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Evaluation of Muscle Work of Serratus Anterior in School Going Children with Normal Bmi in Secondary School Due to Heavy Weight of Bags.

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Abstract

Background

Kids aged 10–16 are still growing, so heavy schoolbags can cause back pain, poor posture, and muscle problems. Bags over 10% of their body weight are risky. One-strap bags can cause uneven shoulders and shoulder blade issues like "scapular winging." The Indian government recommends schoolbags weigh 4–5 kg depending on grade. Doctors use BMI to check health risks and MMT to test muscle strength. Carrying bags the wrong way can lead to long-term joint and muscle issues.

Objective: *To evaluate muscle work of serratus anterior in school going children with normal BMI in secondary school due to heavy weight of the bag, to find out weakness of serratus anterior muscle, to find out average bag weight they carry, to rule out any associated pain due to heavy bag.*

Methods: *A survey was carried out among 250 secondary school students with normal BMI using the MMT method. Eligibility criteria encompassed children with normal BMI and Children studying in secondary. Individuals with a history of shoulder joint injuries, recent shoulder-related fractures, or recent upper limb surgeries will be excluded.*

Results: *Out of 250 secondary school children with normal BMI who were involved in the study a total of 107 students (42.8%) exhibited weakness of serratus anterior muscle, as assessed using MMT. When grouped based on bag weight, it was found that, among students carrying bags weighing less than 3 kg, only 15 students showed weakness (2 bilateral, 5 right side and 8 left side). In contrast students carrying bags heavier than 3 kg has significantly higher incidence of weakness (92 cases), including 30 bilateral, 23 right side and 39 left sided muscle weakness. The majority of weakness cases (71 out of 80) were observed in students with normal BMI, followed by 8 cases in the underweight group and only 1 case in the overweight group. Within normal BMI category, left sided weakness (41) was most prevalent, followed by right sided (20) and bilateral weakness (10).*

Conclusion: *From this project, we can say that carrying heavy school bags every day can make the serratus anterior muscle weaker, even in school kids who are healthy and have normal BMI. This suggests that merely having normal body weight doesn't mean a child is safe from muscle problems. The daily pressure on the shoulders from heavy bags can slowly affect muscle strength without any obvious signs at first. So, it's important to keep school bags light, use both shoulder straps, and encourage good posture and simple exercises to keep the shoulder muscles strong and healthy. Taking care of this early can help prevent pain, poor posture, and other muscle issues later in life.*

Keywords: *Heavy bags, Normal BMI, School going children, Secondary school, Serratus anterior muscles.*

INTRODUCTION:

Students in grades 5 to 10, usually ranging in age from 10 to 16 are in an important stage of growth. Repeated physical stress in these years may lead to long-term health effects. Lately, the problem of heavy school backpacks has become a growing concern among parents, healthcare professionals, and the media. Research shows that carrying overly heavy backpacks is linked to a higher risk of back pain, poor posture, and other muscle and joint problems in children. Some of the study found that about 18.8% of children experienced musculoskeletal pain. It also showed that kids who carried backpacks weighing more than 10% of those with higher body weight were more likely to have this kind of pain compared to those with lighter bags. Research has also shown that gender may play a role, and that a child's Body Mass Index (BMI) can influence their risk of developing musculoskeletal problems. To help prevent these issues, India's Ministry of Human Resource Development has set guidelines for school bag weight: no more than 5 kg for students in grades 10 to 12, 4.5 kg for grades 8 and 9, and 4 kg for grades 5, 6, and 7.[(1)] Using one-strap school bags can seriously affect posture, often causing problems like uneven shoulders and even

