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Original Article

Effectiveness of Parents-Centered Ergonomic Educational Intervention on Their Performance Regarding Safe Musculoskeletal Growth and Development among Their School-age and Adolescent

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ABSTRACT

Background: Musculoskeletal health is a global concern for school-age children and adolescents. Children often face ergonomic risk factors in their daily activities, so it is important to raise parental awareness to prevent musculoskeletal disorders in their children. **Aim:** To assess the effectiveness of parent-centered ergonomic educational intervention on their performance regarding safe musculoskeletal growth and development among their school-age and adolescent. **Subjects and method:** A randomized controlled trial was conducted at pediatric outpatient clinics affiliated with Mansoura University Children's Hospital and Tanta University Hospital. A total of 110 parents and their children were randomly selected. Data collection tool was an interview schedule that included five parts as follow: baseline parents and their children's characteristics; an ergonomics knowledge test, an ergonomics-reported practices checklist, the Standardized Nordic Body Map Questionnaire (SNBMQ), and the Rapid Upper Limb Assessment (RULA). **Results:** The intervention group of parents showed significant improvements in ergonomic knowledge and reported practices compared to the control group ($P < 0.001$). Additionally, the children in the intervention group showed significant differences in musculoskeletal pain and posture three months after the education. **Conclusion and recommendations:** The study suggests that parent-centered ergonomic education can improve knowledge and reported practices and it recommends ergonomic educational interventions to promote safe musculoskeletal growth and development in children.

Keywords: Safe Musculoskeletal Growth, Ergonomic, Educational Interventions, Parents, Performance.

Introduction

Musculoskeletal growth is one of the main health indicators throughout childhood and adolescence, defined as the increase in body size as assessed by weight and height gain. The growing phase is when human beings experience the greatest bio-psycho-social vulnerability. One of the most important indicators of physical development and somatic health of children and adolescents in particular is the state of the musculoskeletal system. Children's musculoskeletal healthy development needs a continuous, cohesive approach considering emerging needs. Genetic, environmental, dietary, psychotropic, pathological, and ergonomic variables are only a few of the aspects that either directly or indirectly affect a child's development **(Alves & Alves, 2018)**. However, the latter still sparks debates regarding its effect on the growth and development of children and adolescents **(Gumasing et al., 2023)**. So, the nurse's primary preventative role is to ensure that the child reaches their full potential for genetically determined musculoskeletal growth, normal posture, perfect balance, and acceptable physical activity.

In 2023, WHO defined musculoskeletal disorders (MSDs) as a group of conditions affecting the bones, muscles, and joints. It ranked as the leading cause of disability worldwide, with low back pain being the single leading cause of disability in 160 countries. Its prevalence in school age children and adolescents was recorded by **Ullah et al. (2022)** as 7% to 63%. Additionally, the evidence by **Alias et al., (2020)** concluded that "the majority of school age children and adolescents (62%) had poor sitting posture while writing and reading. Musculoskeletal (MSK) regions affected due to poor posture were neck 61.3%, shoulder 57%, abdominal region 49.2%, posterior region 54.5%, and arm 72.3%."

Adolescents may be affected psychologically by the dramatic changes in their physical appearance associated with puberty. Many adolescents demonstrate poor posture, a tendency to round shoulders and a shambling, slouchy walk. This is due in part to the imbalance of growth; the skeletal system growing a little more rapidly than the muscles attached to it. In addition, poor posture particularly seems to develop in adolescents who reach adult height before their peers. They slouch to appear no taller than anyone around them. Furthermore, girls may slouch to diminish the appearance of their breast size if they are developing more rapidly than their friends. This also can occur from carrying backpacks that are too heavy. **Yang et al. (2020).**

As declared by **Ullah et al. (2022)**, there are three general causes of musculoskeletal complaints in school-aged children: a heavy schoolbag (weighing more than 10% of body weight), furniture that is not designed to fit the dimensions of a human body, and the children's poor postures. In addition, **Alhowimel et al. (2022)** noted that low levels of physical activity, psychological disease, and a high body mass index were significant contributors to musculoskeletal problems among school-age children and adolescents. Furthermore, the ergonomics study of **Obinna et al., (2021)** reported that mismatches between office furniture and the child’s body dimensions can lead to musculoskeletal diseases and may have an impact on learning tasks like writing, reading, and typing.

El-Tallawy et al. (2021) concluded that MSDs limit blood flow to bones, muscles, ligaments, and tendons, resulting in postural abnormalities, joint stiffness, and discomfort; they also decrease students' concentration and performance, so it may affect academic achievement. On the other side, the medical costs of diagnosis and treatment are a concern. Furthermore, these disorders may lead to more severe consequences in adulthood, as they may affect the individual’s career.

Some of the a fore mentioned risks have been investigated by previous researchers, with recommendations made to develop future intervention strategies for reducing these risks. Intervention programs that have been considered previously include the use of ergonomic furniture, health promotion packages, exercises, and other ergonomic interventions, such as education and training, which can positively affect children’ postures and decrease some musculoskeletal complaints **(Tersa-Miralles et al., 2022)**.

As conceptualized by **Jabeen, and Hussain (2022),** “ergonomics is a multidisciplinary science that deals with the workplace and the process of work and aims to improve the comfort, safety, and efficiency of people, considering physiology, psychology, sociology, and organizational aspects of humans.” According to **Soltaninejad et al., (2021)** ergonomic education plays an important role in improving children’ health and physical and emotional development. Furthermore, **Ryabova et al., (2020)** reported that proper parental understanding of ergonomics and its related risk factors that cause injuries and health issues among children can reduce the multifaceted ergonomic risks. As the parents exert a powerful influence on the physical, mental, psychological, neural, and musculoskeletal growth and development of their offspring **(Gee & Cohodes, 2021)**.

