressure exerted eccentrically induces an active shift in the direction of growth. Based on the Hueter-Volkmann law for bone growth modulation, the "vicious cycle" qualitatively explained the mechanism of scoliotic progression in an iterative manner: asymmetrical stress distribution leads to asymmetrical growth, which causes vertebral wedging and contributes to spinal deformity. Stokes quantitatively analysed the influence of loading asymmetry in scoliotic spines on the rate of scoliotic advancement to validate the "vicious cycle" hypothesis. The fundamental issue with scoliosis is the relative lengthening of the front components of the spine in comparison to the posterior ones. This position in the body's underlying anterior musculoskeletal wall promotes lateral spine deviation, culminating in scoliosis (Roaf, 1966). There is a relative lengthening of the anterior thoracic and lumbar spines in scoliotic patients, implying a primary instability in the sagittal equilibrium

(Deane & Duthie, 1973). Another idea proposed by White et al. is that in normal bending of the mid thoracic spine, the occasional coupling of axial rotations of vertebrae leads the anterior aspect to point toward the convexity of the lateral curve. A minor physiological thoracic curve is observed, therefore he linked the primary scoliotic lesion to the spine's fragile coronal balance and the resulting asymmetrical loading of vertebrae, which might rotate into the convexity of the curve. Reuber et al. suggested two theories. First, scoliosis progresses when the lateral asymmetry in trunk-muscle contraction forces is insufficient to counteract the lateral bending moments produced by superior body segment weights pressing on the curve's laterally offset vertebrae. Reuber et al. proposed a passive mechanism for advancement; the imbalanced moment is theoretically present, and the control system's inability to respond encourages progression. Reuber et al's second hypothesis concerns the long-term reaction of motion segment soft tissues (primarily those of the intervertebral disc) to imbalanced lateral bending forces. Scoliosis will proceed if the lateral tilts on the intervertebral discs continue to rise and become semipermanent in the long run as a result of the practically continuous lateral bending forces caused by the motor control dysfunction.

2.4 Detection of Scoliosis

2.4.1 School Scoliosis Screening

Scoliosis is defined by the Scoliosis Research Society (SRS) as a lateral curvature of the spine larger than 10 degrees (10°) as assessed on a standing radiograph using the Cobb technique. Screening exams for spinal deformity vary from solely visual to physical examination, scoliometer reading, and surface topographic assessments during an annual health care examination. Asymmetry discovered during a clinical examination of the chest and trunk is thought to be a proxy for spinal malformation. The Scoliosis Research Society (SRS) task group decided on the forward-bend Adams test using a scoliometer (a specialised inclinometer) as an effective quantitative assessment, with 5 to 7 degrees of deformity as a positive screening criterion. According to the American Academy of Orthopaedic Sur- geons (AAOS), the Scoliosis Research Society (SRS), the Pediatric Orthopaedic Society of North America (POSNA), and the Amer- ican Academy of Pediatrics (AAP), successful screening programmes require well-trained screening personnel who can use forward-bend tests and scoliometer measurements to accurately identify and refer individuals with scoliosis for further examination. (Hresko et al., 2016). Late detection in scoliosis has become a problem in the society of many countries. A study done in Singapore has shown that the late detection is because of the people not showing any symptom, some of them were lack of knowledge of scoliosis, which means that they did not know the symptoms if one is having scoliosis (Lee et al., 2014). According to Sabirin et al., 2010, some children who show no symptom results in late detection in scoliosis. Scoliosis is typically discovered during a school screening programme. Scoliosis screening in schools (SSS) is regarded as a valuable method for identifying persons with undiagnosed scoliosis at an early stage (Du et al., 2016). Early diagnosis through screening programmes, as well as the use of an appropriate orthopaedic and rehabilitation treatment, are critical for preventing scoliosis development and decreasing the need for surgery (Labelle et al., 2013). SSS is carried out all over the world. SSS originates from the early twentieth century in Europe. SSS has been used in the United States since the early 1960s; however, only about half of the states have passed legislation requiring school screening. Scoliosis screening programmes in schools are required by law in Japan. SSS was once practised in a number of nations (Du et al., 2016). The Malaysian School Health Service does not currently offer a scoliosis screening programme in schools. As a result, scoliosis is frequently discovered late, when individuals become symptomatic and require corrective surgical operations (Sabirin et al., 2010). Deepak et al., 2017 suggests that SSS should be carried out in Malaysia's schools with a positive predictive value of 55.8%.

2.4.2 X-ray Detection

Radiography is the basis to establish the diagnosis of idiopathic scoliosis in eliminating underlying causes, to describe the kind of spinal curvature, measure the flexibility of the curvature, follow disease progression and monitor therapy. Standing frontal radiographs of the complete spine are taken as part of the standard examination (Amzallag-Bellenger et al., 2014). Concerns have previously been raised concerning radiation exposure in children who test positive for scoliosis and have a radiograph but are not diagnosed with it (Morais et al., 1985). All screening programme studies reveal a large incidence of false positives that are recommended for additional investigation and perhaps spinal MRI (Hresko et al., 2016). According to Oakley et al., 2019, in clinical practice, it appears that different patients will receive a varied number of X-rays based on the clinical advancement of their spinal curve and the evaluation of various therapies that may be administered. Treatment evaluation from a brace would add several more over the course of treatment; thus, a 12-year-old who skeletally matures at the age of 16 will receive approximately 10 to 20 X-rays, whereas a child aged 9 years skeletally maturing at the age of 16 will receive approximately 16 to 32 X-rays. A safe estimate is therefore around 10 radiographs as a minimum, with up to 25 radiographs appearing to be normal. Some patients may have up to 40 or 50 radiographs taken. A famous study by Nash et al., 1979 has showed that increased risk for leukemia (3.4%), lung cancer (7.5%), stomach and upper gastrointestinal cancers (1.3%) and breast cancer up to 110% among 13 females with idiopathic adolescent scoliosis who have taken 22 films within 3 years. If postero-anterior films are taken instead of antero-posterior, the risk is reduced to only 3.8%. However, standing AP films are the gold standard in diagnosing scoliosis (Knott et al., 2012). Furthermore, the statement from the AAOS, SRS, POSNA, and AAP emphasised the necessity of educating screening workers in order to reduce inappropriate referrals and optimise the appropriate use of spine radiographs, since not all children referred as a consequence of screening require radiographs (Hresko et al., 2016).

2.5 The Relationship Between Scoliosis and Upper Extremity Functions

2.5.1 Different Curves in Scoliosis

There are studies done to find out the effects of different type of scoliotic curves in body structures of individuals; thus, any impairment. Balance or postural control are found to be affected with the presence of different type of scoliotic curves. Gauchard et al., 2001 found out that the site of the primary curve seems to be significant in terms of lateral disequilibrium and vestibular symmetry. Those with double curves had lower balance than patients with a single curve (Schimmel et al., 2015). Some studies also proof that there are difference in muscle activity using electromyography (EMG) among scoliotic patients with different type of curves. Lumbar type exhibited not only an imbalance in EMG activity where the apex was positioned, but also structural asymmetry (Park et al., 2021). This is supported by the findings of a pilot study that revealed a negative effect for muscles positioned at the lower level of the spine (Gaudreault et al., 2015).

2.5.2 Influence of Scoliosis on Limbs

Scoliosis, a spinal deformity which is believed to generate standing instability and gait pattern modifications that mostly involve lower limbs. Various previous literatures have been done to find out the relationship between lower limbs, including cadence, step length, hip, knee and ankle range of motion, limb length discrepancy towards scoliosis patients (Chen et al., 1998;

Mahaudens et al., 2005; Mahaudens et al., 2010). A complete study of scoliosis patients' lower limb asymmetries during locomotion may assist in the understanding of the physical ramifications of this deformity (Haber & Sacco, 2015). In contrast, the studies on the relationship between upper limbs and scoliosis were lacked as compared to that of lower limbs. However, there were studies which proof that scoliosis is related to upper extremity function and the researchers suggested to implement more studies on this issue in the future (Gündüz et al., 2021; Yagci et al., 2020). Abnormal scapular orientation, kinematics and muscle activation during arm elevation was demonstrated in curve patterns of scoliosis (Turgut et al., 2015). With these findings, scoliosis is found to be possible in affecting upper limbs.

2.5.3 Importance of Upper Extremity

With a disability, it can be challenging to function in society, especially if the impairment affects the hands. The functional use of the hand is required for everyday actions such as dressing, eating, and writing (Boerema et al., 2013). To accommodate deformity or discomfort, lifestyle modifications included withdrawing from significant activities and changing careers (Bell et al., 2011). Impairment or aging can affect the functional usage of the hand due to decreased muscle mass, strength, coordination, finger dexterity (Ranganathan et al., 2001). A prevalent assumption is that increased UL capacity equates to increased UL performance. Performance refers to what people do in their everyday lives, outside of the clinic or laboratory (Waddell et al., 2017). The individuals with conditions such as stroke, and hand injuries may face problem with pinch force in completing daily activities (Ranganathan et al., 2001). The hand strength and functional activities of daily living are found to be directly correlated (Rajan et al., 2005). A minimum pinch force has been identified by Rice et al., 1998 as 2.23 lb in order to access different objects. The ability to coordinate the fingers and operate items in a timely manner is referred to as manual dexterity. This capacity has a significant influence on a person's ability to accomplish everyday activities (bathing, grooming, eating), complete work-related tasks, and engage in leisure activities (Wang et al., 2015). When focus in athletes, successful competition required good reaction time in hands, foot or both. This is because reaction associated with speed of movement (Habib & Biswas, 2017).

2.5.4 Scoliosis Affects Upper Extremity Functions

The effects of scoliosis on upper extremity functions have been argued in many previous studies. It could be said that almost all studies agree that scoliosis will affect upper extremity functions. Various parameters such as strength, endurance, manual dexterity, coordination, and response time must be measured when evaluating upper extremity function (Yagci, 2020). However, most of the studies only revealed about one parameter for upper extremity functions. Martinez-Llorens et al., 2010 revealed that limb muscles strength was reduced in more than half of the patients in the study. Studies on upper extremity proprioception have shown that a proprioceptive dysfunction is a causative factor of asymmetrical spines (Keessen et al., 1992; Cook et al., 1986). Nevertheless, both these studies did not study about the relationship between the direction of curve and upper extremity proprioception. In Malaysia, only studies about effects of scoliosis on shoulder balance are done (Chan et al., 2020; Lee et al., 2021). Yagci et al., 2020 is a study that include various parameters of upper extremity function evaluation. This study revealed about different curve in scoliosis and how it affected upper extremity functions. However, only female adolescents are included in this study. All these findings are indications to the fact: scoliosis affects upper extremity functions.

2.5.5 Upper Extremity Measurements

A simple examination of upper extremity function is required in a number of clinical circumstances. Function measurement is especially important in evaluating the outcomes of hand surgery and upper extremity prosthesis, tracking the progression of hand deformities in musculoskeletal disorders such as rheumatoid arthritis, neurological illnesses, and assessing the efficacy of various types of therapy. It must be remembered that the test we are attempting to construct will have a direct link to what the patient is able to achieve in everyday activities. Individual muscle strength and joint range of motion measurements provide some insight into what the patient may be able to do with his hands (Carroll, 1965). Clinicians can use a variety of methods to assess UE function. Many of these assessments have been rigorously tested for reliability and validity. The measurements are broadly classified into two types:

1) performance measurements, in which the clinician rates or times a sequence of UE activities done by the patient, or 2) self-report measures, in which the clinician asks a series of questions concerning UE actions that the patient or proxy answers verbally (Lang et al., 2013). Various criteria such as strength, endurance, manual dexterity, coordination, and response time must be measured when evaluating upper extremity function (Yagci, 2020).

Even though scoliosis has been studied for so many years, there is still no treatment that can cure it. Depending on the extent of the angle of curvature and its advancement, suggested scoliosis treatments include careful observation (to avoid progression), corset bracing, and, in the end, surgery (Shakil et al., 2014). Surgical intervention is always the last choice due to high-cost and risk of complications post-surgery. Therefore, it is indeed always important to detect scoliosis as early as possible before the progression of scoliotic curvature to a more serious angle. Upper extremity function in relationship with scoliosis should be studied among college students who fall under an age group that just past the peak stage of scoliosis pathogenesis. The data collected is to provide a better overview to the health care workers on this issue.

CHAPTER 3

METHODS

3.1 Research Design

This was a analytical cross-sectional study. As the data gathered from this study only depicts what was happening at one point in time and this study will not observe what will happen in the future, thus it was a cross-sectional study (Olsen & St. George, 2004). This study was carried out to assess upper extremity functions in adolescent idiopathic scoliosis patients. There was comparison but no intervention was introduced; therefore, it was a analytical cross-sectional study.