changes in the spine's alignment. Carrying a heavy bag on just one side puts constant strain on the body, which can negatively impact a young person's posture and the way they walk. Bags that are worn on one shoulder or not positioned correctly can lead to muscle weakness and poor posture over time. This can result in symptoms like shoulder or arm pain, numbness, weakness, and even muscle loss. During a physical exam, doctors may notice weakness in specific muscles like the deltoid, supraspinatus, infraspinatus, and sometimes the wrist extensors.[2] The serratus anterior is a fan-shaped muscle that starts from the side of the upper ribs (usually the first 8 or 9) and connects to different parts of the shoulder blade (scapula), including the top corner, inner edge, and bottom corner. [4] If this muscle becomes weak, the shoulder blade can't stay stable during arm movements. As a result, when you try to move your arm, the shoulder blade sticks out from the back instead of staying flat against the ribcage — a condition known as "scapular winging." This makes it harder for the shoulder to move properly and stay strong against external pressure.[3] When certain muscles around the shoulder work without proper balance from opposing muscles, the scapula (shoulder blade) can move either toward the spine (medially) or away from it (laterally) along the back. This imbalance can weaken the muscles that control the scapula [4] . People with forward head posture often have increased upper back rounding (thoracic kyphosis), which can change the natural placement of the shoulder blades. Among the muscles surrounding the shoulder blade, the **serratus anterior** is the one most often involved in winging. When this muscle isn't working properly, it can't hold the shoulder blade (scapula) tightly against the ribcage. For this reason, the inner edge of the shoulder blade sticks out a condition known as **medial winging**. This can make the shoulder blade stick out all the time, even when you're not moving it. Or, it can mess with how smoothly your shoulder blade moves when you lift or use your arm a problem known as **scapular dyskinesis** or **dysrhythmia**. [5]
As life has become more on-the-go, the physical demands on kids have changed too. Today, students often carry their books and school supplies back and forth in backpacks also called knapsacks, rucksacks, book bags, or school bags. Carrying a backpack has become a regular part of life for schoolchildren. In fact, around 90% of kids in developed countries use a backpack for school. In children and teenagers, musculoskeletal problems can sometimes be linked to their environment especially at school. Since their bones are still growing, any issues during this stage can lead to problems with their joints and muscles later on, including orthopedic or rheumatic conditions. Backpacks are a practical way to carry things while keeping the load close to the spine and balanced, which helps maintain stability. They're commonly used by students to carry everything they need like textbooks, notebooks, water bottles, and lunch boxes. However, when backpacks are too heavy, they can lead to different kinds of muscle and joint pain in children or any musculoskeletal disorders. Studies have found that schoolchildren around the world often experience pain or discomfort in their shoulders and backs. Carrying heavy schoolbags and using them the wrong way can negatively affect students' health. Researches have shown that this can lead to muscle imbalances, repeated strain on the body, extra pressure on joints and ligaments, increased energy use, and even reduced lung capacity. Previous studies from other countries have found that the average weight of schoolbags typically ranges from 4.7 kg to 9.3 kg. [6] The BMI is a tool used by healthcare professionals to help estimate a person's risk for chronic disease. BMI uses height and weight to determine one's optimal health. BMI (kg/m2): Underweight: < 18.5, Normal: 18.5 - 24.9, Overweight: 25.0 - 29.9, Obesity: 30.0 - 34.9 to 35.0 - 39.9, Extreme Obesity: 40.0[7] To assess or to evaluate the muscle strength MMT is used. Manual Muscle Testing (MMT) is among the most commonly used methods to evaluate and documenting muscle strength. [8,9]

METHODOLOGY:
Study site: KCT's Krishna school karad.
Study design: Observational.
Study population: School going children.
Ethical approval: The approval for this study is gained from institutional ethics committee of Krishna Vishwa Vidhyapeeth (deemed to be university), karad. Respondents were given a detail explanation about data collection sheet as well as the study which is to be conducted and informed consent was collected from each participant participating in this study. There was a volunteer involvement of all the respondents in this study whose confidentiality was thoroughly maintained. Protocol no:
Sample size: 250
Inclusion criteria:
- Children with normal BMI.
- Children studying in secondary.

- Asymptomatic students.
- Children who are willing to participate.

Exclusion criteria:
- Subjects with any past history of shoulder joint Injury.
- Recent fractures related to shoulder.
- Recent Surgery in upper limb.

