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Original article

Exercise Ball Gymnastics as a Method of Improving Physical Fitness in Scoliosis

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Abstract: The *aim* of this study was to evaluate the effects of exercise ball gymnastics on the functional state of the respiratory system and the overall level of physical fitness in girls aged 18-19 years with grade 1 scoliosis.
Material and Methods — The study included 62 female students aged 18-19 years with grade 1 scoliosis. Participants were divided into 2 groups: an experimental group (EG; *n*=32) that participated in exercise ball gymnastics and a control group (CG; *n*=30) that followed the standard university physical education program. The state of the respiratory system and level of physical fitness were assessed.
Results — In the EG, *vital capacity* (*VC*) increased by 16% (*P*=0.048), and *expiratory reserve volume* (*ERV*) increased by 38% (*P*<0.001). *Minute ventilation* (*MV*) and *maximum voluntary ventilation* (*MVV*) also increased by 18% and 27%, respectively (*P*=0.046 and *P*<0.001), and *maximum tidal volume* (*TVmax*) increased by 27% (*P*<0.001). In the CG, significant changes occurred in *ERV*, *MVV*, and *TVmax*, with increases of 23%, 16%, and 16%, respectively (*P*<0.001, *P*=0.006, and *P*=0.005). Indicators of overall physical fitness in the EG improved significantly in all tests except forward bending. In the CG, significant improvements were observed in the 2,000-m walk (11%; *P*=0.032) and push-ups on knees (24%; *P*=0.003). Both groups showed significant improvements in standard and sharpened Romberg's tests.
Conclusion — The exercise ball gymnastics method used in this study positively influenced respiratory function indicators and physical fitness levels in students with grade 1 scoliosis, supporting its recommendation for physical education classes in individuals with this condition.

Keywords: exercise ball gymnastics, girls, physical fitness, respiratory system parameters.

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Introduction

Scoliosis is one of the most common musculoskeletal disorders, particularly among schoolchildren and students. Studies indicate that 5% to 10% of adolescents and young adults have various forms of scoliosis; estimates suggest this figure may reach 15% among students, owing to lifestyle factors such as physical inactivity from prolonged academic pursuits.

It is known that spinal curvature leads to numerous adverse effects, including respiratory system pathology. Notably, it causes restrictive-type external respiration dysfunction, with multifactorial decreases in lung volumes, displacement of intrathoracic organs, restricted rib movement, and altered respiratory muscle mechanics [1-3]. Scoliosis may also narrow the bronchial lumen, increasing airflow resistance and exacerbating respiratory failure [4-8]. Severe scoliosis can also lead to pulmonary hypertension. Additionally, scoliosis – especially when severe – significantly limits daily activities, sports participation, and overall physical fitness [9-11].

Given scoliosis's high prevalence and broad adverse impacts on the human body, identifying the most effective correction methods for correcting spinal curvature and its consequences is a key research priority. Physical therapy, physical exercises, and specialized corsets are established interventions for scoliosis of varying degrees, as endorsed by the International Society on Scoliosis Orthopaedic and Rehabilitation Treatment. Exercise ball gymnastics represents one such exercise approach for scoliosis correction [12-14]. However, due to variations in exercise protocols, further in-depth analysis of their effects on various body systems and overall physical fitness of those involved is needed.

Material and Methods

Study Design and Sampling

The study involved 62 female students aged 18-19 years with grade 1 scoliosis, classifying them into a special medical health group. Participants were assigned to 2 groups based on university physical education programming. The experimental group (EG; *n*=32) followed an adapted program incorporating exercise ball gymnastics during practical sessions. The control group (CG; *n*=30) adhered to the standard university program (*Figure* 1). Total physical education hours were equivalent between groups. Assessments occurred twice: at baseline (September) and endpoint (June) of the academic year.