3.2 Setting

Scoliosis screening and upper extremity functional assessments were performed to the students in Physiotherapy Centre, 3rd floor, KA block, Universiti Tunku Abdul Rahman in Sungai Long in Kajang, Selangor and also in A011, Ground Floor, Block A, UTAR in Kampar, Perak who registered to participate in this study.

3.3 Study Population

The population in this study involved male and female scoliosis students who are currently studying in Universiti Tunku Abdul Rahman (UTAR), Sungai Long and Kampar campus.

3.4 Sample Size

Sample size for this study was calculated by using formula of Krejcie and Morgan (1970):

$s = X^2NP(1-P) \div d^2(N-1) + X^2P(1-P)$

s = required sample size

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

N = the population size

P = the population proportion (assumed to be .50 since this would provide the maximum sample size)

d = the degree of accuracy expressed as a proportion (.05)

Krejcie and Morgan (1970) have developed a table (Appendix D) using Krejcie and Morgan formula to determine the sample size needed for a given population. No calculation is needed by using the table. The sample size needed for this study with the given population is 368 and additional 10% was added up to accommodate for possible dropouts due to factors such as participants did not participate in this study completely or some of them might drop out halfway in this study. Thus, with the additional 10%, the sample size needed for this study was 405.

3.5 Sampling Method

This study was done using convenient sampling method. Convenience sampling method is also known as non-probability sampling uses techniques to frequently choose participants from a place, internet site and others. This method is famous as it is inexpensive, takes less time than other sampling methods and is straightforward. In my study, the population is found in Universiti Tunku Abdul Rahman (UTAR) and this study included students from UTAR as convenience due to lacking of time for this study.

3.6 Inclusion Criteria

- Male and female
- Students with age ranging from 18-25 years, from all faculties in Universiti Tunku Abdul Rahman, Sungai Long and Kampar, who are screened with scoliosis.

Male and female individuals diagnosed with idiopathic scoliosis, who are within 18 to 25 years old and are currently studying in any course in UTAR are included in this study.

3.7 Exclusion Criteria

- Students who have spinal correction surgery done before
- Students who have health problem related to pulmonary, cardiac
- Students who are actively participating in any sports, which is more than 5 days in a week

Individuals who have spinal correction surgery done previously are excluded from this study because this study is carried out to determine the upper extremity functions before they receive any treatment. Individuals who have cardiopulmonary problem or have been actively participating in any sports are also excluded from this study as these factors might influence the upper extremity functions other than scoliosis.

3.8 Instrument

1. Scoliometer

The scoliometer is an inclinometer that measures the axial rotation degrees of asymmetries between the sides of the trunk. When creating the instrument, the initial attempt was made to match the values of the scoliometer data with Cobb angles (Coelho et al., 2013). Scoliometer is a validated and reliable equipment to measure the angle of trunk rotation; thus, it can determine whether the student is having scoliosis (Amendt et al., 1990; Côté et al., 1998). Several studies have found a high correlation between the Cobb angles and the axial trunk rotation (ATR) values (Sapkas et al., 2003; Bunnell, 1984).

2. Dexter Evaluation System's Jamar Dynamometer (Baseline Evaluation Instruments)

Hand grip strength, which is tested using a hand dynamometer, is an indication of overall muscular strength (Trampisch et al., 2012). The amount of static force that the hand can squeeze around a dynamometer can be used to quantify hand grip strength. The force has traditionally been measured in kilos and pounds, although it has also been measured in millilitres of mercury and Newtons (Massy-Westropp et al., 2011). Hand Grip Strength: age and gender stratified normative data in a population-based study. DynEx dynamometer is a type of hand dynamometer which is validated and reliable to be used to assess hand grip strength (Shechtman et al., 2005).

3. Pinch gauge by B&L engineering

In strength testing, three types of pinches are commonly used: lateral, three jaw-chuck, and tip pinches. A pinch gauge is used to determine the strength of these pinches. Clinicians utilise pinch measures to compare the pinch strength of clients with normative criteria and documenting gains or losses in a client's strength status. Pinch Gauge is a type of validated and reliable tool and found to be the most accurate in measuring pinch strength (Mathiowetz et al., 1984).

4. Nine Hole Peg Test (NHPT)

According to Wang et al., 2015, the Nine Hole Peg Test (NHPT) is a popular tool for assessing manual dexterity. The 9-HPT was chosen primarily because it was simple to administer in all age groups. The 9-hole peg test was administered quickly (5 minutes to measure both hands). Its validity and reliability had been proved by a few studies (Temporiti et al., 2022; Mathiowetz et al., 1985).

5. Stopwatch, 30-cm ruler

3.9 Procedure

All UTAR students were encouraged to register for scoliosis screening. Booths were set up at Physiotherapy Centre, 3rd floor, KA block, Universiti Tunku Abdul Rahman in Sungai Long in Kajang, Selangor and also A011, Ground Floor, Block A, UTAR in Kampar, Perak. All students who registered earlier were welcomed to receive the assessments, which starts with scoliosis screening first. Assessments to determine the upper extremity functions were carried out too.

Scoliosis Screening

1. Scoliometer

The angle of trunk rotation of the subjects is measured using scoliometer. The male participants were required to remove the shirt while the female participants were required to wear sports bra while shirts were removed. The scoliometer is put on the back at the peak of the curve, moved down the spine, and the amount of tilt is measured in degrees while in a forward bend posture. A Scoliometer reading of more than 5 degrees at the peak of the curve is deemed abnormal (Elshazly et al., 2014). The position of the curve, whether it is in thoracic or lumbar region is observed and recorded. The convexity and concavity will also be observed and recorded.

Upper Extremity Function

2. Handgrip Strength

Both right and left handgrip strength of the subjects will be measured with a Dexter Evaluation System's Jamar Dynamometer (Baseline Evaluation Instruments). All subjects are in seated position with their shoulders adducted and neutrally rotated, elbows flexed at 90 degrees, and forearms and wrists neutral without support (Mathiowetz et al., 1984). Each subject pressed the dynamometer by holding for 3 seconds and performed at least three times with each right and left hand. 20-30s rest period will be given before the next trial.

3. Pinch Strength

Pinch Gauge (B & L Engineering) will be used to measure bilateral pinch strength of both hands. The position of the participant will be the same as assessing the handgrip strength, in which the participants should be sitting with his shoulder adducted and rotated neutrally, his elbow flexed to 90 degrees, and his forearm and wrist in neutral position without support(Mathiowetz et al., 1984). The participant will be pressing the pinch gauge and hold for 3 seconds. Both left and right hands will be performing for all three types of pinches: lateral, three jaw-chuck, and tip pinches. 20-30s rest period will be given before the next trial. There will be 3 trials.

4. Finger Dexterity

The pegboard was specifically placed at the midpoint of the participants' trunk and between the acromion and the extremity of the third finger. The middle point was measured with the shoulder at 90° flexion and the elbow fully extended. The peg-container was facing the hand being tested. Participants began with their forearms leaning just on table and their hands just next to the pegboard, palms downward. The participants were required to complete the test as fast as possible. If the peg falls to the floor, the participants pick it up and continue. If the peg falls to the floor, the participants do not pick it up and continue with the test. The NHPT was performed for 3 times with both the dominant and non-dominant upper limbs after a familiarisation trial (Temporiti et al., 2022).

5. Hand Reaction

The reaction time of the subjects' hand movement in response to a visual stimulus (ruler) is tested using Nelson's Hand Reaction Time Test (Kansal, 2020). A practical demonstration to this test will be given to the subjects before the test is started. The subjects are required to sit in the chair with their forearm and hand rested on the table (fingers are out of the edge of the table). The subjects' thumb and index fingers are held in a pinch posture. The tester will hold one end of the 30-cm ruler and the other end is hang between the subjects' thumb and index fingers with the zero line aligned. The ruler will be dropped at random intervals and the subjects will try to catch the ruler. The distance caught (in cm) will be recorded each trial (Johnson & Nelson, 1969). There will be 3 trials for each subject.

6. Upper Extremity Performance

Closed Kinetic Chain Upper Extremity Stability (CKCUES) test is a reliable test to assess the upper extremity performance of both healthy individuals and individuals having problems with their upper extremity (Tucci et al., 2014). The CKCUES test is done in a push-up posture. Males execute the CKCUES test in a standard push-up position, while females complete it in a modified (kneeling) push-up posture. To identify the initial positioning of the hands, two parallel and aligned lines are drawn on the floor. To begin the test, the individual takes a push-up stance with one hand on each designated line on the floor. The participant then bends over one hand, picks up the opposite hand, reaches over to touch hands, and returns the hand to the starting position for 15 seconds (Ellenbecker et al., 2000). This test is repeated for 3 trials.

Rest period between each assessment is set as 30-s or extended if the subjects requested to.

3.10 Statistical Analysis

All the data gathered from this study was analysed with the use of Statistical Package for the Social Sciences (SPSS) software version 26.0. Descriptive analysis was used to transform raw data into a form that is easier to grasp and analyse and then descriptive information was generated (Zikmund et al., 2003). Descriptive statistics was used for this study to analyse demographic data in part 1 such as gender and others. It was also done on other parts to get the mean score and frequency table. Spearman's Correlation was used to find the correlation of different level of scoliosis: thoracic and lumbar on upper extremity functions and also the correlation of different directions of convexity on the upper extremity functions. Mann-Whitney test was used to compare the upper extremity functions between different level of scoliotic curves and also between the different directions of convexity.

3.11 Ethical Approval

This study has received the ethical approval by the Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman (Appendix A). A research participant information sheet (Appendix B) and an informed consent form (Appendix C) were signed by participants before filling up the questionnaires. Any harmful effect or benefit when participating this study was informed to the participants before filling up the questionnaires and participants had the right to withdraw from this study at any time. For instance, benefit of this study was that they will know if their upper extremity functions are influenced by scoliosis and this was informed to the participants before they fill up the questionnaires. The data confidentiality on the information collected from this study was informed to the participants before they receive the assessments. Their information remained confidential to everyone except for me to analyse the data obtained (Nijhawan, 2013).

CHAPTER 4

RESULTS

4.1 Demographic Data of Respondents

A total of 243 participants were screened for scoliosis and assessed for upper extremity functions via booths held in UTAR campus. There were 52 participants found to be having scoliotic curve. After screening through all the data, it is found that only 40 participants were eligible to participate in this study. Several of them were excluded from this study.

Gender	**n (%)**
Male	20 (50)
Female	20 (50)

Table 4.1 Gender of Participants

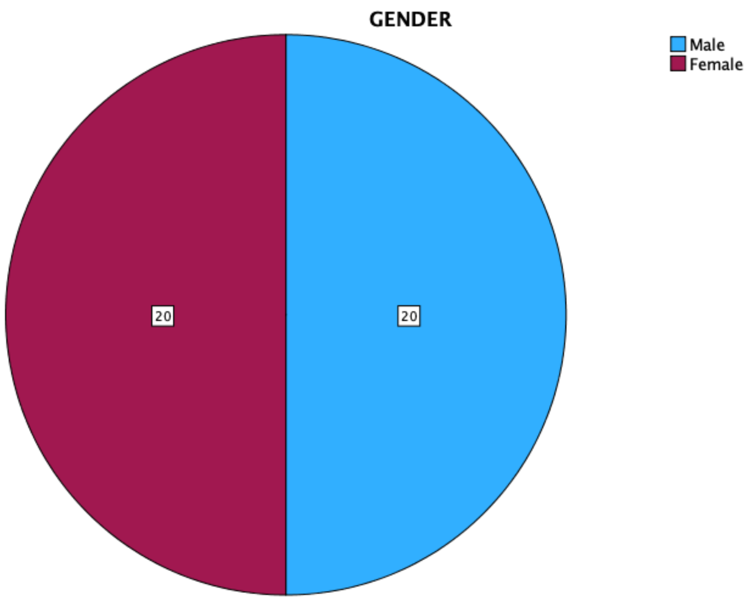

Figure 4.1 Gender of Participants

Table 4.1 and Figure 4.1 present the demographic data of participants, which includes the gender only. Out of 40 participants, 20 (50%) were males while another 20 (50%) were females. All the 40 participants were right-handed.

