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# Prevalence Of Core Muscle Weakness In 18–25 Years College Going Students–A Cross–Sectional Study

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### ABSTRACT

**BACKGROUND:** The core is referred as a muscular box that works as a unit to stabilize the body and the spine. Where the core muscle involves the muscles of hip and trunk and it helps to maintain the stability of the pelvis and spine. When the core muscles function normally, they can maintain the segmental stability, protect the spine and reduce the stress impacting on the intervertebral disc and the lumbar vertebrae. Core stability is very important for stabilization and mobilization and also helps for upper and lower extremity function and it provides the balance and local strength to reduce the back injuries. Core muscle weakness is due to prolonged adaptation and faulty posture and lack of physical activity may lead to excessive load on the lumbar spine and back, poor endurance of muscles, instability of lower extremity and muscular imbalance.

**METHODS:** A Cross sectional study was conducted among 18–25 years college students. A total of 220 students, selected through convenience sampling. Data was collected from the school of Physiotherapy. After taking the consent and explanation about the purpose of the study necessary demographic details including name, age, height, weight, were obtained. Core muscle was assessed by using a Biering Sorensen test, prone plank test and side bridge endurance test.

**RESULTS:** The Core muscle weakness were analyzed using Biering Sorensen test with the weakness of 8.1%, Prone plank test with the weakness of 35.4 % and side bridge endurance test with the weakness of right side (76.3%) and left side (78.1%).

**CONCLUSION:** There is a marked weakness on the lateral part > the posterior part > the anterior part and prevalence of core muscle weakness was found to be more in female students compared to male students.

**KEYWORDS:** College students, core muscle, Biering–Sorensen test, Prone plank test and Side bridge endurance test.

## INTRODUCTION

### PROBLEM STATEMENT

The “core” has been described as a muscular box with the abdominals in the front, paraspinal and gluteus in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature in the bottom <sup>(1)</sup>. The musculoskeletal core of the body includes the spine, hips and pelvis, proximal lower limb and abdominal structures <sup>(2)</sup>. The core is normally defined as which delicate the stability and the balance of movement which occur simultaneously <sup>(3)</sup>. The core acts as an anatomical base for motion of the distal segments. This can be considered ‘proximal stability for distal mobility’ for throwing, kicking or running activities <sup>(4)</sup>. The action of muscles within the core is depends on the balanced activity for both the mobilizers and stabilizers <sup>(5)</sup>. The musculature of the core can be divided into major and minor core muscles. <sup>(6)</sup>

The core muscles are:

Major core muscles are:

- Diaphragm (on the top or the roof)
- Rectus abdominis (at the front)
- Internal and external obliques (on side)
- Pelvic floor muscles (in bottom or floor)
  - Levator ani
  - Pubococcygeus
  - Puborectus
  - Ileococcygeus
  - Ischiococcygeus
- Quadratus Lumborum (In the lower back and above your hips)
- Erector Spinae (next to your spine)
  - Iliocostalis
  - Longissimus
  - Spinalis
- Transverse abdominis (wraps around your midsection horizontally)
- Multifidus (runs along your spine)
- Core Hip muscles (Hip flexors, Extensors, Abductors, Adductors and Rotators)

Minor core muscles are:

- Latissimus dorsi
- Gluteus maximus
- Trapezius

Functions of the core muscles:

- The main functions of core are forward bend, backward bend, lateral bend, twist and axial extension.
- All the core muscles work together to produce a movement in the body.
- The core muscles align the ribs, pelvis, spine and kinetic chain during movement.
- Core provide stability to the thorax, spine and pelvis.
- It transfers the proper load between the upper body and lower body
- Core muscles helps in breathing.
- If we have a stable and strong core it helps to prevent the musculoskeletal injuries.

- It prevents the spine from the excessive load.
- The core muscle contains and protect the internal organs.
- It helps to control the pelvic and lumbar relationship.

Core weakness can be defined as the weakness of the central musculature of the body which includes the abdominal and back muscles, due to lack of physical inactivity and adaptation offaulty postures during prolonged hours of work <sup>(7,8)</sup>. Core Muscle Weakness in females for Biering Sorensen Extension Test is 86.73%, Right Side Plank is 83.89% and Left Side Plank is 76.30%. <sup>(9)</sup>. A study reviewed prevalence of physical inactivity among adults was estimated to be 31.1%. Physical inactivity was more prevalent among males (22.4%) than females (14.4%) <sup>(10)</sup>. Having a strong core will have numerous benefits for the desk workers, athletic persons, people who are all standing for prolonged hour, etc., <sup>(11)</sup>. Simultaneous contraction of the diaphragm, the pelvic floor muscles, and the abdominal muscles, is required to increase intra-abdominal pressure, providing a more rigid cylinder for trunk support, decreasing the load on the spine muscles Muscle and allowing increased trunk stability <sup>(12)</sup>.

There are muscular imbalances that highly contribute to the increased risk of musculoskeletal disorders associated with low back pain <sup>(13)</sup>. It may lead to improper excessive loading on the lumbar spine, back and pelvic floor muscles, poor endurance of muscles, muscle imbalance and lower extremity disorders <sup>(14)</sup>.

#### RATIONALE:

Due to lack of physical activities and prolonged sitting in the class room college students may have a weakness of core muscles due to poor posture. When core muscles get weak , it will need to use the back muscles to keep your core stable. This can lead to create a imbalance in the core muscles and also cause a musculoskeletal injuries of spine, back and shoulders. To prevent the complications like excessive load on the lumbar spine, poor endurance of muscles, imbalance of hip extensors, mechanical LBA and instability of lower extremity. Hence, the purpose of the study is to assess the core muscle weakness and create awareness among college going students.

#### NOVELTY

There is a no previous study conducted on assessment of core muscles for both male and female college students by using this kind of tests (Biering Sorensen test, prone plank test and side bridge endurance test). To prevent the complications of core muscle weakness and create an awareness about core muscle weakness among college going students. This study outlines the assessment of core muscle weakness by using these core muscle endurance/strength tests among college going students.

The complete core muscle tests are listed below

- Biering Sorensen test(endurance)
- Prone plank test (strength & stability)
- Side bridge endurance test(endurance)

#### AIMS OF THE STUDY

The study is to find out the core muscle weakness in 18–25 years college going students.

### OBJECTIVES OF THE STUDY

To evaluate the prevalence of core muscle weakness in 18–25 years among college going students.

### OPERATIONAL DEFINITION

Core muscle:

The core muscle is referred as the Lumbopelvic–hip musculatures, and it acts as an anatomical base for motion of the distal segments. The core musculature includes the muscles of the trunk and pelvis that are responsible for the maintenance of stability of the pelvis and spine. The core activity is involved with almost all extremity activities such as running, kicking and throwing etc.,

Core muscle weakness:

The core muscle weakness is defined as a weakness of the central core musculature of the body which may include the abdominus, back and pelvic floor muscles. Muscle weakness occurs due to lack of physical activity and adaptation of faulty posture for prolonged hours of work may leads to core muscle weakness.