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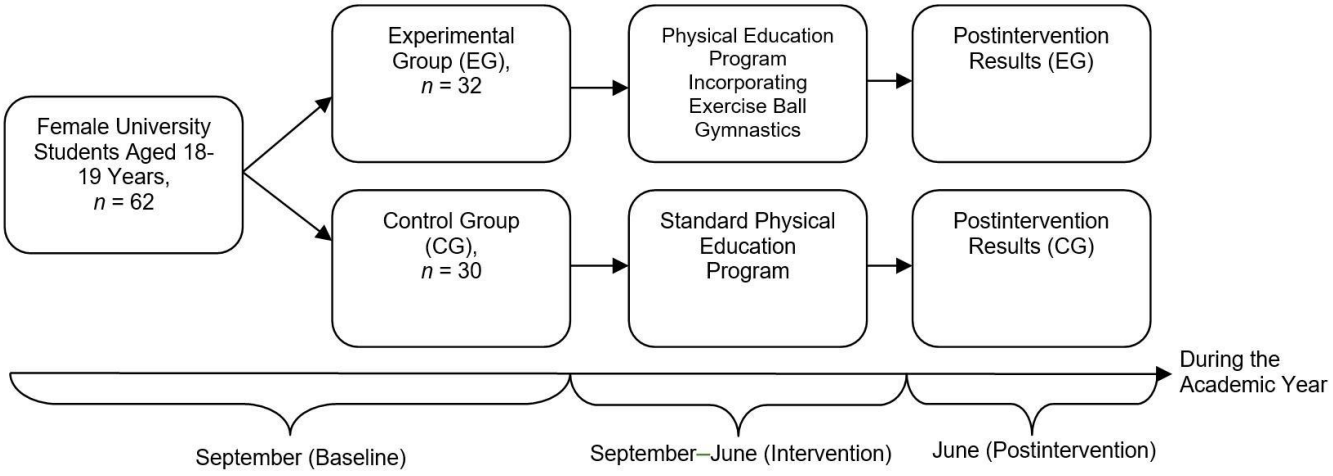

Figure 1. Study Design and Timeline.

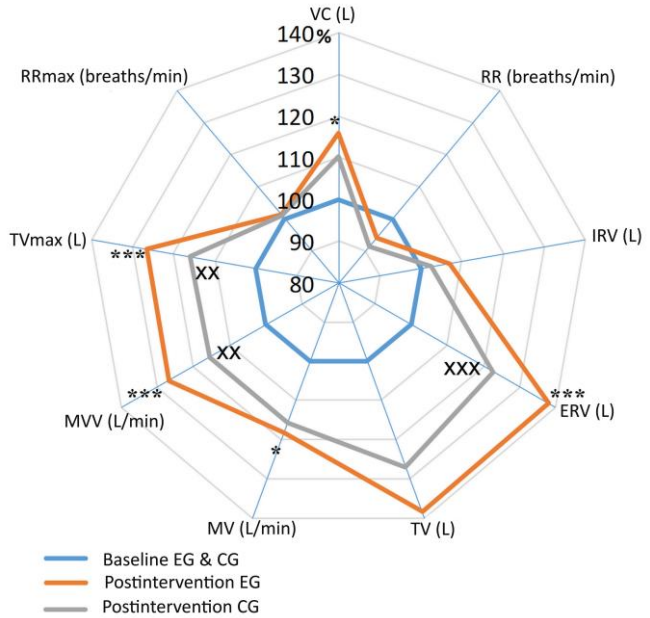

Figure 2. Radar Chart Showing Percentage Relative Change in Respiratory Parameters Before and After Intervention in the Experimental Group (EG) and Control Group (CG).

* Significant increase in EG (*P<0.05, **P<0.01, ***P<0.001);

x Significant increase in CG (x P<0.05, xx P<0.01, xxx P<0.001). Abbreviations: VC, vital capacity; RR, respiratory rate; IRV, inspiratory reserve volume; ERV, expiratory reserve volume; TV, tidal volume; MV, minute ventilation; MVV, maximum voluntary ventilation; TVmax, maximum tidal volume; RRmax, maximum respiratory rate.