4.2 BMI Categories

BMI Categories	n (%)
Underweight	13 (32.5)
Normal	26 (65)
Overweight	1 (2.5)

Table 4.2 BMI categories of Participants

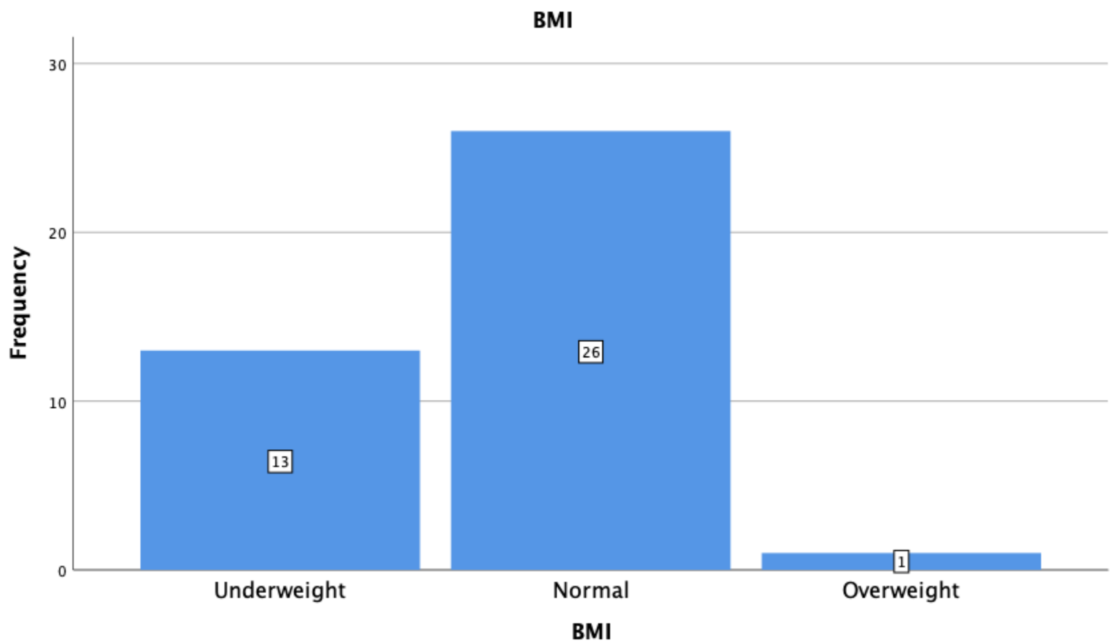

Figure 4.2 BMI categories of Participants

Table 4.2 and Figure 4.2 shows the different BMI categories of the participants in this study. The participants were measured for their height and weight using Human Body Weighing Machine Analog Weight Scale with Height Rod. With these data, BMI values of the participants were calculated and they were categorized into Underweight (BMI < 18.5), Normal (BMI 18.5-24.9) and Overweight (BMI 25.0-29.9). Majority of the participants (65%) were having normal BMI, which consists of 26 participants. 32.5% (n=13) were found to be underweight, while only 1 participant found to be having overweight BMI, which is only 2.5%.

4.3 Different Level of Scoliotic Curve

Level of Curve	n (%)
Lumbar	25 (62.5)
Thoracic	15 (37.5)

Table 4.3 Different Level of Scoliotic Curve of Participants

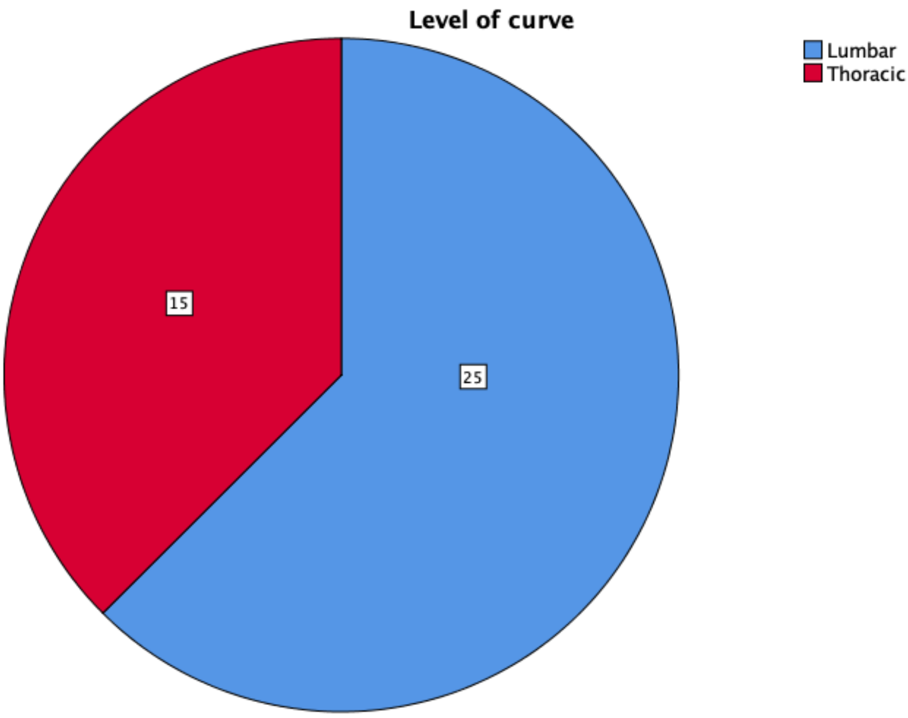

Figure 4.3 Different Level of Scoliotic Curve of Participants

The distribution of different level of scoliotic curve of the participants is displayed in Table 4.3 and Figure 4.3. The curve found in the participants are categorized into two categories: lumbar and thoracic. From the chart above, it is clearly seen that most of the participants (62.5%) were having lumbar curve in which 25 out of 40 of them. The remaining 37.5% participants were having thoracic curve, with a frequency of 15 participants.

4.4 Different Scoliotic Curve Pattern

4.4.1 Convex

Convex	**n (%)**
Left	21 (52.5)
Right	19 (46.5)

Table 4.4 Directions of Curve Pattern of Participants

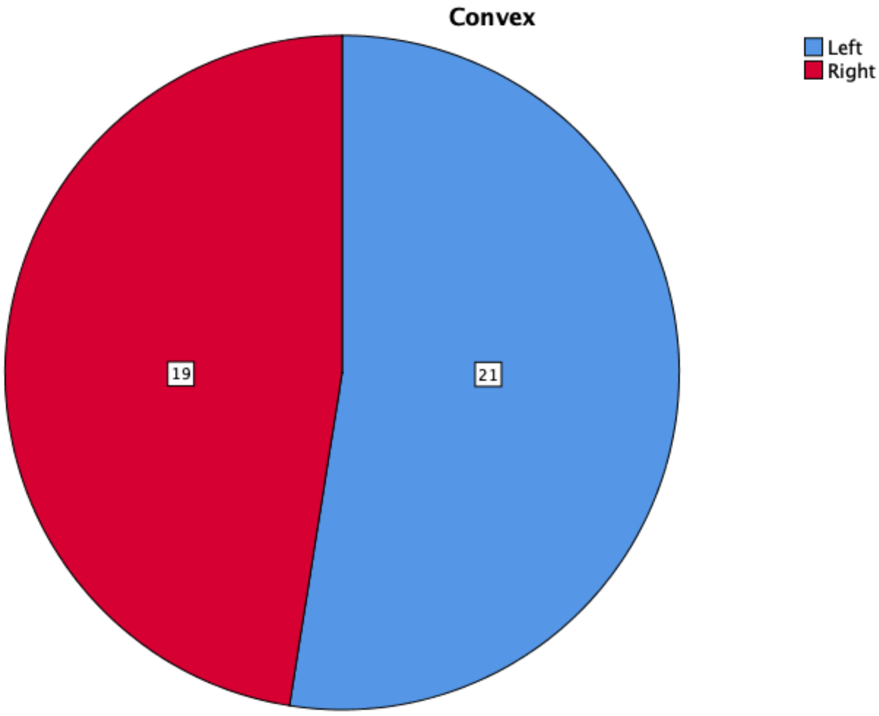

Figure 4.4 Directions of Curve Pattern of Participants

Scoliosis is named based on convexity of the curve. Table 4.4 and Figure 4.4 shows the convexity of scoliotic curve, which is left or right. The distribution is almost equal among the participants. 21 (52.5%) of the participants were having left convex curve while 19 (46.5%) of them were having right convex curve.

4.5 Different Level of Scoliotic Curve According to Gender

	n (%)	
	Level of Curve	
	Lumbar	Thoracic
N	*25 (100)*	15 (100)
Gender		
Male	10 (40)	10 (66.7)
Female	15 (60)	5 (33.3)

Table 4.5 Different Level of Scoliotic Curve According to Gender

Table 4.5 displays the distribution of different level of scoliotic curve based on gender. Out of 25 participants who were having lumbar curve, 10 (40%) of them were male while the remaining 15 (60%) of them were female. For the thoracic group with a total of 15 participants, 10 (66.7%) of them were males while the remaining 5 (33.3%) of them were females.

4.6 Different Scoliotic Curve Pattern According to Gender

	n (%)	
	Convex	
	Left	Right
N	*21 (100)*	19 (100)
Gender		
Male	9 (42.9)	11 (57.9)
Female	12 (57.1)	8 (42.1)

Table 4.6 Different Scoliotic Curve Pattern According to Gender

Table 4.6 presents the distribution of the different directions of convex curves based on different gender of the participants. Out of 21 participants who were having left convex curve, it is found that 9 (42.9%) were males while the remaining 12 (57.1%) were females. 11 (57.9%) male participants and 8 (42.1%) female participants made up the total of 19 participants who were having right convex curve.

4.7 Different Scoliotic Curve Pattern According to Different Level of Scoliotic Curve

	n (%)	
	Convex	
	Left	Right
N	*21 (100)*	19 (100)
Level of Curve		
Lumbar	15 (71.4)	10 (52.6)
Thoracic	6 (28.6)	9 (47.4)

Table 4.7 Different Scoliotic Curve Pattern According to Different Level of Scoliotic Curve

Table 4.7 displays the distribution of the different directions of convex curve based on different level of scoliotic curve: lumbar and thoracic. A total of 21 participants were having left convex curve, 15 (71.4%) of them were in the lumbar group while 6 (28.6%) of them were in the thoracic curve. Out of 19 participants who were having right convex curve, 10 (52.6%) of the participants were in the lumbar group while 9 (47.4%) of them were in the thoracic curve. Based on this data, from the total of 40 participants, 15 of them were left lumbar scoliosis, 9 of them were left thoracic scoliosis, 10 of them were right lumbar scoliosis and 9 of them were right thoracic scoliosis.

4.8 Upper Extremity Function Assessment
4.8.1 Upper Extremity Function Assessment (General)

Upper Extremity Function Assessment	Right Mean ± SD Min-Max	Left Mean ± SD Min-Max
Lateral Pinch Strength (kg)	5.59 ± 1.63 2.70-9.70	5.31 ± 1.60 2.50-10.30
Tip Pinch Strength (kg)	5.08 ± 1.76 2.80-9.70	5.03 ± 2.01 2.20-10.50
Three Jaw-Chuck Pinch Strength (kg)	3.55 ± 1.15 2.00-7.70	3.38 ± 1.22 1.80-6.70
Handgrip Strength (kg)	22.86 ± 8.31 7.30-37.0	21.55 ± 7.00 9.30-34.70
Finger Dexterity (s)	20.92 ± 3.02 10.0-25.7	22.06 ± 2.49 16.7-27.0
Hand Reaction (cm)	16.34 ± 3.90 6.3-26.1	15.82 ± 5.03 3.5-24.1
Upper Extremity Performance (s)	10.65 ± 3.60 5.30-25.30	

Table 4.8 Upper Extremity Function Assessment (General)

Table 4.8 shows the results for upper extremity function assessment of the participants. The higher mean strength in lateral pinch strength test, tip pinch strength test, three jaw-chuck strength test and handgrip strength test indicate higher strength. For finger dexterity, the lower mean time indicates better dexterity. For hand reaction test, the larger mean length indicates poorer hand reaction. For lateral pinch strength test, the mean strength for right upper extremity is slightly higher than that of left upper extremity, which is 5.59 ± 1.63 kg for the right upper extremity and 5.31 ± 1.60 kg for left upper extremity. The mean strength for right tip pinch strength is 5.08 ± 1.76 kg and for the left is 5.03 ± 2.01 kg. The third type of pinch strength test, which is the three jaw-chuck pinch strength test had the mean strength (3.55 ± 1.15 kg) for the right upper extremity and 3.38 ± 1.22 kg mean strength for the left upper extremity. Moving on, for the handgrip strength, the mean strength for right upper extremity is 22.86 ± 8.31 kg while is 21.55 ± 7.00 kg for that of left upper extremity. The mean time for right finger dexterity test 20.92 ± 3.02 s while is 22.06 ± 2.49 s for that of left upper extremity. For the hand reaction test, the mean length for right upper extremity is found to be 16.34 ± 3.90 cm and 15.82 ± 5.03 cm for the left upper extremity. For the final upper extremity assessment, upper extremity performance test was not categorized into left and right upper extremity, the mean time found is 10.65 ± 3.60 s.

