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Effectiveness of an Ergonomic Intervention Program in College Students Carrying Backpack in a Metropolitan City

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ABSTRACT

Background: College going students and backpack is common scenario. Backpack is easiest way to carry necessary stuff. Carrying overstuffed backpacks might be seen harmless but can turn into more than just a weight problem. College students might ignore & not report the problems. Thus, this study can help to check ergonomic intervention effect in one of the various cumulative trauma disorders that the college students may be exposed to.
Objectives: The research was designed to study the effectiveness of an ergonomic intervention program in college students carrying backpack in a metropolitan city.
Design: An interventional prospective study design was chosen for the research.
Methods: After institutional ethics committee approval, samples of 30 college students were recruited using convenient sampling method in this study. Each participant was assessed using standardised tools - Visual Analog scale (VAS),Nordic musculoskeletal questionnaire, backpack questionnaire, case record form at the first day of study & reassessed after 4 weeks post ergonomic intervention. Each participant was discharged after 4 weeks of initial recruitment.
Results: Data was subjected to statistical analysis using Statistical package for social sciences (SPSS v 21.0, IBM). Comparison of frequencies of categories of variables with groups was done using chi square test. 63.3% of participants reported neck pain which was highest followed by low back 30% & upper back pain 26.7%. Post intervention pain intensity on VAS scale was also reduced.
Conclusion: The study concluded that college students carrying backpack had some musculoskeletal problems. Ergonomic intervention provided to them was effective in improvement of muscle power and reducing pain intensity.

Key Words: Backpack, College students, Ergonomics, Musculoskeletal disorders

INTRODUCTION

ERGONOMICS: Is an applied science concerned with designing and arranging things people use, so that the people and things interact most efficiently and safely.

Ergonomics is a science-based discipline that brings together knowledge from anatomy, physiology, psychology; engineering and statistics to ensure that design complement the strengths and abilities of people and minimize the effects of their limitations. College going students & their backpacks is common scenario. Backpack is the easiest way to carry necessary stuffs. Backpack is appropriate way to load spine closely & symmetrically while maintaining stability. Carrying over stuffed backpacks might see harmless but can turn into "more than just a weight problem."[1,2]

However, when used incorrectly, backpacks can cause severe back, neck, and shoulder pain or even injury [1]. College is hard enough; students most the time ignore any such problems. According to a study by Boston University, approximately 85% of university students self-report a discomfort and pain associated with backpack usage. Carrying too much weight might lead to short term and possible long-term health issues. Improper use of backpack can lead to muscle imbalance that could turn into chronic neck and back pain. Backpack worn on one shoulder might cause to lean child to one side causing spine to curve and causing pain. It has been shown in a systemic review by Balamurugan in the year 2017 that the school bag, of approximately more than 10%- 15% of the body weight can cause excessive loading on the spine, the upper part of the body (head and cervical spine), and upper limbs that load their weight into thoracic spine. Excessive loading of school bags has detrimental effects of posture [3,12,20]. Excess and long-term loading causes forward head posture, protracted shoulders, and kyphosis. Backpack loads exceeding 10% of body weight have been shown to increase energy consumption, increase trunk forward lean, and result in decreased lung volumes.[3]

Although musculoskeletal symptoms such as muscle soreness, numbness, shoulder pain, and back pain are believed to be multifactorial in origin. A backpack is considered one of the factors. A badly worn backpack can change posture and gait when walking and this compounds the problems. (Singh and Koh 2009) revealed that it is critical to understand the effects of increased backpack weight on children due to their developing bodies. Too much load on the body changes static and dynamic posture as the body tries to overcome the posterior shift in the Centre of mass. The American Occupational Therapy Association, the American Academy of Orthopedic Surgeons and the International Chiropractic Paediatric Association suggest that the load should not be more than 10%, the American Physical Therapy Association suggests 15%, and the American Association of Chiropractors suggests 5-10% (Cavallo et al 2002). American occupational therapy association gives basic guidelines regarding backpack wearing. Donning of a backpack on shoulder requires muscle activation of the trapezius, latissimus dorsi, erector spinae along with that trunk muscles are also required for stability of pelvic. Awareness among students, teachers, parents to restrict backpack load not heavier than 10% of the children's body weight [1,2,6]. Along with appropriate ergonomic intervention is necessary. [1,2]

Aim: To study the effectiveness of an ergonomic intervention program for college going students carrying backpack.

Objective:

1. To assess specific area related musculoskeletal pain & discomfort by using Nordic scale in participants.
2. To assess pain by using Visual Analog Scale.
3. To assess muscle strength of back and abdominal musculature using manual muscle testing.