Parental' education is a significant part of a nurse's role. Education empowers parents to improve their children's healthy habits and maintain ideal posture. Besides it enables them to optimize the ergonomically designed environment to enable child to study and play with greater comfort. Engaging parents in their children's interventions increases the chances of positive outcomes. For the development of parents' roles in their offspring's care, the role of nursing professionals covers many dimensions as follows: promotion of parents' role construction; guidance and support for the implementation of physical health care; guidance for promoting a safe ergonomic environment; guidance for safe musculoskeletal growth and development **(Reticena et al., 2019)**.

However, when reviewing the ergonomics literature, no extensive descriptions or evaluations were found for parents-centered educational intervention regarding children's inappropriate use of ergonomic factors, although many investigators have supported the recommendations for such strategies **(Jabeen & Hussain, 2022)**. The purpose of this investigation was to evaluate the effectiveness of two sessions of a parents-centered educational intervention emphasizing ergonomics for ensuring safe musculoskeletal growth and development among their school-age and adolescent.

Aim of the study:

To evaluate the effectiveness of parents-centered ergonomic educational intervention on their performance regarding safe musculoskeletal growth and development among their school-age and adolescent**.**

Method:

Research design:

This study was conducted through parallel randomized, controlled trial.

Research Hypotheses:

To achieve the study's aim, the following research hypotheses were developed:

H_1: The post-intervention parents' knowledge regarding ergonomics in the study group would be better than that in the control group.

H_2: The post-intervention parents' reported practices regarding ergonomics in the study group would be better than in the control group.

H_3: After the intervention, the children in the study group would be less musculoskeletal pain and discomfort compared to the control group.

H_4: After the intervention, the children in the study group would have better posture than the control group.

Settings:

The study was conducted at pediatric out-patient clinics affiliated to Mansoura University Children's Hospital and Tanta University Hospital.

***Subjects and sampling*:**

The study subjects were the parents of children aged 6–18 years; both genders; not suffering from any comorbid musculoskeletal and neurological disorders; not undergoing any type of surgery or fracture; as well as the parents who did not receive any educational or training program about ergonomics and accepted to participate in the study.

The total sample was randomly divided into two groups (each group contains 55 parents with their children) using a **simple random technique** by using the random number generation function in commercially available mobile software (random picker, random number generator Pro). The study group was number one (having received the educational program), and the control group was number two (having not received the educational program).

Sample size was determined by using the power analysis program of the **ClinCalc Statistical Software** and based on the study findings of **Waradkar & Palsule, (2021),** the effect size was medium (0.6), the study power was 80%, and the α error was set at 0.05. The minimum acceptable sample size of 45 for each group, an additional 20% was added to allow for participants dropping out of the study, resulting in a final sample size of 55 for each group.

Data collection methods:

The researchers developed a structured interview schedule that included five parts.

Part I: Participants' baseline characteristics. The design of this part was based on the relevant literature **(Mekonnen et al., 2023; NeJhaddadgar et al., 2022; Bello et al., 2022; Mououdi, et al., 2018)**. It included two divisions. The first involved parents' socio-demographic data, which included age, educational level, occupation, marital status, residence, family income, and previous attendance at ergonomics training. The second included a clinical profile of the school-age and adolescent' children, such as age, gender, ranking, education level, height, weight, body mass index, ergonomic risk factors, and previously existing musculoskeletal complaints.

Part II: An ergonomics knowledge test: It was created by the researchers after they reviewed the relevant literature **(Mi◌̃ana-Signes et al., 2019; Bettany-Saltikov et al., 2019; Hamid et al., 2022; Moosa, & Bhayat 2022)** to assess parents' knowledge of ergonomics concept and purpose, and its general principles, ideal neutral postures, appropriate school bag principles, computer using principles, and the appropriate ergonomically designed furniture design. Besides, an introduction to musculoskeletal system anatomy and physiology and its common MS disorders in children and adolescents. The knowledge questions were scored, as the right answers were scored (1 grade) and wrong answers were given (zero). Then total knowledge score was computed and converted into a percent score based on the **Moosa & Bhayat (2022)** study as follows: poor (< 50%), moderate (51% to 69%), and good knowledge scores (≥70%).

Part III: An ergonomics-reported practices checklist. It was constructed by the researchers after reviewing the related literature **(Dugan, 2018; Khorasani et al., 2019; Bettany-Saltikov et al., 2019; Salman et al., 2022)** to assess parents' reported practices regarding risk assessment skills, lifting and moving techniques, positioning and walking techniques, correct computing habits, appropriate lifting technique of the school bag, exercises, and relaxation programs to avoid MSD. The reported practices items were recorded as always being scored (2 points), sometimes being scored (1 point), and never being scored (0 points). The sum of these scores were computed to produce the "total practical score" that was categorized based on the **Moosa & Bhayat (2022)** study as follows: unsatisfactory (< 50%), and satisfactory level (≥50%) that is further divided into incompetent (51% to 69%), and competent scores (≥70%).

Part IV: **Standardized Nordic Body Map Questionnaire (SNBMQ)**. This questionnaire was developed by **Kuorinka et al. (1987)**. It was employed to ascertain whether musculoskeletal symptoms existed. In order to help the children identify the right body parts when answering the questions, the SNBMQ investigates the aching, pain, or discomfort felt in a presented body diagram consisting of nine body parts: the neck, shoulder, upper back, lower back, elbow, arm, hand, thigh, knee, and leg. The SNBMQ asked questions about musculoskeletal discomfort using (yes-or-no) binary choices to conclude if the pain is present (positive) or absent (negative).