4.8.2 Upper Extremity Function Assessment According to Different Gender

Gender	Upper Extremity Function Assessment	Right Mean ± SD Min-Max	Left Mean ± SD Min-Max
Male	**Lateral Pinch Strength (kg)**	6.60 ± 1.55 3.20-9.70	6.26 ± 1.55 3.30-10.30
Female		4.57 ± 0.95 2.70-6.20	4.35 ± 0.96 2.50-5.80
Male	**Tip Pinch Strength (kg)**	6.02 ± 1.76 3.70-9.70	5.95 ± 2.15 2.50-10.50
Female		4.14 ± 1.18 2.80-8.30	4.12 ± 1.38 2.20-8.30

Male	**Three Jaw-Chuck Pinch Strength (kg)**	4.20 ± 1.23 2.70-7.70	3.79 ± 1.28 1.80-6.70
Female		2.90 ± 0.57 2.00-4.00	2.98 ± 1.04 1.80-6.50
Male	**Handgrip Strength (kg)**	28.82 ± 6.63 18.30-37.0	26.18 ± 6.00 13.70-34.7
Female		16.89 ± 4.79 7.30-25.70	16.91 ± 4.38 9.30-25.30
Male	**Finger Dexterity (s)**	20.63 ± 3.61 10.0-25.5	22.15 ± 2.42 16.7-26.0
Female		21.21 ± 2.35 17.0-25.7	21.97 ± 2.61 17.5-27.0

Male	**Hand Reaction (cm)**	16.06 ± 4.55 6.3-26.1	15.24 ± 4.10 8.0-24.1
Female		16.64 ± 3.22 8.4-23.2	16.40 ± 5.88 3.5-23.7
Male	**Upper Extremity Performance (s)**	10.26 ± 2.93 5.30-15.30	
Female		11.04 ± 4.20 6.70-25.30	

Table 4.9 Upper Extremity Function Assessment According to Different Gender

Table 4.8.2 shows the results for upper extremity function assessment according to different gender. For the right upper extremity in terms of lateral pinch strength, the mean strength for males is 6.60 ± 1.55 kg and 4.57 ± 0.95 kg for females. For the left upper extremity of that, the mean strength for males is 6.26 ± 1.55 kg and 4.35 ± 0.96 kg for females. For right tip pinch strength, males has the mean strength of 6.02 ± 1.76 kg and females has the mean strength of 4.14 ± 1.18 kg. For left tip pinch strength, the mean strength for males is 5.95 ± 2.15 kg and 4.12 ± 1.38 kg for females. For the three-jaw chuck pinch strength, it is found that males have the right side mean strength of 4.20 ± 1.23 kg and females have that of 2.90 ± 0.57 kg. For the left side mean strength, males have 3.79 ± 1.28 kg and females have 2.98 ± 1.04 kg. For right handgrip strength, males show mean strength of 28.82 ± 6.63 kg and females show 16.89 ± 4.79 kg. For left handgrip strength, males show mean strength of 26.18 ± 6.00 kg and females show16.91 ± 4.38 kg. In terms of finger dexterity of right upper extremity, males have mean time of 20.63 ± 3.61s and females have mean time of 21.21 ± 2.35 s. For the left upper extremity of that, males have mean time of 22.15 ± 2.42 s and females have mean time of 21.97 ± 2.61 s. For right hand reaction, the mean length for males is 16.06 ± 4.55 cm and for females is 16.64 ± 3.22 cm. For left hand reaction, the mean length for males is 15.24 ± 4.10 cm and for females is 16.40 ± 5.88 cm. For the last assessment, which is upper extremity performance, males show mean time of 10.26 ± 2.93 s and females show mean time of 11.04 ± 4.20 s.

4.8.3 Upper Extremity Function Assessment According to Different Level of Curve

Level of Curve	Upper Extremity Function Assessment	Right Mean ± SD Min-Max	Left Mean ± SD Min-Max
Lumbar	**Lateral Pinch Strength (kg)**	5.16 ± 1.47 2.70-8.70	4.86 ± 1.52 2.50-8.70
Thoracic		6.30 ± 1.69 3.20-9.70	6.05 ± 1.50 4.30-10.30
Lumbar	**Tip Pinch Strength (kg)**	4.74 ± 1.55 2.80-9.70	4.59 ± 1.65 2.20-9.00
Thoracic		5.64 ± 1.99 3.50-9.30	5.78 ± 2.38 3.30-10.50

Lumbar	**Three Jaw-Chuck Pinch Strength (kg)**	3.43 ± 1.24 2.00-7.70	3.08 ± 1.08 1.80-6.70
Thoracic		3.74 ± 1.01 2.50-6.00	3.90 ± 1.31 2.20-6.50
Lumbar	**Handgrip Strength (kg)**	20.52 ± 8.22 7.30-36.7	19.55 ± 7.22 9.30-34.7
Thoracic		26.74 ± 7.12 15.30-37.0	24.87 ± 5.25 16.70-32.0
Lumbar	**Finger Dexterity (s)**	20.63 ± 3.20 10.0-25.70	22.20 ± 2.50 16.70-27.0
Thoracic		21.40 ± 2.75 17.70-25.50	21.83 ± 2.54 18.60-26.0

Lumbar	**Hand Reaction (cm)**	16.98 ± 4.04 8.4-26.1	16.41 ± 5.40 3.5-23.7
Thoracic		15.29 ± 3.54 6.3-19.4	14.83 ± 4.36 8.0-24.1
Lumbar	**Upper Extremity Performance (s)**	11.07 ± 4.03 6.0-25.30	
Thoracic		9.95 ± 2.71 5.30-14.70	

Table 4.10 Upper Extremity Function Assessment According to Different Level of Curve

Table 4.8.3 shows the results for upper extremity function assessment according to different level of curve. For the right upper extremity in terms of lateral pinch strength, the mean strength for lumbar is 5.16 ± 1.47 kg and 6.30 ± 1.69 kg for thoracic. For the left upper extremity of that, the mean strength for lumbar group is 4.86 ± 1.52 kg and 6.05 ± 1.50 kg for thoracic group. For right tip pinch strength, lumbar group has the mean strength of 4.74 ± 1.55 kg and thoracic group has the mean strength of 5.64 ± 1.99 kg. For left tip pinch strength, the mean strength for lumbar is 4.59 ± 1.65 kg and 5.78 ± 2.38 kg for thoracic. For the three-jaw chuck pinch strength, it is found that lumbar group have the right side mean strength of 3.43 ± 1.24 kg and thoracic group have that of 3.74 ± 1.01 kg. For the left side mean strength, lumbar group have 3.08 ± 1.08 kg and thoracic group have 3.90 ± 1.31 kg. For right handgrip strength, lumbar group show mean strength of 20.52 ± 8.22 kg and thoracic group show 26.74 ± 7.12 kg. For left handgrip strength, lumbar group show mean strength of 19.55 ± 7.22 kg and thoracic group show 24.87 ± 5.25 kg. In terms of finger dexterity of right upper extremity, lumbar group have mean time of 20.63 ± 3.20 s and thoracic group have mean time of 21.40 ± 2.75 s. For the left upper extremity of that, lumbar group have mean time of 22.20 ± 2.50 s and thoracic group have mean time of 21.83 ± 2.54 s. For right hand reaction, the mean length for lumbar is 16.98 ± 4.04 cm and for thoracic is 15.29 ± 3.54 cm. For left hand reaction, the mean length for lumbar is 16.41 ± 5.40 cm and for thoracic is 14.83 ± 4.36 cm. For the last assessment, which is upper extremity performance, lumbar group show mean time of 11.07 ± 4.03 s and thoracic group show mean time of 9.95 ± 2.71 s.

4.8.4 Upper Extremity Function Assessment According to Different Direction of Convexity

Direction of Convexity	Upper Extremity Function Assessment	Right Mean ± SD Min-Max	Left Mean ± SD Min-Max
Left	**Lateral Pinch Strength (kg)**	5.19 ± 1.37 3.00-7.70	4.94 ± 1.34 2.50-7.70
Right		6.03 ± 1.82 2.70-9.70	5.71 ± 1.80 3.00-10.30
Left	**Tip Pinch Strength (kg)**	4.60 ± 1.64 2.80-9.70	4.57 ± 1.66 2.20-9.00
Right		5.61 ± 1.78 3.30-9.30	5.55 ± 2.26 2.50-10.50

Left	**Three Jaw-Chuck Pinch Strength (kg)**	3.40 ± 1.24 2.30-7.70	3.37 ± 1.30 1.80-6.70
Right		3.71 ± 1.05 2.00-6.00	3.40 ± 1.17 1.80-6.50
Left	**Handgrip Strength (kg)**	21.01 ± 8.48 7.30-36.70	19.83 ± 6.60 9.30-32.0
Right		24.89 ± 7.84 12.0-37.0	23.44 ± 7.07 9.30-34.70
Left	**Finger Dexterity (s)**	21.59 ± 2.00 18.8-25.70	22.87 ± 2.31 17.5-27.0
Right		20.18 ± 3.78 10.0-25.30	21.16 ± 2.42 16.70-25.0

Left	**Hand Reaction (cm)**	16.05 ± 4.50 6.30-26.10	15.54 ± 5.73 3.5-23.70
Right		16.68 ± 3.20 10.0-23.20	16.13 ± 4.27 8.0-24.10
Left	**Upper Extremity Performance (s)**	11.36 ± 4.17 5.80-25.30	
Right		9.86 ± 2.74 5.30-14.70	

Table 4.11 Upper Extremity Function Assessment According to Different Direction of Convexity

Table 4.8.4 shows the results for upper extremity function assessment according to different direction of convexity. For the right upper extremity in terms of lateral pinch strength, the mean strength for left convexity is 5.19 ± 1.37 kg and 6.03 ± 1.82 kg for right convexity. For the left upper extremity of that, the mean strength for left convexity is 4.94 ± 1.34 kg and 5.71 ± 1.80 kg for right convexity. For right tip pinch strength, left convexity has the mean strength of 4.60 ± 1.64 kg and right convexity has the mean strength of 5.61 ± 1.78 kg. For left tip pinch strength, the mean strength for left convexity is 4.57 ± 1.66 kg and 5.55 ± 2.26 kg for right convexity. For the three-jaw chuck pinch strength, it is found that left convexity have the right side mean strength of 3.40 ± 1.24 kg and right convexity have that of 3.71 ± 1.05 kg. For the left side mean strength, left convexity have 3.37 ± 1.30 kg and right convexity have 3.40 ± 1.17 kg. For right handgrip strength, left convexity show mean strength of 21.01 ± 8.48 kg and right convexity show 24.89 ± 7.84 kg. For left handgrip strength, left convexity show mean strength of 19.83 ± 6.60 kg and right convexity show 23.44 ± 7.07 kg. In terms of finger dexterity of right upper extremity, left convexity have mean time of 21.59 ± 2.00 s and right convexity have mean time of 20.18 ± 3.78 s. For the left upper extremity of that, left convexity have mean time of 22.87 ± 2.31 s and right convexity have mean time of 21.16 ± 2.42 s. For right hand reaction, the mean length for left convexity is 16.05 ± 4.50 cm and for right convexity is 16.68 ± 3.20 cm. For left hand reaction, the mean length for left convexity is 15.54 ± 5.73 cm and for right convexity is 16.13 ± 4.27 cm. For the last assessment, which is upper extremity performance, left convexity show mean time of 11.36 ± 4.17 s and right convexity show mean time of 9.86 ± 2.74 s.

4.9 Correlation Between Scoliosis and Upper Extremity Function

The results of correlation between level of scoliosis and convexity against upper extremity function assessments to assess the correlation between scoliosis and upper extremity function is presented in Table 4.12. Looking at the aspect of level of scoliosis and right lateral pinch strength, (correlation coefficient, r = -0.318, p-value=0.045), Spearman's Correlation test indicates that there is statistically significant correlation and level of scoliosis is negatively and fairly related with right lateral pinch strength. For level of scoliosis and left lateral pinch strength, (correlation coefficient, r = -0.361, p-value=0.022), this indicates that there is statistically significant correlation and level of scoliosis is negatively and fairly related with left lateral pinch strength. For level of scoliosis and right tip pinch strength, (correlation coefficient, r = -0.211, p-value=0.192), this indicates that there is insignificant correlation and level of scoliosis is negatively and poorly related with right tip pinch strength. For level of scoliosis and left tip pinch strength, (correlation coefficient, r = -0.242, p-value=0.133), this indicates that there is insignificant correlation and level of scoliosis is negatively and poorly related with left tip pinch strength. For level of scoliosis and right three jaw-chuck pinch strength, (correlation coefficient, r = -0.204, p-value=0.206), this indicates that there is insignificant correlation and level of scoliosis is negatively and poorly related with right tip pinch strength. For level of scoliosis and left three jaw-chuck pinch strength, (correlation coefficient, r = -0.327, p-value=0.039), this indicates that there is statistically significant correlation and level of scoliosis is negatively and fairly related with left three jaw-chuck pinch strength. For level of scoliosis and right handgrip strength, (correlation coefficient, r = -0.407, p-value=0.009), this indicates that there is statistically significant correlation and level of scoliosis is negatively and fairly related with right handgrip strength. For level of scoliosis and left handgrip strength, (correlation coefficient, r = -0.410, p-value=0.009), this indicates that there is statistically significant correlation and level of scoliosis is negatively and fairly related with left handgrip strength. For level of scoliosis and right finger dexterity, (correlation coefficient, r = -0.036, p-value=0.826), this indicates that there is insignificant correlation and level of scoliosis is negatively and poorly related with right finger dexterity. For level of scoliosis and left finger dexterity, (correlation coefficient, r = -0.078, p-value=0.631), this indicates that there is insignificant correlation and level of scoliosis is negatively and poorly related with left finger dexterity. For level of scoliosis and right hand reaction, (correlation coefficient, r = 0.201, p-value=0.213), this indicates that there is insignificant correlation and level of scoliosis is positively and poorly related with right hand reaction. For level of scoliosis and left hand reaction, (correlation coefficient, r = 0.159, p-value=0.328), this indicates that there is insignificant correlation and level of scoliosis is positively and poorly related with left hand reaction. For upper extremity performance (correlation coefficient, r = 0.128, p-value=0.433), this indicates that there is insignificant correlation and gender is positively and poorly related with upper extremity performance.