Hypothesis:

NULL HYPOTHESIS

(H0): Ergonomic intervention program is not effective for college students carrying backpack.

ALTERNATIVE HYPOTHESIS

(H1): Ergonomic intervention program is effective for college students carrying backpack.

MATERIALS AND METHODS

STUDY DESIGN: An interventional prospective study.

30 participants were recruited in the study post approval from institutional ethics committee. The participants were informed about the nature and objectives of the study & recruited only after signing of Inform consent document.

The eligibility criteria of the participants:

Inclusion criteria:

1. College students (of any stream like science, commerce, arts, medical, law, etc.) carrying a backpack.
2. College going students of the above-mentioned streams with a backpack between the age group of 18 to25 years.
3. Both male and female college students carrying backpack will be include study.

Exclusion criteria :

1. College students using unilateral bags/sling bag.
2. College student diagnosed with known musculoskeletal problems.
3. College students diagnosed with a known psychiatric disorder.
4. College students refusing to participate.

**College students with a psychiatric disorder are excluded from the study because of compliance issues with intervention program and also, they might magnify symptoms related to a musculoskeletal system like pain etc.

Outcome measures:

1. **Visual Analog scale:** It is 0- 10-point scale (0 = no pain & 10= extreme pain.)VAS is a scale used a measure of pain intensity which has been widely used in the diverse adult population.
2. **Nordic musculoskeletal disorder questionnaire:** This questionnaire consists of questions related to low back, neck and shoulder region. The Response is of a dichotomous method (yes or no).It is a scale designed to measure musculoskeletal disorder (questionnaire about trouble with locomotive organs) (neck, shoulder and low back?) (It is freely available scale) [30 31]

   Along with this other study instruments
3. **Manual muscle strength testing by Florence Kendall.**
4. **Study Questionnaire (Backpack questionnaire):** It is a self-designed questionnaire. The questionnaire was formulated based on the review of the literature; the set of questionnaires was given to experts working in musculoskeletal injuries for validation. The study questionnaire includes basic questions related to backpack content it's carrying style. Travelling routes used commonly by participants, along with demographic data. It was mostly consisting of closed ended questions which will be easy to be answered by participants. Instructions for answering the questionnaire written at the start of questionnaire and also well explained to the participant.

5. Case record form

Study procedure: 31 participants were recruited in the study. 1 participant drop out (did not follow up). All the 30 participants were explained about the study protocol and informed consent was taken in their best understanding language. Participants were assessed using the above-mentioned study tools. This is an interventional follow-up study. Assessment of the participants was done on the first day and reassessments done after 4 weeks.

First session: After enrolment of the client, he or she was evaluated by using standardized scales VAS and Nordic Questionnaire. Muscle strength of back and core muscles were checked using the Kendall grading system. The validated study questionnaire was filled along with a case record form. Each participant spent 45 minutes maximum during evaluation.

Second Session: Participants were called for Follow up after a week and compliance with the intervention program is checked.

Third session: Participants who have some doubts regarding the intervention program or facing some difficulties were followed up after 15days. (Not mandatory).

Final session: Re-assessment of the participants was done after 4 weeks by using the same assessment tools/scales.

This assessment and Intervention program were done at OT training school & centre. Participants were part of the study for 4 weeks (minimum 3 visits and maximum 4 visits) and then got discharged.

This activity did not affect the student's routine teaching program because students were evaluated before or after the teaching schedule for the day.

To ensure compliance of the participants for the ergonomic intervention program, a manual was mailed to the participants. This manual included correct and incorrect methods of carrying a backpack, what is ideal backpack, exercises with pictorials. This ergonomic intervention programme was formulated after reviewing available research and literature related to same [1, 8, 10, 13, 16, 24, 29, 33, 41].

Ergonomic intervention program:

1) Postural education: Posture correction techniques taught to the participants. Ideal sitting and standing posture taught by giving auditory cues and visual cues (mirror feedback). While in sitting: shoulders in retraction, if possible, sit on the chair and table of appropriate height, arm rest to support elbows, while working at computer /laptop screen of the at the level of eyes, feet properly rested on floor or use of short stool to support the feet was advised. Lumbar support advised; quick desk stretches taught to the participants. This desk stretch exercises were shown and taught to the participants with the help pictures. In standing, stand in erect posture, with proper distance between legs, locked knees.
2) Ideal carrying technique for carrying backpack technique was taught to participant. Backpack to be carried on both the shoulders and posteriorly on back. It should properly sit on the back around lower curve of the spine, not very low and loosely hanging.
3) Ideal lifting techniques for lifting backpack shown. Stand as close as possible to the object. Bend with both knees keeping a straight spine when picking up a backpack from lower surface or floor (squat lift).
4) If required backpack modifications were suggested in present backpack used by participants.