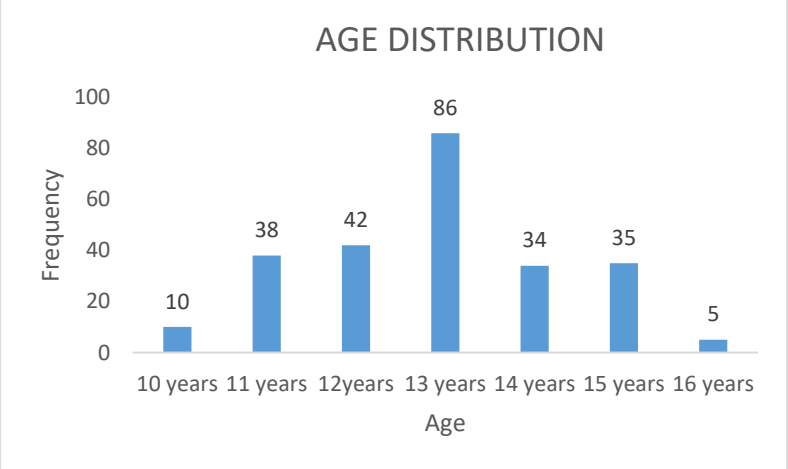
Sampling method: Simple Random Sampling Method.
Method of data collection:
- The study protocol was presented for approval in front of protocol committee and the institutional ethical committee of Krishna Vhiswa Vidhyapeeth (Deemed to be University), Karad.
- After that concerning subject were approached, the purpose of the study was explained and a written consent was taken from the parents of the subjects who were willing to participate into the study.
- A brief demographic data was taken from the participants prior to the assessment.
- Subjects were selected as per inclusion and exclusion criteria.
- During the assessment, the procedure was explained to the subjects.
- Selection of subjects was done randomly.
- Assessment was taken by using outcome measures: **Range of motion** and **Manual muscle testing (MMT).**
- The study was concluded based on statistical analysis.

Statistical method:
Result:

DEMOGRAPHIC DATA:

Table 8.1

AGE	FREQUENCY	PERCENTAGE
10 years	10	4%
11 years	38	15.40%
12 years	42	16.80%
13 years	86	34.40%
14 years	34	13.60%
15 years	35	14%
16 years	5	2%



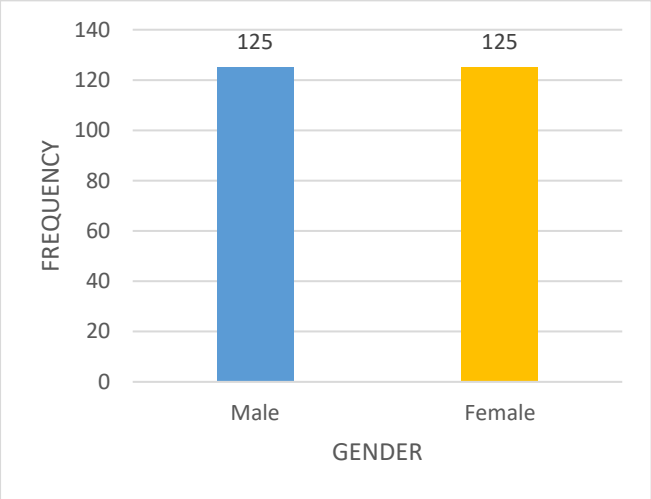
Graph 8.1: Age Distribution

Interpretation: Graph 1 represent the age of the subject ranged from 10 to 16. In 10 years age group there are 10 subjects, in 11year age group there are 38 subjects, 12 years of age group 42 subjects were participated, in 13 year of age group there are 86 subjects, in 14 year of age group there are 34 subjects,

in 15 and 16 years of age group there are 35 and 5 subjects respectively. The largest number of students were aged 13 years (86 students) while the smallest group was 16 years old (only 5 students). Other age group were more evenly spread.

Table 8.2

GENDER	FREQUENCY	PERCENTAGE
MALE	125	50%
FEMALE	125	50%

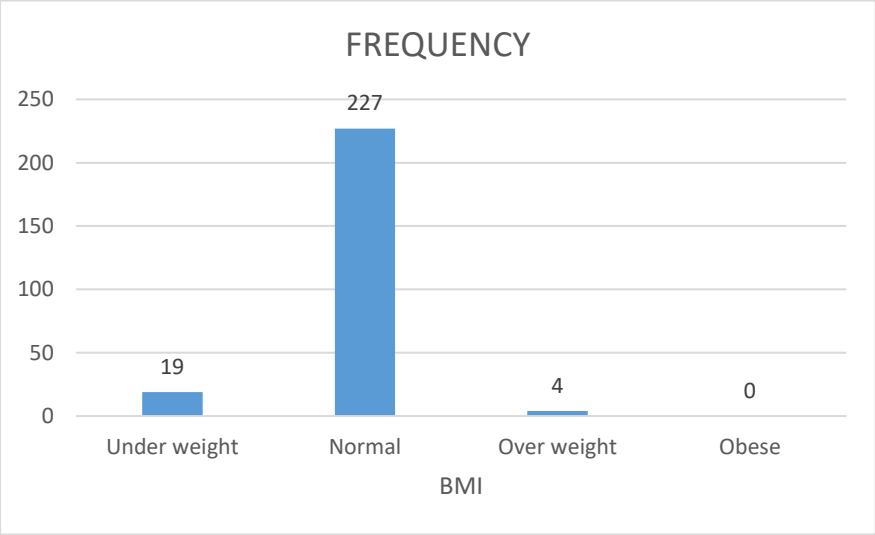


Graph 8.2: GENDER DISTRIBUTION

Interpretation: Graph 2 represents, a total of 250 subjects were taken for the study. Here 50% are male and 50% are female i.e. there are 125 male and 125 female out of 250 subjects. This equal representation ensures that the finding of the study are not biased towards one gender and allows fair comparison of result between male and female.

