RESEARCH PAPER

Effectiveness Of An Ergonomic Health Education Program On The Prevention Of Musculoskeletal Disorders In School Students' Practices

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Abstract:

Background: Life skills education is important for promoting health and well-being among adolescents in a school environment. Applied ergonomic practices related to computer use, ideal posture, appropriate carrying and lifting techniques, and proper schoolbag carrying can play an important role in preventing musculoskeletal disorders..

Goal of study : To assess the effectiveness of an ergonomic health education program on the prevention of musculoskeletal disorders in school students' practices.

Method: A quasi-experimental research design using one group (pre and post) was conducted at the Al-Azhar Model Language preparatory and secondary institutes. A total of 75 school students (adolescents) agreed to participate in the study. Three data collection tools were used: a socio-demographic characteristics self-administered questionnaire, an observation checklist of school students' practices, and students' feedback related to the educational program implementation.

Results: Significance tests demonstrated highly significant improvements in the mean scores of students' practices related to ideal postures, school bag carrying, carrying and lifting techniques, and preventive exercises for the prevention of musculoskeletal disorders throughout the two phases of the educational program ($P \leq 0.001$).

Conclusion and Recommendations: The study reported that the ergonomic education program effectively improved students' observed practices regarding prevention of musculoskeletal disorders. It recommends integrating ergonomic education into school curricula. Future research should focus on evaluating the long-term retention of these practices and exploring strategies for continuous reinforcement to ensure sustained ergonomic benefits among students.

Keywords: Ergonomics, Educational Program, Musculoskeletal Disorders, School Students, Practice.

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Introduction:

Musculoskeletal health is a key indicator of physical well-being in adolescents, reflecting their growth and development. Adolescence represents a pivotal developmental stage characterized by significant skeletal and muscular transformations, rendering individuals more vulnerable to musculoskeletal disorders (MSDs). These disorders, which impact muscles, tendons, nerves, and joints, can lead to pain and physical impairments. **(Faienza et al., 2023)**. As recorded by **(Soares et al., 2020)** Musculoskeletal disorders (MSDs) are among the primary causes of disability globally, with prevalence rates among school-age children and adolescents ranging from 10% to 67%.

Musculoskeletal disorders (MSDs) in school-aged children are affected by a variety of factors, including ergonomic and lifestyle-related risks. **(Salman et al., 2022)**. **Ozyemisci Taskiran et al. (2022)** Inadequately designed school furniture, the excessive weight of schoolbags, and a lack of sufficient physical activity have been identified as significant contributing factors.. **Porubčanová et al. (2024)** Further underscore the significance of psychological stress and an elevated body mass index (BMI) in the development of musculoskeletal disorders (MSDs). Moreover, the increasing utilization of digital devices has been associated with heightened musculoskeletal strain, thereby exacerbating these concerns. **(Jacquier-Bret & Gorce, 2023)**. Despite the high prevalence of Musculoskeletal disorders in this population, awareness and prevention measures are insufficient. **Takala (2018)** underscores the need to address these risks through targeted ergonomic interventions in educational settings.

The adverse effects of musculoskeletal disorders extend beyond mere physical pain and can

disorders by evaluating behavioral changes before and after the intervention.

Method:

Research design:

A quasi-experimental research design using one group (pre and post) was used for this study.

Study Hypotheses:

The post-test mean score of school students' practice of using ergonomic factors and appropriate posture for preventing musculoskeletal disorders would be higher than the baseline practice mean score.

Study Settings & participants:

This study was carried out at the Al-Azhar Model Language preparatory and secondary institutes, situated in the El Mansoura Azharian Zone, which operates under the presidency of the Al-Azhar institutes sector in Mansoura. The study involved two Al-Azhar institutes, one catering to male students and the other to female students.

***Subjects and sampling*:**

The study subjects were school students (adolescents) aged 12–18 years, of both genders, who were willing to participate in the study from the previously mentioned setting.

A convenient sampling technique was utilized to enroll school students in the study. The sample size was determined using the power analysis program of the **ClinCalc Statistical Software**. Based on the study parameters of **Miñana-Signes & Pañego (2023)**, which included a medium effect size (0.42), 90% power, 5% significance level, and a non-response rate of 20%, a minimum of 75 school students is required.