Suggestion/modifications in backpack.

Backpack education program for participants

a) Rest on the back, between neck and the curve of the low back of a student.
b) Include two wades curved, padded, adjustable shoulder straps.
c) Padded back to increase comfort.
d) Straps should be short enough to keep the bag close to the back, but not so short or tight as to discourage using both straps. Hip and chest straps help distribute the weight and maintain stability.
e) Provide multiple compartments for more even weight distribution.
f) Padding of the bags should be of soft material or gel.

5) Breathing exercises. Deep breathing exercises will be taught to client.
6) General range of motion exercises for neck, scapula and shoulder.
7) Core and back muscle strengthening exercises. It includes exercises bridging, straight leg raising, pelvic rotations, side leg raise, plank, crunches (graded exercises program was planned and given to participant as per their capacity)
8) **Energy conservation techniques & work simplification techniques.**
   To reduce fatigue Planning, pacing, prioritization techniques.
   Avoid using shoulder slings or handbags.
   Simplify your task. Use all pockets in backpack (even weight distribution.)
   Place the heaviest items close to your back. Use of lockers in college.
9) Desk stretch exercises. (Encourage frequent change of positions and know what positions to get into that "undo" the position) It included neck, pectoral,

finger, upper middle back stretch, shoulder shrugs, side to side stretch.

Table no. 1 Diagrammatic re- presentation of whole program

	Week 1	Week 2	Week 3 (not mandatory)	Week 4
1. Recruitment on the basis of inclusion criteria, consent taken.	✓			
2. Assessment (Nordic, VAS, questionnaire, MMT)	✓			
3. Implementation of ergonomic program	✓			
4. Compliance with the program check		✓	✓	
5. Increase in the frequency & intensity of program		✓	✓	
6. Providing pdf document about intervention program	✓			✓
7. Re assessment & Discharge				

Some of the figures of given intervention program:

- **Ideal way to carry backpack**

Figure 1

Figure 2

(backpack should fall below your shoulders & above hips)

- **Ideal lifting technique**

Figure 3

- **Neck exercises**

Figure 4

Pectoral stretch

Figure 5

Statistical Analysis

Data obtained was compiled on a MS Office Excel Sheet (v 2010, Microsoft Redmond Campus, Redmond, Washington, United States).

Data was subjected to statistical analysis using Statistical package for social sciences (SPSS v 21.0, IBM).

Descriptive statistics like frequencies and percentage for categorical data, Mean & SD for numerical data has been depicted.

Comparison of frequencies of categories of variables with groups was done using chi square test.

For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

* = statistically significant difference ($p<0.05$)

** = statistically highly significant difference ($p<0.01$)

= non significant difference ($p>0.05$) … for all tables

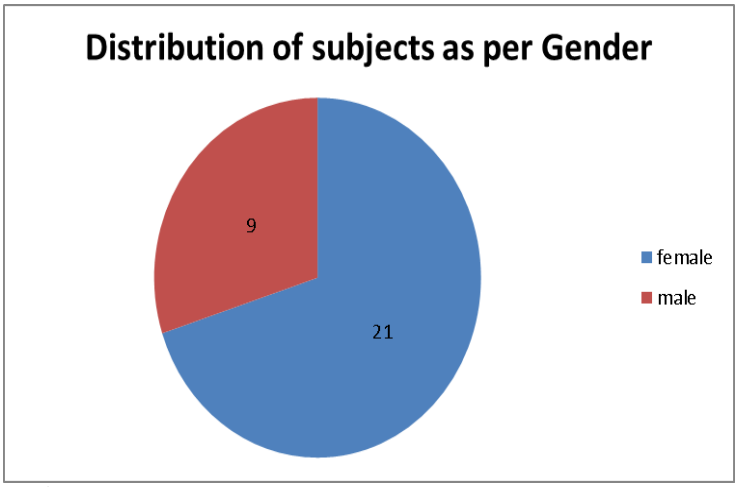
Intra group comparison was done using Wilcoxon Signed rank test (up to 2 observations)