### REVIEW OF LITERATURE:

Mehnazparker et al., (2022)<sup>[4]</sup> conducted a study on “assessment of upper limb and core muscle strength in physiotherapy student aged 20–25 years”. And they concluded that the most of the female physiotherapy students have a weak upper limb and core muscle strength compared to male physiotherapy students. This is one of the factors that leads to musculoskeletal pain and work-related musculoskeletal disorders in physical therapy profession.

Dr.Parul Rakholiya et al., (2021) <sup>[5]</sup> conducted a study on “Prevalence of core muscle weakness in 18–25 years old females”. 212 Healthy female volunteers were included in this study and the core muscle was evaluated by using core endurance tests and core Weakness in females for 60 Degree Flexion Test is 65.40%, for, Biering–Sorensen extension Test is 86.73%, Right Side Plank is 83.89% and Left Side Plank is 76.30%. Level of significance of the entire four tests is below 0.5 respectively which shows significant difference in core muscle weakness of 18–25 years old females. They concluded that the 18–25 years females have core muscle weakness.

PrachitiRajanBhore et al., (2019) <sup>[7]</sup> carried out a study of “prevalence of core weakness in bank employees” and concluded that the bank employees were found to be 72.73%; majority of core weakness was found within the age group of 40–50 years (23.6%) which was relatively higher than other age groups. Prevalence of core weakness was found to be more in male population (65.3%) and in individuals with normal BMI (52.8%)

Poonam.N. Banthia, PriyankaHonkalas et al., (2018) <sup>[8]</sup> found out the title of “Assessment of trunk muscle endurance in female nurses using lumbar functional test” and A cross sectional study was conducted with a sample of 80 nurses between age of 20–30 years also Nurses practicing more than 2 years having BMI within 18.5 – 24.99 kg/m<sup>2</sup> and concluded that there is reduced trunk muscle endurance in female nurses when compared to published normative data. Hence the present study focuses over the assessment of trunk muscle endurance in female nurses using lumbar functional test. Thus the present study proves that there is reduced trunk muscle endurance in female nurses as compared to normative data.

Koumantakis GA et al., (2018)<sup>[2]</sup> stated that Endurance testing of the paraspinal and hip muscles is important for the prediction and prevention of back pain. The title is on the “Muscle Endurance Evaluation with the Sorensen Test and Correlation with Demographics and the Baecke Leisure–Time

Sport Activity Index in Healthy Young Adult “ and concluded that a highly significant association between leisure-time physical activity levels and the isometric endurance as examined with the Sorensen test.

TarunKumar, et al., (2015) <sup>[9]</sup> This study evaluated the “Efficacy of core muscle strengthening exercise in chronic low back pain patients”. These 30 patients divided into two groups: A and B on the basis of duration of low back pain. Group-A patients complain about pain duration for more than twelve months and Group B complains about pain duration from three to twelve months and This study concludes that core muscle strengthening exercise along with lumbar flexibility and gluteus maximus strengthening is an effective rehabilitation technique for all chronic low back pain patients irrespective of duration (less than one year and more than one year) of their pain.

K. A.Chase et al., (2014)<sup>[10]</sup> This study sought to determine normative fitness measurements of core musculature endurance using the plank exercise. 102 college male and female participants were recruited. Participants were instructed in plank positioning. The total time held in proper plank position was recorded. The mean time held in the plank position was  $106.15 \pm 49.52$  and  $117.66 \pm 53.49$  seconds for females and males and finally data suggest that 1.58 min in females and 1.83 min in males (50<sup>th</sup> percentile values) could be considered average duration of the plank exercise for this age group. Future testing to include other age groups and levels of fitness will be undertaken to broaden the range of normative values available for fitness testing.

## METHODOLOGY

### STUDY SETTING

The study was conducted at School of Physiotherapy, AVMC Campus, Puducherry.

### SELECTION OF SUBJECT

According to the inclusion and exclusion criteria, 220 samples were selected through convenience sampling.

### VARIABLES

Independent variables:

- Age
- Gender
- BMI
- Height
- Weight

Dependent variables:

- Biering Sorensen test
- Prone plank test
- Side bridge endurance test (both right and left side)

### MEASUREMENT TOOLS

- Biering Sorensen test
- Prone Plank test
- Side bridge endurance test

**MATERIALS USED:**

- Stopwatch
- Yoga mat
- Weight scale
- Stadiometer

**STUDY DESIGN**

A Cross-sectional study

**SAMPLING**

The sampling of the study is convenience sampling

**CRITERIA**

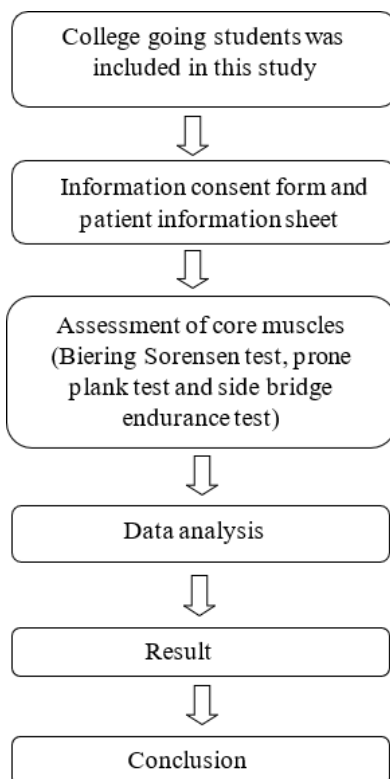
Inclusion criteria:

- Age criteria 18–25 years.
- Both genders (Male and Female).
- Students willing to participate in the study.
- Students who are regularly attending the classes.

Exclusion criteria:


- Any recent surgeries to the back and abdomen.
- Recent spine fracture or trauma.
- Low back pain.
- Any congenital anomaly.
- Any systemic illness.

**STUDY PROCEDURE:**



3.2 TREATMENT PROCEDURE

Before participation in the study, all the subject volunteers were explained about the purpose of the study and signed in institutionally agreed concern form. Subjects who met the selectioncriteria was included in the study. A Biering Sorensen test, prone plank test and side bridge endurance test was used to assess the core muscles weakness.