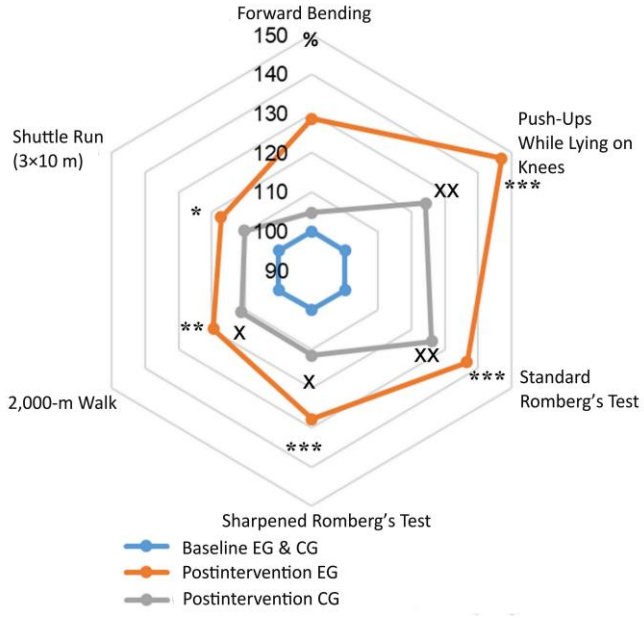

Figure 3. Dynamics of Physical Fitness and Balance Levels in Female EG and CG, %.

* Significant differences in the increase in results in EG: * P<0.05, ** P<0.01, *** P<0.001;

x Significant differences in the increase in results in CG: x P<0.05, xx P<0.01, xxx P<0.001.

Assessment of the Respiratory System

Respiratory function was evaluated using an automated spirometer (SPIROS-100; Altonika, Russia). Measured parameters included Vital Capacity (VC), L; Respiratory Rate (RR), breaths/min; Inspiratory Reserve Volume (IRV), L; Expiratory Reserve Volume (ERV), L; Tidal Volume (TV), L; Minute Ventilation (MV), L/min; Maximum Voluntary Ventilation (MVV), L/min; Maximum Tidal Volume (TVmax), L; and Maximum Respiratory Rate (RRmax), breaths/min.

Assessment of Physical Fitness Level

Physical fitness was assessed via the following tests: forward bend, cm (measured standing on a gymnastic bench, with the support level as 0 cm and results recorded to the nearest 3 fingertips); 2,000-m walk, min; push-ups on knees, repetitions; and shuttle run (3×10 m), s. These tests evaluate basic physical qualities. The standard Romberg's test (main stance, eyes closed), s; and the sharpened Romberg's test (right leg forward, hands extended, eyes closed), s; were also performed to assess balance.

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Table 1. **Dynamics of Respiratory System Parameters in Experimental Group (EG) and Control Group (CG)**

Parameter	*Baseline (1)*	*Postintervention EG (2)*	*Postintervention CG (3)*	*P-Value (1-2)*	*P-Value (1-3)*
Vital Capacity (VC), L	2.94±0.22	3.41±0.06	3.24±0.09	0.048	0.219
Respiratory Rate (RR), breaths/min	19.95±1.70	18.77±0.14	18.23±0.58	0.638	0.718
Inspiratory Reserve Volume (IRV), L	1.70 (1.21; 2.95)	1.82±0.09	1.74±0.08	0.864	0.415
Expiratory Reserve Volume (ERV), L	0.66 (0.13; 1.39)	0.91±0.04	0.81±0.02	<0.001	<0.001
Tidal Volume (TV), L	0.52 (0.14; 1.58)	0.72±0.04	0.66±0.04	0.316	0.301
Minute Ventilation (MV), L/min	11.07 (1.72; 16.24)	13.09±0.30	12.81±0.83	0.046	0.877
Maximum Voluntary Ventilation (MVV), L/min	73.76±2.15	93.50±2.99	85.30±3.01	<0.001	0.006
Maximum Tidal Volume (TVmax), L	1.53±0.06	1.93±0.02	1.77±0.06	<0.001	0.005
Maximum Respiratory Rate (RRmax), breaths/min	47.85±2.20	48.50±2.45	48.37±2.55	0.236	0.288

Table 2. **Dynamics of Physical Fitness and Balance Levels in Female Experimental Group (EG) and Control Group (CG)**

Test	*Baseline*	*Postintervention EG*	*Postintervention CG*	*P (EG vs. Baseline)*	*P (CG vs. Baseline)*
2,000-m walk, minutes	24.05±1.30	19.33±1.54	21.37±1.01	P=0.006	P=0.032
Push-up test (on knees), repetitions	17.91±1.30	26.32±1.94	22.23±0.94	P<0.001	P=0.003
3×10 m shuttle run, seconds	11.26±0.96	9.32±0.11	10.11±0.54	P=0.022	P=0.602
Forward bend, cm	4.20±0.80	5.40±0.30	4.40±0.30	P=0.388	P=0.632
Standard Romberg's test, seconds	82.12±3.20	112.2±5.80	103.5±5.50	P<0.001	P=0.005
Sharpened Romberg Test (SRT), seconds	54.3±2.24	69.4±3.00	60.6±1.80	P<0.001	P=0.027

