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Effect of Body Mass Index on Core Stability and Balance in Young Adults: A Cross-Sectional Survey

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ABSTRACT
Background: Because of an unhealthy diet, obesity is leading in adolescents nowadays. However, a higher BMI can create various diseases or functional abnormalities. The negative consequences of higher BMI extend well beyond physiological aspects obese individuals are less efficient and greater at risk for injury than normal-weight individuals in a larger number of work-related tasks and daily activities that involve upright standing positions.
Aim: This present study aims to evaluate the effect of Body Mass Index on Core Stability and Dynamic Balance in young adults of Anand District.
Materials and Methods: A total number of 198 adolescents were screened by taking their BMI-containing measurements of height and weight. Among this total of 60 participants were extracted and further assessed for core stability and balance using reliable tools such as star tape, yoga mat, stopwatch, and measure tape. The prone Plank Rating Score was used to analyze core stability. SEBT was used to check the balance in every direction. It was factorial analysis therefore participants who failed to perform SEBT were also included in the result.
Results and Discussion: Statistical analysis of the study was done using SPSS version 29 software. The data was entered into the computer using a Microsoft Excel sheet, tabulated, and subjected to statistical analysis. The Mean and SD values for different variables like age were 21 ± 1.60 years, and BMI was 26.27 ± 3.00. Balance was assessed by SEBT right and left in every direction. Core stability was analyzed using Prone Plank mean 50.87 ± 40.11. The association between all these values was analyzed using Spearman's correlation method and found weakly negative and weakly positive correlations.
Conclusion: The current study concludes that higher BMI can affect balance and core stability. However, the associations are weakly negative for each other.

Keywords: Obesity, BMI, Core stability, Balance

CHAPTER 1:
INTRODUCTION

A condition, known as obesity is defined by a body mass index (BMI) where an excess of body fat has collected to the point where it may be harmful to health.[1] The Latin word obese, which itself is a compound of the terms ob, and here, which indicates to consume and eat away, is where the word obesity originated.[2] It causes severe disability and a reduced quality of life and is linked to several musculoskeletal disorders, including osteoporosis, low back pain, osteoarthritis, soft tissue complaints, and abnormalities in gait.[3] Dietary consumption, exercise habits, metabolism, family history, and physical activity are all contributing factors to obesity, the two most common reasons are inactivity and a diet high in calories.[4]

The burden of obesity is widely known for its impact on health from a physiological aspect. For instance, there are associations with diseases such as type 2 diabetes, coronary heart disease, pulmonary dysfunction, musculoskeletal disease, cancer, and many others—the negative consequences of obesity. However, extends well beyond these physiological aspects. For instance, when compared to healthy-weight people, the chances of suffering from a fall-related injury requiring medical treatments are 15 to 79 % higher for overweight individuals, and injuries such as sprains, strains, and dislocations are more often due to falls.[5] The rise in overweight and obesity prevalence in developing nations such as India has been correlated with changes in the population and epidemiology, such as a decrease in mortality and fertility and an increase in diseases connected to lifestyle choices. According to a study on worldwide trends, by 2030, 5.0% of Indians will be obese, and 27.8% of the population will be overweight. According to another study, by 2030, 20% of adults in rural India are expected to be overweight or obese.[6]

Despite its simplicity, the body mass index (BMI) is the most commonly used anthropometric parameter. Because Asian populations differ structurally from Western populations, there is disagreement over the appropriate BMI classification for Asian populations. Reduced BMI cut-off points have been suggested by the International Obesity Task Force to define overweight and obesity in the Asian population.[7] According to earlier estimates, there are more than 300 million obese persons in the world. According to data from the World Health Organization (WHO), 39% of men and 40% of women worldwide, or around 1.9 billion persons aged 18 and over, were overweight in 2016.[8] Overweight and obesity are the sixth most common risk factors for mortality worldwide, accounting for over 2.8 million deaths per year. [9]

Not only is the prevalence of obesity high, but it is also rising. Adult obesity rates more than increased by fourfold from 15% to 31% between 1980 and 2000. The correlation between fat and a higher risk of falls and ensuing injuries is one of the several issues raised by the high and rising incidence of obesity. When compared to non-obese persons, obese people fall almost twice as frequently (27% vs. 15%), and falls are the most common (36%) cause of injuries in the obese. It can be assumed that obese people have a worse capacity to regain their balance following a postural perturbation based on the higher risk of falls associated with obesity and the observation that most falls are caused by some form of postural disturbance.[10] Apart from a higher overall mortality rate, those who are fat are more likely to experience mobility limitations. The inability to carry out these fundamental physical duties limits one's ability to maintain strength and mobility and to carry out daily activities.[11]

The detrimental effects of a higher BMI go far beyond physiological factors; obese people are less productive and more likely to sustain injuries in many work-related tasks and daily activities that require standing up straight for extended periods than people of normal weight.[12] The body's capacity to regulate the trunk in response to both internal and external disruptions, including forces produced by distant body components as well as from expected or sudden disruptions. It has not been investigated how CS and different BMIs relate, although the fact that CS training is widely used. Still, it's well acknowledged that Walking and standing body balance performance can be affected by both CS and BMI.[13] The center of gravity (COG), or the anatomical site where movement originates, is found in the human core, making it a crucial region.[14]

The "core" has been compared to a box, with the diaphragm acting as the roof, the pelvic floor and pelvic girdle musculature as the bottom, the abdominals in the front, the paraspinal and glutes in the rear, and the hip abductors and trunk rotators positioned laterally. The terms "lumbar stabilization" and "lumbopelvic stabilization" are also frequently used to describe core stability. The muscle control necessary to preserve functional ability in the lumbopelvic hip area is described by all of these concepts. [15] The lower and upper extremities are biomechanically created and connected to the core via a kinetic chain. In all kinds of physical activity, it maximizes the production of force and reduces joint tensions for both athletes and normal individuals.[16] The axial skeleton, which comprises the pelvic and shoulder girdles, as well as all soft tissues (such as ligaments, tendons, articular and fibro-cartilage, regardless of whether the soft tissue ends on the axial or appendicular skeleton (upper and lower extremities), muscles, and fascia) with a proximal attachment starting on the axial skeleton.[15]

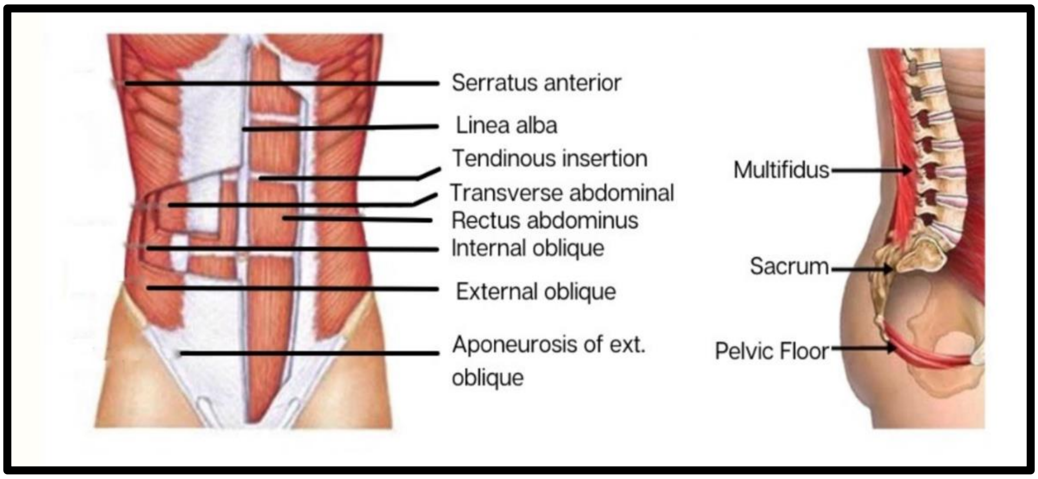


Fig.1.1 Muscles of Core

According to some research, body mass index (BMI) and dynamic balance have a strong connection, with overweight students showing inadequate dynamic balance compared to children with normal BMI.[18] The process of regulating the body's center of gravity within its support base has been dubbed balance, and it requires regular modifications due to alterations to joint alignment and muscle activity.[19] From a neuro-physiological, biomechanical, and functional standpoint, balance control can be studied. Additionally, the ability to stabilize the core better accounts for the vertebral segments' greater optimal control.[20] Obesity affects the biomechanics of daily activities and changes the shape of the body by adding mass to certain areas. Multifidus, Transverse Abdominis, External and Internal Oblique, Rectus Abdominis, Para Spinalis, Gluteus, Hip muscles, and in rare instances, the diaphragm are instances of core muscles.[21]

Trunk flexion is primarily produced by the rectus abdominis. However, lateral trunk flexion is also produced by the internal and external oblique muscles. Furthermore, ipsilateral and contralateral trunk rotation are produced by the internal and external oblique muscles, respectively. Among the abdominal muscles, the transversus abdominis is arguably the most significant since it produces a significant rise in intraabdominal pressure and offers the highest level of lumbopelvic hip complex (LPHC) stability during dynamic movement. Furthermore, it has been documented that the transversus abdominis tightens before the commencement of limb movement, much like the multifidus muscle of the transverse spinal group.[22] Core stability is achieved through the stabilization of one's torso, thus allowing optimal production, transfer, and control of force and motion to the terminal segment during an integrated kinetic chain activity.[23]

Core stability is dependent on the lumbopelvic musculature, which applies compressive stresses on the spine. High BMI can have negative consequences on core stability. Additionally, it restores the body's balance following a disturbance. It involves the use of balance, power, endurance, and core strength along with the coordination of the hip, abdominal, and spinal muscles.[24] Three systems—neuro control, passive, and active systems—support and regulate spine stability. The neural system includes muscle, ligament, and tendon motion and force, as well as the neural control center. The mechanical passive features of the intervertebral discs, skeletal muscles, spinal ligaments, joint capsules, vertebrae, and facet articulations are all part of the passive system. The dynamic forces of the skeletal muscles and their tendons, which are working on the spinal column, make up the active system.[25]

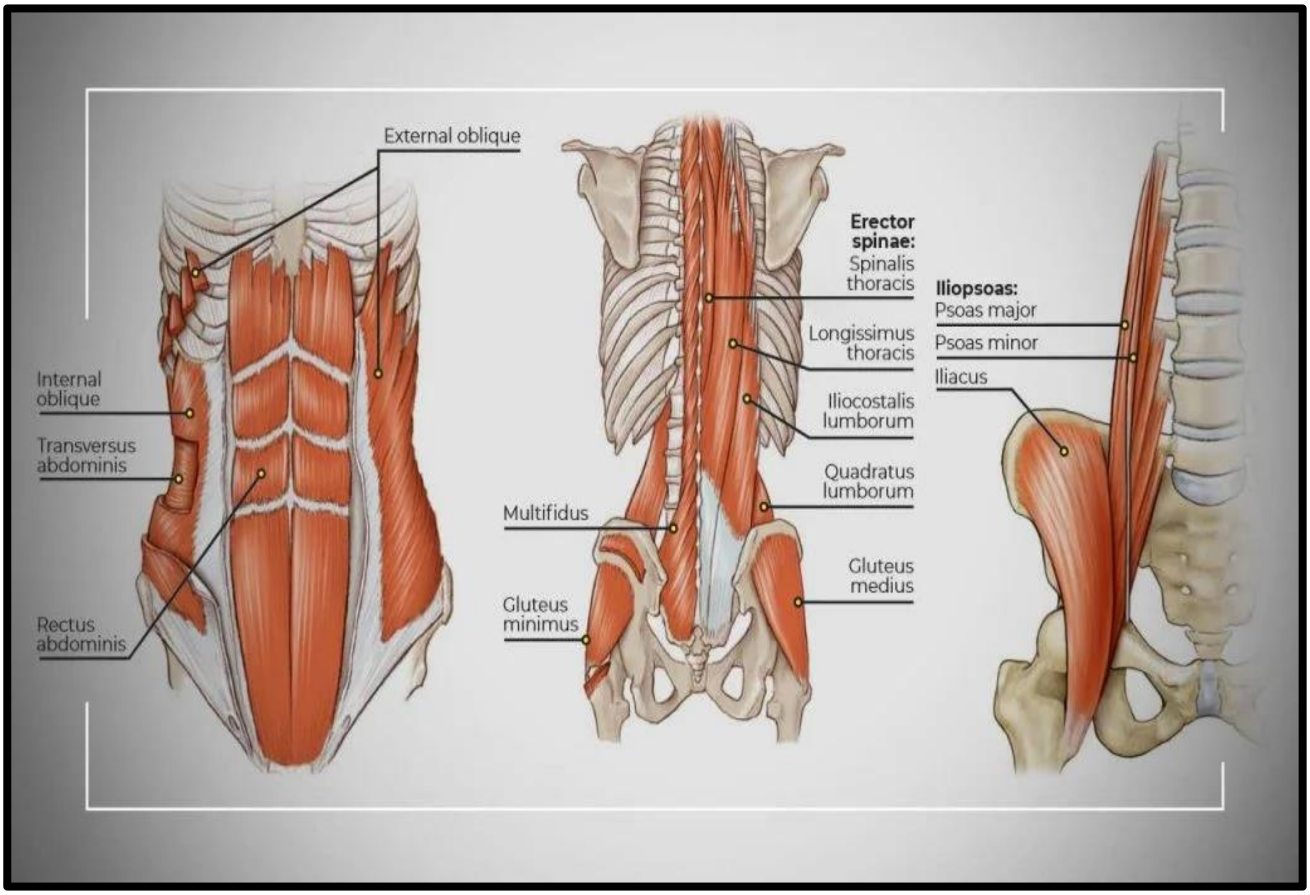


Fig.1.2 Deep Core Muscles

The prone bridge technique is considered essential for assessing trunk muscles. It requires keeping the hips and back neutral and being prone on the forearms and toes. It has been found that this position is effective in stimulating the muscles of the core.[26]