Data collection tools:

Data were collected through using the following three tools:

Tool I: **School students' Scio-demographic characteristics self-administrated questionnaire.**

The researchers developed this tool after reviewing of relevant literatures with the guidance of **(Miñana-Signes & Pañego, 2023; Veshovda et al., 2023; Toloza, et al., 2021).** It included socio-demographic and clinical data of students such as age, gender, school year, residence, family income, height, weight, BMI, ergonomic risk factors, previously existing musculoskeletal complaints, and previous attendance at training about back health, ergonomics, and appropriate postural behaviors.

Tool II: Observation checklist of school student' practices.

greatly hinder children's concentration and academic achievement, as well as their long-term health. Discrepancies between the physical dimensions of students and classroom furniture can disrupt essential learning tasks like writing and reading.**(Depreli et al., 2024)**. If left untreated, these disorders can progress into adulthood and affect career prospects and the quality of life overall. **(Soares et al., 2020)**.

Educational programs focused on ergonomics have shown considerable promise in alleviating musculoskeletal issues among students. Research-backed methods, including modifications to furniture, organized posture education, and specific physical workouts, have been effective in lowering the risk of musculoskeletal disorders in teenagers.**(Khalil et al., 2018)**. Studies provide additional evidence that ergonomic education initiatives can effectively enhance students' postural practices, promoting lasting musculoskeletal well-being.**(Pani et al., 2024)**. The integration of these initiatives into school curricula not only addresses the immediate concerns but also promotes a healthier and more sustainable learning environment.

As a multidisciplinary field, ergonomics incorporates physiological, environmental, and psychological considerations to optimise the safety, comfort, and efficiency of everyday activities.**(Karmacharya et al., 2025)**. In educational settings ergonomic education has been shown to play a key role in protecting the health of children and promoting their physical and emotional development. **(Soltaninejad et al., 2021)**. Ergonomic interventions can create environments that support productivity and well-being by addressing these interrelated factors.

By teaching teachers, parents, and students about fundamental ergonomics, community health nurses play a crucial role in preventing musculoskeletal disorders (MSDs). They promote musculoskeletal health and lower the risk of injury by providing targeted advice on things like posture correction, safe lifting techniques, and the best workstation arrangement. By encouraging ergonomic practices in homes and schools, nurses enable students to develop healthy habits that last a lifetime. Additionally, reducing long-term issues connected to poor ergonomics requires increasing awareness and encouraging behavioral changes.**(Hegazy et al., 2024)**.

Thus, this study aims to assess the effectiveness of an ergonomic health education program on adolescents' practice in preventing musculoskeletal

A pilot study was implemented to test the face validity of the first draft of the ergonomics program's assisted materials and tool on 10% of the total sample size of students (8), who weren't included in the sample. Accordingly, the necessary modifications by the experts and piloted students were made as adding questions about appropriate positions.

The internal consistency of the developed tools as observational checklist and feedback scale was tested using Cronbach's alpha coefficient, and it showed high reliability (0.9 and 0.86 respectively).

Ethical considerations:

The study protocol was approved by the research ethics committee of the Faculty of Nursing, Mansoura University (No:). The researchers obtained formal approval to conduct the study through a letter from the Mansoura Faculty of Nursing to the presidency of the Al-Azhar Institutes sector in Mansoura. Verbal consent was obtained from the students and written consent was also obtained from the caregivers of the students participating in the study by answering questions after ensuring their right to withdraw at any time. The nature of the study did not cause any harm or pain to the entire sample. Confidentiality and privacy were taken into consideration regarding the collected data.

Procedure: The study was conducted from February 2024 to April 2025 through three phases:

Phase 1: Assessment phase:

The researchers collected the students' socio-demographic and clinical data before applying the educational program by administering the first study tool. The researchers assessed students' practices regarding postural tasks and the use of ergonomic factors for preventing musculoskeletal disorders using the observational checklist.

Phase 2: Development of the ergonomic educational program:

The researcher established the educational program goals and objectives, taking into account the existing evidence-based literature and baseline assessment of the students' practice. They determined the timetable for sessions, teaching methods, media to be used learners' activities, and evaluation methods. The researcher selected the teaching place (computer lab), managed the program finances (supplied all printing and material media), and defined the learning objectives of the program.