RESULT

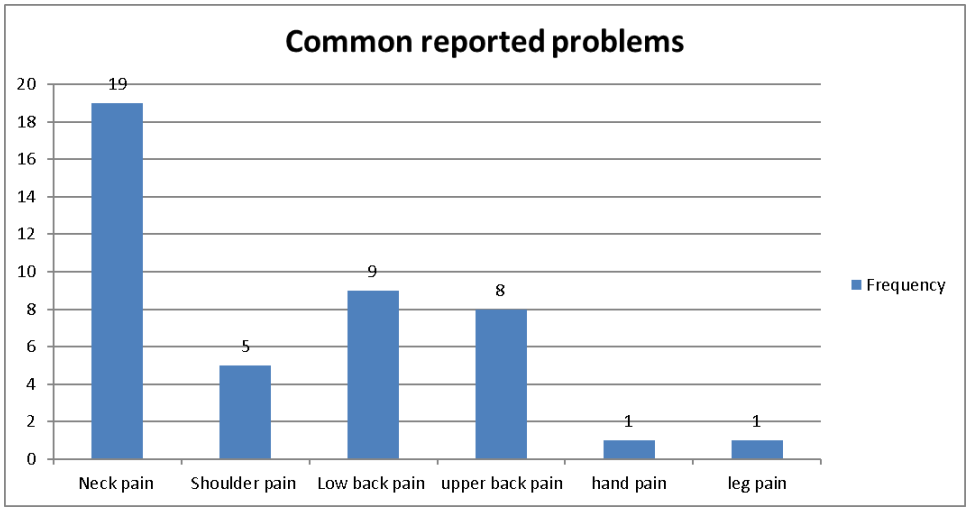
30 participants were recruited in the study. The minimal age was of 18 years and maximum age was 24 years reported between 30 participants.

Table no 2 .Descriptive statistic of weight, height, backpack weight , BMI of participants.

	N	Minimum	Maximum	Mean	Std. Deviation
Weight (kg)	30	38	84	56.97	9.926
Height (m)	30	1.43	1.68	1.5517	.07023
Backpack weight (kg)	30	1.0030	3.8250	1.972433	.7276917
BMI (kg/m^2)	30	17.8000	33.2000	23.523333	3.1618069

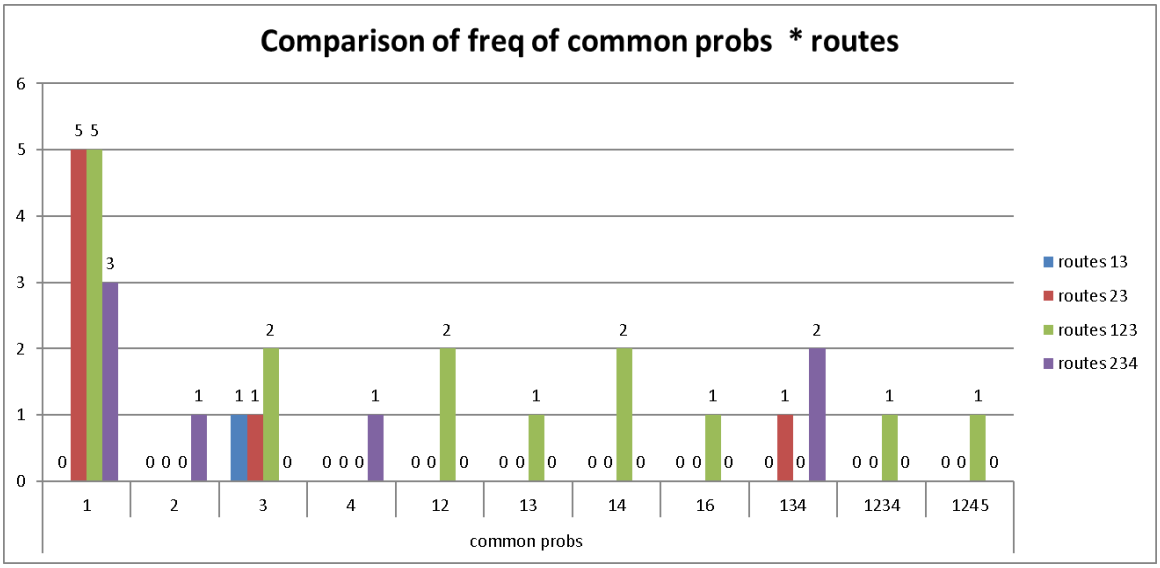


Graph 1 gives distribution of gender among the study participants recruited in the study. Among 30 participants 21 (70%) were female and 9 (30%) were male. Indicates female participated more in number than male.



Graph 2 reported commonly experienced problems by participants in backpack questionnaire. Backpack questionnaire is one of the study tools.

Among 30 students, percentage of the participants who experienced neck pain (63.3%) was highest. After neck pain most commonly, reported problem was low back pain with 30% following upper back pain 26.7%. 16.7% participants reported shoulder pain. Hand pain 3.3% and leg pain 3.3% were also reported.