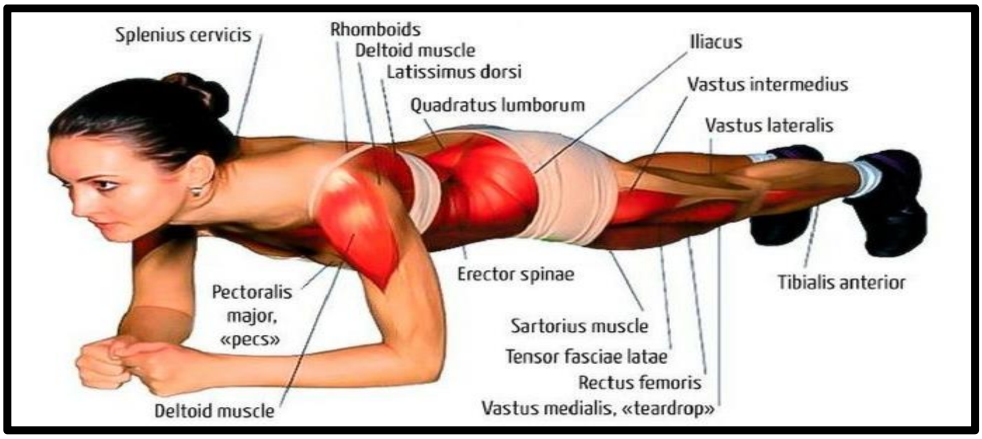


Fig.1.3 Muscles activated in Prone Plank

Core stability is seen as a crucial component of such fundamental movement patterns as joint stability, proprioception, mobility, strength, and neuromuscular control. A person's awareness of their limb positioning is referred to as proprioception in part. This awareness is often assessed using active and passive joint position sensations. Proprioceptors, also known as mechanoreceptors, are present in the facet joints, spinal ligaments, paraspinal muscles, and intervertebral discs of the spine. The paraspinal muscles' muscle spindles are in charge of keeping an eye on the position and movement of the trunk, particularly in the midrange. Any proprioceptive deficiency is expected to harm the quality of motion as developing motion patterns requires monitoring trunk motion.[27]

An imbalance between the energy consumed from food and the energy exerted is the etiology or cause of obesity. The extra energy is stored in fat cells, which grow larger and/or multiply. It's the pathological lesion associated with obesity is the hyperplasia or hypertrophy of fat cells. The increased release of free fatty acids and other peptides from enlarged fat cells, as well as the weight of excess fat, are the two main causes of the clinical issues linked to obesity. Muscle weakness is a result of obesity, which is an outcome of insufficient physical activity as well as indirectly muscles at the bottom, the paraspinals and gluteus muscles at the back, and the abdominals in front.[28]

When all forces acting on the body are zero, or the net force, the state of equilibrium is called balance.[29] Postural stability is influenced by weight, although it is unclear if the gender differences in fat distribution in men and women have an impact on balance.[30] When the human body is viewed in a static position, such as an inverted pendulum; these postural changes may be connected to shifting the center of gravity, which causes changes in the equilibrium of individuals as their bodies adapt to changes in their center of gravity, either consciously or unconsciously, to maintain it within its support core.[31]

The spine is shielded by the feed-forward action of the core muscles from excessive motion and compressive stresses brought on by outside stimuli. Without strong core muscles, the body can no longer stabilize itself while doing an activity. Insufficient core muscle function can result in the spine being overstressed, which can cause lower back pain, lower back injuries, and lower extremities injuries.[32]

The ability to return the body to a point of equilibrium after experiencing a disturbance is known as postural stability and balance, and it is essential for performing particular task different activities of daily life. Increased postural sway can eventually result in falls and is a common effect of aging and certain diseases.[33] As with the later stages of pregnancy [34] excess body weight has an impact on posture linearly as body mass index (BMI) rises.[35,36] This includes a forward shift in the center of gravity, an increase in lumbar lordosis along with a pelvic forward tilt, and a pronounced dorsal kyphosis and secondary cervical lordosis.[37,38] More forward displacement of the Centre of pressure during dynamic standing balancing activities has been specifically linked to obesity.[39] The negative consequences of obesity, however, extend well beyond these physiological aspects. when compared to healthy-weight people, the chances of suffering from a fall-related injury requiring medical treatments are 15 to 79 % higher for overweight individuals [40], and injuries such as sprains, strains, and dislocations are more often due to falls. [41]

Obese people also frequently demonstrate abnormal postures. Increased body weight and mass change how the limbs and overall body create and respond to forces. Furthermore, excessive weight alters the musculoskeletal system, which is crucial for functional ability and postural balance. This adjustment has special significance since it greatly raises the amount of ankle torque needed to maintain the body in the upright position when the Center of Mass (COM) is moved anteriorly. Because it shifts the line of gravity closer to the body's base of support (BOS), an anterior shift in whole body COM also jeopardizes stability. Another crucial component of functional movement is range of motion (ROM). The ability to sustain and regain equilibrium may be impacted by the trunk and lower limbs' joint range of motion capacity, particularly when the disturbance's amplitude increases. This is particularly important for obese people, for whom recovering from large amplitude disturbances may pose the most challenge to their equilibrium. Deficits in balance in the elderly are closely linked to overweight, central obesity, and total muscle fitness. In a variety of both static and dynamic balance field tests, BMI is a key performance factor.[42] Additionally, obesity raises the number of attentional resources required to keep one's posture stable. When people are expected to maintain stability during distraction, like when multitasking during daily activities, this could result in poor balance.[43]

At 40 years of age, age-related impairments in balance have been seen. Women between the ages of 40 and 60 experience the greatest loss in medial-lateral balance. Women start to lose strength in their hips and quadriceps as well as their somatosensory perception before the age of fifty. Tests of dynamic balance have been developed to forecast fall risk, mostly in older adults. To identify those who are at risk of falling, balance assessments should be credible, dependable, and simple. College-aged individuals who participate in sports and recreational activities have been subjected to the dynamic single-limb balance test known as the **Star Excursion Balance Test (SEBT).** According to studies, dynamic balance declines with aging.[44]

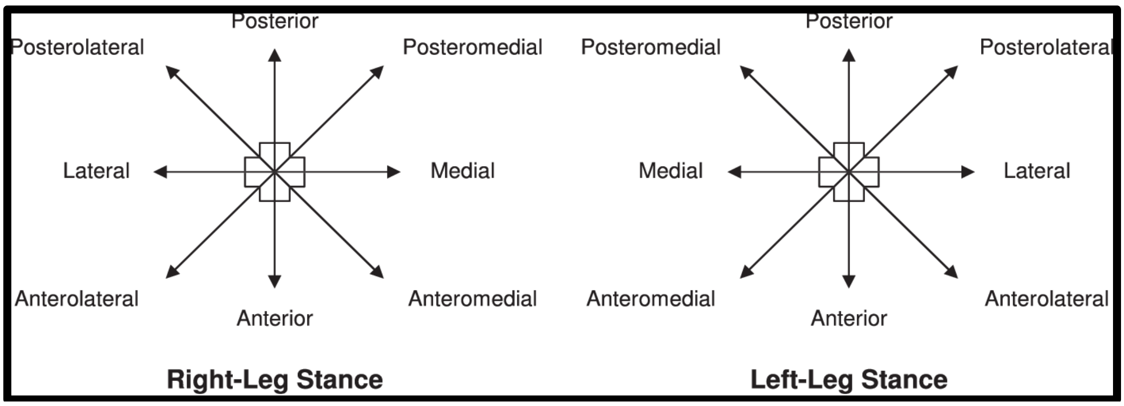


Fig: 1.4 Star Balance Excursion Test

Gait abnormalities brought on by obesity are linked to a higher risk of falls. Numerous studies have revealed that obese people have much lower walking speeds, step lengths, and step frequencies than non-obese people. In addition, obese people have longer stance phases and longer periods of double support.[45] When paired with low muscular mass, adipose tissue buildup, and body mass increases can lead to a decrease in body balance and a major risk factor for falls. This can result in the biomechanical failure of muscular responses and the loss of stability mechanisms.[45]

Most medical professionals are focusing their study on assessing the dynamic stability of lower limb joints to better understand how the body maintains joint stability during a variety of activities or how common mechanisms of injury occur. However, because exercise and sports performance are dynamic, it is now necessary to evaluate postural stability using sensitive, economical tests that yield accurate results while optimally testing the dynamic stability of the joints. The Star Excursion Balance Test (SEBT), a star-shaped functional task that requires single-leg squats while reaching as far as possible with the non-stance limb along each of eight designated lines on the ground spaced 45° apart, is a popular clinical and research testing tool used primarily in sports. According to **Gray** (1995), this test was designed to challenge body equilibrium dynamically as a rehabilitative activity. The result of the SEBT performance was determined by the participant's limb's reaching distance in the following directions: anterolateral (AL), anterior (A), anteromedial (AM), medial (M), posteromedial (PM), posterior (P), posterolateral (PL), lateral (L), and so on. During the test, the participant avoided movements that were deemed to be errors, such as failing to return to the starting position after reaching. The distance reached in each direction during the SEBT was a measure of the neuromuscular control; a greater distance reached indicated a more dynamic postural control, whereas shorter reaching distances were usually linked to mechanical or sensorimotor system limitations. Few studies have been conducted to date on the position that muscle activation plays in maintaining neuromuscular control during SEBT in the healthy population.[46]

To pass the test, candidates must be able to manipulate the opposing limb while maintaining balance on the stance leg. As the opposing leg stretches along a line in the designated direction, the stance leg moves in a closed kinetic chain, causing motion at the ankle, knee, and hip joints. To make sure that the leg is not being used for support, the person hits the line with the furthest part of their foot, using as little force as possible. The person returns to a bilateral stance while keeping their balance after measuring the reach distance. This test is an effective clinical indicator of functional performance after injury because it puts the body's postural control system to the test by moving the center of mass concerning the base of support.[47]

The number of tests for assessing dynamic balance is relatively low, compared to the numerous outcome measures for assessing balance. The Star Excursion Balance Test evaluates the dynamic balance of the lower limb in a quick, easy-to-administer, and inexpensive manner.[48] There is a correlation between poor balance and ligament damage risk. Improving it lessens these issues, and optimizing coordination processes also has a positive impact on how well teenage soccer players do on balance tests. Exercises for building balance involve strengthening the sensory and motor abilities necessary for optimal performance. Balance is crucial for accurate technical executions in sports, such as soccer, and it also plays a part in injury prevention. However, by developing regular mobility patterns at home and at school, young people with vision and hearing impairments can attain well-being and pave the road for resilience. The physical fragility of the obese elderly is evident; it is linked to reduced walking speed and greater body balance in orthostatism, poor muscle effectiveness, limited physical training, lack of strength, and impaired sensory function. Additionally, the amount of PA (Physical Activity) affects postural control.[49]

1.1 NEED FOR THE STUDY:

- Among young adults, obesity reduces motor skills as well as verbal and social skills and daily life activities such as standing and walking.
- Proper dynamic balance control is a key aspect of locomotion of an individual and activities of daily living. A person's body weight has a prediction over his postural stability. Body Mass Index is an important variable that must be considered during lower limb rehabilitation.
- Core stability is believed to serve as a muscular corset that works as a unit to stabilize the body and spine with and without limb movements and it has a direct effect on obesity.
- Hence, there is a need to study the correlation of body mass index with foot posture, core stability, and balance in the young adult population.