Part V: Rapid Upper Limb Assessment (RULA). It was created in **1993** at the University of Nottingham's Institute for Ergonomics by **Lynn McAtamney and Nigel Corlett**. In order to prevent the "healthy subject effect," in which a subject may appear to have excellent posture while the evaluation is done, this observation-based posture assessment approach tries to analyze posture without notifying the child **(Syazwan et al., 2011; Terra, Tonetto et al., 2023)**. RULA emphasizes the upper body while also including the lower body. It generates a numerical score for the observed posture by using a number of images of various body positions that are gradually combined together. Additionally, suggestions are set to each score between 1:7, categorized into four distinct classes, as shown in **Figure 2 (McAtamney and Corlett, 1993)**.

Class	Points	Action level
CLASS I -	1 or 2	Posture is acceptable if not maintained or repeated for long periods
CLASS II -	3 or 4	Investigate, it is possible that improvement actions are necessary
CLASS III -	5 or 6	Investigate, as changes are needed soon
CLASS IV -	7	Investigate and take action immediately

Figure 2. Action level RULA classes

Source: Adapted from McAtamney and Corlett (1993)

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 (0.9)** of the first draft of the ergonomics program and the study tool.

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 parents (21), who weren't included in the sample. Accordingly, the necessary modifications by the experts and piloted parents were made as adding questions about school bag.

The reliability of the parents' care reporting sheet, and the Standardized Nordic Body Map Questionnaire (SNBMQ) were tested by Cronbach's α and emerged as very good (0.80, and 0.94 respectively). Additionally, the Rapid Upper Limb Assessment (RULA) for children reliability emerged as (Cronbach's alpha = 0.81 for arm, 0.79 for wrist, 0.78 for neck, 0.81 for trunk, and 0.83 for leg)

Ethical considerations:

- The protocol of the present research was approved by the research ethics committee of the faculty of Nursing, Mansoura University (NO: 0531).
- The researchers received formal approval to conduct the study

through a letter from the Mansoura Faculty of Nursing to the directors of Mansoura Children's University Hospital and Tanta University Hospital.

- Verbal and written consent was also secured from parents participating in the study by answering questions after guaranteeing their right to withdraw at any time.
- Nature of the study did not cause any harm or pain for the entire sample.
- Confidentiality and privacy were put into consideration regarding the data collected.

Procedure:

The study was conducted from September to December 2023 through three phases:

Preparation of the ergonomics educational program.

The process of the ergonomics program's development was based on the updated evidence and the results of the need assessment of the parents by collecting preliminary data about their knowledge and reported practices level regarding ergonomics **Part I, II & III**, in addition to assessing baseline data of their children's characteristics, posture and musculoskeletal complaints by **Part I**, **IV, & V**. **Then, the** formulation of the first ergonomics program draft included the planning of an educational program' session and the preparation of the assisted materials (handout).

The implementation phase:

The ergonomics program's timetable, including the program's date, time, content, teaching methods, and duration of each session, was distributed among the participating parents individually before the start of the program. The ergonomics program was implemented through three sessions. to illustrate the following content: an introduction to ergonomics and the pediatric musculoskeletal system development and its related disorders; the appropriate ergonomically furniture design; the adaptation of the studying environment to avoid MSDs; the appropriate exercises and relaxation techniques to avoid MSDs; risk assessment skills; ideal neutral postures; correct computing habits; the correct school bag criteria; the appropriate lifting, moving, walking and positioning; and the recommended office equipment location.

Logistics of the program:

Item	Description
Number of the program sessions	Three sessions (two theoretical and one practical sessions)
Theoretical Session one:	
Duration of the session	90 minutes
Content of the session	• An introduction to musculoskeletal system anatomy and physiology. • The main musculoskeletal disorders.
Theoretical Session two:	
Duration of the session	90 minutes
Content of the session	• An introduction to ergonomics. • Computer using principles • The correct school bag criteria • Ideal neutral postures • The adaptation of the studying environment to avoid MSDS
Teaching methods of the theoretical sessions	Brainstorming, discussions, and lectures.
Session three:	
Duration of the session	90 minutes
	• Risk assessment skills • The appropriate body mechanisms during different situations. • The exercises to avoid work related musculoskeletal disorders • Correct computing habits • Lifting and moving techniques • Positioning and walking techniques
Teaching methods	Demonstrations , and re-demonstration

The materials and methods of delivering the ergonomics program varied widely and included active learning sessions, discussions, problem-solving exercises, lectures, and informational handouts.

The evaluation phase:

The parents' knowledge and reported practices towards ergonomics were reassessed immediately after the ergonomics program's implementation by **Part II & III**. After three months of the ergonomics program's implementation, the school-age children's, and adolescents' outcomes, including posture and musculoskeletal complaints, were reassessed using **Part IV& V** besides the parents' knowledge and reported practices towards ergonomics.

Statistical analysis:

Data were coded and analyzed using the Statistical Package for 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, Kolmogorov-Smirnov was used. Inferential statistics, including repeated measures analysis of variance, Chi-square, McNemar's, Wilcoxon signed-rank and independent t tests were used to test the research hypotheses. The significance level was set at 5%.

Results:

Socio-demographic and clinical characteristics of the parents and their children:

Table (1&2) reveal homogeneity regarding all tested socio-demographic and clinical characteristics between the two study groups of parents and their children. Similarity-determining tests show no significant difference **(P>0.05)** between each other regarding all the previously mentioned characteristics. The mean ages in the intervention and control groups were 40.98±7.23, and 38.80±6.53, respectively. More than half of the study group (50.9%) and the control group (63.6%) had bachelor's degrees. In both groups, the occupations of participants weren't working or housewives (intervention group: 50.9%, control group: 58.2%). As regards marital status, more than half of the study group (52.7%) and the control group (63.6%) were married. Concerning residence, slightly more than half of both study groups resided in rural areas. Regarding family income, more than three-fourths of both study groups had enough income. In terms of previous attendance at an ergonomics training program, a large percent of the study participants hadn't attended any training courses (intervention group: 96.4%, and control group: 94.5%).