Furthermore, the correlation coefficient, r was 0.219 and p-value was 0.174 for convexity and right lateral pinch strength. This indicates that there is insignificant and convexity is positively poorly related with right lateral pinch strength. The correlation coefficient, r was 0.204 and p-value was 0.204 for convexity and left lateral pinch strength. This indicates that there is insignificant and convexity is positively poorly related with left lateral pinch strength. The correlation coefficient, r was 0.337 and p-value was 0.034 for convexity and right tip pinch strength. This indicates that there is statistically significant and convexity is positively fairly related with right tip pinch strength. The correlation coefficient, r was 0.221 and p-value was 0.170 for convexity and left tip pinch strength. This indicates that there is insignificant and convexity is positively poorly related with left tip pinch strength. The correlation coefficient, r was 0.233 and p-value was 0.149 for convexity and right three jaw-chuck pinch strength. This indicates that there is insignificant and convexity is positively fairly related with right three jaw-chuck pinch strength. The correlation coefficient, r was 0.056 and p-value was 0.729 for convexity and left three jaw-chuck pinch strength. This indicates that there is insignificant and convexity is positively poorly related with left three jaw-chuck pinch strength. The correlation coefficient, r was 0.223 and p-value was 0.166 for convexity and right handgrip strength. This indicates that there is insignificant and convexity is positively fairly related with right handgrip strength. The correlation coefficient, r was 0.276 and p-value was 0.085 for convexity and left handgrip strength. This indicates that there is insignificant and convexity is positively poorly related with left handgrip strength. The correlation coefficient, r was -0.202 and p-value was 0.212 for convexity and right finger dexterity. This indicates that there is insignificant and convexity is negatively fairly related with right finger dexterity. The correlation coefficient, r was -0.352 and p-value was 0.026 for convexity and left finger dexterity. This indicates that there is statistically significant and convexity is negatively fairly related with left finger dexterity. The correlation coefficient, r was 0.61 and p-value was 0.71 for convexity and right hand reaction. This indicates that there is statistically insignificant and convexity is positively moderately related with right hand reaction. The correlation coefficient, r was 0.007 and p-value was 0.968 for convexity and left hand reaction. This indicates that there is insignificant and convexity is positively poorly related with left hand reaction. The correlation coefficient, r was -0.191 and p-value was 0.238 for convexity and upper extremity performance. This indicates that there is insignificant and convexity is negatively poorly related with upper extremity performance.

Correlations			Level of Scoliosis	Convexity
Spearman's rho	Lateral Pinch Strength	Right	-0.318*	0.219
			(0.045)	(0.174)
		Left	-0.361*	0.204
			(0.022)	(0.206)
	Tip Pinch Strength	Right	-0.211	0.337*
			(0.192)	(0.034)
		Left	-0.242	0.221
			(0.133)	(0.170)
	Three Jaw-Chuck Pinch Strength	Right	-0.204	0.233
			(0.206)	(0.149)
		Left	-0.327*	0.056
			(0.039)	(0.729)

Handgrip Strength	Right	-0.407**	0.223
		(0.009)	(0.166)
	Left	-0.410**	0.276
		(0.009)	(0.085)
Finger Dexterity	Right	-0.036	-0.202
		(0.826)	(0.212)
	Left	0.078	-0.352*
		(0.631)	(0.026)
Hand Reaction	Right	0.201	0.61
		(0.213)	(0.710)
	Left	0.159	0.007
		(0.328)	(0.968)
Upper Extremity Performance	-	0.128	-0.191
		(0.433)	(0.238)

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.12 Correlation Between Scoliosis and Upper Extremity Function

4.10 Correlation Between Convexity and Upper Extremity Function

The results for the correlation between convexity and upper extremity function is presented in Table 4.13. The left and right convexity is studied among the upper extremity function. Looking at the aspect of left convexity and left lateral pinch strength, (correlation coefficient, r = 0.652, p-value=0.001), this indicates that there is statistically significant correlation and left convexity is positively and moderately related with left lateral pinch strength. For right convexity and left lateral pinch strength, (correlation coefficient, r = 0.952, p-value<0.001), this indicates that there is statistically significant correlation and level of scoliosis is positively and very strongly related with left lateral pinch strength.

Looking at the aspect of left convexity and right tip pinch strength, (correlation coefficient, r = 0.782, p-value<0.001), this indicates that there is statistically significant correlation and left convexity is positively and moderately related with right tip pinch strength. For right convexity and right tip pinch strength, (correlation coefficient, r = 0.588, p-value=0.008), this indicates that there is statistically significant correlation and right convexity is positively and fairly related with right tip pinch strength. Looking at the aspect of left convexity and left tip pinch strength, (correlation coefficient, r = 0.787, p-value<0.001), this indicates that there is statistically significant correlation and left convexity is positively and moderately related with left tip pinch strength. For right convexity and left tip pinch strength, (correlation coefficient, r = 0.462, p-value=0.046), this indicates that there is statistically significant correlation and right convexity is positively and fairly related with left tip pinch strength.

For the aspect of left convexity and right three jaw-chuck pinch strength, (correlation coefficient, $r = 0.784$, p-value<0.001), this indicates that there is statistically significant correlation and left convexity is positively and moderately related with right three jaw-chuck pinch strength. For right convexity and right three jaw-chuck pinch strength, (correlation coefficient, $r = 0.770$, p-value<0.001), this indicates that there is statistically significant correlation and right convexity is positively and moderately related with right three jaw-chuck pinch strength. Looking at the aspect of left convexity and left three jaw-chuck pinch strength, (correlation coefficient, $r = 0.508$, p-value$=0.019$), this indicates that there is statistically significant correlation and left convexity is positively and fairly related with left three jaw-chuck pinch strength. For right convexity and left three jaw-chuck pinch strength, (correlation coefficient, $r = 0.657$, p-value$=0.002$), this indicates that there is statistically significant correlation and right convexity is positively and moderately related with left three jaw-chuck pinch strength.

Next, for the aspect of left convexity and right handgrip strength, (correlation coefficient, $r = 0.676$, p-value$=0.001$), this indicates that there is statistically significant correlation and left convexity is positively and moderately related with right handgrip strength. For right convexity and right handgrip strength, (correlation coefficient, $r = 0.752$, p-value<0.001), this indicates that there is statistically significant correlation and right convexity is positively and moderately related with right handgrip strength. Looking at the aspect of left convexity and left handgrip strength, (correlation coefficient, r = 0.697, p-value<0.001), this indicates that there is statistically significant correlation and left convexity is positively and moderately related with left handgrip strength. For right convexity and left handgrip strength, (correlation coefficient, r = 0.797, p-value<0.001), this indicates that there is statistically significant correlation and right convexity is positively and moderately related with left handgrip strength.

For the aspect of left convexity and right finger dexterity, (correlation coefficient, r = -0.075, p-value=0.747), this indicates that there is insignificant correlation and left convexity is negatively and poorly related with right finger dexterity. For right convexity and right finger dexterity, (correlation coefficient, r = 0.041, p-value=0.867), this indicates that there is statistically significant correlation and right convexity is positively and poorly related with right finger dexterity. Looking at the aspect of left convexity and left finger dexterity, (correlation coefficient, r = 0.109, p-value=0.637), this indicates that there is statistically correlation and left convexity is positively and fairly related with left finger dexterity. For right convexity and left finger dexterity, (correlation coefficient, r = 0.043, p-value=0.861), this indicates that there is insignificant correlation and right convexity is positively and poorly related with left finger dexterity.

For the aspect of left convexity and right hand reaction, (correlation coefficient, r = 0.071, p-value=0.759), this indicates that there is statistically insignificant correlation and left convexity is positively and poorly related with right hand reaction. For right convexity and right hand reaction, (correlation coefficient, r = -0.277, p-value=0.252), this indicates that there is insignificant correlation and right convexity is negatively and poorly related with right hand reaction. Looking at the aspect of left convexity and left hand reaction, (correlation coefficient, r = 0.172, p-value=0.457), this indicates that there is insignificant correlation and left convexity is positively and fairly related with left hand reaction. For right convexity and left hand reaction, (correlation coefficient, r = -0.171, p-value=0.484), this indicates that there is insignificant correlation and right convexity is negatively and poorly related with left hand reaction.

For the aspect of left convexity and upper extremity performance, (correlation coefficient, r = -0.017, p-value=0.941), this indicates that there is insignificant correlation and left convexity is negatively and poorly related with upper extremity performance. For right convexity and upper extremity performance, (correlation coefficient, r = 0.341, p-value=0.153), this indicates that there is insignificant correlation and right convexity is positively and fairly related with upper extremity performance.

Correlations

			Convexity	
			Left	Right
Spearman's rho	Lateral Pinch Strength	Right	1.000	1.000
			(-)	(-)
		Left	0.652**	0.952**
			(0.001)	(<0.001)
	Tip Pinch Strength	Right	0.782**	0.588**
			(<0.001)	(0.008)
		Left	0.787**	0.462*
			(<0.001)	(0.046)
	Three Jaw-Chuck Pinch Strength	Right	0.784**	0.770**
			(<0.001)	(<0.001)

	Left	0.508*	0.657**
		(0.019)	(0.002)
Handgrip Strength	Right	0.676**	0.752**
		(0.001)	(<0.001)
	Left	0.697**	0.797**
		(<0.001)	(<0.001)
Finger Dexterity	Right	-0.075	0.041
		(0.747)	(0.867)
	Left	0.109	0.043
		(0.637)	(0.861)
Hand Reaction	Right	0.071	-0.277
		(0.759)	(0.252)
	Left	0.172	-0.171
		(0.457)	(0.484)

Upper Extremity Performance	-	-0.017 (0.941)	0.341 (0.153)

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.13 Correlation Between Convexity and Upper Extremity Function

4.11 Correlation Between Level of Scoliosis and Upper Extremity Function

The results for the correlation between level of scoliosis and upper extremity function is presented in Table 4.14. The different level of scoliosis, which is thoracic and lumbar is studied among the upper extremity function. The correlation between level of scoliosis and upper extremity function is calculated. Looking at the aspect of thoracic and left lateral pinch strength, (correlation coefficient, r = 0.690, p-value=0.004), this indicates that there is statistically significant correlation and thoracic is positively and moderately related with left lateral pinch strength. For lumbar and left lateral pinch strength, (correlation coefficient, r = 0.874, p-value<0.001), this indicates that there is statistically significant correlation and lumbar is positively and very strongly related with left lateral pinch strength.

Looking at the aspect of thoracic and right tip pinch strength, (correlation coefficient, r = 0.718, p-value=0.003), this indicates that there is statistically significant correlation and thoracic is positively and moderately related with right tip pinch strength. For lumbar and right tip pinch strength, (correlation coefficient, r = 0.683, p-value<0.001), this indicates that there is statistically significant correlation and lumbar is positively and moderately related with right tip pinch strength. Looking at the aspect of thoracic and left tip pinch strength, (correlation coefficient, r = 0.411, p-value=0.128), this indicates that there is insignificant correlation and thoracic is positively and fairly related with left tip pinch strength. For lumbar and left tip pinch strength, (correlation coefficient, r = 0.640, p-value=0.001), this indicates that there is statistically significant correlation and lumbar is positively and moderately related with left tip pinch strength.

For the aspect of thoracic and right three jaw-chuck pinch strength, (correlation coefficient, r = 0.822, p-value<0.001), this indicates that there is statistically significant correlation and thoracic is positively and strongly related with right three jaw-chuck pinch strength. For lumbar and right three jaw-chuck pinch strength, (correlation coefficient, r = 0.739, p-value<0.001), this indicates that there is statistically significant correlation and lumbar is positively and moderately related with right three jaw-chuck pinch strength. Looking at the aspect of thoracic and left three jaw-chuck pinch strength, (correlation coefficient, r = 0.278, p-value=0.316), this indicates that there is insignificant correlation and thoracic is positively and poorly related with left three jaw-chuck pinch strength. For lumbar and left three jaw-chuck pinch strength, (correlation coefficient, r = 0.638, p-value=0.001), this indicates that there is statistically significant correlation and right convexity is positively and moderately related with left three jaw-chuck pinch strength.