1.2 AIM OF THE STUDY:

This present study aims to evaluate the effect of Body Mass Index on Core Stability and Balance in young adults of Anand District.

1.3 OBJECTIVE OF THE STUDY

- To determine the effect of Body Mass Index on Core Stability.
- To determine the effect of Body Mass Index on Dynamic Balance.
- To evaluate the effect of Body Mass Index on Core Stability and Dynamic Balance in young adults.

CHAPTER: 2

REVIEW OF LITERATURE

- **Effect of Obesity on Core Stability:**

Sami S. AlAbdulwahab and Shaji John Kachanathu (2016) conducted a study on the **effect of Body mass index on foot posture alignment, and core stability in a healthy young adult population**. They recruited 39 young adults and found that there was a significant association between BMI FPI and CS in healthy subjects.

Paul A. Butterworth and Anita E. Wluka (2014) conducted a study on **Foot posture, range of motion, and plantar pressure characteristics in obese and non-obese individuals.** They recruited 69 participants and found that obesity increases the stresses applied to the foot directly through increased body weight, and indirectly via alterations to foot structure, which may partly explain the link between obesity and the development of foot pain.

- **Effect of Core stability on Dynamic Balance:**

Annamma Varghese, (2014) conducted a study **on The Effect Of Core Stability Training On Dynamic Balance In Healthy Young Adults in a Randomized Control Trial.** The results of the study revealed the presence of significant improvement in core stability and dynamic balance in the experimental group following the core stability training program. For all the directions, normalized maximum excursion distances increased significantly in the experimental group. This improvement in reach distance verifies the positive effect of core stability training on dynamic balance.

- **Effect of Obesity on Balance:**

APARNA SARKAR and SEEMA KAPOOR (2011) conducted a study on the **Effects of Obesity on Balance and Gait Alterations in Young Adults**. They recruited 60 participants and they found that the balance in the obese individuals of both genders was poorer than that of non-obese in the same age group as well as the increased body mass seems to produce Postural Instability in both genders.

Sertel, Meral PT, PhD; Tülay PT, PhD; Eylem PT, PhD (2017) conducted a study on the **Effects of Body Mass Index on Balance, mobility, and Functional Capacity in Older Adults.** They recruited 149 older people and that increased weight in older adults affects balance and mobility; obesity would lead to impaired balance and an increase in associated problems.

HANNAH C. DEL PORTO, CELIA M. PECHAK, DARLA R. SMITH, and REBECCA J. REED-JONES conducted the study on **Biomechanical Effects of Obesity on Balance.** They analyzed the literature-related effect of Obesity on balance and they found a correlation between obesity and balance.

Julia Greve; Angelica Alonso; Ana Carolina P.G. Bordini; and Gilberto Luis Camanho conducted a study on **the correlation between body mass index and postural balance.** They recruited 40 males, age 26 ± 5 years, body mass 72.3 ± 11 kg, height 176 ± 6 cm, and BMI 23.3 ± 3.2 kg/m² were submitted to functional stability tests using the Biodex Balance System to compare stability with BMI. They found that High BMI demands more displacements to maintain postural balance.

George Danut Mocanu and **Gabriel Murariu** conducted a study on **The Association of Gender and Body Mass Index on the Values of Static and Dynamic Balance of University Students (A Cross-Sectional Design Study)**. The investigated group consists of 195 undergraduate students, from various specializations (99 males and 96 females, ages = 20.16 ± 1.98, BMI = 24.15 ± 5.68). The independent variables gender and BMI levels (underweight, normal weight, and overweight/obese) were defined. The participants were evaluated using a series of 7 tests: one leg standing test with eyes closed, stork test, flamingo test, Bass test, functional reach test, walk and turn field sobriety test, and Fukuda test. The analysis of Spearman correlation coefficients indicates several significant associations between elevated BMI values and decreased performance on balance tests. The BMI step comparison confirms the difficulties of the overweight group in assessing balance, with the lowest scores in maintaining static positions and the most errors in dynamic balance tests, with significant differences from normal and underweight in most tests ($p < 0.05$).

Lucinda E. Bouillon, PT, Ph.D., Joshua L. Baker, PT, Ph.D. conducted a study on **Dynamic Balance Differences as Measured by the Star Excursion Balance Test Between Adult-aged and Middle-aged Women.** They recruited Fifty-three healthy, recreationally active women and Each participant performed 3 reaches for 3 trials (anteromedial, medial, and posteromedial) in a randomized order. The 3 reach trials were converted to a normalized value (percentage of participant's height) and assessed as an overall mean for the 1-way analysis of variance. Lower postural control scores based on the Star Excursion Balance Test were found for the older women as well and the younger women were able to reach approximately 7 cm farther during the anterior, anteromedial, and posteromedial excursions.

- **Effect of obesity on Star Excursion Balance Test:**

Lucinda E. Bouillon, PT, PhD, and Joshua L. Baker, PT, PhD conducted the study on **Dynamic Balance Differences as Measured by the Star Excursion Balance Test Between Adult-aged and Middle-aged Women**. They recruited 35 women subjects and they found lower postural control scores in older women and younger women were able to reach approximately 7 cm of excursions.

Daniel Waddington, Jade Warren, and David Diep (2015) conducted a study on **the effect of body mass on the performance of the Star Excursion Balance Test (SEBT).** They recruited 28 subjects and found that it is effective in detecting reach deficits related to increased body mass; as applied by gender-specific empathy suits. This indicates its potential use as a clinical tool to quantify dynamic balance ability**.**

- **Validity and reliability of Prone Bridge Test:**

Richard W. Bohannon and Michal Steff (2017) conducted a study on **The prone bridge test: Performance, validity, and reliability among older and younger adults.** They recruited 60 younger and 60 older subjects and found that the Prone Bridge Test activates core musculature and can be used as an alternative to curl-ups for younger individuals as well as it is a valid and reliable assessment for both younger and older individuals.

CHAPTER: 3

MATERIALS AND METHODOLOGY

STUDY DESIGN: Cross-Sectional Study

STUDY SETTING: This study was conducted in Anand district for young adults whose ages are between 18-25 years.

SAMPLE SIZE: The sample size of the study was 60 subjects.

STUDY POPULATION: Young Adult Population of age group 18 – 25 years.

SAMPLING METHOD: Convenient Sampling Method

CRITERIA FOR SELECTION:

- **Inclusion criteria:**

1. 18-25 years of age
2. Voluntarily participation
3. Body Mass Index: ≥ 23 kg/m^2

- **Exclusion criteria:**

The following symptoms present during the past 6 months

- Foot Pain
- Plantar Fasciitis
- Low Back Pain
- Trauma
- Limb Length Discrepancy
- Any Lower Limb Surgery
- Having any Neurological, Psychological, Musculoskeletal, and Cardiovascular Disorders.

MATERIAL USED IN THE STUDY:

1. Pen, Consent Form
2. Yoga Mat
3. Paper
4. Marker
5. Star Balance Tape
6. Measure tap
7. Data Record Sheet
8. Weighing Machine

9. Stop Watch
10. Stadiometer

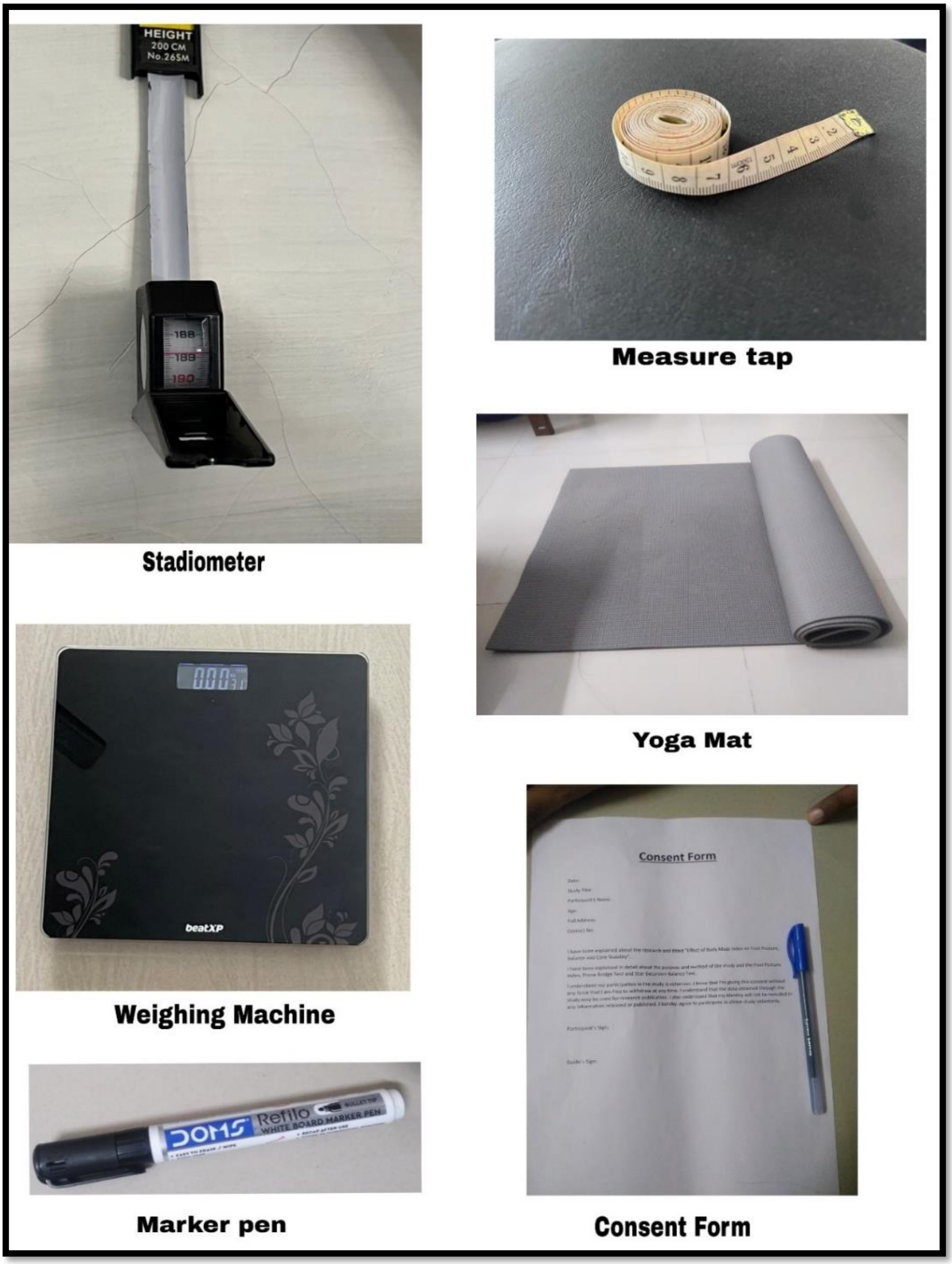


Fig.3.1 Objectives- Stadiometer, measure tap, Yoga Mat, Weighing Machine, Consent Form, Marker Pen