TEST	PROCEDURE	SCORE
Biering Sorensen test	<p>Ask the participants to lie on prone of the end of thetable at the level between the anterior iliac spine [ASIS] and umbilicus hanging off the table. The therapist leans over the patient to firmly stabilize thelower limbs and pelvis at the ankles. Ask patient to raise their head, chest and trunk, so the trunk is straight. Use of stopwatch to time the effort, activating it at the “begin” command, the patient must lift their head, chest, and trunk from the table and hold the position as long as they can and stopping it when the patients show obvious signs of fatigue and begins to flater.</p> 	<p>Normal holding timefor men is 28 sec (less than 28 sec is considered asweakness)</p> <p>Normal holding timefor women is 29 sec (less than 29 sec is considered asweakness).</p>



<p>test</p>	<p>Prone plank</p> <p>Ask the Participants to lie prone on floor or mat. from the prone position, ask the patients to place the feet apart, with the ankles at 90°, knees straight, and pelvis tilted into a neutral position to engage the core. The elbows were bent to 90° and placed directly below the shoulders with the back flat. The forearms could be angled in, but the hands could not be clasped together. Then tell the patients to lift your body weight on your toes and forearm and keep your body completely straight and suck your belly button into their spine.</p> 	<p>The normal holding time for men is 77 sec.</p> <p>The normal holding time for women is 63 sec.</p>
<p>Side bridge endurance test(both right and left side)</p>	<p>Ask the participants to be on their side lying with legs extended aligning the feet on top of each other, resting on their lower forearm with elbow flexed to 90°. And the upper arm placed on the side of the body. The hip should be elevated off the mat and the body should be in the straight alignment and ask the patient to hold this position for as long as possible, and the position is maintained until the patients feels fatigue or complains of pain.</p> 	<p>Normal holding time for men is 95 secs (less than 95 secs is considered as weakness)</p> <p>Normal holding time for women is 75 secs (less than 75 secs is considered as weakness)</p>





FIGURE-1: Picture shows the Prone plank test in male students



FIGURE 2 : Picture shows the side bridge endurance test in female students(left side)



FIGURE 3: Picture shows the Biering Sorensen test in male student

COLLECTION OF DATA

This study was carried out in School of Physiotherapy, Aarupadai Veedu Medical College Campus, Kirumampakkam, Puducherry. For this study 220 members of students were voluntarily participated in the study. The volunteers were selected based on the inclusion and exclusion criteria. The data is collected with the help of Biering Sorensen test, Prone plank test and Side bridge endurance test.

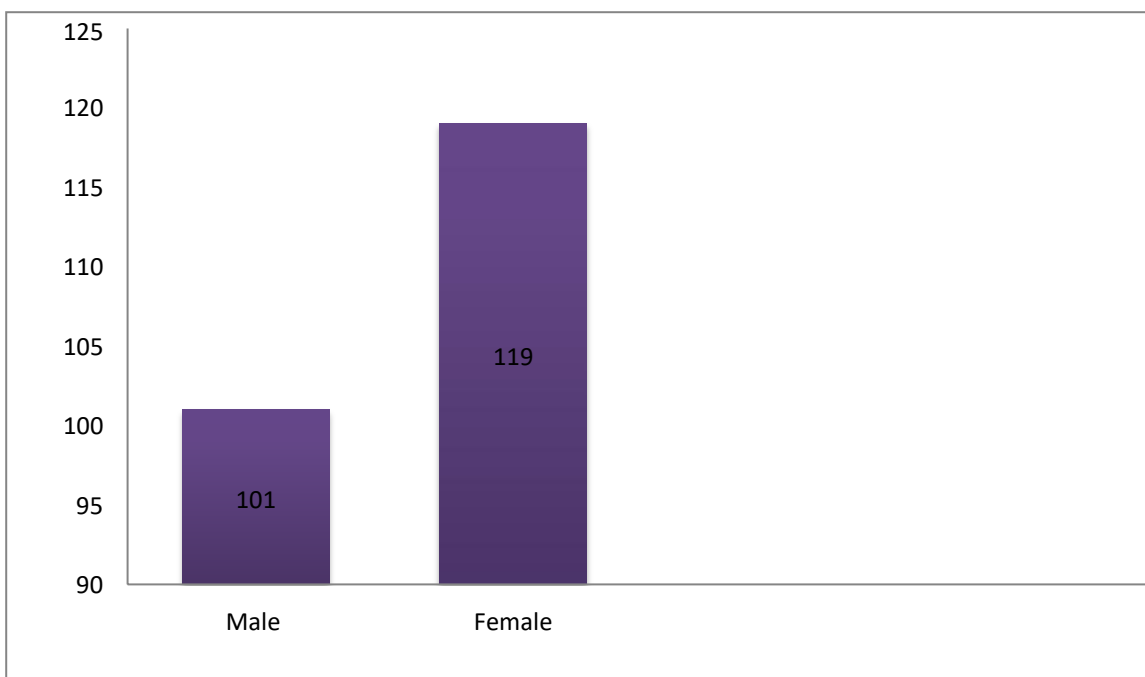
STATISTICAL TECHNIQUES

The data were entered and analyzed using excel and SPSS Version 29. categorical variables were presented using frequency and percentage. Continuous variables were summarized as mean ± SD. Chi- square test was performed to find out the association of core muscle weakness and demographic variables. P value less than 0.05 was considered as statistically significant.

DATA ANALYSIS:

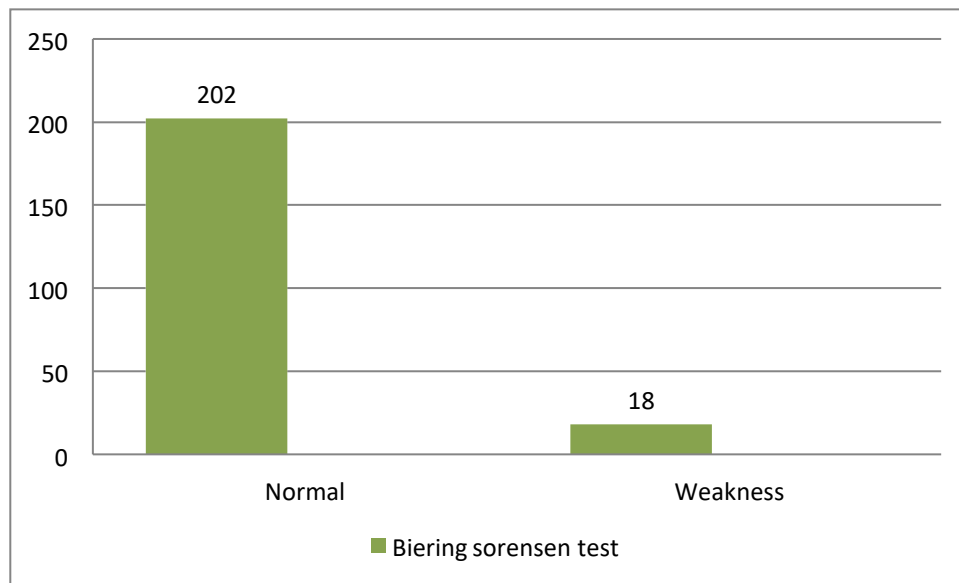
Characteristics	Values
Number of students	220
Age	19.46±1.79
Gender	Male =109 Female =119