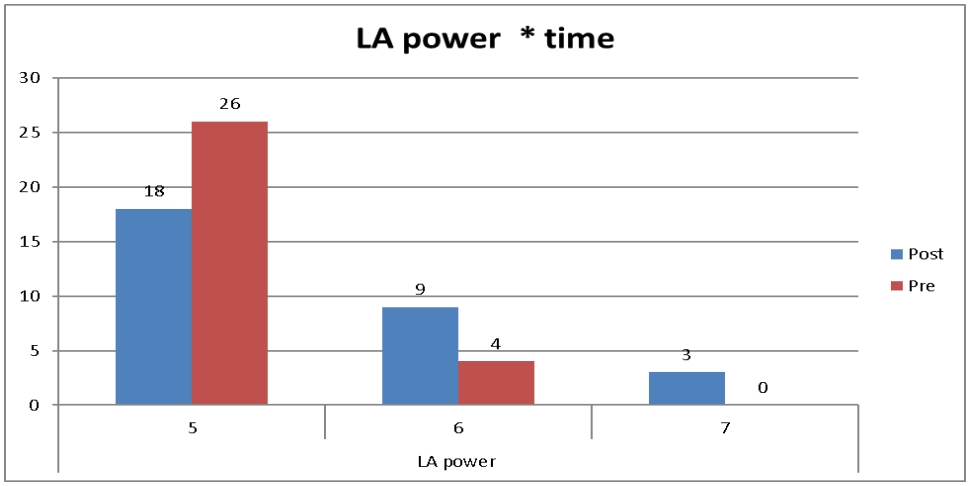


Graph 3 This graph is about the comparison between commonly reported problems and travelling route . Numbers allotted to each of them was as follows.

Bus = 1 Train =2 Walk =3 Taxi (t)=4
Pain in (neck =1 shoulder =2 low back =3 upper back=4 hand=5 leg=6)

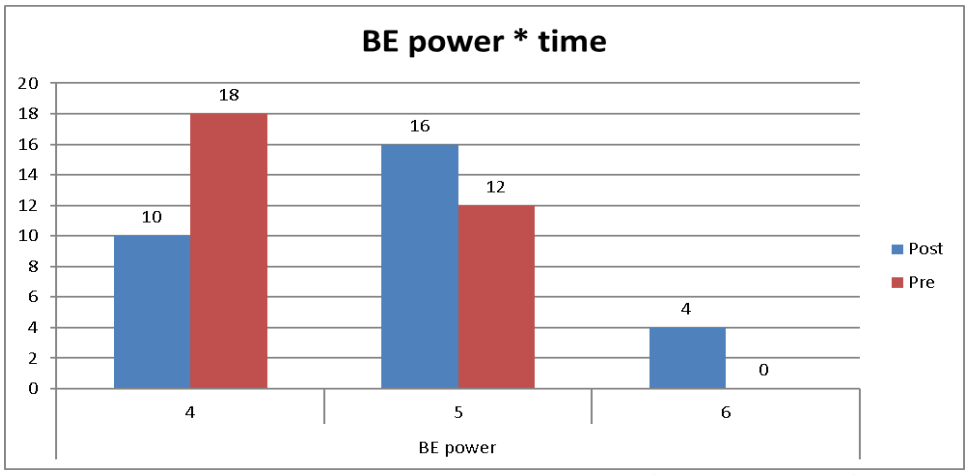
There was a statistically non significant difference seen for the frequencies between the groups ($p>0.05$). Table number 7 in the study compared the frequency on commonly reported problems of the participants to their route of travelling. Common problems were depicted using numbers as pain in (first column - neck =1, shoulder =2, low back =3 , upper back =4 , hand =5 , leg 6) & numbers (1= Bus , 2= Train , 3 = walk , 4= Taxi used for travel routes in the first raw of the table.)

From this table we concluded that participants who commonly used Bus, train & walk-in combination for longer time duration reported maximum musculoskeletal pain problems compared to those who used single or two modes of travelling.