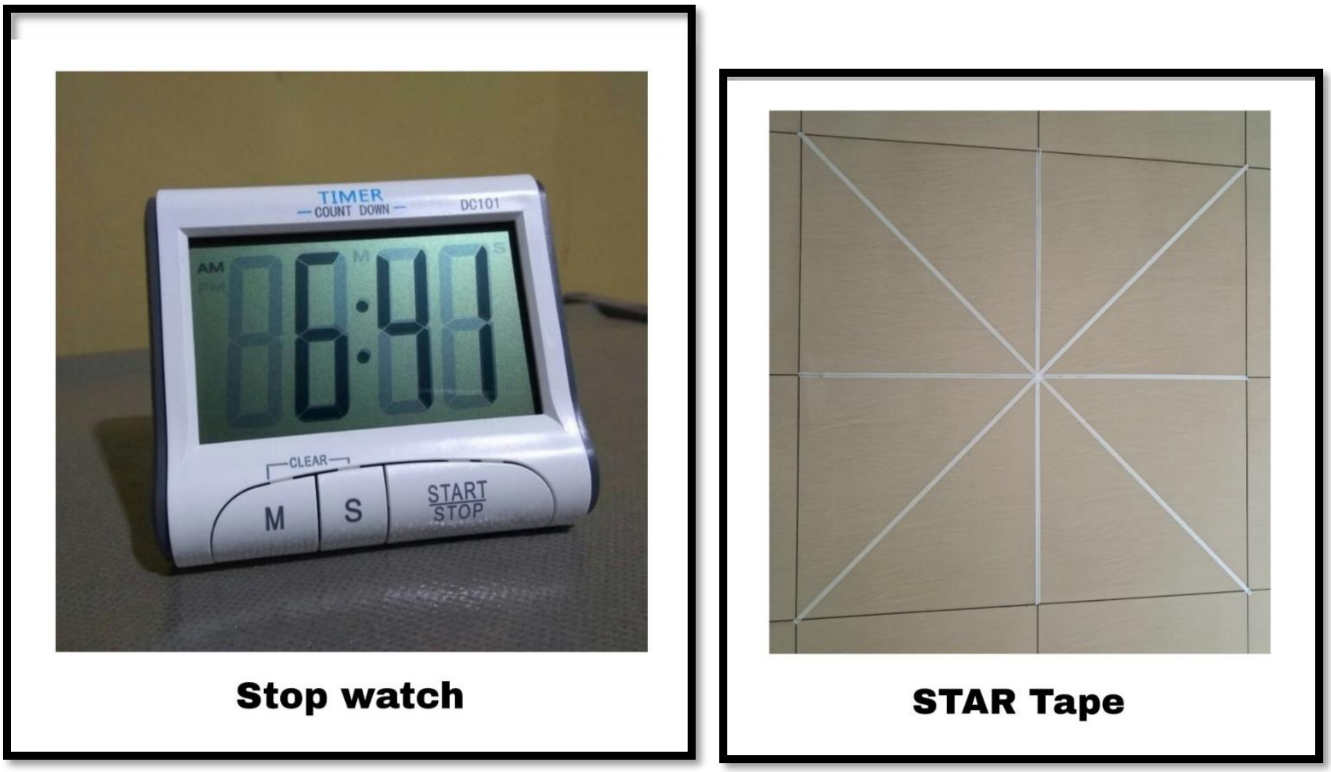
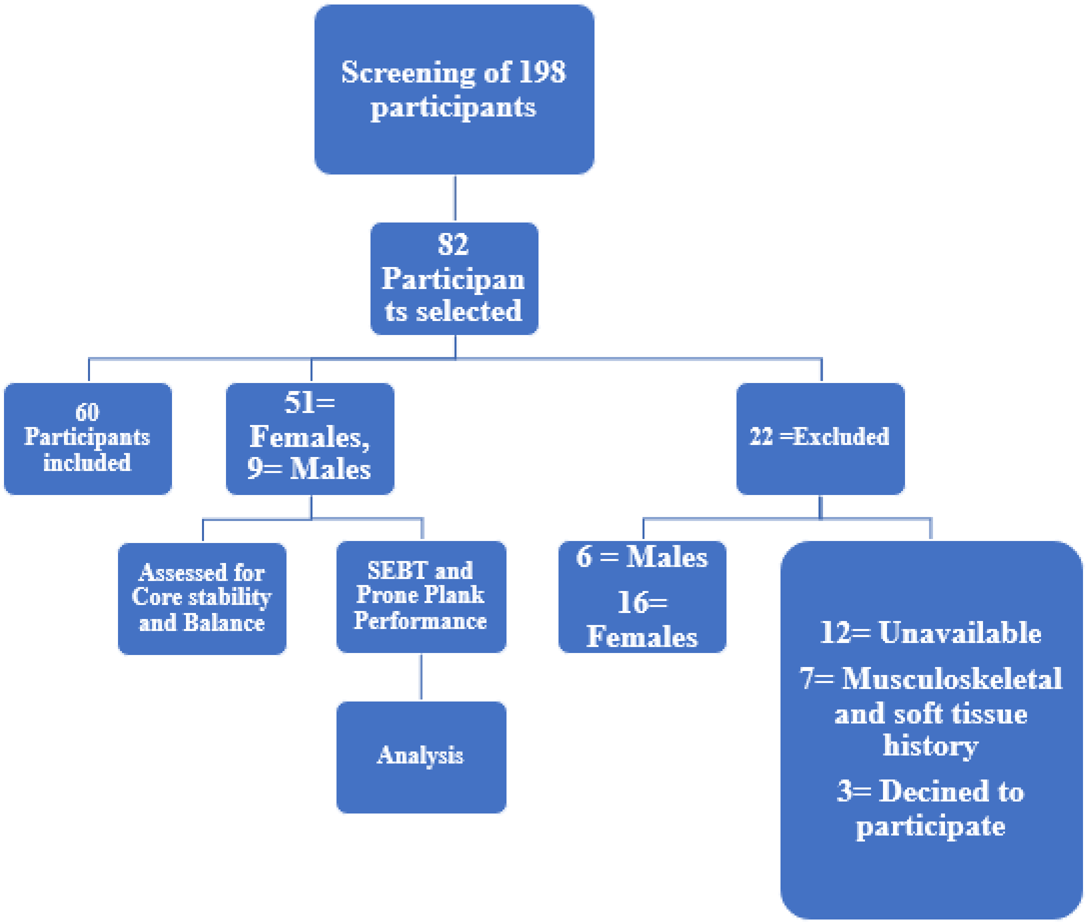


Fig.3.2 Objectives- STAR Tape and Stop Watch

PROCEDURE:

A group of individuals from Anand City, ages 18 to 25, were chosen as the participants, and they were informed about the study's whole approach. Subsequently, informed consent was obtained to engage in the study willingly. The Body Mass Index test was completed by 198 adult participants in total. Asian BMI classification was used to determine the subject's obesity class. Participants were chosen based on their BMI, which ranged from 23 kg/m^2 to 30 kg/m^2 or more. Eighty-two of these were chosen for additional research. Twenty-two of them were eliminated for various reasons. The Prone Plank Test and SEBT were then used to evaluate the core stability and balance of the final 60 participants. Each subject completed the Prone Plank Test three times, and the average hold time was recorded for analysis. A factorial analysis has been conducted in SEBT. Every SEBT direction was applied to the lower limbs. The study covered successful attempts in every direction, and analysis was conducted in accordance with that information by the SEBT formula. This entire test has only been taken once.



OUTCOME MEASURES:

1) Body Mass Index
2) Prone Plank Test
3) Star Excursion Balance Test

1) BODY MASS INDEX

Purpose: To measure the weight category of the subject

Equipment: Weigh Machine, Stadiometer, Data Record Sheet

Procedure:

The subject was supported by a wall and measured for height and weight using a stadiometer. According to it, the BMI formula (BMI= Height^2 / Weight) was used by therapists to measure weight categories. Subjects were divided into the Asian Class of BMI category.

Table 3.1: ASIAN Classification of Body Mass Index:

Class	Weight Category
Underweight	< 18.5 kg/m^2
Normal weight	18.5 -22.9 kg/m
Overweight	23-24.9 kg/m^2
Obesity class I	25-29.9 kg/m^2
Obesity class II	≥ 30.0 kg/m^2

2) PRONE PLANK TEST

Purpose: To evaluate the strength of core muscles

Equipment: Stopwatch, Yoga mat, Record sheet

Procedure:

The participant was instructed to lie on their back and elevate their body while supporting themselves with both elbows (supine, hook-lying position, lower extremity natural body alignment, lumbar spine, and pelvis neutral). A stopwatch was set to record the time when the subject took the entire position and to stop when the subject terminated the test. This test was done three times, and the hold time average was calculated.

Table 3.2: Interpretation for prone plank test:

Rating	Time
Excellent	> 6 minutes
Very Good	4-6 minutes
Above Average	2-4 minutes
Average	1-2 minutes
Below Average	30-60 seconds
Poor	15-30 seconds
Very Poor	< 15 seconds

Prone Plank Test

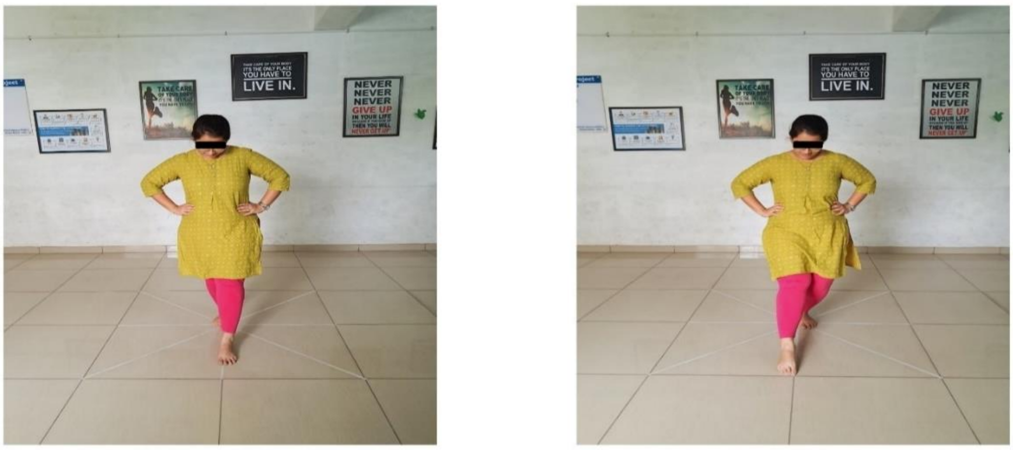
Prone Plank Test

Fig 3.3 Prone Plank Test

3) STAR EXCURSION BALANCE TEST

Purpose: To evaluate the dynamic balance of the lower limb
Equipment: Marker pen, Measure Tape, Record Sheet, SEBT Tapes
Procedure:

1. The participant took off their shoes. They were then told to stand in the middle of the star and wait for more instructions. The athlete should finish the circuit in a clockwise manner, using the left leg for balance and the right foot as the reaching foot.
2. The person is encouraged to finish the circuit with their left leg in an anticlockwise direction when balancing on their right leg.
3. The athlete is then told to put both hands firmly on their hips, reach with one foot as far as they can, and lightly touch the line before coming back up to the beginning upright position.
4. The test administrator stated the location of the anticlockwise circuit performance with a pencil.
5. The athlete is then told to reach as far as they can with one foot and lightly touch the line, then to come back and touch the line with their toe while keeping their hands firmly planted on their hips.
6. After the test, this may be measured from the center point to figure out the reach distance for each reach direction.
7. The nearest 0.5 cm was selected to record reach distances.
8. Before switching feet, they did this again for each reach direction using the same foot.
9. They repeated this procedure thrice per leg after completing a full circle (every reach direction) with each foot.
10. The participant was allowed to leave the testing area after completing three successful reaches with each foot in all directions.
11. The reach distance of each successful attempt was noted by the test administrator using a pencil to determine the participant's SEBT score following the test.