Table 8.3

BMI	FREQUENCY	PERCENTAGE
UNDERWEIGHT	19	7.60%
NORMAL	227	90.80%
OVERWEIGHT	4	1.60%
OBESE	0	0.00%



Graph 8.3: BMI

Interpretation: This graph shows the body mass index (BMI) distribution of 250 students who took part in the study. Most of the student i.e. 227 of them have normal BMI, indicating that 6they main6tain healthy weight related to their height. A small group of 19 students are underweight suggesting they may

be below the recommended weight for their height and age. Only 4 of them are slightly overweight. And there are no students in the obese category.

In this study we have done**, interpretation of statistical analysis of BMI VS Weight of the bag.** The **correlation between BMI and Weight of the school bag carried by students.**

• Correlation coefficient (r) : 0.2005.

This indicates a weak positive correlation between BMI and the Weight of the bag. In simple terms, as BMI increases slightly, the weight of the school bag also tends to increase slightly but the relationship is not strong.

• Coefficient of Determination (r^2): 0.04221.

This means that only 4.2% of the variation in the weight of the bag can be explained by BMI. The rest of the variation (about 95.8%) is likely due to other factors not related to BMI.

• Confidence Interval (CI 95%): 0.08348 to 0.3214.

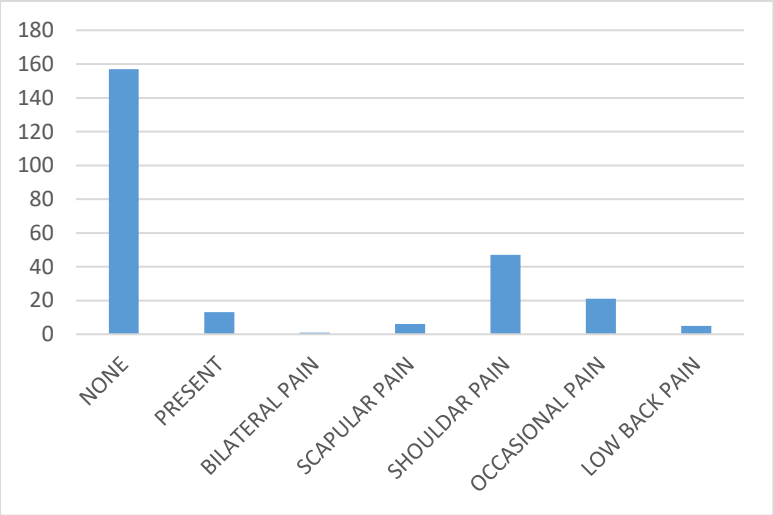
This range shows that the true correlation is very likely to fall between these two values, reinforcing that the correlation is positive but weak.

• P-value: 0.0011.

This value is less than 0.05, indicating that the correlation is statistically significant. In simple words, the relationship between BMI and the Weight of Bag is not due to random chance.

Table 8.4

PAIN	FREQUENCY	PERCENTAGE
NONE	157	62.80%
PRESENT	13	5.20%
BILATERAL PAIN	1	0.40%
SCAPULAR PAIN	6	2.40%
SHOULDAR PAIN	47	18.80%
OCCASIONAL PAIN	21	8.40%
LOW BACK PAIN	5	2%