Table 1: Showing the characteristics and values of the students



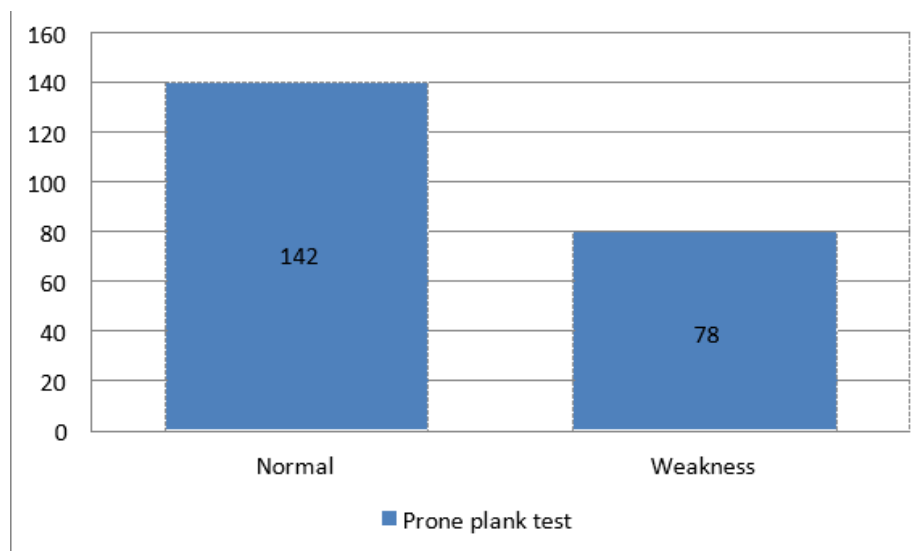
GRAPH:1 This bar graph shows the number of male and female population

BIERING SORENSEN TEST:

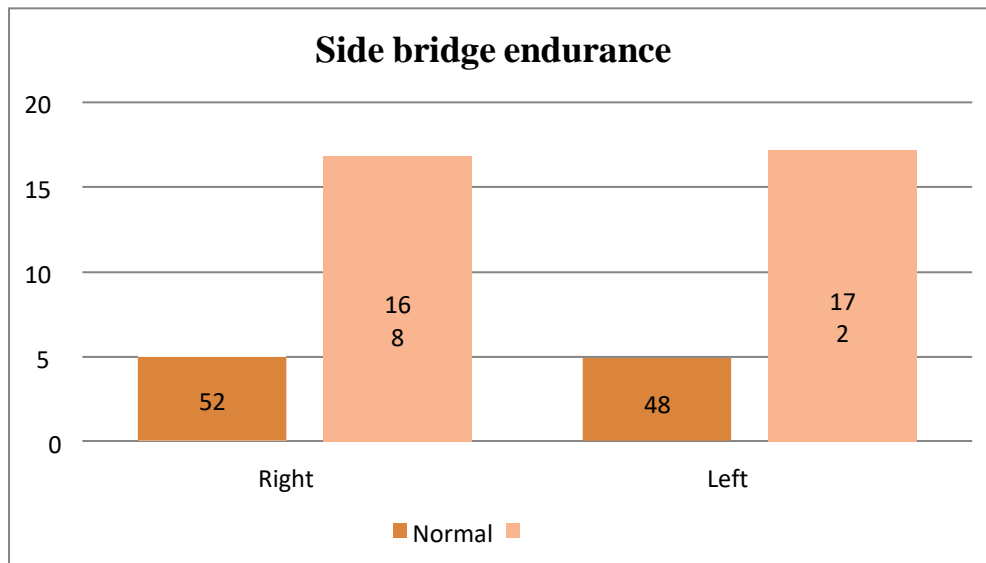


GRAPH 2.1 Shows the graphical represents of Biering Sorensen test

PRONE PLANK TEST:



GRAPH : 2.2 Shows the graphical represents of Prone plank test

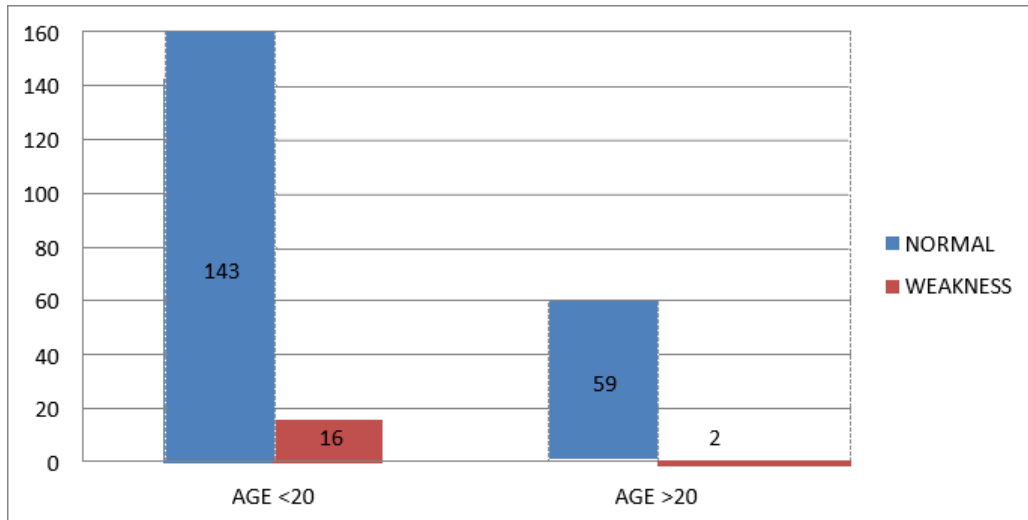


GRAPH: 2.3 Shows the graphical represents of Side bridge endurance test ( Right side andLeft side)