Anterior (Left) **Anterior (Right)**

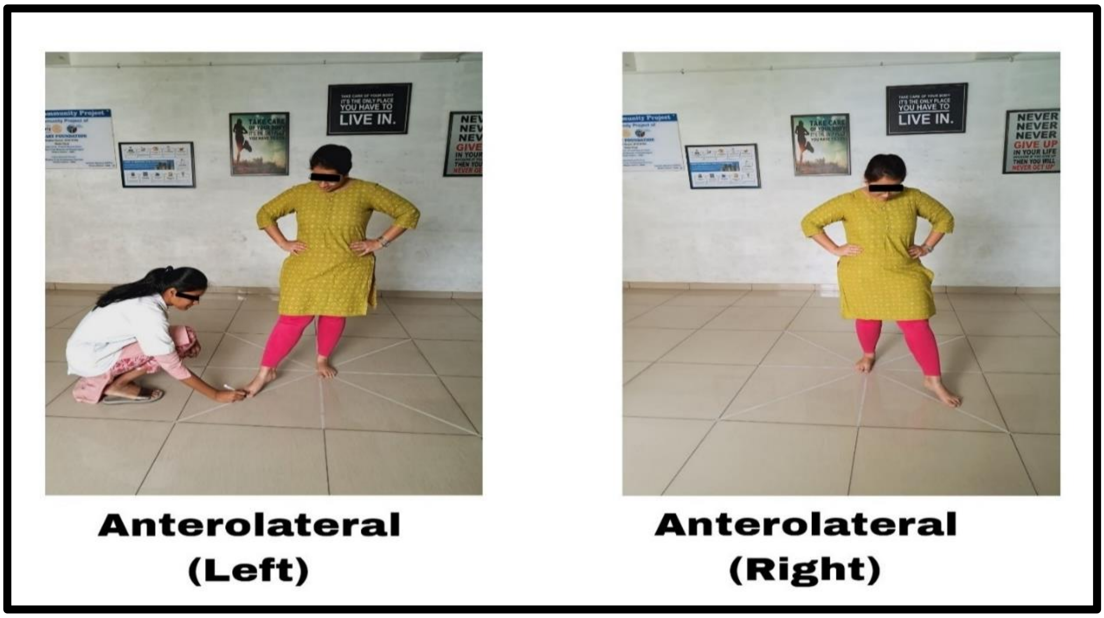


Fig.3.4 Anterior SEBT (Left and Right), Anterolateral (Right and Left)

Fig.3.5 Lateral SEBT (Right & Left), Posterolateral SEBT (Right & Left)

Fig. 3.6 Posterior SEBT (Left) and Posterolateral SEBT (Right)

Fig. 3.7 Medial SEBT (Left) and Anteromedial SEBT (Right)

Star Excursion Balance Test performance scores using the following equation:

- Average Distance in each Direction (cm) = Reach 1 + Reach 2 + reach 3 / 3

- Relative (normalised) Distance in Each Direction (%) = Average Distance in each Direction / leg length × 100

CHAPTER: 4
RESULT

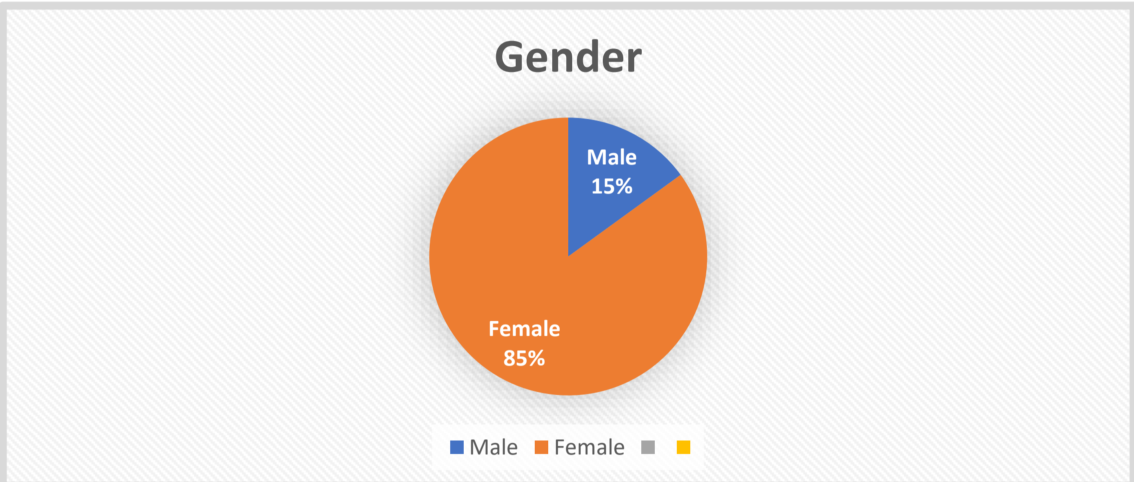
Statistical analysis of the study was done using SPSS version 29 software. The data was entered into the computer using a Microsoft Excel sheet, tabulated, and subjected to statistical analysis.

- Descriptive statistical analysis means (SD) and frequency (%) were used to depict the profile of the patient.
- Normal distribution was checked by SPSS and data was not normally distributed.
- To find out the correlation between Body Mass Index and Core Stability as well as Body Mass Index and Balance, Normal distribution has been checked first.
- Kolmogorov-Smirnov depicts that all variables do not follow a normal distribution as a p-value of all parameters less than 0.05.
- Therefore, **Spearman's rank** correlation was used to find a correlation of BMI with other variables (Balance and Prone Plank).

Table 5.1: Baseline Characteristics of Participants

Sr No.	**Characteristics**	**Values (MEAN & SD)**
1	No. Of participants	60 (N)
2	Mean Age	21 ± 1.60
3	Gender Male Female	60 (N) 9 51
4	BMI	26.47 ± 3.00
5	Height	159.13 ± 8.37
6	Weight	67.45 ± 10.42

Interpretation: The above-mentioned table shows Baseline characteristics of Participants where a total of 60 participants were selected after screening 198 young adults in the Anand district.



Graph 5.1: Gender Data Proportion

Table 5.2: Characteristics of Main Outcome Variables

Sr No.	Characteristics	Values (MEAN & SD)
1	BMI	26.47 ± 3.00
2	Average Prone Plank timing	50.87 ± 40.114
3	SEBT (Anterior right)	70.38 ± 9.755
4	SEBT (Anterolateral Right)	69.27 ± 14.729
5	SEBT (Lateral Right)	65.90 ± 15.843
6	SEBT (Posterolateral Right)	61.40 ± 19.485
7	SEBT (Posterior Right)	54.10±21.872
8	SEBT (Posteromedial Right)	43.97 ± 28.077
9	SEBT (Medial Right)	39.42 ± 30.376
10	SEBT (Anteromedial Right)	40.33 ± 33.975
11	SEBT (Anterior Left)	70.53 ± 10.820
12	SEBT (Anterolateral Left)	67.08 ± 16.583
13	SEBT (Lateral Left)	61.48 ± 19.125
14	SEBT (Posterolateral Left)	56.70 ± 22.161
15	SEBT (Posterior Left)	49.03 ±26.176
16	SEBT (Posteromedial Left)	39.92 ± 30.687
17	SEBT (Medial Left)	35.05 ± 32.439
18	SEBT (Anteromedial Left)	33.57± 35.677

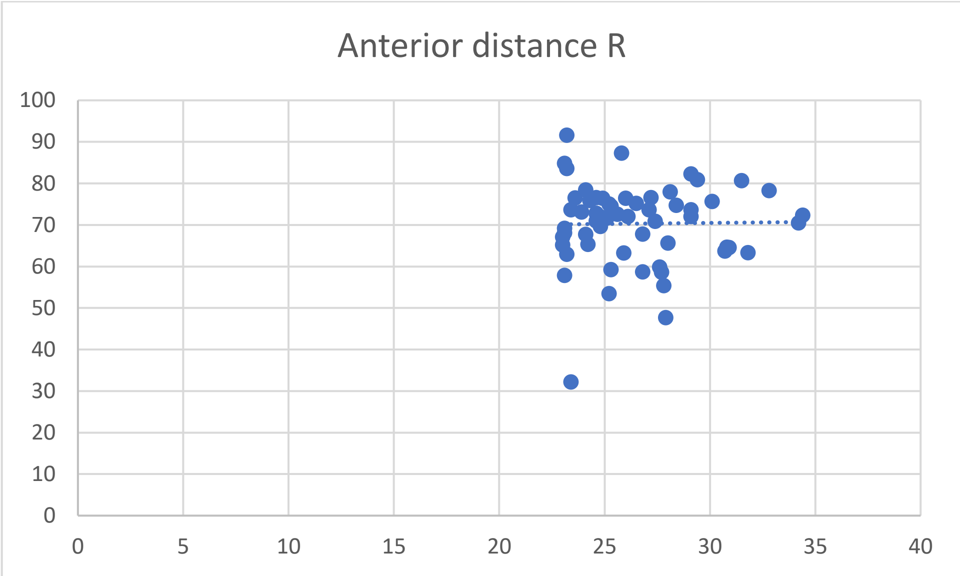
Interpretation: The above-mentioned table states the mean values of the main outcome variables assessed on participants. The Obesity class was decided through Body Mass Index during screening, whereas height was assessed by a stadiometer, and weight was assessed by a digital weighing machine. Dynamic balance was checked by the Star Excursion Balance Test. Core stability was assessed by the Prone Plank Test. The plank rating was given according to average hold timing.

Table 5.3: Correlation analysis between Body Mass Index and Anterior direction of SEBT Test

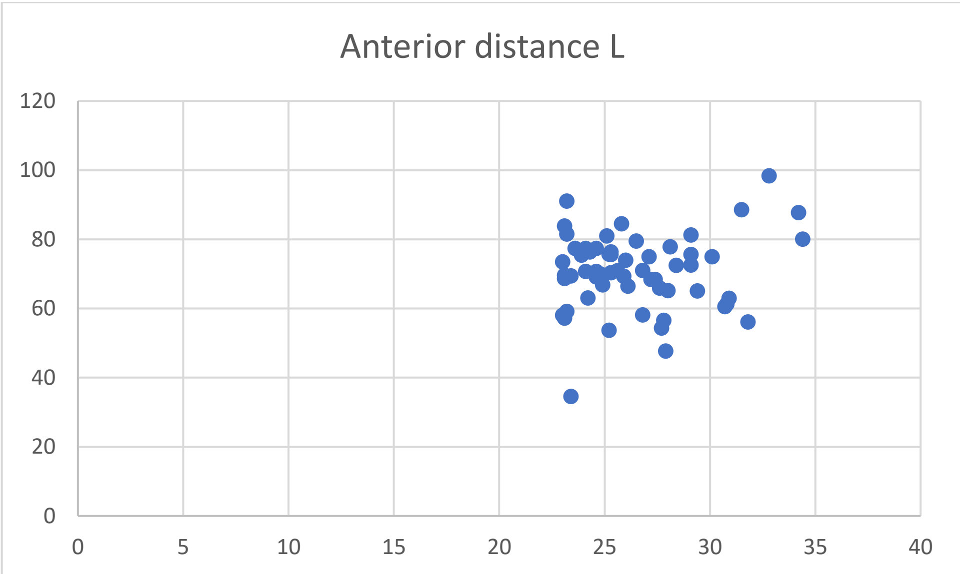
Variable	Body Mass Index		
	R	P	N
Anterior direction SEBT (Right)	**-0.010**	**0.940**	**60**
Anterior direction SEBT (Left)	**0.012**	**0.930**	**60**

(*P-value < 0.05=Statistically not Significant for both the sides)

Interpretation: The table above illustrates a very weak negative association between the Anterior direction of SEBT on the right side and Body Mass Index. Also, it shows a very weak positive association in the same direction for the left side with BMI. Spearman's Correlation analysis method was used with an assumption of P-value < 0.05, which is statistically not significant.