Regarding the children characteristics, the mean age of children was 15.60±1.48 and 15.20 ± 1.68 in the interventional and control groups, respectively. More than half the study group and the control group were males who studied at the primary level; besides, they were the first children. The mean heights of the study and control groups were 1.48±0.11 and 1.45±0.12 respectively. The mean weights of the study and control groups were 47.47±11.84 and 45.54 ±10.55, respectively. The mean body mass index of the study and control groups were 21.52±5.16 and 21.92±6.12 respectively. The most prevalent ergonomic risk factor among both study groups was a heavy school bag (49%). In terms of previously existing musculoskeletal complaints, more than half of the study group (60%), and the control group (52.7%), suffer from postural abnormalities.

Parents' knowledge about musculoskeletal system and ergonomics:

Table (3) portrays the distribution of parents' knowledge in both groups regarding the musculoskeletal system, the ergonomics concept and its principles, school bag principles, and computer use principles at the three study phases. At the baseline assessment, poor knowledge scores were reported by both study groups regarding all the above-mentioned categories. Compared to the immediate post-test, this poor mean score elevated in the interventional group but remained diminished in the control group as follows: ergonomics concept (interventional group: 6.81±0.69, and control group: 2.67±1.05); musculoskeletal system (interventional group: 4.92±0.26, and control group: 3.63±1.51); school bag principles (interventional group: 3.69±0.57, and control group: 0.84±0.56); and computer use principles (interventional group: 8.50±1.39, and control group: 3.61±2.36). In the same line, follow-up results reported the same improvement in the interventional group's mean scores of all previously mentioned knowledge categories, compared to the same lower mean knowledge scores in the control group. Furthermore, RM-ANOVA results of the interventional group indicated very high statistical differences with a huge effect size regarding all previously mentioned categories ($p \leq 0.001$), compared with insignificant differences detected in the control group at the three study stages (P=0.07, P=0.2, P=0.06,and P=0.284 respectively).

Table (4) shows the distribution of parents' knowledge in both groups towards ideal neutral postures and ergonomically designed furniture. At the baseline survey, poor levels of knowledge were indicated by both study groups regarding both knowledge categories. Compared to immediate post-tests, the study group showed good mean scores, in contrast to the control group, who reported lower knowledge mean scores: ideal neutral postures (interventional group: 9.32±1.61, and control group: 6.32±1.61); and ergonomically designed furniture (interventional group: 6.69±0.57, and control group: 4.63±1.26). Similarly, follow-up results showed similar mean knowledge scores in both study groups. Additionally, RM-ANOVA results reported very high statistical differences with a large effect size in the study group regarding both knowledge categories ($p<0.001$). Compared with the control group results, insignificant differences were indicated at the three study stages ($P=0.93$, and $P=0.06$, respectively).

Comprehensively, RM-ANOVA results demonstrated very high statistical improvements in the total interventional group knowledge mean score from baseline (21.21±5.98) to immediate post-test (39.96±2.60) and 3 months post-test (33.54±3.01) at ($F=395.82$, P-value≤ 0.001, $\eta^2=0.88$), in contrast to the control group results, which showed insignificant differences at ($F= 1.31$, P-value$=0.272$ $\eta^2=0.02$), with minimal change of mean score from baseline (20.96±5.70) to immediate post-test (21.63±5.19) and 3 months post-test (21.41±4.72) at the three study stages.

Parents' reported practices about ergonomics:

Table (5) reveals the distribution of parents' practices in both groups regarding risk assessment, correct computing habits, exercises, and relaxation techniques at the three study phases. At the pre-test assessment, an unsatisfactory practices mean score was reported by both study groups regarding all the above-mentioned categories. Compared to immediately after results, this unsatisfactory mean score improved in the interventional group but remained low in the control group as follows: risk assessment (interventional group: 24.58±2.63, and control group: 5.52±3.65); correct computing habits (interventional group: 12.29±2.86, and control group: 6.30±2.85); and exercises and relaxation techniques (interventional group: 41.56±6.28, and control group: 15.18±5.51). As regards follow-up results, a competent level was reported in the interventional group toward all previously mentioned practices categories, compared to an unsatisfactory level in the control group. In addition, the RM-ANOVA results of the interventional group showed very high statistical differences with a huge effect size regarding all previous practices categories ($p \leq 0.001$), compared with insignificant differences detected in the control group at the three study stages (P=0.07, P=0.12, and P=0.27 respectively).

Table (6) demonstrates the distribution of parents' practices in both groups towards lifting & moving techniques and positioning & walking techniques. At the baseline survey, an unsatisfactory level of practices was indicated by both study groups regarding both practices categories. Compared to immediate post-tests, the study group showed good practices mean score, in contrast to the control group, which reported a lower mean score: lifting and moving techniques (interventional group: 12.63±2.52, and control group: 6.05±2.79); and positioning and walking techniques (interventional group: 30.85±6.35, and control group: 10.60±6.64). Regarding follow-up results, they showed similar mean practices scores in both study groups. The RM-ANOVA test also reported very high statistical differences with an elevated effect size in the study group regarding both practices categories ($p \leq 0.001$), in the control group results, insignificant differences were indicated at the three study stages (P=0.06, and P=0.341, respectively).

Totally, the RM-ANOVA test demonstrated very high statistical differences in the total interventional group practices mean score from baseline (41.67±12.73) to immediate post-test (122.10±9.52) and three months post-test (112.21±12.72) at (F=981.02, P-value≤0.001, η^2=0.95), in contrast to the control group results, which showed insignificant differences at (F= 3.44, P-value=0.06, η^2=0.06), with lower change of mean score from baseline (47.34±9.42) to immediate post-test (44.80±14.16) and 3 months post-test (43.41±412.97) at the three study stages.