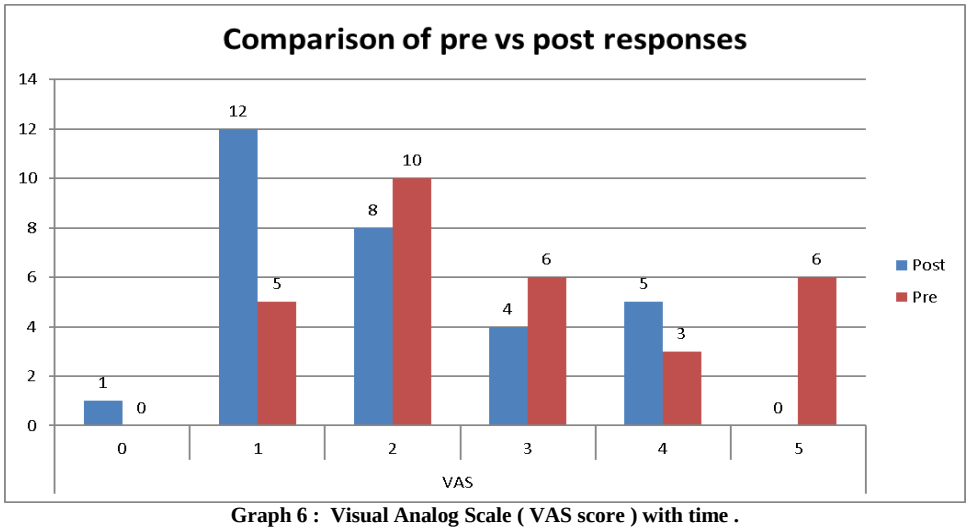
Graph 4: This graph compared power of lower abdominal (LA) muscles with time.

We studied comparison of power of lower abdominal muscle group with time. There was a statistically significant / highly significant difference seen for the frequencies between the groups ($p<0.01$, 0.05) with higher frequency for LA power 5 in pre and higher of LA power 6 in post.



Graph 5 It compares back extensors (BE) muscle power with time after the intervention of 4 weeks.

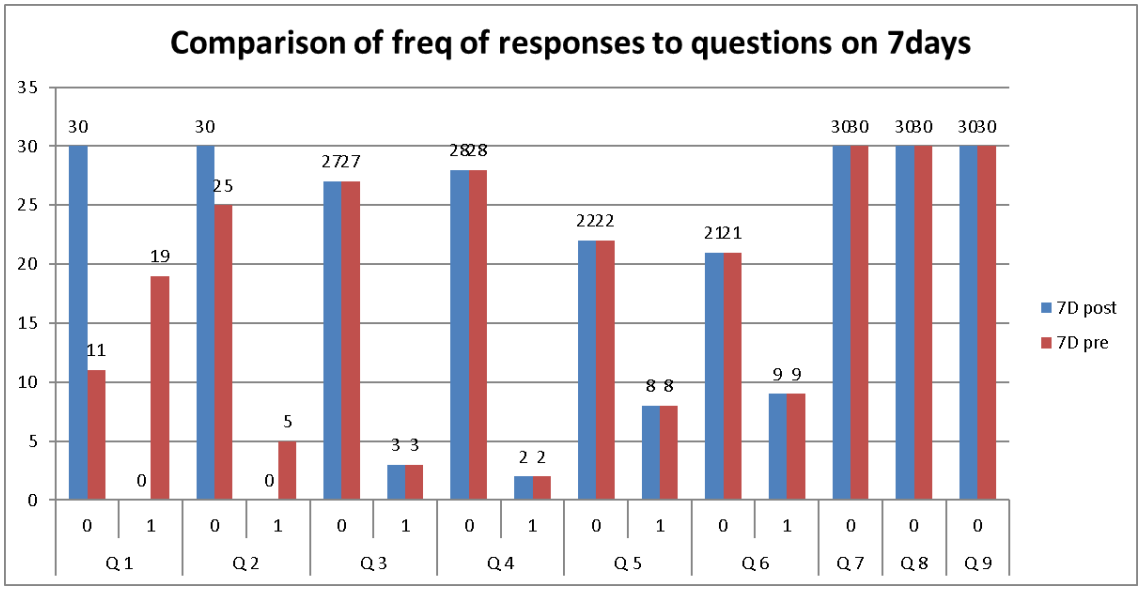
There was a statistically significant / highly significant difference seen for the frequencies between the groups ($p<0.01$, 0.05) with higher frequency for BE power 4 in pre and higher of BE power 5 & 6 in post.



Graph 6 : Visual Analog Scale (VAS score) with time .