Statistical Analysis

Data were analyzed using *Statistica* version 8.0 (*StatSoft* Inc., USA). The normal distribution of the measured variables was assessed with the Shapiro-Wilk test. Non-normally distributed data were reported as medians (Me) with interquartile ranges (Q25; Q75); normally distributed data as means±standard error. The Wilcoxon signed-rank test was used for paired comparisons. Statistical significance was set at $P<0.05$.

Results

Effective medical monitoring during physical education for students with scoliosis requires assessing external respiration function and physical fitness levels. Grade 1 scoliosis involves slight lateral spinal curvature (up to 10 degrees), yet even this can negatively affect respiratory function and overall physical condition.

Both the EG and CG showed slight increases in absolute respiratory parameter values. In the EG, statistically significant improvements occurred in *VC*, *ERV*, *MV*, *MVV*, and *TVmax*. *VC* increased by 16% ($P=0.048$), *ERV* by 38% ($P<0.001$), *MV* by 18% ($P=0.046$), *MVV* by 27% ($P<0.001$), and *TVmax* by 27% ($P<0.001$). In the CG, significant changes were seen in *ERV*, *MVV*, and *TVmax*, with increases of 23% ($P<0.001$), 16% ($P=0.006$), and 16% ($P=0.005$), respectively (*Figure 2*, *Table 1*).

An analysis of changes in the overall level of physical fitness among the girls demonstrated improvements in performance in both studied groups. Thus, statistically significant differences in the EG were noted in all conducted tests. In the 2,000-m walk test, results improved by 20% ($P=0.006$). Students improved their results by 47% ($P<0.001$) in push-ups on the knees and by 17% ($P=0.022$) in the shuttle run (3×10 m). In the CG, statistically significant differences were observed only in the 2,000-m walk test and in push-ups on the knees. Results increased by 11% ($P=0.032$) and 24% ($P=0.003$), respectively (*Figure 3*, *Table 2*).

Both groups also showed significant improvements in standard and sharpened Romberg's tests. In the EG, the standard Romberg's test improved by 37% ($P<0.001$) and the sharpened one by 28% ($P<0.001$); in the CG, by 26% ($P=0.005$) and 12% ($P=0.027$), respectively (*Figure 3*).

Discussion

Inspiratory muscles, including the diaphragm, are morphologically and functionally akin to skeletal muscles and respond similarly to physical training. This study demonstrates that exercise ball gymnastics has a more pronounced positive effect on respiratory function than the standard university physical education program [15-17].

Exercise ball routines increase chest excursion amplitude, enhance lung ventilation, and improve gas exchange efficiency by activating intercostal muscles and the diaphragm – key players in respiration. In students with scoliosis, especially those with grade 1 scoliosis, these adaptations can boost vital capacity and reduce airway resistance [18-20].

It is known that scoliosis often shifts the general center of pressure, impairing balance. The findings indicate improved balance quality and postural stability in both simple and complex conditions, even with altered support areas [18, 21].

By engaging deep trunk stabilizers (particularly, back and abdominal muscles) on an unstable surface, exercise ball gymnastics enhances movement coordination, strengthens the muscular corset, increases spinal flexibility, and ultimately elevates overall physical fitness [16, 17, 22].

Conclusion

Thus, developing tailored physical education approaches, considering participants' health specifics, can enhance corrective outcomes. The exercise ball gymnastics method evaluated here positively influences respiratory function and physical fitness in students with grade 1 scoliosis, warranting its inclusion in physical education programs for this population.

Ethical Approval

This study adhered to the World Medical Association Declaration of Helsinki (1964, as amended) and comparable ethical standards. All participants provided voluntary informed consent.

Limitations

Key limitations include the small sample size. Future research could extend the study duration and include male participants.

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Conflict of interest

The authors declare no conflicts of interest.

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AI or AI-Assisted Technologies Used

The authors confirm that no AI or AI-assisted technologies were used in writing this paper.

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