Children's outcomes (posture and MSK complaints):

Table (7) shows the lifetime prevalence of musculoskeletal pain reported most commonly in the neck, shoulders, upper extremities and back among both children groups at baseline assessment. After three months of the ergonomics program's implementation, the children in the interventional group reported the absence of neck, shoulders, upper extremities, and back pain among the largest percent of the participants (90.9%, 87.3%, and 18.2%, respectively), while the participants in the control group didn't show any improvement regarding their MS pain. McNemar's test also indicated statistically significant improvements with a huge effect size regarding all the above-mentioned MS pain at ($p<0.05$), compared to the control group, which showed insignificant results regarding all the reported MS pain at ($P>0.05$).

Table (8) reveals the comparison of the posture assessment results between both children groups. At the baseline assessment, the Mann-Whitney test indicated homogeneity between the both children's groups regarding the posture assessment (**P-value=0.55).** After three months of the ergonomics program implementation, the children in the interventional group demonstrated significant improvement with a high effect size in the posture score at (**Z= 7.28, P-value**≤0.001**,** $\mathbf{r_{C}=0.98}$), compared to the control group, which showed an insignificant result regarding the posture score at (**Z = 1.73, P-value=0.083,** $\mathbf{r_{C}=-0.23}$).

Table (1): Parents' demographic and occupational characteristics

Demographic and occupational characteristics	Total number of parents =110				P- value Significance test
	Interventional N=(55)		Control N= (55)		
	No.	%	No.	%	
Who fill sheet					
The mother	49	89.1	51	92.7	0.507
The father	6	10.9	4	7.3	
Age					
25- <35	18	32.7	22	40	0.518
35-<45	23	41.8	20	36.4	
-45 and more	14	25.5	13	23.6	
$\bar{X}$(SD)	40.98(7.23)		38.80(6.53)		
Educational level					
Secondary	18	32.7	14	25.5	0.391
University	28	50.9	35	63.6	
Higher studies	9	16.4	6	10.9	
Occupation					
Governmental work	8	14.5	4	7.3	0.449
Free work	19	34.5	19	34.5	
Not working/housewife	28	50.9	32	58.2	
Marital status					
Married	29	52.7	35	63.6	0.509
Divorce	21	38.2	16	29.1	
Widow	5	9.1	4	7.3	
Residence					
Urban	24	43.6	28	50.9	0.445
Rural	31	56.4	27	49.1	
Family income					
Enough	43	78.2	45	81.8	0.634
Not enough	12	21.8	10	18.2	
Previous attendance at training about ergonomics					
No	53	96.4	52	94.5	0.647
Yes	2	3.6	3	5.5	

P-value for Chi-square test and/or Independent t test, **P** Significance * Significant ($p \leq 0.05$).

Table (2): School-age and adolescent children's clinical profile

Clinical profile	Total number of parents =110				Significance test
	Interventional N=(55)		Control N= (55)		
	No.	%	No.	%	
Age					
6-<10ys	17	30.9	25	45.5	0.283
10-14ys	20	36.4	13	23.6	
≥14ys	18	32.7	17	30.9	
$\bar{X}$(SD)	15.60(1.48)		15.20(1.68)		
Gender					
Male	32	58.2	36	65.5	0.432
Female	23	41.8	19	34.5	
Ranking					
First	33	60	29	52.7	0.661
Second	18	32.7	18	32.7	
Third	3	5.5	6	10.9	
Above third	1	1.8	2	3.6	
Education level					
Primary	29	52.7	26	47.3	0.841
Preparatory	21	38.2	23	41.8	
Secondary	5	9.1	6	10.9	
Height					
$\bar{X}$(SD)	1.48(0.11)		1.45(0.12)		0.137
Weight					
$\bar{X}$(SD)	47.47(11.84)		45.54(10.55)		0.370
Body mass index (BMI)					
$\bar{X}$(SD)	21.52(5.16)		21.92(6.12)		0.715
Ergonomic risk factors					
Awkward posture	14	25.5	11	20	0.722
Heavy school bag	27	49	27	49	
Non-ergonomic designed furniture	14	25.5	17	31	
Previously existing musculoskeletal complaints					
Postural abnormalities	33	60	29	52.7	0.661
Joint stiffness	18	32.7	18	32.7	
Pain and/or discomfort	3	5.5	6	10.9	
Sprains and strains	1	1.8	2	3.6	

Table (3): Parents' knowledge categories scores toward the musculoskeletal system and ergonomics throughout the three study phases (n=110)