The researcher developed this checklist after reviewing the related literature **(Miǒana –Signes et al., 2021; Szilágyi et al., 2021; Minghelli et al., 2021; Salman et al., 2022)**. It is divided into two sections. The first section assesses postural tasks for preventing musculoskeletal disorders. This part includes six tasks as follows: ideal standing; ideal seating; ideal walking; light loading; heavy load lifting; and heavy object shifting. These tasks were adapted from **Minghelli et al. (2021)**. Each task includes three to four steps to implement. The second part is related to using ergonomic factors for preventing musculoskeletal disorders including optimal school bag carrying, correct computing habits, and preventive exercises for musculoskeletal disorders.

Scoring interpretation:

Score	Percentage	Inference
Less than 23.8 marks	<34%	Poor
From 23.8 to less than 46.9 marks	34%-<67%	Fair
46.9 marks and more	67%-100%	Good

Tool III: Students' feedback related to educational program implementation.

This questionnaire evaluated students' feedback immediately after the educational sessions' implementation with respect to setting, instructor, educational content and method of teaching **(Mohamed et al., 2017).** The researcher awarded one score for each "yes" response and zero score for "No" or missed responses. The total feedback level was 22 scores and classified as good, average, and poor as follows:

Scoring interpretation:

Score	Percentage	inference
<11 scores	<50%	Poor
11 to less than 16.5 scores	50%-<75%	Fair
16.5 and more scores	75%-100%	Good

Validity and reliability:

Academic experts assessed the effectiveness of the ergonomics program and the study tool regarding their content, language, layout, and structure to compute the **content validity index (0.92)** of the first draft of the ergonomics program and the study tool.

students in the computer laboratory and was presented in a clear and concise form.

Phase 4: Evaluation phase

The final step of data collection was evaluating the students' response to the proposed educational program and the extent to which outcomes have been achieved. The students' practice related to musculoskeletal disorder prevention was evaluated two times using the study tools, once before implementing the educational program (pre-test) and the second time after implementing the educational program (post-test). A comparison between students' pre-test and post-test findings was done to determine the effectiveness of the educational program on students' practice regarding the prevention of musculoskeletal disorders. Additionally, the feedback of the students related to the educational session was evaluated.

Statistical analysis:

Data were coded and analyzed using the Statistical Package for the Social Sciences version 21.0 (SPSS Inc, Chicago, IL). Descriptive analyses using numerical summaries, including measures of central tendency and dispersion, were performed on the research data to describe the sample characteristics. For determining normality, the Kolmogorov-Smirnov test was used. Inferential statistics, including repeated measures analysis of variance, Chi-square, McNemar's test, Wilcoxon signed-rank test, and independent t-tests, were used to test the research hypotheses. The significance level was set at 5%.

Results:

Socio-demographic and health data of the students:

Table (1) shows that 80% of the studied students were aged 12 to less than 15 years with a mean age of 13.14±1.16 years old. 70.7% of them were male. Regarding students' residence, it was noticed that 90.7% of the studied students resided in rural areas. Concerning the students' income, 69.3% of them had adequate income. The students' anthropometric measurements revealed that the mean weight, height, and body mass index were within the normal range among all the studied samples (46.66±5.14, 149.46±8.14, and 20.87±1.48, respectively). It is also revealed from the same table that 80% of the studied students suffered from ergonomic hazards, as nearly half of them mentioned that they were following incorrect postures while sitting (50.7%), carrying school

Phase 3: Implementation phase:

The educational program was scheduled at a time that did not conflict with the students' class schedules. Before each session, the researcher explained the objectives of the session to the participating students. The researcher observed each student's posture, carrying school bag habits, computer usage habits, and protective exercises for musculoskeletal disorders. On the first day of the educational program, the researcher gave an over-view of the program components, which took 10 min. then the educational program implemented over three sessions (one theoretical and two practical sessions) as it was illustrated in **Box (1)**.

Box (1): Logistics of the educational program sessions: -

Logistics	Description
Target group	School students (adolescents)
The number of participants	Convenient 75 school students were divided into four groups,
The number of groups	Two groups receive sessions per week.
The number of students in each group	Each group consisting of 15 to 20 students.
Coordinator/ facilitators	The researcher (one tutor)
Duration	Two weeks
Duration of session	One hour /session.
Numbers of sessions	Three sessions.
Time	10 -11 am.