Graph 5.2 – Linear Regression between BMI and Anterior direction of SEBT (Right)



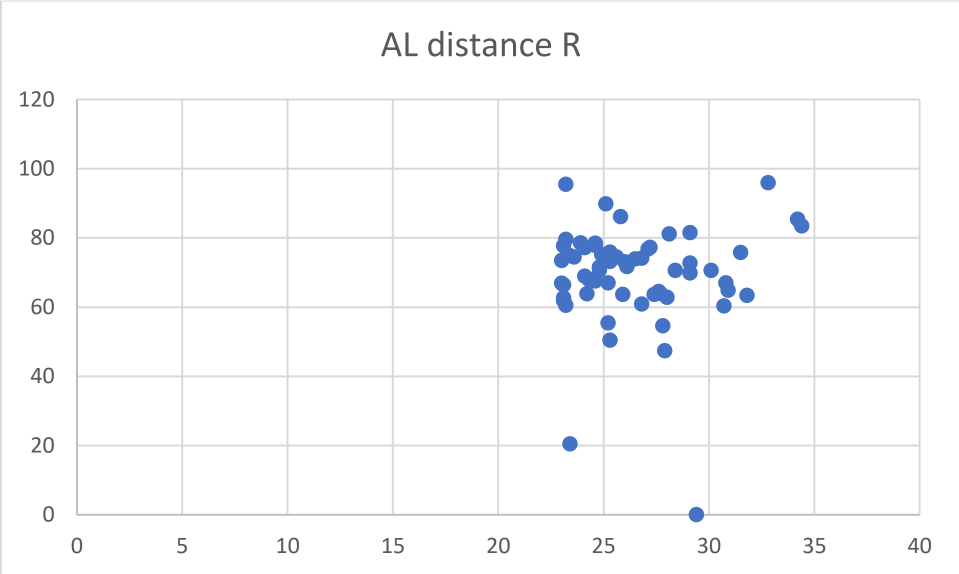
Graph 5.3 – Linear Regression between BMI and Anterior direction of SEBT (Left)

Table 5.4: Correlation analysis between Body Mass Index and Anterolateral direction of SEBT Test

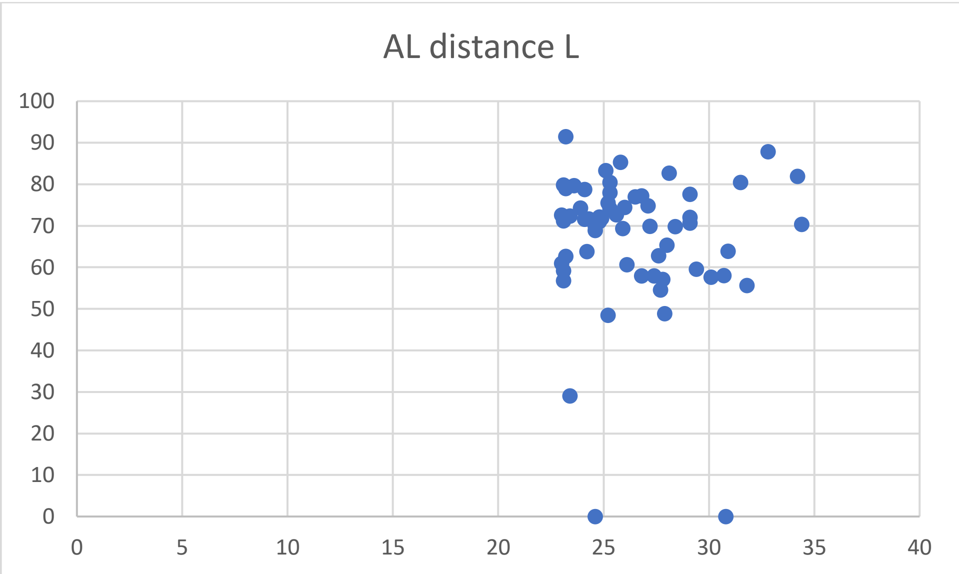
Variable	Body Mass Index		
	R	P	N
Anterolateral Direction SEBT (Right)	0.006	0.961	60
Anterolateral Direction SEBT (Left)	-0.117	0.375	60

(*P-value < 0.05=Statistically not Significant for both the sides)

Interpretation: The table above illustrates a very weak positive association between the Anterolateral direction of SEBT on the right side and Body Mass Index. Also, it shows a very weak negative association in the same direction for the left side with BMI. Spearman's Correlation analysis method was used with an assumption of P-value < 0.05, which is statistically not significant.



Graph 5.4 – Linear Regression between BMI and Anterolateral direction of SEBT (Right)



Graph 5.5 – Linear Regression between BMI and Anterolateral direction of SEBT (Left)

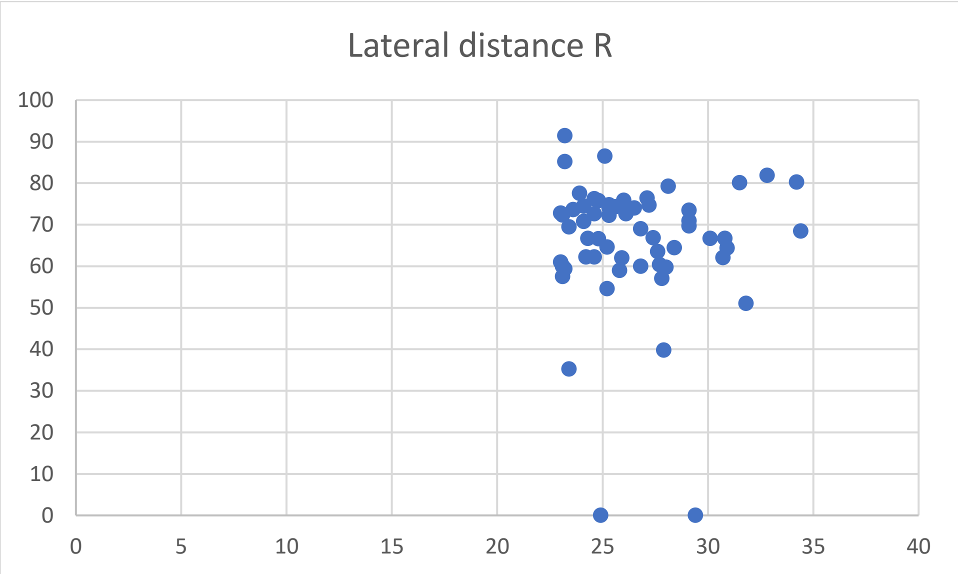
Table 5.5: Correlation analysis between Body Mass Index and Lateral direction of SEBT Test

Variable	Body Mass Index		
	R	P	N
Lateral Direction SEBT (Right)	-.004	0.976	60
Lateral Direction	-0.264	0.041	60

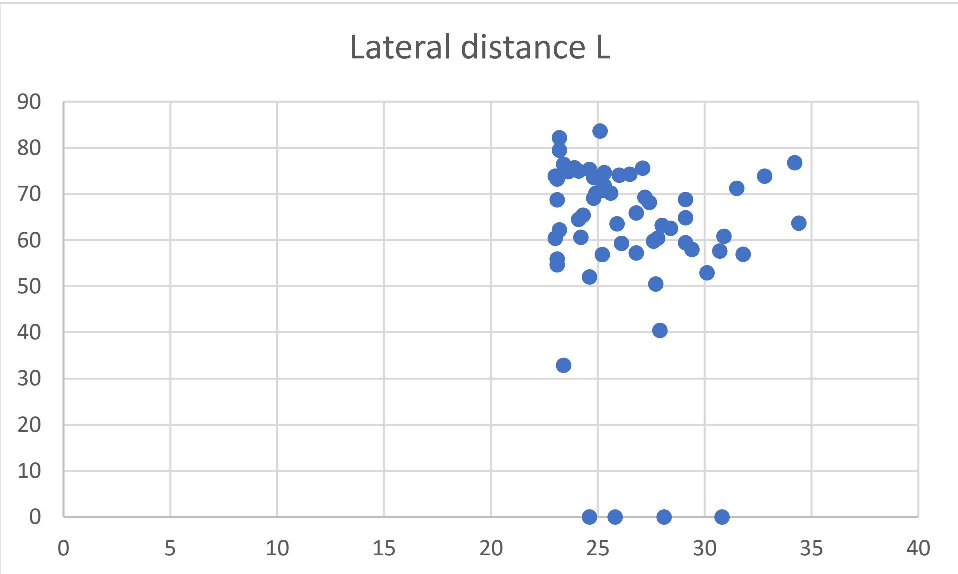
SEBT (Left)			

(*P-value < 0.05=Statistically Significant for left side)
(*P-value < 0.05=Statistically not Significant for right side)

Interpretation: The table above illustrates a very weak negative association between the Anterolateral direction of SEBT on the right side and Body Mass Index. Also, it shows a weak negative association in the same direction for the left side with BMI. Spearman's Correlation analysis method was used with an assumption of P-value < 0.05, which is statistically not significant.



Graph 5.6 – Linear Regression between BMI and Lateral direction of SEBT (Right)



Graph 5.7 – Linear Regression between BMI and Lateral direction of SEBT (Left)

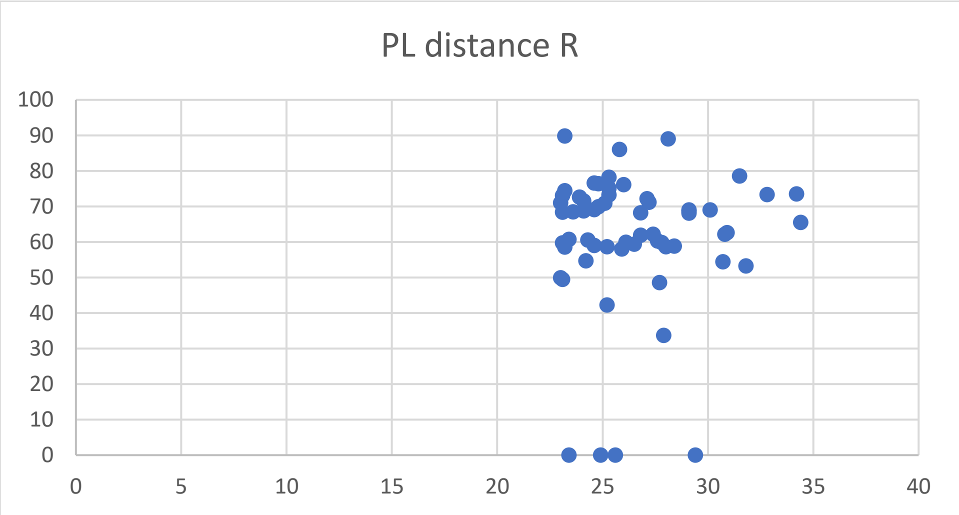
Table 5.6: Correlation analysis between Body Mass Index and Posterolateral direction of SEBT Test

Variable	Body Mass Index		
	R	P	N
Posterolateral Direction SEBT (Right)	-0.022	0.868	60
Posterolateral Direction SEBT (Left)	-0.135	0.303	60

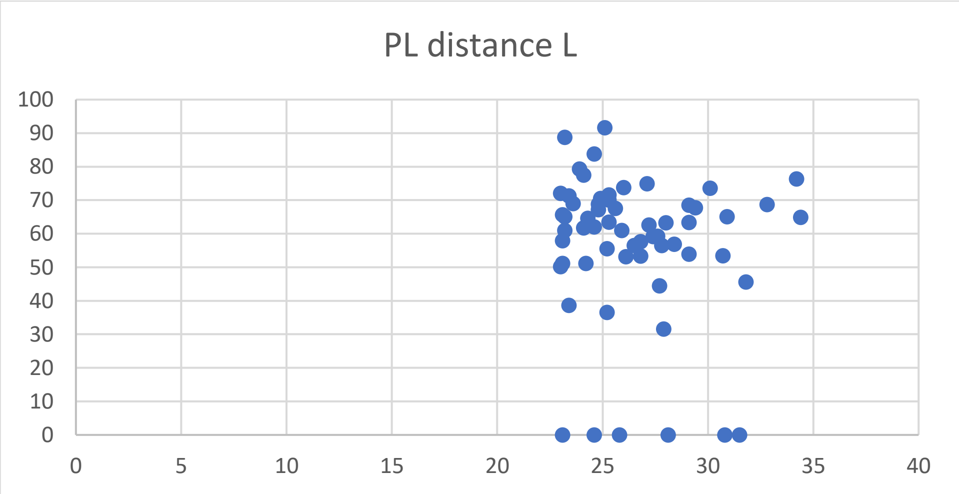
(*P-value < 0.05=Statistically not Significant for both the sides)

Interpretation: The table above illustrates a very weak negative association between the Anterior direction of SEBT on the right side and Body Mass Index. Also, it shows a very weak negative association in the

same direction for the left side with BMI. Spearman's Correlation analysis method was used with an assumption of P-value < 0.05, which is statistically not significant.