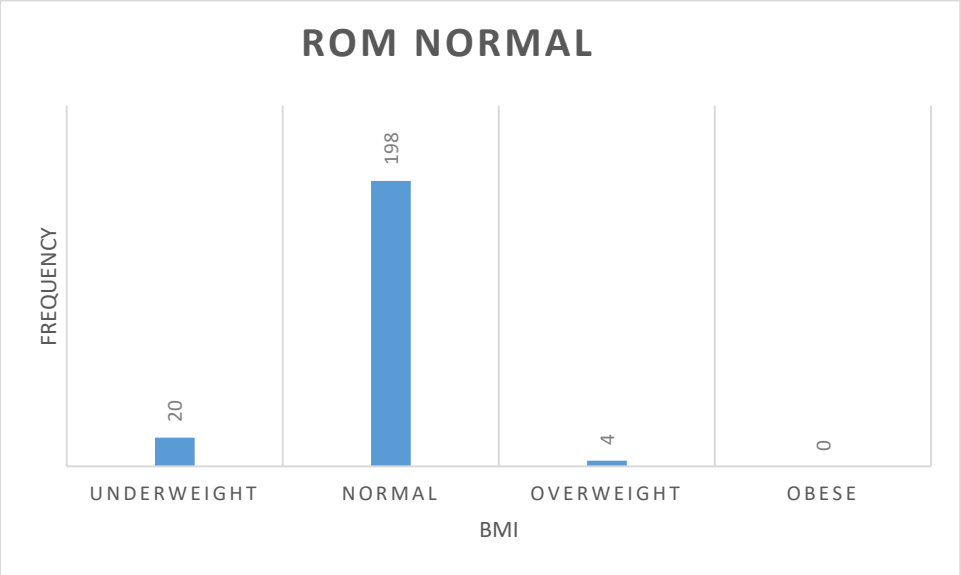


Graph 8.4: Pain Distribution

Interpretation: This graph represents that, how many students reported different types of pain. Most of the students said they did not have any pain at all, which is a positive sign. However, a small number of students reported having pain, including shoulder pain, low back pain, scapular pain, occasional pain, and even bilateral pain in shoulder. Shoulder pain and occasional pain of upper limb appear to be the most common among those who did report discomfort. This could be related to the heavy weight of school bags, which may be affecting certain parts of their bodies, especially the upper back and shoulder.

Table 8.5 (a)

BMI	ROM Normal
Underweight	20
Normal	198
Overweight	4
Obese	0

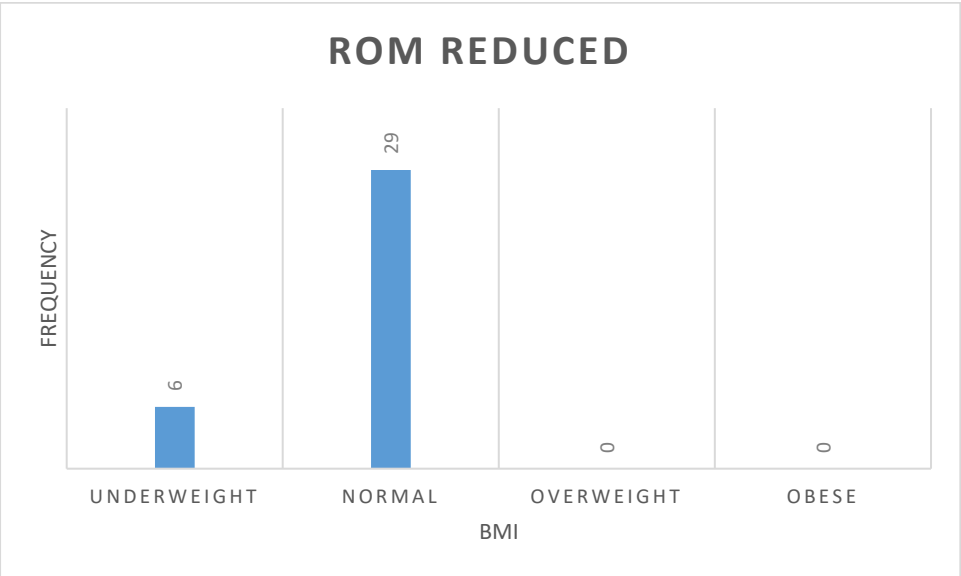


Graph 8.5(a) BMI VS Normal ROM

Interpretation: the graph 5(a) and 5(b) represents the correlation between Body Mass Index (BMI) and Range of Motion (ROM). The first graph i.e. graph 5(a) (ROM Normal) the most student are under the category of normal BMI-that's 198 students. 20 students are underweight who has normal Range of Motion. And 4 students have normal ROM which are overweight.