The educational program covered main topics such as musculoskeletal disorders, back health, ergonomics, ideal posture, postural tasks and ergonomics measures and exercises for preventing musculoskeletal disorders. An illustrative colored booklet about the prevention of musculoskeletal disorders was designed by the researcher to be distributed to students included in the study. The booklet contained photos and illustrations to facilitate students' understanding of the content and enhance the learning process. Different teaching methods and materials were used to match all learning styles, such as brainstorming, group discussion, role-playing, real-life demonstrations, re-demonstrations, illustrated pictures, and videos. The educational program was implemented for

In comparison with the post-test results, the level of students' practice improved to a "Good" level among 89.3% of the students. For the ideal walking domain, 78.7% of the students showed a "Poor" level of practice, contrasted with 90.7% who achieved a "Good" level after the program implementation. Additionally, the paired t-test reported highly statistically significant differences with large effect sizes between the mean scores of all the students' practice domains: ideal standing posture (t=27.62, P≤0.001, d=4.96); ideal seated posture (t=23.22, P≤0.001, d=3.87); and ideal walking (t=27.44, P≤0.001, d=4.39) throughout the two educational program phases.

Table 2: *Students' Score Level of observed practice regarding the postural assessment tasks before, and after the program implementation.*

Items	Pre-Test n=75		Post-test n=75		Significance tests
	No.	%	No.	%	
Ideal standing posture score = (10)					
Poor	30	40	00	00	χ^2=138.75, * p ≤ 0.001
Fair	45	60	3	4	
Good	00	00	72	96	
Mean (SD)	4.00(1.47)		9.84(0.78)		t=27.62, * p ≤ 0.001 d =4.96
Ideal seated posture score = (10)					
Poor	46	61.3	00	00	χ^2=124.91, * p ≤ 0.001
Fair	29	38.7	8	10.7	
Good	00	00	67	89.3	
Mean (SD)	2.74(1.94)		9.48(1.51)		t=23.22, * p ≤ 0.001 d =3.87
Ideal walking score = (8)					
Poor	16	21.3	00	00	χ^2=124.27, * p ≤ 0.001
Fair	59	78.7	7	9.3	
Good	00	00	68	90.7	
Mean (SD)	3.26(0.90)		7.65(1.09)		t=27.44, * p ≤ 0.001 d =4.39

χ2: Chi square test, t: Paired t-test, d: Cohen's D (effect size of t test),*P<0.05 significant.

Table (3) indicates the total studied students' observed practice domains of light loading, heavy load lifting, and heavy object shifting before and after the educational program implementation. Before the educational program, 81.3% of students demonstrated a "Poor" level of practice in light loading, compared to 94.7% who bags incorrectly (48%), and using non-ergonomically suitable furniture and chairs (40%).

Table 1: *School students' Scio-demographic and health data.*

Item	N(75)	%
Age		
12 < 15	60	80
15-18	15	20
Mean (SD)	**13.14(1.16)**	
Gender		
Male	53	70.7
Female	22	29.3
Residence		
Rural	68	90.7
Urban	7	9.3
Income		
Not adequate	15	20
Adequate	52	69.3
Adequate and saving	8	10.7
Weight		
Mean (SD)	**46.66(5.14)**	
Height		
Mean (SD)	**149.46(8.14)**	
Body mass index		
Mean (SD)	**20.87(1.48)**	
Suffered from ergonomic hazard	**60**	**80**
If yes, mention it		
Following incorrect postures while sitting	38	50.7
Using not ergonomically suitable furniture and chairs	30	40
Carrying not suitable shaped and sized school bag	22	29.3
Incorrectly carrying school bag	36	48

Students' observed practice about the prevention of musculoskeletal disorders:

Table (2) illustrates the total number of students who were observed practicing ideal standing posture, ideal seated posture, and ideal walking before and after the educational program implementation. Before the program, 60% of students demonstrated a "Fair" level of practice in ideal standing posture, compared to 96% who showed a "Good" level immediately after the program implementation. In terms of ideal seated posture, 61.3% of students were rated as "Poor" before the program.

musculoskeletal disorders before and after the educational program implementation. Before the program, 50.7% of the students had a "Poor" level of practice in school bag carrying, compared to 96% who showed a "Good" level immediately after the program. Regarding the ideal posture for using computers, 70.7% of the students had a "Poor" level before the program, which improved to a "Good" level for 85.3% of students after the program. In the preventive exercises for musculoskeletal disorders domain, 100% of students had a "Poor" level of practice before the program, but 96% achieved a "Good" level after the program. The preventive exercises domain included two subcategories: shoulder rotation and wall pushups exercises. Before the program, all students had a "Poor" level of knowledge in these subcategories, but after the program, 97.3% and 93.3% of students reached a "Good" level in shoulder rotation and wall pushups exercises, respectively.