Next, for the aspect of thoracic and right handgrip strength, (correlation coefficient, r = 0.519, p-value=0.047), this indicates that there is statistically significant correlation and left convexity is positively and fairly related with right handgrip strength. For lumbar and right handgrip strength, (correlation coefficient, r = 0.756, p-value<0.001), this indicates that there is statistically significant correlation and lumbar is positively and moderately related with right handgrip strength. Looking at the aspect of thoracic and left handgrip strength, (correlation coefficient, r = 0.512, p-value=0.051), this indicates that there is insignificant correlation and thoracic is positively and fairly related with left handgrip strength. For lumbar and left handgrip strength, (correlation coefficient, r = 0.838, p-value<0.001), this indicates that there is statistically significant correlation and lumbar is positively and strongly related with left handgrip strength.

For the aspect of thoracic and right finger dexterity, (correlation coefficient, r = 0.215, p-value=0.442), this indicates that there is insignificant correlation and thoracic is positively and poorly related with right finger dexterity. For lumbar and right finger dexterity, (correlation coefficient, r = -0.282, p-value=0.172), this indicates that there is insignificant correlation and lumbar is negatively and poorly related with right finger dexterity. Looking at the aspect of thoracic and left finger dexterity, (correlation coefficient, r = 0.231, p-value=0.407), this indicates that there is insignificant correlation and thoracic is positively and poorly related with left finger dexterity. For lumbar and left finger dexterity, (correlation coefficient, r = -0.240, p-value=0.248), this indicates that there is insignificant correlation and right convexity is negatively and poorly related with left finger dexterity.

For the aspect of thoracic and right hand reaction, (correlation coefficient, r = -0.537, p-value=0.039), this indicates that there is statistically significant correlation and thoracic is negatively and fairly related with right hand reaction. For lumbar and right hand reaction, (correlation coefficient, r = 0.176, p-value=0.401), this indicates that there is insignificant correlation and lumbar is positively and poorly related with right hand reaction. Looking at the aspect of thoracic and left hand reaction, (correlation coefficient, r = 0.231, p-value=0.408), this indicates that there is insignificant correlation and thoracic is positively and fairly related with left hand reaction. For lumbar and left hand reaction, (correlation coefficient, r = 0.231, p-value=0.408), this indicates that there is insignificant correlation and right convexity is positively and poorly related with left hand reaction.

For the aspect of thoracic and upper extremity performance, (correlation coefficient, r = 0.153, p-value=0.586), this indicates that there is insignificant correlation and thoracic is negatively and poorly related with upper extremity performance. For lumbar and upper extremity performance, (correlation coefficient, r = 0.241, p-value=0.245), this indicates that there is insignificant correlation and lumbar is positively and fairly related with upper extremity performance.

Correlations

			Level of Scoliosis	
			Thoracic	Lumbar
Spearman's rho	Lateral Pinch Strength	Right	1.000	1.000
			(-)	(-)
		Left	0.690**	0.874**
			(0.004)	(<0.001)
	Tip Pinch Strength	Right	0.718**	0.683**
			(0.003)	(<0.001)
		Left	0.411	0.640**
			(0.128)	(0.001)
	Three Jaw-Chuck Pinch Strength	Right	0.822**	0.739**
			(<0.001)	(<0.001)

	Left	0.278	0.638**
		(0.316)	(0.001)
Handgrip Strength	Right	0.519*	0.756**
		(0.047)	(<0.001)
	Left	0.512	0.838**
		(0.051)	(<0.001)
Finger Dexterity	Right	0.215	-0.282
		(0.442)	(0.172)
	Left	0.231	-0.240
		(0.407)	(0.248)
Hand Reaction	Right	-0.537*	0.176
		(0.039)	(0.401)
	Left	0.231	-0.073
		(0.408)	(0.728)

Upper Extremity Performance	-	0.153 (0.586)	0.241 (0.245)

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.14 Correlation Between Level of Scoliosis and Upper Extremity Function

4.12 Comparison Between Level of Scoliosis and Upper Extremity Function

The results of comparison of the level of scoliosis and upper extremity function is presented in Table 4.15. The level of scoliosis includes thoracic and lumbar. The Mann-Whitney test indicated that the right lateral pinch strength of thoracic curve (Mean Rank=25.23) was significantly higher than that of the lumbar curve (mean Rank=17.66), U=116.500, z = -1.986 (corrected for ties), p=0.047. The test also indicated that the left lateral pinch strength of thoracic curve (Mean Rank=25.87) was significantly higher than that of the lumbar curve (mean Rank=17.28), U=107.000, z = -2.252 (corrected for ties), p=0.024. The test also indicated that the left three-jaw chuck pinch strength of thoracic curve (Mean Rank=25.37) were significantly higher than that of the lumbar curve (Mean Rank=17.58), U=114.500, z = -2.043 (corrected for ties), p=0.041. The test indicated that the right handgrip strength of thoracic curve (Mean Rank=26.57) was significantly higher than that of the lumbar curve (Mean Rank=16.86), U=96.500, z = -2.543 (corrected for ties), p=0.011. The test also indicated that the left handgrip strength of thoracic curve (Mean Rank=26.60) was significantly higher than that of the lumbar curve (Mean Rank=16.84), U=96.000, z = -2.558 (corrected for ties), p=0.011.

Rank						
Upper Extremity Function		Level of Scoliosis	Mean Rank	U	Z	P-value
Lateral Pinch Strength	Right	Thoracic	25.23	116.500	-1.986	0.047
		Lumbar	17.66			
	Left	Thoracic	25.87	107.000	-2.252	0.024
		Lumbar	17.28			
Tip Pinch Strength	Right	Thoracic	23.63	140.500	-1.316	0.188
		Lumbar	18.62			
	Left	Thoracic	24.10	133.500	-1.509	0.131
		Lumbar	18.34			
Three Jaw-Chuck Pinch Strength	Right	Thoracic	23.53	142.000	-1.275	0.202
		Lumbar	18.68			

	Left	Thoracic	25.37	114.500	-2.043	0.041
		Lumbar	17.58			
Handgrip Strength	Right	Thoracic	26.57	96.500	-2.543	0.011
		Lumbar	16.86			
	Left	Thoracic	26.60	96.000	-2.558	0.011
		Lumbar	16.84			
Finger Dexterity	Right	Thoracic	21.03	179.500	-.0224	0.823
		Lumbar	20.18			
	Left	Thoracic	19.33	170.000	-0.490	0.624
		Lumbar	21.20			
Hand Reaction	Right	Thoracic	17.50	142.500	-1.258	0.208
		Lumbar	22.30			
	Left	Thoracic	18.13	152.000	-0.992	0.321

		Lumbar	21.92			
Upper Extremity	-	Thoracic	18.60	159.000	-0.797	0.425
		Lumbar	21.64			

Table 4.15 Comparison of Level of Scoliosis Between Upper Extremity Function

4.13 Comparison Between Convexity and Upper Extremity Function

The results of comparison of both right and left convexity and upper extremity function are presented in Table 4.16. The test indicated that the right tip pinch strength of right convexity (Mean Rank=24.58) was significantly higher than that of the left convexity (mean Rank=16.81), U=122.000, z = -2.103 (corrected for ties), p=0.035. The test also indicated that the left finger dexterity of left convexity (Mean Rank=24.36) was significantly higher than that of the right convexity (Mean Rank=16.24), U=118.500, z = -2.197 (corrected for ties), p=0.028.

Rank

Upper Extremity Function		Convexity	Mean Rank	U	Z	P-value
Lateral Pinch Strength	Right	Left	18.10	149.000	-1.370	0.171
		Right	23.16			
	Left	Left	18.26	152.500	-1.275	0.202
		Right	22.97			
Tip Pinch Strength	Right	Left	16.81	122.000	-2.103	0.035
		Right	24.58			
	Left	Left	18.07	148.500	-1.382	0.167
		Right	23.18			
Three Jaw-Chuck Pinch Strength	Right	Left	17.95	146.000	-1.453	0.146
		Right	23.32			
	Left	Left	19.88	186.500	-.0353	0.724
		Right	21.18			

Handgrip Strength	Right	Left	18.05	148.000	-1.395	0.163
		Right	23.21			
	Left	Left	17.48	136.000	-1.721	0.085
		Right	23.84			
Finger Dexterity	Right	Left	22.71	153.000	-1.260	0.208
		Right	18.05			
	Left	Left	24.36	118.500	-2.197	0.028
		Right	16.24			
Hand Reaction	Right	Left	19.83	185.500	-.0379	0.704
		Right	21.24			
	Left	Left	20.43	198.000	-0.041	0.968
		Right	20.58			
Upper Extremity	-	Thoracic	22.60	155.500	-1.193	0.233
		Lumbar	18.18			

Table 4.16 Comparison of Convexity Between Upper Extremity Function

4.14 Comparison of Upper Extremity Function Between Different Convexity of Different Level of Scoliosis

The comparison of the upper extremity function between different convexity of different level of scoliosis is presented in Table 4.17. The test indicated that the right lateral pinch strength of right convex thoracic (Mean Rank=9.89) was significantly higher than that of the left convex thoracic (mean Rank=5.17, U=10.000, z = -2.007 (corrected for ties), p=0.045. The test also indicated that the left lateral pinch strength of right convex thoracic (Mean Rank=10.00) was significantly higher than that of the left convex thoracic (Mean Rank=5.00), U=9.000, z = -2.125 (corrected for ties), p=0.034.

The test indicated that the right finger dexterity of left convex lumbar (Mean Rank=15.47) was significantly higher than that of the right convex lumbar (mean Rank=9.30, U=38.000, z = -2.056 (corrected for ties), p=0.040. The test indicated that the upper extremity performance of left convex lumbar (Mean Rank=15.57) was significantly higher than that of the right convex lumbar (mean Rank=9.15), U=36.500, z = -2.140 (corrected for ties), p=0.03

Rank

Level of Scoliosis	Upper Extremity Function		Convexity	Mean Rank	U	Z	P-value
Thoracic	Lateral Pinch Strength	Right	Left	5.17	10.000	-2.007	0.045
			Right	9.89			
		Left	Left	5.00	9.000	-2.125	0.034
			Right	10.00			
	Tip Pinch Strength	Right	Left	5.42	11.500	-1.830	0.067
			Right	9.72			
		Left	Left	6.00	15.000	-1.415	0.157
			Right	9.33			
	Three Jaw-Chuck Pinch Strength	Right	Left	6.42	17.500	-1.126	0.260
			Right	9.06			
		Left	Left	7.00	21.000	-0.709	0.478

		Right	8.67			
Handgrip Strength	Right	Left	7.17	22.000	-0.590	0.555
		Right	8.56			
	Left	Left	5.83	14.000	-1.533	0.125
		Right	9.44			
Finger Dexterity	Right	Left	8.08	26.500	-0.059	0.953
		Right	7.94			
	Left	Left	10.17	14.000	-1.535	0.125
		Right	6.56			
Hand Reaction	Right	Left	8.75	22.500	-0.531	0.596
		Right	7.50			
	Left	Left	8.00	27.000	0.000	1.000
		Right	8.00			
Upper Extremity	-	Left	6.17	16.000	-1.298	0.194
		Right	9.22			

Lumbar	Lateral Pinch Strength	Right	Left	13.43	68.500	-0.361	0.718
			Right	12.35			
		Left	Left	13.37	69.500	-0.306	0.759
			Right	12.45			
	Tip Pinch Strength	Right	Left	11.73	56.000	-1.056	0.291
			Right	14.90			
		Left	Left	12.53	68.000	-0.389	0.697
			Right	13.70			
	Three Jaw-Chuck Pinch Strength	Right	Left	12.10	61.500	-0.751	0.453
			Right	14.35			
		Left	Left	13.67	65.000	-0.556	0.578
			Right	12.00			
	Handgrip Strength	Right	Left	11.70	55.500	-1.082	0.279
			Right	14.95			
		Left	Left	12.17	62.500	-0.694	0.488

		Right	14.25			
Finger Dexterity	Right	Left	15.47	38.000	-2.056	0.040
		Right	9.30			
	Left	Left	14.93	46.000	-1.614	0.107
		Right	10.10			
Hand Reaction	Right	Left	11.73	56.000	-1.054	0.292
		Right	14.90			
	Left	Left	12.70	70.500	-.250	0.803
		Right	13.45			
Upper Extremity	-	Left	15.57	36.500	-2.140	0.032
		Right	9.15			

Table 4.17 Comparison of Level of Scoliosis Between Convexity and Upper Extremity Functio

CHAPTER 5

DISCUSSION

5.1 Discussion

5.1.1 Sociodemographic Variables and Upper Extremity Function Among Scoliosis

This study found out the correlation of upper extremity function, which includes the three types of pinch strength, handgrip strength, finger dexterity, hand reaction and upper extremity performance in scoliosis subjects who were screened in campus with scoliometer readings five degree or above. 40 out of 243 screened subjects were found to have scoliotic curve and were also assessed for upper extremity function. The influence of different direction of convexity of scoliotic curve on upper extremity function are reported. This study also looked into the influence of different level of scoliosis, which is thoracic and lumbar on upper extremity function.