Table 8.5(b)

BMI	ROM Reduced
Underweight	6
Normal	29
Overweight	0
Obese	0

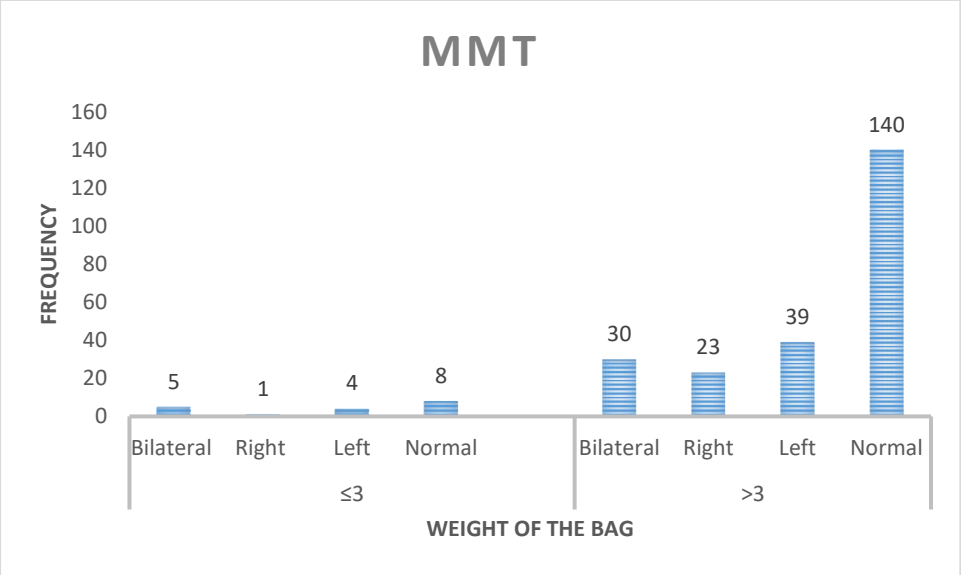


Graph 8.5(b) BMI VS Reduced ROM

Interpretation: In second graph i.e. graph 5(b) (ROM Reduced), 29 students with normal BMI has reduced ROM and few students i.e. 6 underweight students also had reduced ROM. There are no overweight and obese students were recorded with reduced ROM. This shows that while most students with normal BMI had healthy movements, some still show limited motion, which might be due to factors like posture, muscle weakness or the weight of school bags.

Table 8.6(a)

Weight of bag	MMT	Frequency
≤3	Bilateral	5
	Right	1
	Left	4
	Normal	8
>3	Bilateral	30
	Right	23
	Left	39
	Normal	140



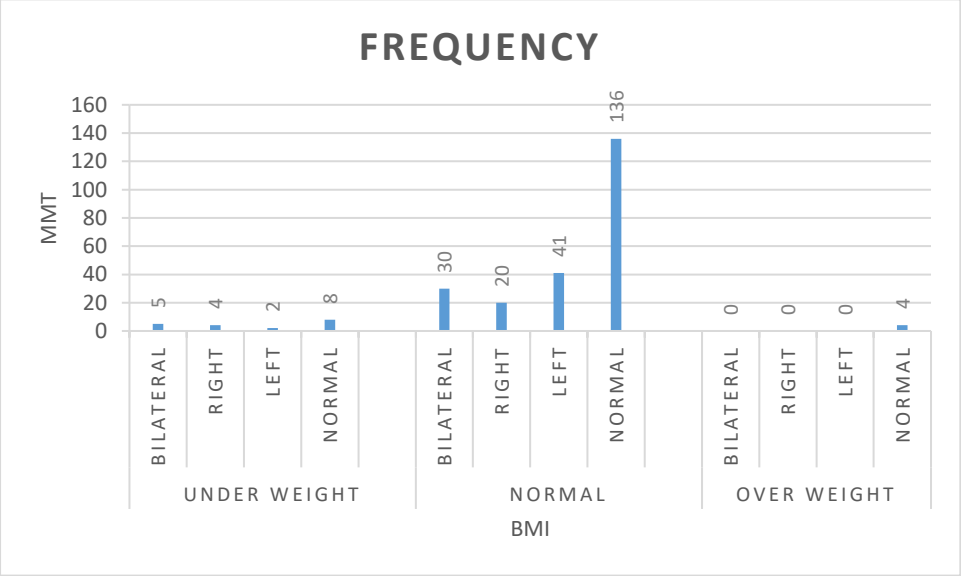
Graph 8.6(a) Weight of the bag VS MMT

Interpretation: This graph 6(a) illustrates the relationship between the weight of the bag and the Manual Muscle Testing (MMT) outcome in students the data is divided into two groups based on the bag weight: ≤3kg and >3 kg, and within each group, it categorizes the muscle strength as bilateral weakness, right side weakness, left side weakness or normal muscle strength.