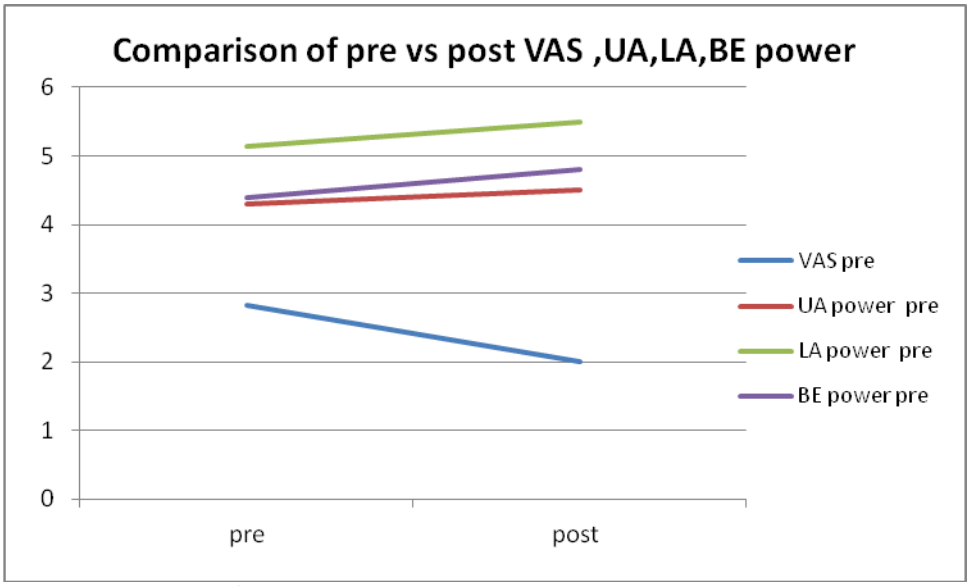
It is the comparison of pre- and post-intervention responses of VAS score of the study participants. Pre-VAS score on the first day of the recruitment was compared to last of study (4th week / 28 day). Participants reported that at end of intervention their intensity of pain reduced on VAS scale.

Nordic musculoskeletal questionnaire is one of study outcome measure used in the study. Most of the questions from this questionnaire are based on 12 months response. Therefore no changes were observed in those responses from participants. Following graph is about responses of 7 days questions of Nordic musculoskeletal questionnaire.



Graph 7 : compared questions from 1 to 9 pre- and post-intervention related to last 7 days. Question number 1 related to neck pain and question 2 is related to shoulder pain.

There was a statistically significant / highly significant difference seen for the frequencies between the groups ($p<0.01$, 0.05) for Q1 with higher frequency response 1 in pre and higher of response 0 in post. Q 2 with higher frequency for response 0 in post. There was a statistically non-significant difference seen for the frequencies between the groups ($p>0.05$) for Q3 to 6.



Graph 8 studied pre vs post results of Visual Analog Scale VAS scores, upper abdominal (UA), lower abdominal (LA) and back extensor (BE) muscle power.

There was a statistically significant / highly significant difference seen for the values between the time intervals ($p<0.01$, 0.05). During Intra group comparison mean scores were used, as sample size is small to use chi square test.

For VAS with higher values at pre as compared to post

For UA with higher values at post as compared to pre

For LA with higher values at post as compared to pre

For BE with higher values at post as compared to pre.

DISCUSSION

30 participants were recruited in this interventional prospective study.

Among 30 participants 21 (70%) were female and 9 (30%) were male. Indicates female participants recruited in the study more in number than male. This may be because of the convenient sampling method.

As per American occupational Therapy Association, Backpack Awareness states that students can carry 10-15 % weight of their body weight [1, 6, 40]. In Graph 2, we studied descriptive statistics of height, weight, BMI and backpack weight of 30 recruited participants. All the participants backpack weight follows this guideline.

Many research articles reported musculoskeletal pain and injuries related to backpack weight, backpack carrying. Also states that they can be multifactorial in origin.[1, 2, 16] In our research we found out commonly experienced problems by participants, which might be because of their backpack. Participants reported Neck pain and low back pain more frequently could be because donning & carrying style of backpack [14]. Apart from that subjects reported shoulder pain, upper back pain, hand and leg pain which might be due to poor postural habits & carrying backpack improperly.

We Compared commonly reported problem between male and female participants to identify any specific problem seen in any particular gender to co-relate with another specific contributory factor. As the literature states that neck pain was commonly seen in female then male 18. Study result could not co -relate any specific problem to a specific gender.