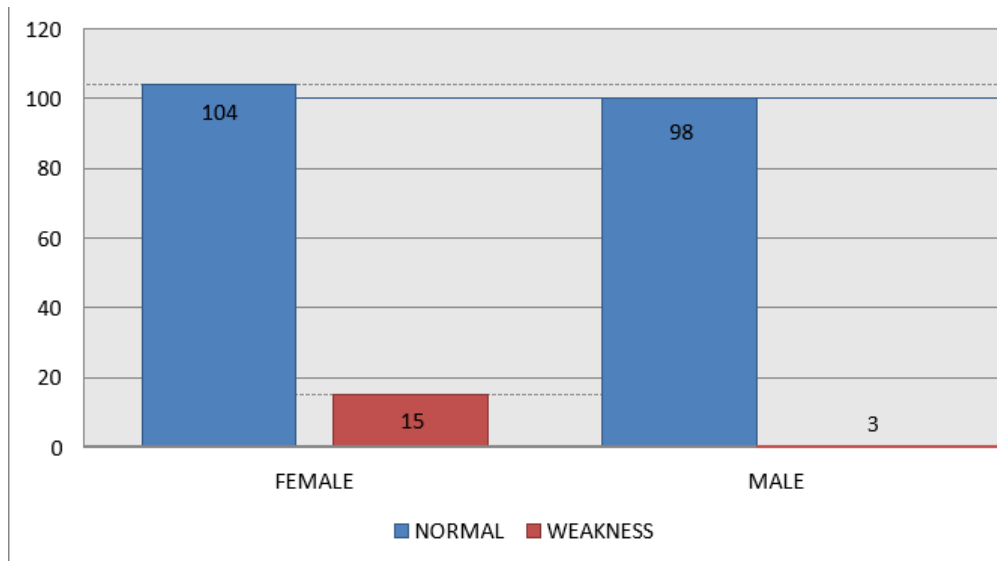
BIERING SORENSEN TEST

Characteristics		Overall population	Normal	Weakness
Gender	Male	101	48.5%	16.7%
	Female	119	51.5%	83.3%
Age	>20	117	29.2%	11.1%
	<20	102	70.8%	88.9%
BMI	Underweight	34	16.8%	0.0%
	Normal	130	63.9%	5.6%
	Overweight	42	17.3%	38.9%
	Obese	14	2.0%	55.6%

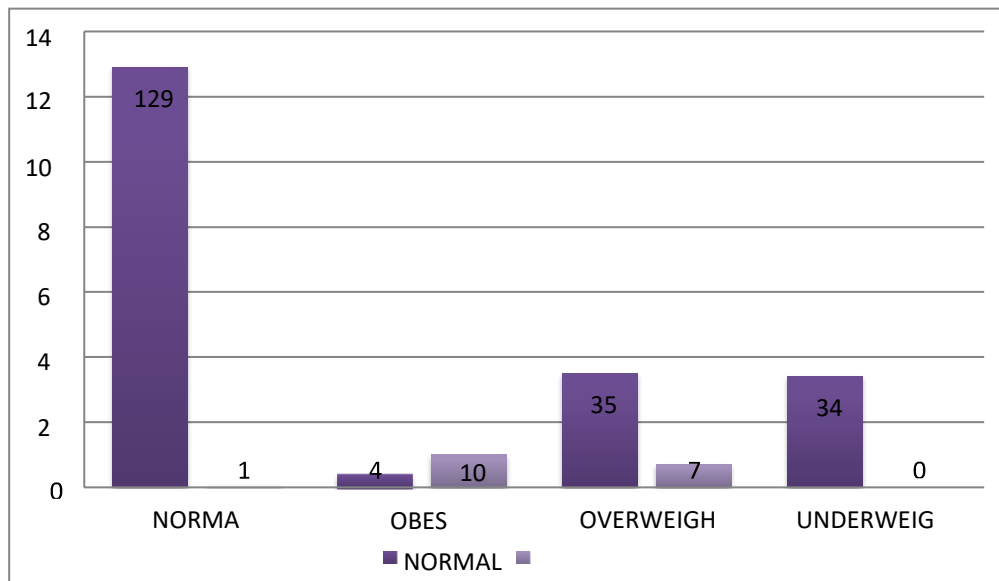
Table 2: The table shows the Biering Sorensen test characteristic and its percentage.



GRAPH: 3.1. Shows the graphical represent of Biering Sorensen test according to the age



GRAPH: 3.2. Shows the graphical represent of Biering Sorensen test according to the Gender

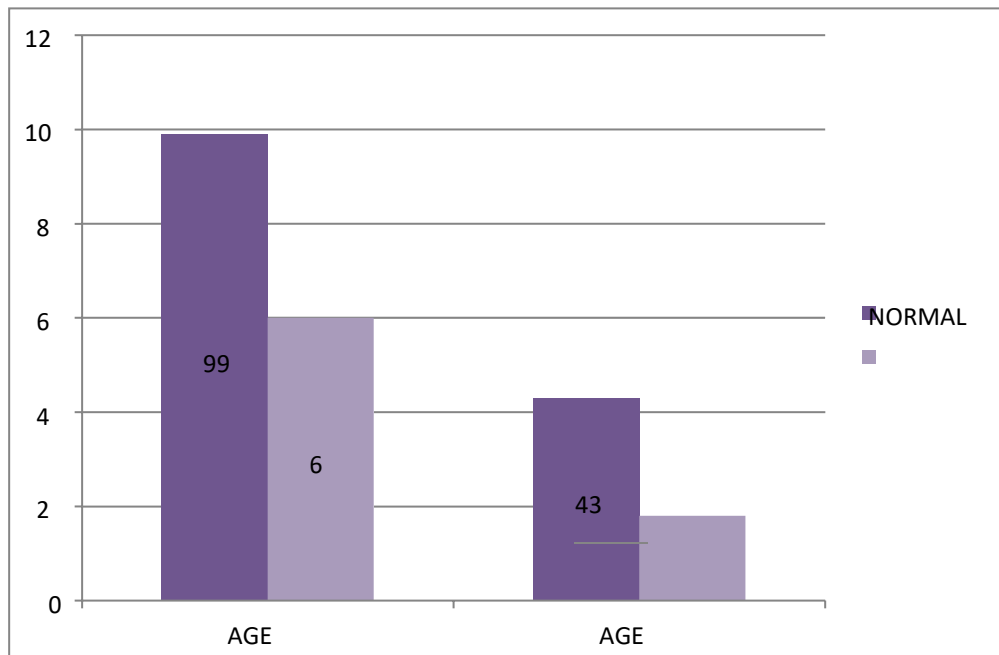


GRAPH: 3.3. Shows the graphical represents of Biering Sorensen test according to thereBMI Range