Items	Interventional N=(55)						Control N=(55)					
	Pre		Immediate Post		After 3 months		Pre		Immediate Post		After 3 months	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Musculoskeletal anatomy, physiology and its common disorder score=(5)												
Poor	12	21.8	00	00	1	1.8	14	25.5	13	23.6	9	16.4
Average	7	12.7	00	00	15	27.3	5	9.1	5	9.1	5	9.1
Good	36	65.5	55	100	39	70.9	36	65.5	37	67.3	41	74.5
$\overline{X}$(SD)	3.54(1.28)		4.92(0.26)		4.00(0.81)		3.45(1.38)		3.63(1.51)		3.87(1.23)	
Significance test	F=31.98		P-value≤0.001		η^2=0.37		F=2.65		P-value =0.075		η^2=0.04	
Ergonomics concept, purpose and principals score=(7)												
Poor	43	78.2	00	00	00	00	43	78.2	44	80	47	85.5
Average	10	18.2	2	3.6	3	5.5	12	21.8	10	18.2	7	12.7
Good	2	3.6	53	96.4	52	94.5	00	00	1	1.8	1	1.8
$\overline{X}$(SD)	2.32(1.26)		6.81(0.69)		5.96(0.88)		2.58(1.19)		2.67(1.05)		2.60(1.19)	
Significance test	F= 327.63		P-value≤0.001		η^2=0.86		F= 1.634		P-value=0.20		η^2=0.02	
School bag principles score=(4)												
Poor	43	78.2	00	00	4	7.3	53	96.4	50	90.9	52	94.5
Average	12	21.8	3	5.5	18	32.7	2	3.6	5	9.1	3	5.5
Good	00	00	52	94.5	33	60	00	00	00	00	00	00
$\overline{X}$(SD)	0.96(0.69)		3.69(0.57)		2.61(0.95)		0.80(0.48)		0.84(0.56)		0.73(0.55)	
Significance test	F=172.46		P-value≤0.001		η^2=0.76		F=2.89		P-value =0.06		η^2=0.05	
Computer using principles score=(9)												
Poor	37	67.3	4	7.3	6	10.9	37	67.3	37	67.3	37	67.3
Average	5	9.1	1	1.8	6	10.9	10	18.2	5	9.1	7	12.7
Good	13	23.6	50	90.9	43	78.2	8	14.5	13	23.6	11	20
$\overline{X}$(SD)	3.61(2.36)		8.50(1.39)		7.49(1.67)		3.50(2.32)		3.61(2.36)		3.56(2.33)	
Significance test	F=171.37		P-value≤0.001		η^2=0.76		F=1.27		P-value=0.284		η^2=0.023	

Table (4): Parents' knowledge categories scores toward ergonomics throughout the three study phases, Cont

Items	Parents No=110											
	Interventional N=(55)						Control N=(55)					
	Pre		Immediate Post		After 3 months		Pre		Immediate Post		After 3 months	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ideal neutral postures score=(10)												
Poor	14	25.5	2	3.6	2	3.6	17	30.9	11	20	15	27.3
Average	27	49.1	5	9.1	15	27.3	26	47.3	28	50.9	25	45.5
Good	14	25.5	48	87.3	38	69.1	12	21.8	16	29.1	15	27.3
$\bar{X}$(SD)	6.14(2.0)		9.32(1.61)		7.85(1.77)		6.09(2.13)		6.32(1.61)		6.14(2.1)	
Significance test	F= 73.20		P-value≤0.001		η^2=0.58		F=0.064		P-value=0.93		η^2=0.001	
Ergonomically designed furniture score=(7)												
Poor	14	25.5	00	00	3	5.5	15	27.3	11	20	16	29.1
Average	9	16.4	00	00	1	1.8	12	21.8	11	20	12	21.8
Good	32	58.2	55	100	51	92.7	28	50.9	33	60	27	49.1
$\bar{X}$(SD)	4.61(1.22)		6.69(0.57)		5.61(0.95)		4.50(1.38)		4.63(1.26)		4.4(1.42)	
Significance test	F=61.09		P-value≤0.001		η^2=0.53		F=2.80		P-value=0.06		η^2=0.05	
Total knowledge score score=(42)												
Poor	20	36.4	00	00	00	00	23	41.8	21	38.2	19	34.5
Average	34	61.8	00	00	3	5.5	31	56.4	30	54.5	35	63.6
Good	1	1.8	55	100	52	94.5	1	1.8	4	7.3	1	1.8
$\bar{X}$(SD)	21.21(5.98)		39.96(2.60)		33.54(3.01)		20.96(5.70)		21.63(5.19)		21.41(4.72)	
Significance test	F=395.82		P-value≤0.001		η^2=0.88		F= 1.31		P-value=0.272		η^2=0.02	

F for repeated measure ANOVA, **η^2** = partial eta squared, **P** Significance * Significant ($p \le 0.05$).

Table (5): Parents' practices categories scores toward ergonomics throughout the three study phases

Items		Parents No=110											
		Interventional N=(55)						Control N=(55)					
		Pre		Immediate Post		After 3 months		Pre		Immediate Post		After 3 months	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Risk assessment skills score=(26)													
Unsatisfactory		52	94.5	00	00	00	00	53	96.4	46	83.6	50	90.9
Satisfactory	Incompetent	3	5.5	5	9.1	10	18.2	2	3.6	9	16.4	5	9.1
	Competent	00	00	50	90.9	45	81.8	00	00	00	00	00	00
$\overline{X}$(SD)		4.87(3.04)		24.58(2.63)		22.30(2.55)		5.03(2.47)		5.52(3.65)		5.29(3.00)	
Significance test		F=808.8		P-value≤0.001		η^2=0.94		F= 2.71		P-value=0.07		η^2=0.04	
Correct computing habits score=(14)													
Unsatisfactory		37	67.3	00	00	2	3.6	37	67.3	28	50.9	33	60
Satisfactory	Incompetent	10	18.2	14	25.5	17	30.9	10	18.2	20	36.4	14	25.5
	Competent	8	14.5	41	74.5	36	65.5	8	14.5	7	12.7	8	14.5
$\overline{X}$(SD)		6.16(2.95)		12.29(2.86)		11.74(3.03)		6.16(2.95)		6.30(2.85)		6.23(2.90	
Significance test		F= 72.07		P-value≤0.001		η^2=0.57		F= 2.34		P-value=0.12		η^2=0.04	
Exercises, and relaxation programs score=(44)													
Unsatisfactory		47	85.5	00	00	3	5.5	43	78.2	38	69.1	41	74.5
Satisfactory	Incompetent	8	14.5	7	12.7	10	18.2	12	21.8	17	30.9	14	25.5
	Competent	00	00	48	87.3	42	76.4	00	00	00	00	00	00
$\overline{X}$(SD)		14.41(4.85)		41.56(6.28)		28.85(9.56)		14.83(5.06)		15.18(5.51)		15.00(5.30)	
Significance test		F= 239.84		P-value≤0.001		η^2=0.81		F=1.29		P-value=0.279		η^2=0.02	

F for repeated measure ANOVA, **η^2** = partial eta squared, **P** Significance * Significant (p≤ 0.05).