5.1.2 Comparison of Right and Left Upper Extremity Function

Both right and left upper extremity were assessed for all the assessments mentioned above, except for upper extremity performance, as upper extremity performance test involved both upper limbs to perform at the same time. Generally, and also looking from the aspect of different level of scoliotic curve or different direction of convexity, this study has presented with the findings that right side of upper extremity had better function than that of left side, except for hand reaction test. In this study, all the subjects involved were right-handed. Previous literatures on handedness support the right-handed subjects had significantly stronger dominant hand than non-dominant hand, which means right-handed subjects had stronger right hand (Incel et al., 2002). A common rule of thumb stated that the dominant hand is 10% stronger than the nondominant hand and is found in right-handed people (Petersen et al., 1989).

However, the subjects in this study showed better hand reaction in left hand. This condition is further supported by a few previous studies (Annett & Annett, 1979; Nisiyama & Ribeiro-do-Valle, 2014). The right hand's sub movement times were longer than the left hand's (Nisiyama & Ribeiro-do-Valle, 2014). The majority of individuals responded faster to the left stimuli (Annett & Annett, 1979). This might be due to greater sensitivity of non-dominant hemispehere (Annett & Annett, 1979). There were controversies in which the studies found that right-handed subjects had better dominant hand reaction than that of left hand (Chouamo et al., 2021; Dexheimer et al., 2022). Male participants were found to have a faster hand reaction time as compared to the females (Chouamo et al., 2021).

In addition to that, grip strength was found to be affected by multi-factors such as time of the day, cooperation of the subjects and others (Incel et al., 2002). Any possible of these factors might be responsible for the results of this study in other upper extremity function other than hand reaction only. As both genders were included for this study, it might be possible to be one of the factors that affect the findings.

5.1.3 Correlation Between Scoliosis and Upper Extremity Function

Both left and right convexity of scoliotic curve were found to be correlated with all three types of pinch strength and also handgrip strength. This study also showed that lumbar curvature is correlated with all three types of pinch strength and handgrip strength while surprisingly, thoracic curvature only correlated with the right pinch strength and handgrip strength. Previous research has looked at muscular function in scoliosis patients. To the best of our knowledge, only one study explored the correlation of upper extremities with scoliosis (Martinez-Llorens et al., 2009). No study has been done to find out the correlation of different level or curvature pattern with scoliosis. This was in contrast with our expectation that thoracic is correlated with more upper limb functions (Yagci et al., 2020). The unequal number of subjects having different level of scoliotic curvature in the present study may be the possible factor that influence the results.

The strength of non-dominant handgrip was directly correlated with scoliosis (Martinez-Llorens et al., 2009). This finding was in contrast with the present study, in which thoracic curvature is correlated with dominant hand. Muscle function loss was common and impacted the muscle groups, such as inspiratory muscles, expiratory muscles, upper and lower limbs, as well as dominant and non-dominant extremities (Martinez-Llorens et al., 2009). The origins of muscle dysfunction in scoliosis are unknown, the systemic pathways may play a role. Muscle function can be influenced by a variety of circumstances. Some of them, such as dietary condition, physical activity level, or systemic inflammation, might be shared by several muscles, whilst others are unique to each muscle type (Martinez-Llorens et al., 2009). Muscle weakness has an impact on upper limb function and daily life activities. Although there is no straight link between muscular strength and function, it is influenced by personal and environmental variables (Seferian et al., 2015). Therefore, any change in these factors may be the possible reason that there was no correlation of non-dominant hand in thoracic curvature.

The present study also found that there was no significant correlation between upper extremity performance and different scoliotic curvature. This was further support by a previous study, which claims that there is no significant difference between upper extremity performance (Yagci et al., 2020). The CKCUES test that was used in the present study was to assess the total upper extremity functional stability and performance, particularly for the shoulder segment in the closed kinetic chain. According to the results for the present study and the previous study, it was clearly seen that upper extremity performance did not appear to be affected by different level of scoliosis or curvature pattern. This study showed that different level of scoliosis or curvature pattern had more effect on upper extremity strength, particularly pinch and handgrip strength. Another possible reason that contributed to this finding wa that the assessment that was used for the hand's strength in the present study was more sensitive than that of the shoulder, since reliable equipment were used in pinch strength and handgrip strength.

5.1.4 Comparison Between Level of Scoliosis and Upper Extremity Function

Moving on, the findings of this present study on the comparison between the level of scoliosis and upper extremity function was surprisingly in contrast with the previous studies. It was found that the subjects with main lumbar scoliotic curvature had a significantly weaker lateral pinch strength and handgrip strength in both right and left upper extremities compared to that of the subjects with main thoracic scoliotic curvature. Previous study proposed that the subjects with main thoracic scoliotic curvature had weaker lateral pinch strength, hand dexterity and hand reaction compared to that of subjects with main lumbar scoliotic curvature (Yagci et al., 2020). In addition to that, when compared with the subjects without scoliosis, the subjects with thoracic scoliotic curvature presented weaker handgrip strength (Yagci et al., 2020).

In the present study, the number of subjects in different level of scoliotic curvature categories was not equal, with the number of subjects in lumbar curvature was 10 subjects more than that of thoracic curvature. A larger-than-necessary sample will be more representative of the population and hence yield more accurate results. If the sample size is high enough, even little variations between groups or trivial correlations can be recognised as statistically significant (Andrade, 2020). This might be the possible reason for the present study to be in contrast with the previous studies. There was also possibility of less severe degree of thoracic curvature which turns out to be more strength as compared to that of lumbar curvature. The scoliosis Cobb angle degree were found to be negatively correlated with upper extremity functions (Gündüz et al., 2021). The severity of scoliosis was found to be associated with the extension of lumbar spine (Smith et al., 1989).

5.1.5 Comparison Between Convexity and Upper Extremity Function

When the subjects were separated into left and right convexity, right tip pinch strength was reported to be significantly stronger at the right convex curvature. However, left finger dexterity was reported to be significantly performed better at the right convexity. This meant that the opposite side of right convexity, which is the left concavity showed better finger dexterity. In addition, when different level of scoliosis: thoracic and lumbar curvatures was categorized into left and right convexity categories, the study demonstrated that right and left lateral pinch strength is significantly greater in right convex thoracic curvature. This indicated that right lateral pinch strength is stronger on convex curvature while left lateral pinch strength was stronger on the concave side. The right finger dexterity was found to be significantly better in right convex lumbar curvature.

This was interesting as all the significant difference in upper extremity functions was found to be performed better in right convexity for right upper extremity and is better in concavity for left upper extremity. This finding was debatable since previous studies had different findings on this issue. There was a tendency toward improved function on the convex side (Yagci et al., 2020). On top of that, individuals with single thoracic and lumbar scoliosis on the convex side appeared to have higher upper extremity functions (Yagci et al., 2020). Another study found that adolescents idiopathic scoliosis have abnormal shoulder and scapular, particularly on the concave side (Turgut et al., 2017).

There were studies that in contrast with it, in which they claimed that convex curvature is affected more as compared to concave side (Burwell et al., 2012, June; Burwell et al., 2012; Yarom & Robin, 1979). Muscles on both sides of the spinal curvature have pathologic alterations. Although no statistically significant side differences were discovered, the morphologic alterations and overall trends indicate that the concave side is more severely damaged (Yarom & Robin, 1979). A significant difference in both left and right upper extremity was not associated with the direction of the curve was demonstrated in a study (Cook et al., 1986). The growth of the magnitude of the curvature was correlated with the posture, biomechanics variables and might in turns worsens the curve (Burwell et al., 2012).

5.2 Strength and Limitation of Study

This study had some strengths that should be emphasized. The biggest strength was that this study investigated and compared the upper extremity functions in different level of scoliosis and also directions of convexity of the curvature among scoliosis participants, which had only done in one previous study. Most of the studies investigated the scoliosis as a whole instead of categories and the upper extremity functions. This study also presented the data to describe up to five upper extremity function assessment in scoliosis subjects. A more reliable findings can be obtained as the subjects recruited in this subject have similar age. During the scoliosis screening event, qualified helpers were recruited to help in the scoliosis screening process as well as the upper extremity assessment, this will assist in the accuracy of obtaining the results.

Nevertheless, due to time constriction, the sample size recruited was relatively small and the population involved in this study were UTAR students only. This was also evident in the present study that all the 40 subjects included only one ethnicity. Not only that, the subjects recruited in this study had unequal number of subjects in the level of scoliosis category. There were more subjects in lumbar group which might affect the accuracy of the results. The severity of the curvature, particularly the scoliometer readings are not interpreted in this study due to time constriction. The study design of the present study, which was a cross-sectional study, had limit the possibility of establishing the causal-relationship between the different level of scoliotic curvature or directions of convexity on the upper extremity functions. Besides, the convenience sampling method in this study did not allow the equal opportunity of the subjects to be chosen to be recruited in this study. This lead to sampling bias.

5.3 Recommendations of Study

As mentioned above, it is recommended for the future study done by recruiting a larger sample size that involve multi-racial and different institution. As there are different races in Malaysia, the present study done may not draw a relevant conclusion. Other institutions are suggested to be involved to increase the target sample size. Next, if the future researchers have the intention to do a similar study, it is recommended to investigated the different level of scoliosis or curvature pattern on different gender as well as the severity of curvature. Since these two variables are not investigated in the present study, it is therefore hoped that this can be studied in the future to give a explore more on scoliosis, which is a complex condition. It is also suggested that the duration of the study can be lengthen. Various restrictions were found to be associated with short period of study, especially when the period to collect the data is short. It is believed that the standard and also the quality of a research study could be increased massively if a longer period of a study is provided. On top of that, it is suggested that a similar study in the future could be done as there is possibility of scoliotic curvature to progress to a more severe degree.

CHAPTER 6

CONCLUSION

While the effect of scoliosis on the upper extremity functions is still an issue to be find out in the population and most of the previous studies did not involve the college students, this study established (i) the influence of different level of scoliosis: thoracic and lumbar and also (ii) both right and left curvature convexity on upper extremity functions among college students.

As expected, this study found that dominant hand has better upper extremity functions as compared to non-dominant hand in right-handed population in scoliosis patients regardless of different type of scoliotic curvature.

The results revealed that there was correlation between both right and left convexity on the upper extremity function, which include both right and left lateral pinch strength, tip pinch strength, three jaw-chuck pinch strength and handgrip strength. Lumbar scoliotic curvature is also found to be significantly correlated with both right and left of all three types of pinch strength and handgrip strength. However, thoracic curvature was only significantly related with right pinch strength and handgrip strength. There was clearly no significant correlation between level of scoliosis and convexity with both right and left upper extremity function, finger dexterity and also hand reaction. Possible factors such as involvement of shoulder kinematics and hand muscle dysfunction would be contributed to these results.

The findings in this study presented the data that lumbar curvature had more influence with significant difference on the upper extremity functions: lateral pinch strength and handgrip strength. This might be due to more lumbar curvature subjects as compared to thoracic curvature. The severity of the curvature was not determined in this study, there was a possibility of more severe lumbar curvature which had more effect on upper extremity functions. Besides, the influence of curvature pattern, that is convexity on upper extremity functions was not defined as right convexity was found to be having better upper extremity performance for both left and right upper extremities. The previous studies had different findings on this issue, in which some stated that convexity had more influence while some claimed that concavity had more influence.

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APPENDICES

APPENDIX A - ETHICAL APPROVAL LETTER

UNIVERSITI TUNKU ABDUL RAHMAN
Wholly Owned by UTAR Education Foundation (Company No. 578227-M)

Re: U/SERC/224/2022

4 November 2022

Mr Muhammad Noh Zulfikri Bin Mohd Jamali
Head, Department of Physiotherapy
M. Kandiah Faculty of Medicine and Health Sciences
Universiti Tunku Abdul Rahman
Jalan Sungai Long
Bandar Sungai Long
43000 Kajang, Selangor

Dear Mr Muhammad Noh,

Ethical Approval For Research Project/Protocol

We refer to your application for ethical approval for your students' research project from Bachelor of Physiotherapy (Honours) programme enrolled in course UMFD3026. We are pleased to inform you that the application has been approved under Expedited Review.