Table 4**:** *Students' Score Level of observed practice regarding the computer habits, carrying school bag, and preventive exercises for musculoskeletal disorders before, and after the program implementation.*

showed a "Good" level after the program implementation. For heavy load lifting, 90.7% of students showed a "Poor" level before the program, which improved to a "Good" level for 89.3% of students after the program. In the heavy object shift domain, 81.3% of students had a "Poor" level of practice before the program, while 92% achieved a "Good" level after the program.

Additionally, the paired t-test showed highly significant differences with large effect sizes between the mean scores of all students' practice domains: light loading (t=33.45, P≤0.001, d=5.41), heavy load lifting (t=30.31, P≤0.001, d=3.36), and heavy object shifting (t=33.49, P≤0.001, d=5.42) throughout the educational program phases.

Table 3: *Students' Score Level of observed practice regarding the postural assessment tasks before, and after the program implementation.*

Items	Pre-Test n=75		Post-test n=75		Significance tests
	No.	%	No.	%	
Light loading score = (4)					
Poor	61	81.3	00	00	χ^2=137.55, * p ≤ 0.001
Fair	14	18.7	4	5.3	
Good	00	00	71	94.7	
Mean (SD)	0.37(0.78)		3.86(0.47)		t=33.45, * p ≤ 0.001 d =5.41
Heavy load lifting score = (6)					
Poor	68	90.7	00	00	χ^2=135.06, * p ≤ 0.001
Fair	7	9.3	8	10.7	
Good	00	00	67	89.3	
Mean (SD)	1.28(0.90)		5.70(0.86)		t=30.31, * p ≤ 0.001 d =3.36
Heavy object shift score = (4)					
Poor	61	81.3	00	00	χ^2=133.20, * p ≤ 0.001
Fair	14	18.7	6	8	
Good	00	00	69	92	
Mean (SD)	1.18(0.39)		3.80(0.56)		t=33.49, * p ≤ 0.001 d =5.42

χ2: Chi square test, t: Paired t-test, d: Cohen's D (effect size of t test),*P<0.05 significant.

Table (4) shows the total number of students studied, their observed practice domains of school bag carrying, ideal posture for using computers, and preventive exercises for

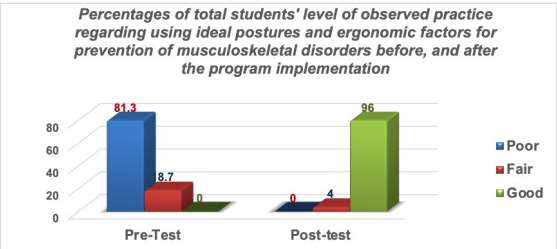
Compared to the post-test results, the level of students' practice improved to a "good" level among 96% of the sample with a mean score of 67.17±6.78. It is also noticed from the same table that the Paired t-test showed a highly statistically significant difference between the means of the total students' practice score toward using ideal postures and ergonomic factors for the prevention of musculoskeletal disorders throughout the two educational program phases (t=43.47, P≤0.001, d=7.05).

Table 5: *Students' total score level of observed practice regarding using ideal postures and ergonomic factors for prevention of musculoskeletal disorders before, and after the program implementation.*

Items	Pre-Test n=75		Post-test n=75		Significance tests
	No.	%	No.	%	
Total observed practice score=(70)					
Poor	61	81.3	00	00	χ^2=140.11, * p ≤ 0.001
Fair	14	18.7	3	4	
Good	00	00	72	96	
Mean (SD)	17.50(7.29)		67.17(6.78)		t=43.47, * p ≤ 0.001 d =7.05

χ2: Chi square test, t: Paired t-test, d: Cohen's D (effect size of t test),*P<0.05 significant.