Table (6): Parents' practices categories scores toward ergonomics throughout the three study phases, Cont

Items		Interventional N=(55)						Control N=(55)					
		Pre		Immediate Post		After 3 months		Pre		Immediate Post		After 3 months	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Lifting and moving techniques score=(14)													
Unsatisfactory		38	69.1	1	1.8	1	1.8	41	74.5	34	61.8	38	69.1
Satisfactory	Incompetent	13	23.6	12	21.8	15	27.3	10	18.2	17	30.9	13	23.6
	Competent	4	7.3	42	76.4	39	70.9	4	7.3	4	7.3	4	7.3
$\overline{X}$(SD)		6.07(2.86)		12.63(2.52)		12.32(2.69)		5.85(2.86)		6.05(2.79)		5.89(2.92)	
Significance test		F=168.36		P-value≤0.001		η^2=0.75		F=3.59		P-value=0.06		η^2=0.06	
Positioning and walking techniques score=(36)													
Unsatisfactory		43	78.2	0	0	5	9.1	41	74.5	32	58.2	38	69.1
Satisfactory	Incompetent	12	21.8	11	20.0	14	25.5	14	25.5	23	41.8	17	30.9
	Competent	0	0	44	80.0	36	65.5	0	0	0	0	0	0
$\overline{X}$(SD)		9.67(4.74)		30.85(6.35)		27.47(7.40)		9.91(5.01)		10.60(6.64)		10.13(6.28)	
Significance test		F=297.59		P-value≤0.001		η^2=0.85		F=1.08		P-value=0.341		η^2=0.02	
Total practices score score=(134)													
Unsatisfactory		50	90.9	0	0	1	1.8	54	98.2	49	89.1	51	92.7
Satisfactory	Incompetent	5	9.1	0	0	1	1.8	1	1.8	6	10.9	4	7.3
	Competent	0	0	55	100.0	53	96.4	0	0	0	0	0	0
$\overline{X}$(SD)		41.67(12.73)		122.10(9.52)		112.21(12.72)		47.34(9.42)		44.80(14.16)		43.41(412.97)	
Significance test		F=981.02		P-value≤0.001		η^2=0.95		F= 3.44		P-value=0.06		η^2=0.06	

Parents No=110

F: RM- ANOVA, **$\overline{X}$:** Mean, **SD:** Standard deviation, **η^2:** Partial Eta Squared (the effect size of RM-ANOVA), **P:** Significance. * Significant ($p \leq 0.05$)

Table (7): Comparison of the pain frequency in different body parts between both children study groups before and after three months of the program's implementation

Items	Children No=110								Significance test between baseline data
	Interventional N=(55)				Control N=(55)				
	Pre		After 3 months		Pre		After 3 months		
	No.	%	No.	%	No.	%	No.	%	
Neck and Shoulder Pain									
Negative	44	80	50	90.9	42	76.4	44	26.7	**χ^2=0.213**
Positive	11	20	5	9.1	13	23..6	11	6.7	**P-value=0.644**
Significance test	χ^2_{mc}		**P-value=0.031**		χ^2_{mc}		**P-value=0.50**		
Upper Extremity Pain									
Negative	40	72.7	48	87.3	42	76.4	39	70.9	**U=0.192**
Positive	15	27.3	7	12.7	13	23..6	16	29.1	**P-value=0.664**
Significance test	χ^2_{mc}		**P-value =0.008**		χ^2_{mc}		**P-value=250**		
Lower Extremity Pain									
Negative	51	92.7	52	94.5	49	89.1	53	96.4	**U=0.440**
Positive	4	7.3	3	5.5	6	10.9	2	3.6	**P-value=0.507**
Significance test	χ^2_{mc}		**P-value=1.00**		χ^2_{mc}		**P-value=0.125**		
Back pain									
Negative	38	69.1	45	81.8	36	65.5	38	69.1	**U=0.165**
Positive	17	30.9	10	18.2	19	34.5	17	30.9	**P-value=0.684**
Significance test	χ^2_{mc}		**P-value=0.016**		χ^2_{mc}		**P-value=0.50**		
Overall pain									
Negative	47	85.5	53	96.4	44	26.7	41	74.5	**U=0.573**
Positive	8	14.5	2	3.6	11	6.7	14	25.5	**P-value=0.449**
Significance test	χ^2_{mc}		**P-value=0.031**		χ^2_{mc}		**P-value=0.250**		

χ^2_{mc} : McNemar's test for paired dichotomous observations, **χ^2:**Chi-square test **P**: Significance. * Significant ($p \leq 0.05$)

Table (8): Comparison of the posture assessment score between both children study groups before and after three months of the program's implementation

Items	**Children No=110**								**Significance test between baseline data**
	Interventional N=(55)				**Control N=(55)**				
	Pre		**After 3 months**		**Pre**		**After 3 months**		
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	
Posture level									
Class I	13	23.6	41	74.5	22	40	20	36.4	**U=1.42**
Class II	42	76.4	14	25.5	33	60	35	63.6	**P-value=0.55**
Median (range)	2(1.0)		1.0(1.0)		2(1.0)		2(1.0)		
Significance test	**Z= 7.28**	**P-value**≤0.001	**r_C=0.98**		**Z = 1.73**	**P-value=0.083**	**r_C=-0.23**		

Z: Wilcoxon signed-rank test, **r_C:** effect size of Wilcoxon signed-rank test (matched pairs biserial correlation), **U:** Mann Whitney**, P**: Significance. * Significant (p≤ 0.05)

Discussion:

Parents bear a significant responsibility for the safety of their children's musculoskeletal system development. In the family environment, habits are formed about how to use ergonomic factors. Behavior is shaped through parents , both intentionally and incidentally **(Tomczyk, & Potyrała, 2021)**. Thus, the appropriate parents' performance about the use of ergonomic factors for their children not only allows parents to avoid ergonomic threats but is also a factor in the protection of their children from musculoskeletal problems. **(McDougall et al., 2018)**. To our knowledge, this is the first research to evaluate the effectiveness of parents-centered ergonomic educational intervention on their performance regarding safe musculoskeletal growth and development among their children.