Table 8.6(b)

BMI	MMT	Frequency
Under weight	Bilateral	5
	Right	4
	Left	2
	Normal	8

Normal	Bilateral	30
	Right	20
	Left	41
	Normal	136
Over Weight	Bilateral	0
	Right	0
	Left	0
	Normal	4



Graph 8.6(b) BMI VS MMT

Interpretation: In graph 6(b), it shows the relationship between Body Mass Index (BMI) and Manual Muscle Testing (MMT) results in school going children. It compares that frequency of muscle weakness (bilateral, right, left) and normal muscle strength across BMI groups (underweight, normal, and overweight)

INTERPRETATION OF CHI-SQUARE TEST RESULT:

The result of Chi-Square test used to examine the association between muscle strength (MMT) and three different variables: Weight of the Bag, BMI, and the combination of both (Weight + BMI).

- **Weight of the bag:**

Chi-Square value: 3.958
Degrees of freedom: 3
This suggest a weak association between weight of school bag and Muscle Strength. The Chi-Square value is relatively low, so this relationship is not statistically strong on its own.

- **BMI:**

Chi-Square value: 9.206
Degrees of freedom: 6
This shows a moderate association between BMI and Muscle Strength. The higher value compared to Weight alone suggests BMI may play a more significant role in Muscle Strength differences.

- **Combined effect of Weight of bag + BMI:**

Chi-Square value: 13.164
Degrees of freedom: 12
This indicates a strong association when both Weight of the Bag and BMI are considered together. The higher Chi-Square value and Degrees of Freedom suggest that the combined effect of these two factors is more impactful on Muscle Strength than either factor alone.

DISCUSSION:

The present study aimed to evaluate the strength of the serratus anterior muscle in secondary school children who have a normal BMI but regularly carry heavy school bags. Using Manual Muscle Testing (MMT) as a method, the study explored how to daily habit of carrying backpacks may influence muscle performance. The serratus anterior plays a key role in stabilizing the scapula and helping with overhead arm movements. In school going children, especially those in their growing years, carrying heavy bags for long duration can put continuous stress on this muscle. Over time, this may lead to muscle fatigue, weakness, or even postural issues like round shoulders and scapular winging.
This study set out to see how heavy school bags might be affecting the strength of the serratus anterior muscle in school children who have a normal BMI. This muscle is important because it helps keep the shoulder blade stable and moving properly. We tested its strength using Manual Muscle Testing (MMT), looking for signs of weakness on one side, both sides, or no weakness at all.

In the normal BMI group (n = 227), just over half of the children (59.9%) had normal serratus anterior strength. The rest (40.1%) showed weakness — 13.2% in both shoulders, 8.8% only on the right, and 18.1% only on the left. In the underweight group (n = 19), fewer children had normal strength (42.1%), and more than half (57.9%) had some form of weakness. Interestingly, all overweight children in this study (n = 4) had normal muscle strength, but this finding should be taken cautiously because of the very small sample size.

The fact that many normal-BMI children had weakness suggests that body weight alone isn't the main factor — it's more likely related to how the school bag is carried. Previous research shows that heavy backpacks can pull the shoulders downward and forward, changing how the shoulder blade moves and making the serratus anterior work less efficiently over time (Mackenzie et al., 2013; Negrini & Carabalona, 2002).

We also noticed that left-sided weakness was more common than right-sided. This could be because some students prefer carrying the bag on one shoulder, often the left, which matches earlier studies linking one-strap carrying to uneven muscle strain (Chow et al., 2005). When one side of the muscle works harder and the other less, over time it can lead to imbalance, shoulder blade winging, and even neck or shoulder discomfort (Cools et al., 2014).

These results support the recommendations from ergonomic studies that a child's school bag should weigh no more than 10–15% of their body weight (Brackley & Stevenson, 2004; Dockrell et al., 2015). Alongside weight limits, it would help to teach students how to wear backpacks correctly (using both straps) and encourage exercises that keep the shoulder stabilizing muscles strong.

Of course, there are limits to what our study can say. MMT is a widely used and practical test, but it's still subjective and depends on the examiner's technique and the student's effort (Florence et al., 1992). Also, because this study looked at one point in time, we can't be certain that heavy bag use directly causes the weakness — only that they're linked. Future studies could follow children over several years and use more objective tools like muscle activity sensors (EMG) to confirm these results.