Figure 1: *Percentages of total students' level of observed practice regarding using ideal postures and ergonomic factors for prevention of musculoskeletal disorders before, and after the program implementation (n=75).*



Items	Pre-Test n=75		Post-test n=75		Significance tests
	No.	%	No.	%	
School bag carrying score = (8)					
Poor	38	50.7	00	00	χ^2=138.90, * p ≤ 0.001
Fair	37	49.3	3	4	
Good	00	00	72	96	
Mean (SD)	1.88(1.56)		7.80(0.78)		t=29.11, * p ≤ 0.001 d =4.80
Ideal posture for using computers score = (10)					
Poor	53	70.7	00	00	χ^2=120.66, * p ≤ 0.001
Fair	22	29.3	11	14.7	
Good	00	00	64	85.3	
Mean (SD)	2.57(1.75)		9.37(1.53)		t=26.19, * p ≤ 0.001 d =4.13
Preventive exercises for musculoskeletal disorders score = (10)					
Poor	75	100	00	00	χ^2=150.00, * p ≤ 0.001
Fair	00	00	3	4	
Good	00	00	72	96	
Mean (SD)	0.20(0.10)		9.65(1.03)		t=76.57, * p ≤ 0.001 d =12.91
Shoulder rotation exercise score = (4)					
Poor	75	100	00	00	χ^2=150.00, * p ≤ 0.001
Fair	00	00	2	2.7	
Good	00	00	73	97.3	
Mean (SD)	0.0(0.0)		3.85(0.42)		t=78.46, * p ≤ 0.001 d =12
Wall pushups score = (6)					
Poor	75	100	00	00	χ^2=150.00, * p ≤ 0.001
Fair	00	00	5	6.7	
Good	00	00	70	93.3	
Mean (SD)	0.20(0.40)		5.80(0.71)		t=62.89, * p ≤ 0.001 d =9.71

χ2: Chi square test, t: Paired t-test, d: Cohen's D (effect size of t test),*P<0.05 significant.

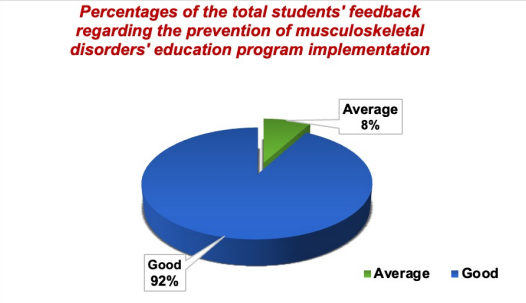
The total score of the studied students' practice regarding the use of ideal postures and ergonomic factors for the prevention of musculoskeletal disorders before and after the educational program implementation is clarified in **Table (5) and Figure (1)**. At the preliminary assessment, 81.3% of the studied students demonstrated a "Poor" level of practice, with a mean score of 17.50±7.29.

The total score of the students' feedback on the implementation of the educational program for preventing musculoskeletal disorders is presented in **Table (6) and Figure (2)**. The evaluation results showed that 92% of attendees rated the program as "Good," with a mean score of 20.85 ± 2.46.

Table 6: Students' total feedback regarding the ergonomic education program implementation (n=75)

Items	No.	%
Total feedback score=(22)		
Mean (SD)	**20.85(2.46)**	
Average	6	8
Good	69	92

Figure 2: *Students' total feedback regarding ergonomic program implementation (n=75)*



Discussion:

Musculoskeletal complaints are prevalent issues among school students, significantly impairing their academic performance **(Elhossiney et al., 2023)**. Given the rising prevalence of musculoskeletal complaints among adolescents, integrating ergonomic principles into school programs is essential **(Atia et al., 2023)**. Hence, educating students on these principles and how to apply them can empower them to adopt healthier postural habits and reduce injury risks, ultimately fostering long-term well-being.

In Egypt, there is limited data on ergonomics. Based on this, an ergonomics educational program was implemented to assess its effect on preventing musculoskeletal disorders among school students. Research indicates that adolescence is a crucial stage characterized by rapid skeletal and muscular development, increasing the risk of musculoskeletal disorders (MSDs). Key contributing factors include inadequately designed school furniture, heavy schoolbags, and lack of physical activity. Since this stage is an ideal time to introduce ergonomics into the curriculum, adolescent students were selected as study participants.

Regarding postural behavior, the significant tests reported highly significant improvements with a large effect size of the current ergonomic educational program on the students' practice of ideal standing posture, ideal seated posture, and ideal walking from baseline assessment to post-test results. These findings are aligned with a recent study by **Araújo et al. (2023)** who highlighted that developing health promotion strategies through postural education programs in schools can increase children's and adolescents' learning to improve their practical knowledge, contributing to the development of healthier postural habits in daily living activities and decreasing musculoskeletal pain symptoms.