Graph 5.8 – Linear Regression between BMI and Posterolateral direction of SEBT (Right)



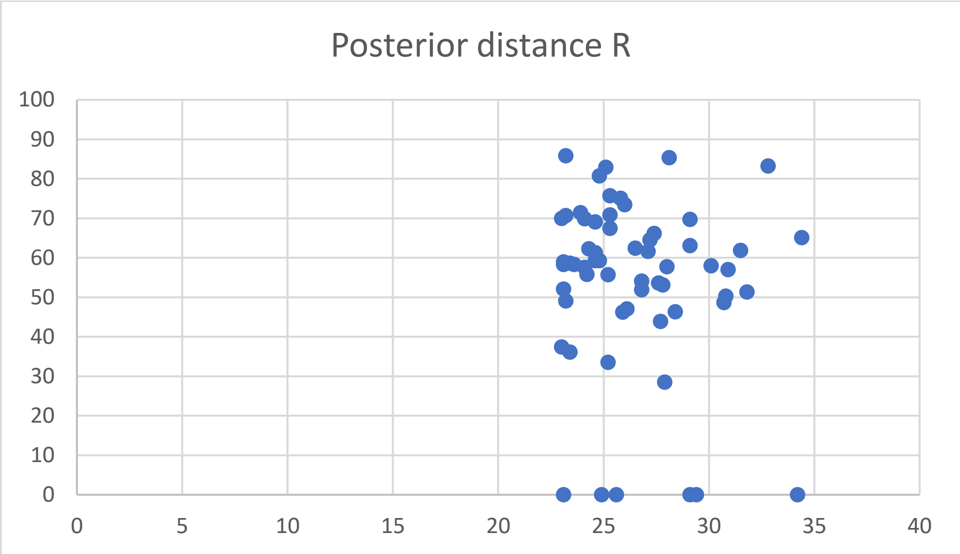
Graph 5.9 – Linear Regression between BMI and Posterolateral direction of SEBT (Left)

Table 5.7: Correlation analysis between Body Mass Index and Posterior direction of SEBT Test

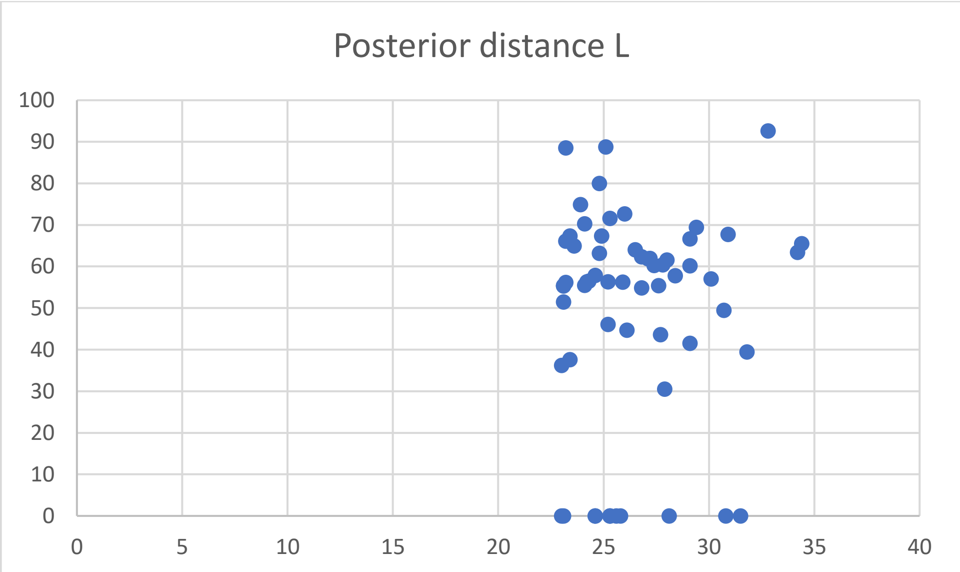
Variable	Body Mass Index		
	R	P	N
Posterior Direction SEBT (Right)	-0.131	0.320	60
Posterior Direction SEBT (Left)	0.033	0.803	60

(*P-value < 0.05=Statistically not Significant for both the sides)

Interpretation: The table above illustrates a very weak negative association between the Anterior direction of SEBT on the right side and Body Mass Index. Also, it shows a very weak positive association in the same direction for the left side with BMI. Spearman's Correlation analysis method was used with an assumption of P-value < 0.05, which is statistically not significant.



Graph 5.10 – Linear Regression between BMI and Posterior direction of SEBT (Right)



Graph 5.11 – Linear Regression between BMI and Posterior direction of SEBT (Left)

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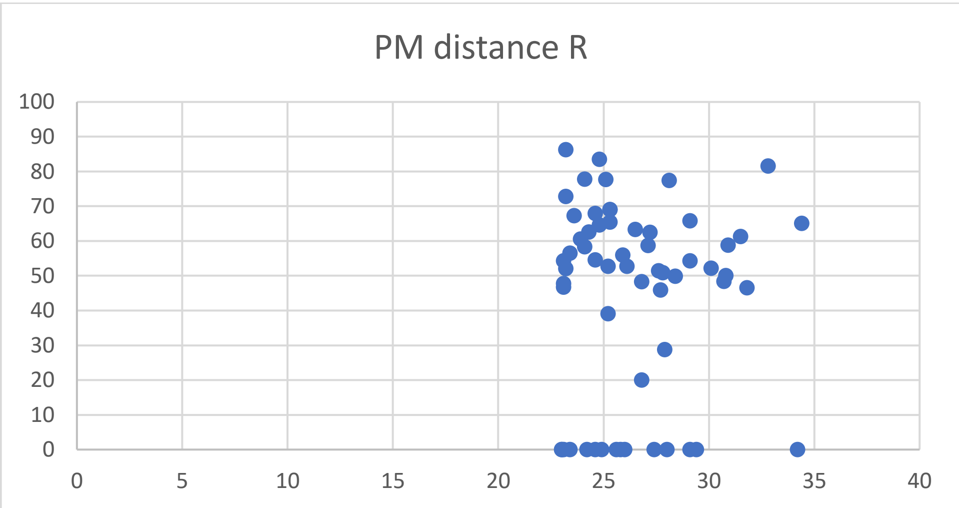
Table 5.8: Correlation analysis between Body Mass Index and Posteromedial direction of SEBT Test

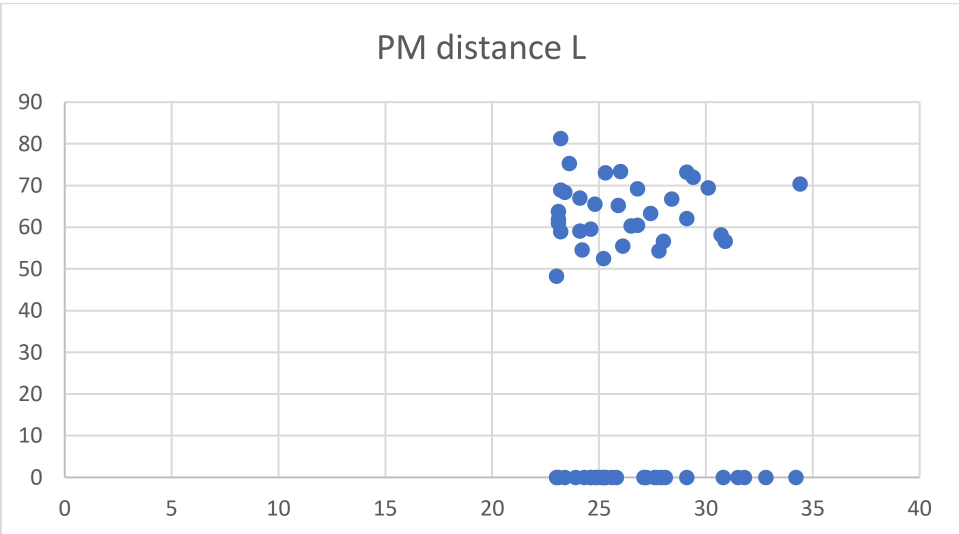
Variable	Body Mass Index		
	R	P	N
Posteromedial Direction SEBT (Right)	-0.064	0.628	60
Posteromedial Direction SEBT (Left)	-0.068	0.605	60

(*P-value < 0.05=Statistically not Significant for both the sides)

Interpretation: The table above illustrates a very weak negative association between the Anterior direction of SEBT on the right side and Body Mass Index. Also, it shows a very weak negative association in the same direction for the left side with BMI. Spearman's Correlation analysis method was used with an assumption of P-value < 0.05, which is statistically not significant.



Graph 5.12 – Linear Regression between BMI and Posteromedial direction of SEBT (Right)



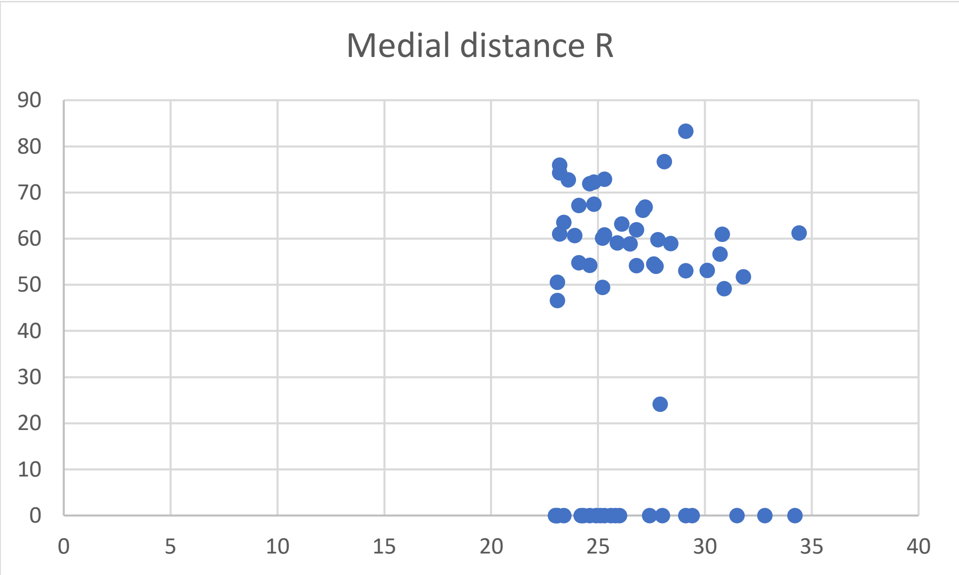
Graph 5.13 – Linear Regression between BMI and Posteromedial direction of SEBT (Left)

Table 5.9: Correlation analysis between Body Mass Index and Medial direction of SEBT Test

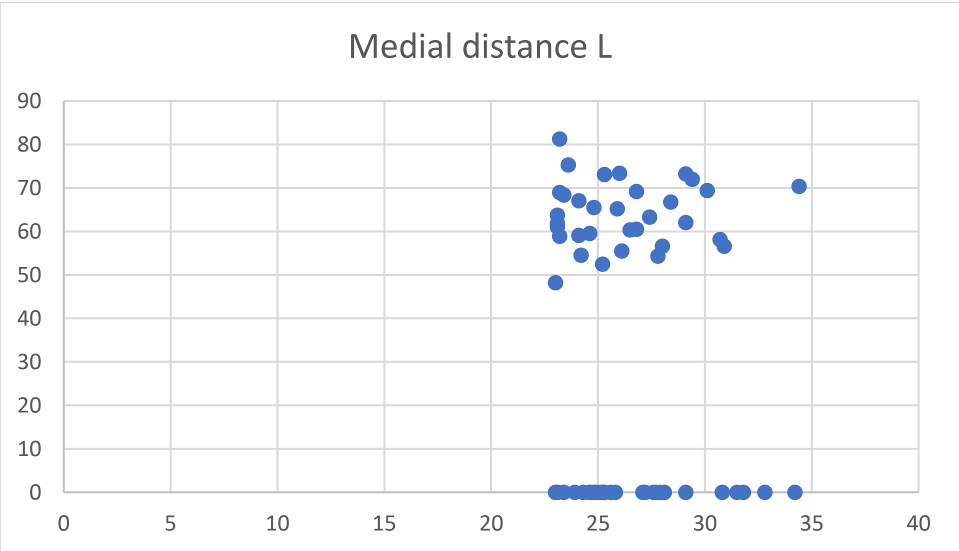
Variable	Body Mass Index		
	R	P	N
Medial Direction SEBT (Right)	-0.048	0.717	60
Medial Direction SEBT (Left)	-0.102	0.438	60

(*P-value < 0.05=Statistically not Significant for both the sides)

Interpretation: The table above illustrates a very weak negative association between the Anterior direction of SEBT on the right side and Body Mass Index. Also, it shows a very weak negative association in the same direction for the left side with BMI. Spearman's Correlation analysis method was used with an assumption of P-value < 0.05, which is statistically not significant.