Maximum numbers of participants were using Bus, train & walk-in combination as a travelling mode. Similar assessment has been done by following researchers where they said that weight of backpack was not an individual contributor factor of musculoskeletal pain there were other contributing factors. [3, 43, 44]

In the research comparison of frequency of commonly reported problems with a common mode of travelling was done. From Graph 3 one can say that the participants who used a combination of 3 routes (Bus, Train, Walk) at a time reported pain in multiple regions. Most commonly used routes are Bus, Train and walk. Frequent change of routes means that much time of the backpack load which increases duration of carrying backpack. Previous study by Clare Haselgrove in 2008 concludes that Perceived school bag load, duration of carriage and method of transport to school are associated with back and neck pain18.On the Bus there are no racks to keep the bags, so probably, these students were carrying the backpack on their shoulders throughout the travel (Ant/Post). Also, when combined routes are involved, frequent change in positions is required which might lead to problems. Study Compared pre- and post-VAS (Visual Analog scores). On the first day of evaluation no participant reported zero scoring on VAS. Participant reported pain, but could not locate from where exactly the pain sensation was originated as VAS dose not related to any specific body part. VAS with higher values at pre as compared to post is seen through graphs. This difference is seen might be because of the compliance with intervention program which includes proper backpack wearing and carrying techniques. Postural education program, Safe lifting techniques, Desk stretches

exercises. There was a statistically non-significant difference seen for the frequencies between the groups that are because of small sample size. And might be because of socio- economic status of individuals, also now a day's backpacks which are available in the market are of good ergonomic design. In the study conducted by Feingold on Effect of education on backpack wearing and posture concluded that reduction in pain improved quality of life of the person [27]. Regarding socio economic factors, in our study we did not assess socio- economic condition of the participants; however, we found some articles which have mentioned how Socio-economic condition contributed as one of many factors [2, 42].

Improvement is seen in the form of post intervention higher values of muscle power grades of upper abdominals, lower abdominals and back extensors as compared to Pre interventions. Intervention is given for 4 weeks, which includes bridging, core muscle strengthening, back extensor strengthening. This program did not target any one muscle group; however significant improvement is seen in muscle power of back extensors and lower abdominals. We can say that this program is more beneficial for back extensor muscles and lower abdominals of individuals. Intervention program was uniform for all the participants; hence targeted exercises for any one group were not given.

During the evaluation of the participants, they mentioned about a gym factor as part of their regular training. Most of them visited a gym before the enrolment in the study. We could not refrain them from going to their routine as it was not mentioned anywhere in the study. On the Nordic musculoskeletal questionnaire Reponses from the participants during last 12 months. There was statistically non-significant difference seen for the frequencies between the groups. This could be because of the fact that the study duration had been for 4 weeks. The participant got discharged from the study after 4 weeks. After that comply with the program was not assessed.

Results for this could not be calculated as all variables had common response. As earlier mentioned in this study, students neglect problems related to musculoskeletal system and continue their daily routine which might be harmful to them in future [2, 11, 16].

There was a statistically significant / highly significant difference seen for the frequencies between the groups for trouble with neck and shoulder as compared with other locomotive organs may be because of the compliance with exercises related to neck, shoulder, upper back as they could performed these exercises at any time in a day. These exercises did not require specific place & convenient to follow. Graph 8 studied pre- and post-scores of VAS, strength / power of upper abdominal, lower abdominal, back extensors. There was a statistically significant / highly significant difference seen in the values between the time intervals .Chang WD in 2015 studied effect of Core strength training for patients with chronic low back pain which recommended training of deep trunk muscles to alleviate back pain .This significance is might be because of Muscle strength of upper abdominal, lower abdominal and back extensors improved post intervention which may be directly contributes to reduction in post VAS score [13, 15, 17, 27]. Along with this intervention program includes knowledge about safe lifting and carrying techniques for backpack. The ideal style of wearing a backpack. Maintain good posture while standing and sitting. Desk stretching exercises. Work simplification and energy conservation techniques.

Participants subjectively reported that this intervention program was very easy to follow. Not very time consuming. Improvement in posture is seen due to stretching exercises. Body posture improvement. Participants reported reduction in the intensity of pain. This intervention program also educated them

about good postural habits and ideal backpack guidelines.

Limitations of the study

1. This ergonomic program is uniform for all the subjects.
2. Small sample size.
3. Nordic questionnaire is more sensitive as screening tool.
4. Inclusion criteria should be more precise (to avoid participations from the subjects who already undergoing some sort of muscle building programs)

Scope of study / suggestion

1. A study should be conducted on a large sample size.
2. Long term effectiveness of the intervention should be assessed.

CONCLUSION

This study concludes that college going students carrying backpack had some musculoskeletal problems which they neglect. The ergonomic intervention program provided to them, showed significant in improvement in lower abdominals and back extensor muscle power. Pain& upper abdominal muscle strength improves post intervention however it is not statistically significant. On NORDIC questionnaire significant improvement is seen in seven days questions related to neck pain and shoulder pain. A more Elaborative study should be conducted in the future to overcome limitations of this study.

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Conflicts of Interest

There are no conflicts of interest.

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