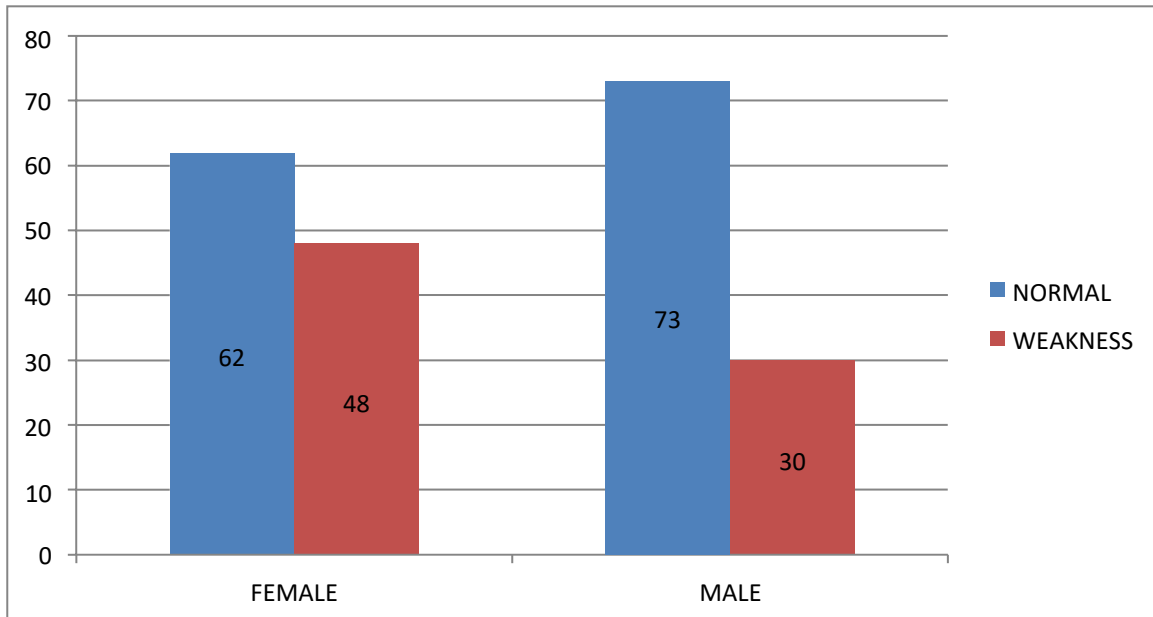
FOR PRONE PLANK TEST

Characteristics		Overall population	Normal	Weakness
Gender	Male	101	50.0%	38.5%
	Female	119	50.0%	61.5%
Age	>20	117	30.3%	23.1%
	<20	102	69.7%	76.9%
BMI	Underweight	34	18.3%	10.3%
	Normal	130	71.8%	35.9%
	Overweight	42	18.3%	37.2%
	Obese	14	0.7%	16.7%

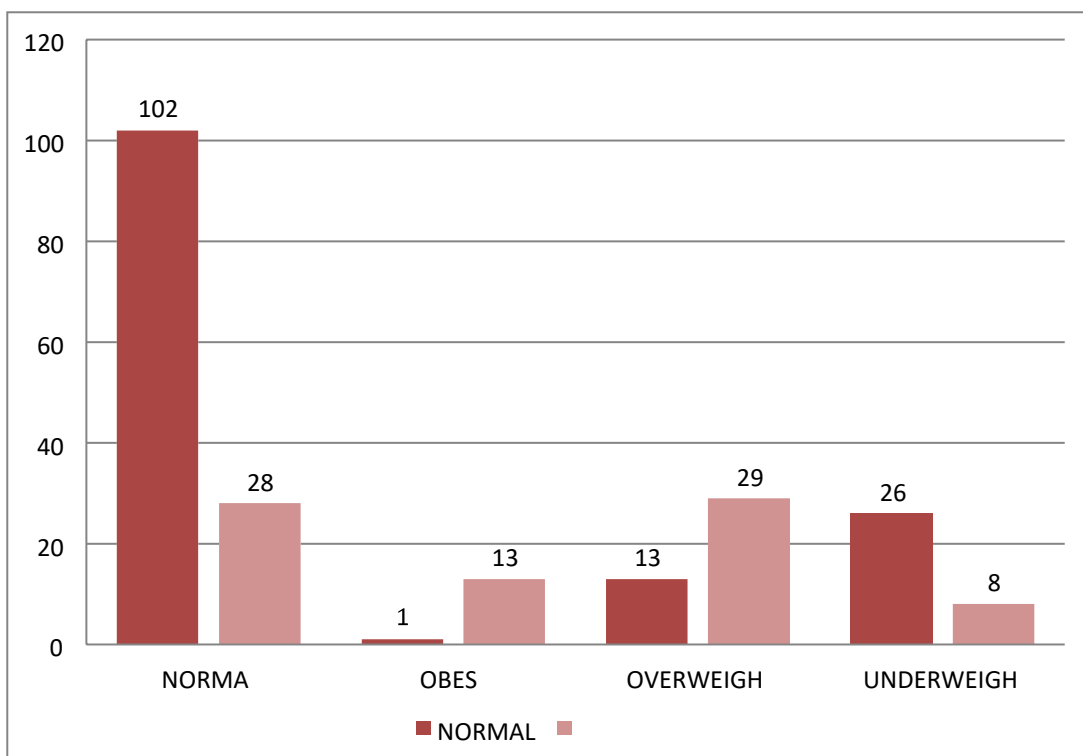
Table 3: The table shows the Prone plank test characteristic and its percentage.



GRAPH : 4.1. Shows the graphical represents of Prone plank test according to the age



GRAPH: 4.2. Shows the graphical represent of Prone plank test according to the Gender

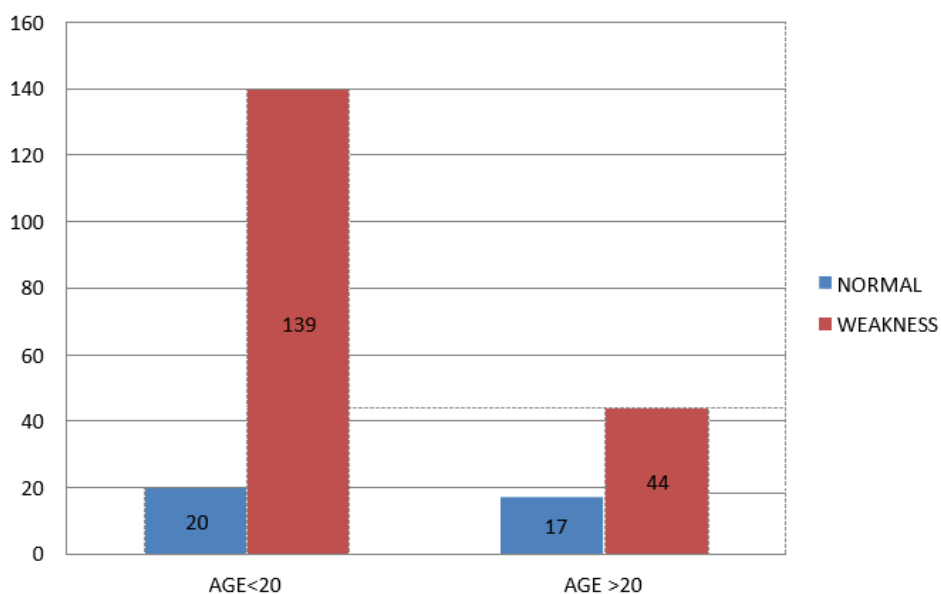


GRAPH: 4.3. Shows the graphical represents of Prone plank test according to the BMIRange