Graph 5.14 – Linear Regression between BMI and medial direction of SEBT (Right)



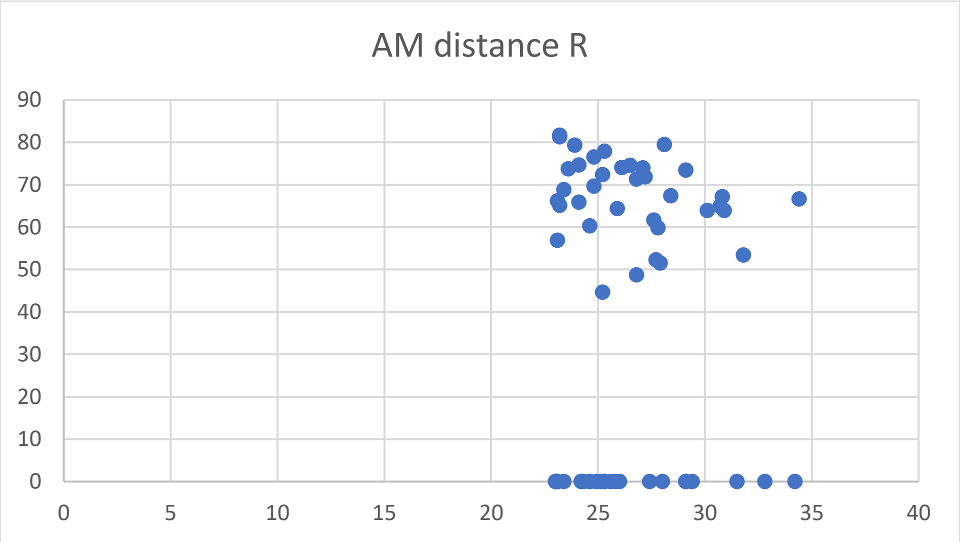
Graph 5.15 – Linear Regression between BMI and medial direction of SEBT (Left)

Table 5.10: Correlation analysis between Body Mass Index and Anteromedial direction of SEBT Test

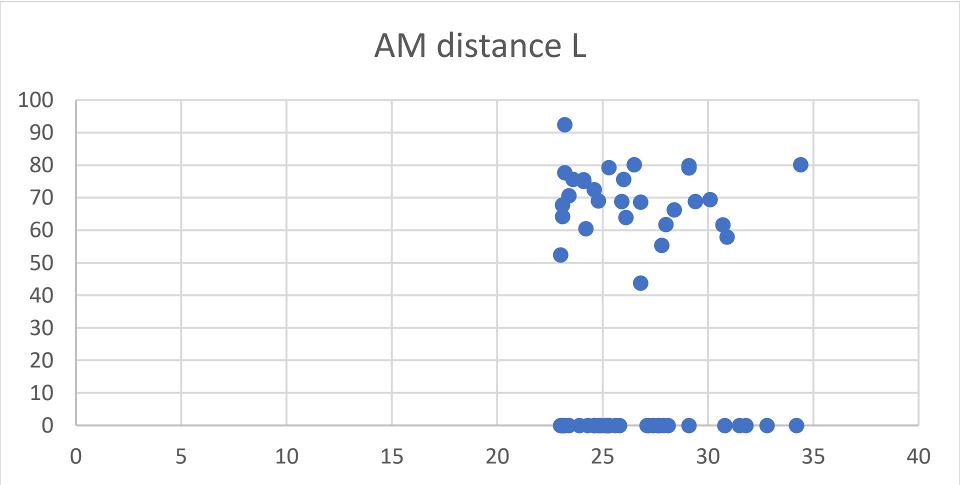
Variable	Body Mass Index		
	R	P	N
Anteromedial Direction SEBT (Right)	-0.068	0.605	60
Anteromedial Direction SEBT (Left)	-0.048	0.718	60

(*P-value < 0.05=Statistically not Significant for both the sides)

Interpretation: The table above illustrates a very weak negative association between the Anterior direction of SEBT on the right side and Body Mass Index. Also, it shows a very weak negative association in the same direction for the left side with BMI. Spearman's Correlation analysis method was used with an assumption of P-value < 0.05, which is statistically not significant.



Graph 5.16 – Linear Regression between BMI and Anteromedial direction of SEBT (Right)



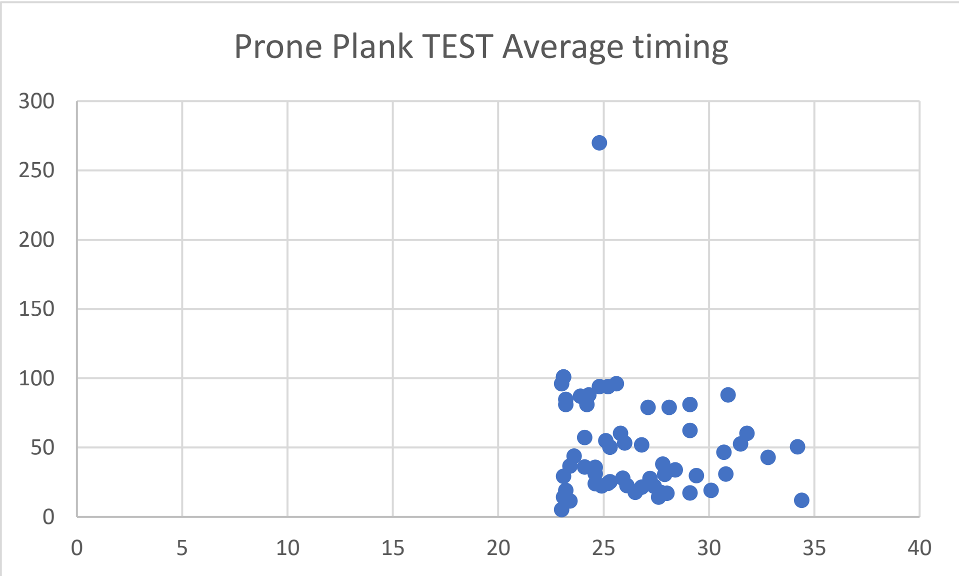
Graph 5.17 – Linear Regression between BMI and Anteromedial direction of SEBT (Left)

Table 5.11: Correlation analysis between Body Mass Index and Prone Plank Test Rating:

Variable	Body Mass Index		
	R	P	N
Prone Plank Test Rating	-0.149	0.256	60

(*P-value < 0.05=Statistically not Significant)

Interpretation: The table above illustrates a very weak negative association between the rating of the prone plank test and Body Mass Index. For that, Spearman's Correlation analysis method was used with an assumption of P-value < 0.05, which is statistically not significant.



Graph 5.18 – Linear Regression between BMI and Prone Plank Rating

CHAPTER: 5

DISCUSSION

The effect of Body mass index on the stability of the core and balance in young adults aged between 18 to 25 years in the community area of Anand City, which is determined by such tests as the prone plank test and the star excursion balance test. According to numerous research, it is evident that some tests, such as the plank test and Star excursion balance test are more accurate or reliable for the measurement of core stability and balance in young ages respectively.

However, the plank test is mostly used to assess core stability in people of all ages and the star excursion balance test is frequently used in sports persons to evaluate their dynamic balance and risk of injuries due to falls. The study aimed to "See the effect of BMI on core stability and dynamic balance in young adults, therefore in this study, these two components were taken as an assessment tool. To find out the impact of BMI, we studied several factors and found correlations among them by using the IBM SPSS Software Version 29. To analyze this relation, Spearman's correlation method was used because data was not normally distributed. We studied the correlation between Body Mass Index (BMI) and Core Stability (CS) as well as the correlation between Body Mass Index (BMI) and Balance. All the outcome measures included in this study are reliable.

This multi-centric observational study includes a screening of all the young adults from different colleges in the Anand district. In that, 198 individuals were screened via Body Mass Index (BMI). Participants who had a past medical history or normal BMI were excluded as per exclusion criteria. 60 participants were included according to the inclusion criteria in the research after obtaining their written consent. All selected participants were further assessed for core stability via the prone plank test and they were also assessed for balance via the Star Excursion Balance Test (SEBT). The mean age was 21 ± 1.60. Among 198 participants, 51 were females (85%) and 9 were males (15%). These participants were meeting our inclusion criteria. The mean BMI value for the participation was 26.47 ± 3.00

At the time of screening, ASIAN classification was used to select the BMI class for the participants who were included in the study. The participants were performed with balance via the Star Excursion Balance Test for both the lower limbs. The mean SD value for BMI was 1.85 ± 0.36. Whereas, a very weak negative correlation has been seen in both the lower extremities for every direction of SEBT (Anterior right and left, anterolateral right and left, lateral right, posterolateral right and left, posterior right and left, posteromedial right and left, medial right and left, anteromedial right and left) except the lateral direction of the left lower extremity. Because in the lateral direction, a very weak positive correlation is found. At last, we found that there is a very weak negative correlation between BMI and balance with data not statistically significant. Because in every direction of both limbs, the P-value is greater than 0.05.

According to a Corbeil study, those who are obese and have an irregular distribution of body fat, especially in the abdomen, may be more likely to fall than people who are not obese. This research validates the results of the Star Excursion Balance Test (SEBT), which demonstrated a statistically significant reduction in reach distance in all directions among obese people in comparison to non-obese subjects. When the fat people were being tested, loss of balance was also noticed in addition to a decrease in reach distance. Although fat mass might be thought of as a potential protective layer when falling, the extra weight from the fat mass itself has certain drawbacks.

To find out the correlation between BMI and Core Stability, we found that there is a very weak negative correlation. The effectiveness and quality of standing, body balancing, and walking are influenced by CS and BMI. Our study shows that the correlation is negative, i.e., as the Body Mass Index increases the plank holding time i.e., the core muscle stability decreases. As weight status increased adolescents had more difficulty in performing tests that involved moving their body mass or holding it in position. King AC et.al., studied increased body fat mass that hurts postural stability. The correlation between body mass index and plank holding time hurts postural stability. Ervin et al. studied the relationship between core, upper, and lower body strength with body mass status in adolescents. They reported that increasing body mass negatively impacted front bridge times in adolescent females and males. Those who have more BMI, need to control weight so can have good core stability. Young adults who are overweight or obese are more likely to have poor core muscle function, which raises their risk of musculoskeletal disorders, illnesses like injuries, and discomfort in the lower back.

CHAPTER: 6
CONCLUSION

This study suggests that equilibrium may be impacted by rising obesity or high BMI rates. Previous studies have shown that core stability is also important for maintaining balance. The evaluation of young teenagers' balance and core stability took an hour. To determine the impact of BMI on balance, we discovered that most individuals experienced balance problems when performing SEBT. For the right lower extremity, we discovered impaired balance in the posteromedial, medial, and anteromedial regions. Additionally, it was discovered that the right lower extremity's medial and anteromedial directions had inadequate balance. Finally, this study showed that balance and BMI had a very unfavourable association. We discovered that there is a very minimal correlation between core stability and BMI, indicating that there is very little influence of BMI on balance and core stability.

CHAPTER: 7
LIMITATIONS

1. This study consists small sample size.
2. Lack of equal distribution in terms of gender as there were more female participants in comparison to males can contradict the derived result.
3. Heterogenous distribution in terms of age.

CHAPTER: 8
FUTURE RECOMMENDATIONS

1. Further studies need to be conducted on a larger sample size with nearly equal gender distribution.
2. After deriving the number of participants with the presence of poor balance, therapeutic interventions can be applied and their effects to be assessed.

CHAPTER:9
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