The details of the research projects are as follows:

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
1.	Knowledge and Attitude Towards Overweight and Obesity Among Physiotherapy and Medical Students: A Cross-Sectional Study	Ching Yung Shan	Mr Muhammad Noh Zulfikri Bin Mohd Jamali	4 November 2022 – 3 November 2023
2.	Effects of Different Gluteal Strengthening Programs on Strength, Pain, Functional Disability and Balance Among University Students with Non-specific Chronic Low Back Pain: A Randomized Controlled Trial	Lee Kah Yi		
3.	Effects on Menstrual Cycle on Dynamic Balance and Muscle Strength Among Recreational Players	Ler Chai Hong		
4.	Knowledge and Awareness Towards Pneumonia Among UTAR Non-Health Sciences Undergraduate Students	Chooi Yan Yee	Pn Nurul Husna Binti Khairuddin	
5.	The Effect of Active Video Games on 6-Minute Walk Test in Overweight and Obese Children	Chin Jay Ven		
6.	Association of Functional Ability of Upper Extremity and Scoliosis Among College Students: A Correlational Study	Sammi Leong Sing Yee	Dr Deepak Thazhakkattu Vasu	
7.	Contracture and Posterior Tibial Tendon Dysfunction on Ankle Instability Among Young Adults with Pes Planus	See Wan Ni		
8.	A Correlational Study of the Relationship Between Flat Foot with Anterior Pelvic Tilt and Sacroiliac Joint Dysfunction Among Undergraduate Students	Tan Bee Thong		
9.	Association Between Physical Activity, Learning Style and Academic Performance Among UTAR Health Science Undergraduates	Yeoh Zhe Yi	Ms Kamala a/p Krishnan	

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Sungai Long Campus : Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor Darul Ehsan, Malaysia
Tel: (603) 9086 0288 **Fax:** (603) 9019 8868
Website: www.utar.edu.my

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
31.	Association of Postural Awareness with Sedentary Behavior and Back Pain During the Hybrid Study Among Undergraduate Students	Low Xin Yuen	Mr Martin Ebenezer Chellappan	4 November 2022 – 3 November 2023
32.	Impact of Social Media Addiction on Physical Activity Among Undergraduate Students	Mak Kai Nan		
33.	Tibial Torsion and Leg Length Discrepancy in Idiopathic Scoliosis Among UTAR Students	Khoo Wan Qi	Pn Nadia Safirah Binti Rusli	
34.	Prevalence of Patellofemoral Pain Among University Students	Khoo Wen Han		
35.	Prevalence of Varicose Veins Among Fast Food Employees in Cheras, Selangor: A Cross Sectional Study	Ropheca Phuah Su Hui		
36.	The Effect of Unstable Modified Wall Squat on Dynamic Balance Among Recreational Athletes	Chu Sin Jiet	Mr Sathish Kumar Sadagobane	
37.	Knowledge, Perception, and Attitude Towards Breast Cancer and Breast Self-Examination (BSE) Among Non-medical Private University Students	Foo Jes Mynn		
38.	Perception, Knowledge and Attitude Towards the Impact of Daytime Nap on the Risk of Stroke Among Non-Healthcare Undergraduate Students: A Cross-Sectional Study	Chan Chi Kuan	Mr Tarun Amalnerkar Co-Supervisor: Ms Swapneela Jacob	
39.	Awareness, Knowledge and Attitude Toward Orthostatic Hypotension Among Elderlies	Ch'ng Hui Kee		
40.	Effect of TikTok on Student Learning Among Physiotherapy Students	Tan Eng Jing	Mr Avanianban Chakkarapani	
41.	Awareness Towards Tourette Syndrome Among Health Science and Non-health Science Students in A Private University, Malaysia	Tan Kai Xuan		
42.	Effect of Scapular Retraction Exercise on Forward Head Posture Among University Students	Tay Kai Wei	Ms Mahadevi A/P Muthurethina Barathi	
43.	Comparison Between Effect of Lower Limb Cyclic Stretching and Ballistic Stretching on Jumping Distance Among Undergraduate Students: A Comparative Study	Ng Zi Ru		
44.	Relationship of Physical Activity with Anxiety and Depression Among University Students	Ong Aiwei		
45.	Gender Discrepancy and Its Association with Shoulder Pain Among Malaysian Recreational Badminton Players	Khoo Je-Yique	Pn Nur Aqliliriana Binti Zainuddin	
46.	Obesity, Eating Habits and Physical Activity Before and During Covid-19 Pandemic Among University Lecturers	Khoo Tze Sean		

The conduct of this research is subject to the following:

(1) The participants' informed consent be obtained prior to the commencement of the research;

(2) Confidentiality of participants' personal data must be maintained; and

(3) Compliance with procedures set out in related policies of UTAR such as the UTAR Research Ethics and Code of Conduct, Code of Practice for Research Involving Humans and other related policies/guidelines.

(4) Written consent be obtained from the institution(s)/company(ies) in which the physical or/and online survey will be carried out, prior to the commencement of the research.

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Sungai Long Campus : Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor Darul Ehsan, Malaysia
Tel: (603) 9086 0288 **Fax**: (603) 9019 8868
Website: www.utar.edu.my

Should the students collect personal data of participants in their studies, please have the participants sign the attached Personal Data Protection Statement for records.

Thank you.

Yours sincerely,

Professor Ts Dr Faidz bin Abd Rahman
Chairman
UTAR Scientific and Ethical Review Committee

c.c Dean, M. Kandiah Faculty of Medicine and Health Sciences
Director, Institute of Postgraduate Studies and Research

Kampar Campus : Jalan Universiti, Bandar Barat, 31900 Kampar, Perak Darul Ridzuan, Malaysia
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APPENDIX B - RESEARCH PARTICIPANT INFORMATION SHEET

<u>Research Participant Information Sheet</u>

Universiti Tunku Abdul Rahman
Faculty of Medicine and Health Sciences
Department of Physiotherapy
Bachelor of Physiotherapy (Honours)

<u>Information Sheet to Participate in the Study</u>
<u>ASSOCIATION OF FUNCTIONAL ABILITY OF UPPER EXTREMITY AND SCOLIOSIS AMONG COLLEGE STUDENTS: A CORRELATIONAL STUDY</u>

Student Investigator: Sammi Leong Sing Yee
Department: Department of Physiotherapy
Course Name and Course Code: UMFD3026 Research Project
Year and Semester: Year 3 Semester 1

You are being asked to volunteer for this research study that is being conducted as part of the requirement to complete the above mentioned Course.

Please read this information sheet and contact me to ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study
The purpose of this study is to assess the functions of upper extremity in adult idiopathic scoliosis among college students.

Approximately 405 students will participate in this study.

Procedures

If you agree to be in this study, you will be asked to complete all the assessments to find out your upper limb functions level.

Length of Participation

You will spend around 20 minutes to complete the assessments.

Risks and Benefits

There are no risks from being in this study.

There are benefits in participating in this study, a talk with exercises demonstration to improve scoliosis will be held and students diagnosed with scoliosis are welcomed to participate in it and thus awareness on this issue can be increased.

Confidentiality

No information that will make it possible to identify you, will be included in any reports to the University or in any publications.
Research records will be stored securely and only approved researchers will have access to the records.

Voluntary Nature of the Study

Participation in this study is voluntary. If you withdraw or decline participation, you will not be penalized or lose benefits or services unrelated to the study. If you decide to participate, you may decline to answer any question and may choose to withdraw at any time.

Contacts and Questions

If you have any questions, clarifications, concerns or complaints, about the research, the researcher conducting this study can be contacted at 017-9840722 or email to sammilsy6107@1utar.my.

Concerns, or complaints about the research and wish to talk to someone other than individuals on the research team or

Please keep this information sheet for your records.

APPENDIX C - INFORMED CONSENT FORM

<u>Research Participant Consent Form</u>

Universiti Tunku Abdul Rahman
Faculty of Medicine and Health Sciences
Department of Physiotherapy
Bachelor of Physiotherapy (Honours)

<u>Consent Form to Participate in the Study</u>
<u>ASSOCIATION OF FUNCTIONAL ABILITY OF UPPER EXTREMITY AND SCOLIOSIS AMONG COLLEGE STUDENTS: A CORRELATIONAL STUDY</u>

Student Investigator: Sammi Leong Sing Yee
Department: Department of Physiotherapy
Course Name and Course Code: UMFD3026 Research Project
Year and Semester: Year 3 Semester 1
Supervisor: Mr Deepak Thazhakkattu Vasu

I have read the provided information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have, has been answered to my satisfaction. I understand that I will be given a copy of this form, and the researcher will keep another copy on file. I consent voluntarily to be a participant in this study.

Name of Participant: ________________________________

IC No: ______________________ Date: ________________

APPENDIX D - PERSONAL DATA PROTECTION NOTICE

PERSONAL DATA

PROTECTION NOTICE

Please be informed that in accordance with Personal Data Protection Act 2010 ("PDPA") which came into force on 15 November 2013, Universiti Tunku Abdul Rahman ("UTAR") is hereby bound to make notice and require consent in relation to collection, recording, storage, usage and retention of personal information.

1. Personal data refers to any information which may directly or indirectly identify a person which could include sensitive personal data and expression of opinion. Among others it includes:

   a) Name
   b) Identity card
   c) Place of Birth
   d) Address
   e) Education History
   f) Employment History
   g) Medical History
   h) Blood type
   i) Race
   j) Religion
   k) Photo
   l) Personal Information and Associated Research Data

2. The purposes for which your personal data may be used are inclusive but not limited to:

   a) For assessment of any application to UTAR
   b) For processing any benefits and services
   c) For communication purposes
   d) For advertorial and news
   e) For general administration and record purposes
   f) For enhancing the value of education
   g) For educational and related purposes consequential to UTAR
   h) For replying any responds to complaints and enquiries
   i) For the purpose of our corporate governance
   j) For the purposes of conducting research/ collaboration

3. Your personal data may be transferred and/or disclosed to third party and/or UTAR collaborative partners including but not limited to the respective and appointedoutsourcing agents for purpose of fulfilling our obligations to you in respect of the purposes and all such other purposes that are related to the purposes and also in providing integrated services, maintaining and storing records. Your data may be

shared when required by laws and when disclosure is necessary to comply with applicable laws.

4. Any personal information retained by UTAR shall be destroyed and/or deleted in accordance with our retention policy applicable for us in the event such informationis no longer required.

5. UTAR is committed in ensuring the confidentiality, protection, security and accuracy of your personal information made available to us and it has been our ongoing strict policy to ensure that your personal information is accurate, complete, not misleading and updated. UTAR would also ensure that your personal data shall not be used for political and commercial purposes.

Consent:

6. By submitting or providing your personal data to UTAR, you had consented and agreed for your personal data to be used in accordance to the terms and conditionsin the Notice and our relevant policy.

7. If you do not consent or subsequently withdraw your consent to the processing and disclosure of your personal data, UTAR will not be able to fulfill our obligations or to contact you or to assist you in respect of the purposes and/or for any other purposes related to the purpose.

8. You may access and update your personal data by writing to us at
.

Acknowledgment of Notice

[ ] I have been notified and that I hereby understood, consented and agreed perUTAR above notice.

[ ] I disagree, my personal data will not be processed.

……………
……………
Name:
Date:

APPENDIX E - KREJCIE AND MORGAN (1980) TABLE

Krejcie and Morgan table to determine sample size

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

N=population size

S=sample size

APPENDIX F - ONLINE REGISTRATION FORM

Full Name (as per NRIC) *

Your answer

Gender *

- ○ Male
- ○ Female

Age *

- ○ < 18
- ○ 18 - 25
- ○ > 25

UTAR Email (Eg. xxx@1utar.my) *

Your answer

UTAR Student ID (Eg. 20UMB01234) *

Your answer

Contact Number (Eg.010-xxx xxxx) *

Your answer

Campus *

- ◯ Sungai Long
- ◯ Kampar

Have you had any spinal correction surgery done before? *

- ◯ Yes
- ◯ No

Which day will you attend? *

- ◯ 10th November 2022 (Sungai Long) - FULL
- ◯ 11th November 2022 (Sungai Long) - FULL
- ◯ 2nd December 2022 (Kampar)

APPENDIX G - POSTER WITH QR CODE

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APPENDIX I - TURNITIN REPORT

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ASSOCIATION OF FUNCTIONAL ABILITY OF UPPER EXTREMITY AND SCOLIOSIS AMONG COLLEGE STUDENTS: A CORRELATIONAL STUDY by Sammi Leong Sing Yee

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paper text:

Darby, 2017, lordosis are curves that are concave posteriorly (convex anteriorly) while kyphosis are curves that are concave anteriorly (convex posteriorly). These organic shapes

6**have function to** disperse **mechanical stress** whilst at **rest movement. When viewed from** behind (**posteriorly), it** looks to be **vertically straight**

(Glassman et al., 2005). A particular spinal disease is defined as

6**any increase or** reduction **in the angulations of** the normal **curve or** any **deviation**

Dickson, 1996). Scoliosis is characterised by an abnormal deviation

6**between or within the vertebrae**, causing **an exaggerated curvature in the frontal plane. In**