FOR SIDE BRIDGE ENDURANCE TEST

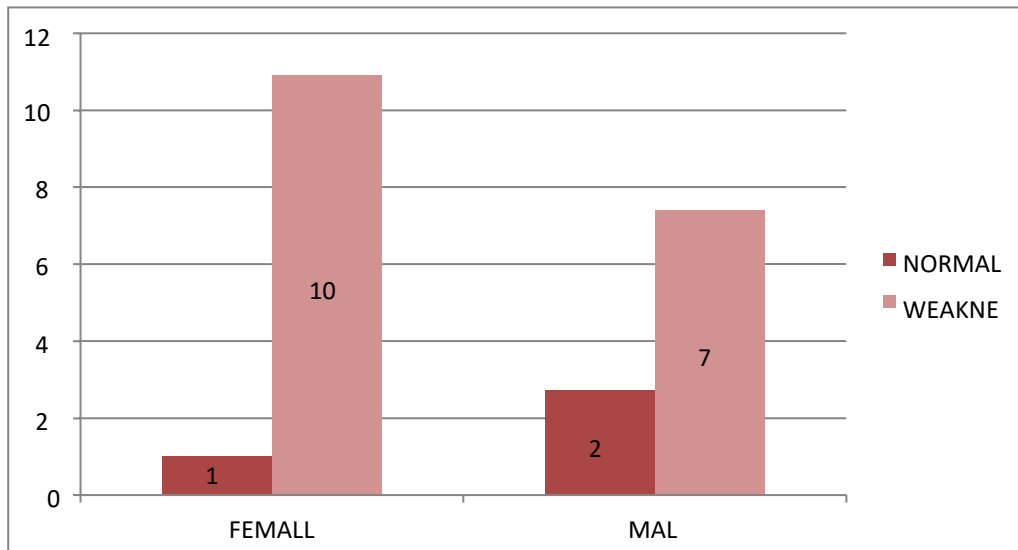
Characteristics		Overall population	Normal	Weakness
Gender	Male	101	73.0%	40.4%
	Female	119	27.0%	59.6%
Age	>20	117	45.9%	24.0%
	<20	102	54.1%	76.0%
BMI	Underweight	34	21.6%	14.2%
	Normal	130	73.0%	56.3%
	Overweight	42	5.4%	21.9%
	Obese	14	0.0%	7.7%

Table 4: The table shows the side bridge endurance test characteristic and its percentage.

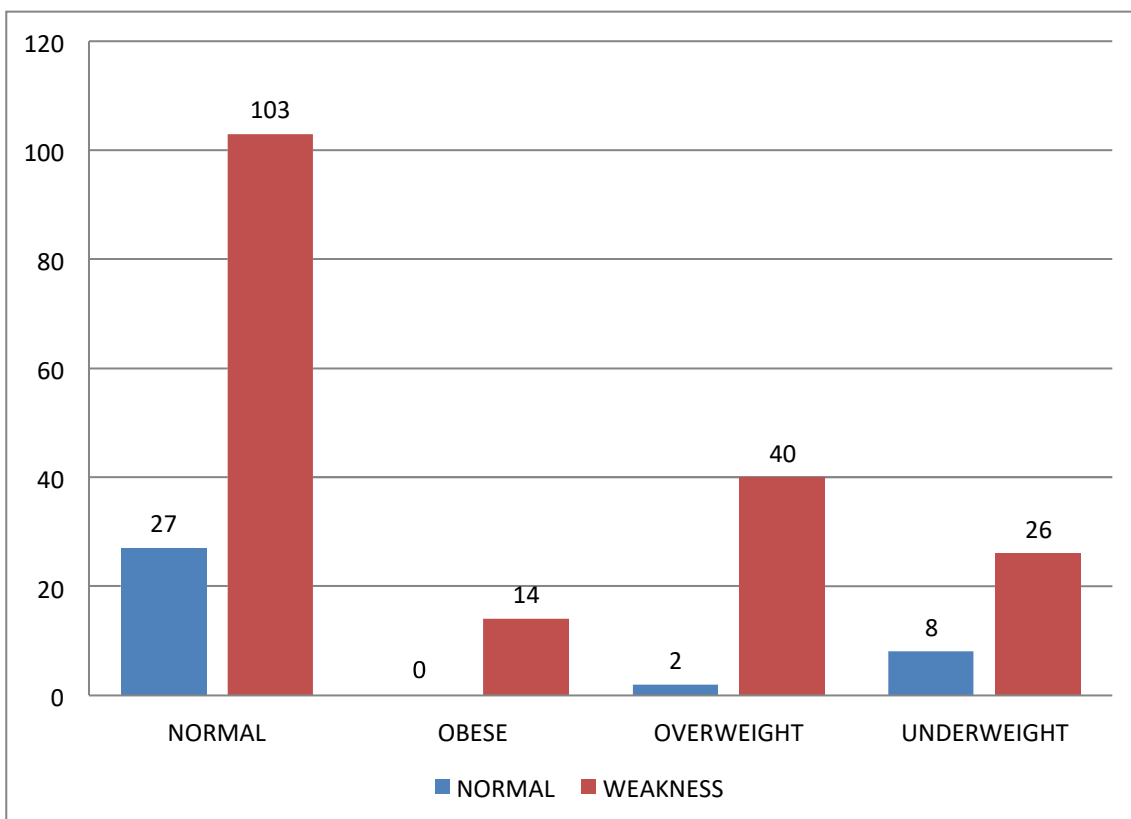


GRAPH: 5.1. Shows the graphical represents of side bridge Endurance test according to the age





GRAPH: 5.2. Shows the graphical represents of side bridge endurance test according to the Gender



GRAPH: 5.3. Shows the graphical represents of side bridge endurance test according to the BMI Range

**RESULT**

- In this study we analyzed the core muscle weakness among college students based on the three-core muscle test
- ✓ The Biering Sorensen test is used to assess the spine extensor part of core strength
- ✓ Prone plank test is used to assess the anterior part of core strength.
- ✓ Side bridge endurance test is used to assess the lateral part of core strength.
- Overall, the Biering Sorensen test showed a weakness of 8.1 % among 220 students.
- Overall, the Prone plank test showed a weakness of 35.4% among 220 students.

- Overall, the Side bridge endurance test showed a weakness of 76.3% on Right side and 78.1% on the Left side.
- In this study showed that the students were having the core muscle weakness of lateral part of more on the left side > the right side, than the posterior part than the anterior part of core.

#### DISCUSSION:

This study was designed to analyse the core muscle weakness among college going students. In this study totally 220 students were included. Out of 220 students 119 were female students and 101 were male students.

In this study totally three different types of core muscle test are used to determine the weakness they are Biering Sorensen test, Prone plank test and Side bridge endurance test were performed. The study finds the core muscle weakness percentage for overall 220 students.