Additionally, this finding is supported by the systematic review of **Bettany-Saltikov et al. (2019)** on programs for the promotion of awareness of back health, ergonomic principles, and postural behavior among school students aged 4 to 18. The study cited that training programs on ergonomics and correct postures through distance education for students could boost their exercise behavior and physical activity. According to **Miñana-Signes et al. (2019)**, who studied the effectiveness of structured teaching educational intervention on knowledge and practice of body mechanics among school children in schools, emphasized that the practice regarding body mechanics can help school children adapt proper posture and bag-carrying methods, which can prevent musculoskeletal disorders among them in the future.

Heavy schoolbags can pull neck muscles and may lead to headaches, as well as pain in the shoulders, lower back, neck, and arms. Additionally, carrying a schoolbag on one shoulder can cause muscle strain **(Guessogo et al., 2020)**. The current study showed significant

improvement after the implementation of an ergonomic program on school bag carrying practices. These improvements can be attributed to the increased awareness of proper ergonomics by students, which leads to positive changes in behaviour. First, students often lack knowledge of the right way to carry their school bags, including proper weight distribution, ideal bag construction and carrying posture. The training programme probably filled these gaps by providing scientific demonstrations and hands-on applications.

These results are consistent with previous studies by **Meenakshi et al. (2023)** and **Ashtekar et al. (2018)**, who concluded that the educational interventions were effective in improving the practice of bagging school bags. Another research study from by **Kabilmiharbi and Santhirasegaram (2017)** showed that the design of school bags also plays an important role in the prevalence of neck and back pain. Similarly, the Ashtekar et al. study (2018) carried out in Maharashtra also reported a significant reduction in school bag weights following successive interventions.

Use of computers is on the rise among adolescents, with increased potential for related musculo-skeletal pain and postural abnormalities (Cheung et al., 2021). The present study therefore focused on improving the practice of adolescent students on the ideal position of the computer and showed an observed improvement after ergonomic instruction. These improvements may have a positive impact on students' postural behaviour when using computers. Sellschop et al. support this conclusion. (2018), which evaluated the impact of ergonomic interventions in the school environment using computers and found improvements in the students' posture and ergonomic behavior. This suggests that such programmers can be beneficial in promoting healthy habits of use of computers.

At the post-tests, the current ergonomic education program also showed noteworthy gains in the practice of students' lifting and carrying techniques of heavy objects. This might be because, prior to the ergonomic program's implementation, the children under study had not received any prior instruction or information about safe carrying and lifting techniques. These results are consistent with **Helmy et al. (2019)**, which showed that most of the children in the study did not know how to lift and carry heavy objects properly before the intervention. However, this percentage dropped to zero after the educational intervention.

The current study showed significant improvements in the students' practice of prevention of musculo-skeletal disorders. This finding is in line with **Cheung et al. (2021)**, which have shown that structured exercise programmes increase flexibility and reduce the incidence of musculoskeletal pain. In addition, interventions promoting physical activity and stretching exercises are widely recognised for their preventive effect on musculo-skeletal disorders in both young and elderly patients. **(Hirase et al., 2023; McDonald &Salisbury, 2019)**. **Alves and Alves (2019)** It was also noted that physical exercise is safe for all age groups, from childhood to adolescence, does not seem to impair linear growth in children and helps to idealise the development of skeletal and muscular tissue, ensuring beneficial effects throughout life..

This finding is also in line with **Zhou et al. (2024)**, who highlighted that preventive exercises exert significant positive effects on body composition, cardiopulmonary function, and muscle fitness in children and adolescents. Therefore, we suggest including such types of preventive exercises for musculoskeletal disorders in their physical education curriculum, which can further improve the students' physical fitness.

Despite these different perspectives, the current study provides strong evidence to support the effectiveness of the ergonomic learning programme in improving students' musculo-skeletal prevention practices. The significant improvements in all areas studied underline the importance of integrating ergonomic education into school curricula. Future research should focus on assessing the long-term maintenance of these practices and exploring strategies for

continuous reinforcement to ensure that students continue to benefit from ergonomic benefits.

Conclusion:

The findings of this study supported the hypothesis and indicated that the ergonomic education programme positively improved the musculo-skeletal disorders in the children studied.

Recommendations:

It is important to ensure that teachers and parents are well informed on key aspects of musculo-skeletal health, including the appropriate weight of school bags, good exercise, good body mechanics and ideal positions for sitting and standing in the classroom. The implementation and dissemination of educational interventions can increase knowledge and practice on musculo-skeletal disorders among adolescents and their teachers. In addition, further research is needed to support widespread adoption of preventive measures against musculo-skeletal disorders in schoolchildren.

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