The data analysis indicates uniformity on all the studied Scio demographic and clinical characteristics between the interventional and control groups of the parents and their children who participated in the baseline assessment. As, inferential tests showed insignificant differences (P>0.05), this is compatible with a comparative study conducted by **Tigli et al., (2020),** who reported the similarity between the study and control groups. This similarity is the basic requirement for any case-control study, as revealed by a consistent study by **(Oner et al., 2019).**

Regarding the **parents' musculoskeletal system and ergonomics knowledge**, **RM-ANOVA results** indicated very high statistical improvements immediately after and at follow up with a huge effect size on the intervention group mean scores **(ES=0.8)**, compared to negligible changes in the mean score of the control group results. The results of the current research were supported by the study of **Jabeen and Hussain, (2022)** who cited that "awareness regarding ergonomics can also prove to be a healthy sign towards students' better posture, comfort, and health." It can be demonstrated through parental education and implementing ergonomic techniques by demonstrating healthy exercises and reducing academic pressure." additionally, a randomized clinical trial that was implemented by **Chu et al. (2019)** concluded that "parents who received the text-messaging program reported higher levels of improved knowledge at 1 and 3 months of follow-up compared with the control group."

Heavy backpacks, improperly ergonomically designed furniture, and poor computer habits are the most glaring factors that lead to students' postural deviation and persistent pain in the body **(Jabeen & Hussain, 2022).** Therefore, this research emphasized providing parents-centered education about these factors, which revealed significant improvements in the interventional parent group throughout the three study phases, as demonstrated by RM-ANOVA results (P-value ≤0.001), compared to non-significant differences in the control group. This finding is also supported by **Al-Hinai et al. (2018),** who cited that "provision of ergonomically designed furniture positively impacts students' posture, comfort, and health." Additionally, **Buchman- Pearle et al. (2023)**, stress on the implementation of interventions such as ergonomically designed furniture, postural education and physical activity breaks leads to improved health outcomes, better posture and improved academic performance.

Jabeen and Hussain (2022) cited that "incorporating parents and school authorities in active ergonomic practices is very crucial for students to regain their energy and make them active and agile." Thus, the present research focused on providing the parents with skill-based education about ergonomic risk assessment, correct positioning, walking, lifting, and moving techniques, besides suitable exercises, and relaxation techniques, which revealed significant improvements in the interventional parents group immediately and three months after intervention implementation, as indicated by RM-ANOVA results (P-value≤0.001), compared to non-significant differences in the control group. This finding is supported by **Kumar et al. (2020),** who suggested that "ergonomics training must be a part of the school curriculum to improve parents, teachers, and students' performance."

Additionally, **Choudhary et al. (2020)** recommended that parents be guided to monitor their children's body posture at home as well to avoid ergonomic risk factors. Hence, the role of parents cannot be ignored in changing the unhealthy computer habits of their children by making them carry appropriate backpacks and enabling them to adopt appropriate body mechanisms during all body postures. The research findings also agreed with **Abubakar (2020),** who stated that "parents also should become part of the ergonomic system and help their wards in physical exercises and guide them to improve sitting positions at home."

Our findings show that the best and most practical approach to generating in depth behavioral changes in schoolchildren is to educate their parents about ergonomics in their children's daily lives. As inappropriate posture and musculoskeletal pain are largely attributable to ergonomic risks, not only in the school environment but also in many other daily activities. Thus, our research included the evaluation of two secondary outcomes: musculoskeletal pain and posture. The musculoskeletal pain results revealed significant improvements with a huge effect size regarding all MS pain at ($p<0.05$), compared to the control group, which showed insignificant results regarding all the reported MS pain at ($P>0.05$). This outcome agreed with two studies by **Bulguroğlu et al. (2023) and Abdolahi et al., (2022),** who concluded that "specific training programs including posture and ergonomics may raise ergonomic awareness in terms of reducing musculoskeletal pain."

As regards the posture evaluation results after the ergonomics program implementation, the children in the interventional group demonstrated significant improvement with a high effect size in the posture score (P-value≤0.001, r_C=0.98), compared to the control group, which showed an insignificant result regarding the posture score (P-value=0.083). This conclusion is compatible with the finding of **Khalili et al., (2018)** who reported "a significant effect of educational intervention based on the stages-of-change model on practicing the correct posture." This result also agreed with another study by **Gaikwad et al., (2023),** entitled "Effectiveness of ergonomic training in work-related musculoskeletal pain and posture among school-going students—an experimental study", which showed a positive effect of the ergonomic training on posture among school-going children.

Conclusion and recommendations:

This study concluded that the findings supported the study hypotheses, as the educational intervention had a significant effect on improving the parents' knowledge and practices toward safe musculoskeletal development and ergonomics. Additionally, the children in the intervention group showed significant reduction in musculoskeletal pain and improvement in posture three months after the education. Therefore, continuous efforts to raise awareness and skill levels among parents regarding the use of ergonomic principles in their children's daily lives should be recommended by implementing various strategies, education modules, and providing appropriate training programs at regular intervals.

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