For Biering Sorensen test

From the overall population out of 220 students 202 students are normal and 18 students have weakness.

According to gender category, out of 101 male students 98 are normal and 3 are weakness. Out of 119 females 104 students are normal and 15 students have weakness.

- According to age category, the students are divided into 2 groups (age less than 20 and age greater than 20). Students with age <20, 143 students are normal and 16 students have weakness. Students with age >20, 59 students are normal and 3 students have weakness.
- According to BMI category, out of 220 population 130 students come under normal BMI category, out of 130 students 27 students are normal and 103 students have weakness. 34 students come under the underweight category, out of 34 students 8 students are normal and 26 students have weakness. 42 students come under the overweight category, out of 26 students 35 are normal and 7 have weakness. 14 students come under the obesity category out of 14 students 4 students are normal and 10 have weakness.

For prone plank test

- From the overall population out of 220 students 142 students are normal and 78 students have weakness.
- According to gender category, out of 101 males 71 students are normal and 30 students have weakness. Out of 119 females 62 are normal and 48 have weakness.
- According to age category, the students are divided into 2 groups (age less than 20 and age greater than 20). Students with age <20, 99 students are normal and 60 students have weakness. Students with age >20, 43 students are normal and 18 students have weakness.
- According to BMI category, out of 220 population 130 students come under normal BMI category, out of 130 students 102 students are normal and 28 students have weakness. 34 students come under the underweight category, out of 34 students 26 students are normal and 8 students have weakness. 42 students come under the overweight category, out of 26 students 13 are normal and 29 have weakness. 14 students come under the obesity category out of 14 students 1 student is normal and 13 have weakness.

For side bridge endurance test

- For right side, out of 220 students, 52 students are normal and 168 have weakness. For left side, out of 220 students, 48 students are normal and 172 have weakness.
- According to gender category, out of 101 males 27 students are normal and 74 students have

weakness. Out of 119 females 10 are normal and 109 have weakness

- According to age category, the students are divided into 2 groups (age less than 20 and age greater than 20) Students with age <20, 20 students are normal and 139 students have weakness. Students with age >20, 17 students are normal and 44 students have weakness.
- According to BMI category, out of 220 population 130 students come under normal BMI category, out of 130 students 27 students are normal and 103 students have weakness. 34 students come under the underweight category, out of 34 students 8 students are normal and 26 students have weakness. 42 students come under the overweight category, out of 26 students 2 are normal and 40 have weakness. 14 students come under the obesity category out of 14 students 0 students are normal and 14 have weakness.

The results of the study by Dr. Parul Rakholiya et al 2021, concluded that 18–25 years females have core muscle weakness and they used 60 Degree Flexion Test, Biering–Sorensen Extension Test and Side Plank test to assess the core muscles.

The results of the study by Prachiti Rajan Bhore et al 2019, concluded that core muscle weakness in bank employees was found to be more within the age group of 45–50 years and also concluded that male having more weakness and the individuals with normal BMI.

Due to core muscle weakness, it impacts on the posture, gait, endurance, fatigue and general fitness of the individual. The weakness may lead to muscular imbalance and in turns musculoskeletal disorder. In order to prevent that we have to analyze the core muscle weakness and we prescribe the target strength to a weakened core muscles.

#### CONCLUSION:

- Based on the statistical data and result it was concluded that the core muscle weakness among college students was observed more in the lateral part of core musculature mainly on the Left side (78.18%) than the right side (76.36%) by using the Side bridge endurance test. The Core muscle weakness of anterior and posterior part of core is 35.4% by using the Prone plank test. The core muscle weakness in less in the spine extensor part of core is 8.1% by using the Biering Sorensen test.
- Due to lack of physical activity, prolonged sitting in the class and also physiological variations female students are having core muscle weakness than the male students.

#### LIMITATIONS

- The study is to analyze the core muscle weakness among college students only.
- The age group is between 18–25 years only.
- In this study core muscle weakness were analyzed using various clinical test not using any equipments.
- The study duration period was limited upto 3–4 weeks
- It is a non –invasive measure of clinical test.

#### SUGGESTIONS

- The core muscle weakness can be analyzed with various population along with EMG or biofeedback device among Health care professions, Students, Desk job workers, long standing job workers, Industrial workers and Agricultural Labours.
- Based on the study, we can prescribe the target core muscle exercise for the individuals with weakened core.

## BIBLIOGRAPHY

1. Richardson C, Jull G, Hodges P, et al. Therapeutic exercise for spinal stabilization and low back pain: scientific basis and clinical approach. Edinburgh (Scotland): Churchill Livingstone; 1999.
2. Bennell K, Baechle TR, Earle RW, Wathen D. Resistance training. In: Baechle TR, Earle RW, editors. Essentials of strength training and conditioning. 2nd ed. Champaign (IL): Human Kinetics, 2000: 395–425
3. Putnam CA. Sequential motions of body segments in striking and throwing skills. J Biomech 1993; 26: 125–35
4. Cresswell AG, Oddsson L, Thorstensson A. The influence of sudden perturbations on trunk muscle activity and intra-abdominal pressure while standing. Exp Brain Res 1994; 98 (2): 336–41
5. Beckman SM, Buchanan TS: Ankle inversion injury and hypermobility: effect on hip and ankle muscle electromyography onset latency.
6. <https://mobilephysiotherapyclinic.in/deep-core-muscles/>
7. Chang WD, Lin HY, Lai PT. Core strength training for patients with chronic low backpain. Journal of Physical Therapy Science. 2015;27(3):619–22.
8. Dr. Parul Rakholiya, Dr. Ishna Mistry, Dr. Rushali Patel, Dr. Princy Tank and Dr. Drashti Sonpal
9. Rakholiya P, Mistry I, Patel R, Tank P, Sonpal D. Prevalence core muscle weakness in 18– 25 years old females. IJAR. 2021;7(9):37–40.
10. Bhore PR, BATHIA K, KANASE S, JADHAV A. Prevalence of Core Weakness in Bank Employees. Journal of Clinical & Diagnostic Research. 2019 Mar 1;13(3).
11. Cholewicki J, Juluru K, McGill SM, et al. Intra-abdominal pressure mechanism for stabilizing the lumbar spine. J Biomech 1999; 32 (1): 13–7
12. Anderson A, Hoffman J, Johnson B, Simonson A, Urquhart L. Core strength testing: developing normative data for three clinical tests. Retrieved from Sophia, the St. Catherine University repository website: [https://sophia.stkate.edu/dpt\\_papers/32](https://sophia.stkate.edu/dpt_papers/32)
13. Rathore M, Trivedi S, Abraham J, Sinha MB. Anatomical correlation of core muscle activation in different yogic postures. International Journal of Yoga. 2017;10(2):59.