In short, our findings highlight that even children with a healthy BMI can develop serratus anterior weakness if their school bags are too heavy or carried incorrectly. Schools and parents can help by watching bag weights, promoting proper carrying habits, and encouraging shoulder-strengthening activities.

CONCLUSION:

From this project, we can say that carrying heavy school bags every day can make the serratus anterior muscle weaker, even in school children who are healthy and have normal BMI.

This shows that just having normal body weight doesn't mean a child is safe from muscle problems. The daily pressure on the shoulders from heavy bags can slowly affect muscle strength without any obvious signs at first.

So, it's important to keep school bags light, use both shoulders straps, and encourage good posture and simple exercises to keep the shoulder muscles strong and healthy.

Taking care of this early can help prevent pain, poor posture, and other muscle issues later in life.

REFERENCES:

1. Sankaran, S., John, J., Patra, S. S., Das, R. R., & Satapathy, A. K. (2021). Prevalence of musculoskeletal pain and its relation with weight of backpacks in school-going children in Eastern India. Frontiers in Pain Research, 2, 684133.

2. Pascoe, D. D., Pascoe, D. E., Wang, Y. T., Shim, D. M., & Kim, C. K. (1997). Influence of carrying book bags on gait cycle and posture of youths. Ergonomics, 40(6), 631-640.

3. Barnett, N. D., Mander, M., Peacock, J. C., Bushby, K., Gardner-Medwin, D., & Johnson, G. R. (1995). Winging of the scapula: the underlying biomechanics and an orthotic solution. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine, 209(4), 215-223.

4. Martin, R. M., & Fish, D. E. (2008). Scapular winging: anatomical review, diagnosis, and treatments. Current reviews in musculoskeletal medicine, 1(1), 1-11.

5. Ng, C. Y., & Wu, F. (2021). Scapular winging secondary to serratus anterior dysfunction: analysis of clinical presentations and etiology in a consecutive series of 96 patients. Journal of shoulder and elbow surgery, 30(10), 2336-2343.

6. Corraya, T. A. (2017). The school bag's weight influence on the physical status of school going children (Doctoral dissertation, Bangladesh Health Professions Institute, Faculty of Medicine, the University of Dhaka, Bangladesh).

7. Obese, H. J. O. R. (1998). Body mass index (BMI). Obes Res, 6(2), 51S-209S.

8. Cuthbert, S. C., & Goodheart Jr, G. J. (2007). On the reliability and validity of manual muscle testing: a literature review. Chiropractic & osteopathy, 15(1), 4.

9. Kendall, F., McCreary, E., & Provance, P. (1994). Muscles, testing and function. Medicine and Science in Sports and Exercise, 26(8), 1070.

10. Brackley, H. M., & Stevenson, J. M. (2004). Are children's backpack weight limits enough?: A critical review of the relevant literature. Spine, 29(19), 2184-2190.

11. Chow, D. H., Kwok, M. L., Cheng, J. C., Lao, M. L., Holmes, A. D., Au-Yang, A., ... & Wong, M. S. (2006). The effect of backpack weight on the standing posture and balance of schoolgirls with adolescent idiopathic scoliosis and normal controls. Gait & posture, 24(2), 173-181.

12. Cools, A. M., Dewitte, V., Lanszweert, F., Notebaert, D., Roets, A., Soetens, B., ... & Witvrouw, E. E. (2007). Rehabilitation of scapular muscle balance: which exercises to prescribe?. The American journal of sports medicine, 35(10), 1744-1751.

13. Dockrell, S., Simms, C., & Blake, C. (2013). Schoolbag weight limit: can it be defined?. Journal of school health, 83(5), 368-377.

14. Florence, J. M., Pandya, S., King, W. M., Robison, J. D., Signore, L. C., Wentzell, M., & Province, M. A. (1984). Clinical trials in Duchenne dystrophy: standardization and reliability of evaluation procedures. Physical therapy, 64(1), 41-45.

15. Mackenzie, W. G., Sampath, J. S., Kruse, R. W., & Sheir-Neiss, G. J. (2003). Backpacks in children. Clinical Orthopaedics and Related Research®, 409, 78-84.

16. Negrini, S., & Carabalona, R. (2002). Backpacks on! Schoolchildren's perceptions of load, associations with back pain and factors determining the load. Spine, 27(2), 187-195.