ABSTRACT

BACKGROUND. Juvenile spinal osteochondrosis (JSO) affects vertebral endplates and may cause intervertebral discs alterations. **The condition** is typically related to pain, and weakness and shortening of trunk muscles. Sling suspension therapy (SST) has been shown to reduce lumbar pain effectively. It is, however, unclear whether SST is superior to other treatment methods in reducing pain, correcting posture, and activating trunk stabilizers in JSO.

OBJECTIVE: In this study, we intended to compare the effectiveness of two different exercise modalities; Sling Suspension Therapy and Gym Ball Exercise in the treatment of JSO in adolescent girls.

METHODS: a randomised controlled single centre clinical trial (ClinicalTrials.gov Identifier: NCT03851367) was carried out in an inpatient rehabilitation unit at a sanatorium. Forty adolescent girls (age 16.3 ± 0.47 yrs.), who were diagnosed with JSO (according to ICD-10 Version: 2016 - M 42.0) were randomly assigned into two groups: Group 1 – Sling suspension therapy (SST), Group 2 – Gym ball exercises (GBE). Both groups received interventions for 3 weeks, 15 sessions, and 30 minutes a day for 5 consecutive days a week. Back pain, endurance of trunk muscles and standing posture were evaluated pre- and post- interventions.

RESULTS: Both groups demonstrated significant improvement in all measured outcomes. SST was more effective in reducing pain ($p < 0.05$), increasing the endurance of trunk muscles ($p < 0.05$) and improving the standing posture ($p < 0.05$) compared to GBE ($p < 0.05$).

CONCLUSIONS: Sling suspension therapy is more effective compared with Gym ball exercises in the treatment of juvenile spinal osteochondrosis in adolescent girls in terms of back pain, posture and endurance of trunk muscles.

Keywords: spinal osteochondrosis, back pain, suspension therapy, Gym ball, standing posture, endurance.

1. Introduction

Juvenile spinal osteochondrosis (JSO) is a disorder characterized by osteochondrosis of vertebral epiphyses in childhood. In 1921, Scheuermann first described juvenile osteochondrosis affecting vertebral bodies [1]. The disease most commonly affects intervertebral discs. There might be several reasons, but the exact etiology of this disorder is unknown. The clinical picture of JSO is characterized by moderate pain, kyphotic posture, and limitations of spinal mobility [2]. It has been found that most patients with spinal osteochondrosis do not need surgical treatment, and the main aims of treatment are to reduce morbidity and decrease the duration of symptoms with supervised symptomatic conservative treatment [3]. Treatment depends on the severity of dystrophic processes and as a whole is aimed to slow down degenerative changes. Early accurate diagnosis and appropriate management will lead to improved prognosis [4]. Conservative treatment includes ice, electrotherapy, acupuncture, reloading taping techniques, soft tissue massage, and exercise [5]. Patients are advised to perform spinal strengthening exercises [4]. These exercises could be performed on stable and unstable surfaces and involve various methods and equipment.

One of the main tasks in the treatment of JSO related back pain is training of trunk stabilizing muscles [4]. This might be achieved by using Sling suspension therapy (SST) [6].

Another commonly used option in the treatment of JSO is a Gym ball, also known as Swiss ball, core training programmes that are popular trends in physiotherapy [7]. Both exercise modes are used in the treatment of back pain and muscle training in adolescents with JSO, but to the best of the authors' knowledge, no study has compared SST with GBE in this population.

Therefore, the purpose of this clinical trial was to compare the effectiveness of Sling suspension therapy to Gym ball exercise programme in patients with JSO in terms of back pain, endurance of trunk muscles, and standing posture.

2. Methods

Ethical approval was granted by a local bioethics committee **(BEK-KIN(M)-2016-7).** All participants and their representatives were informed in detail of the purpose and procedure of the study and they signed an informed consent form. The study was conducted in accordance with the Declaration of Helsinki Ethical Principles and Good Clinical Practices.

2.1. Study design

A randomised controlled single centre clinical trial (ClinicalTrials.gov Identifier: NCT03851367).

2.2. Subjects

Subjects were recruited from an inpatient rehabilitation department, specializing in the treatment of children and adolescents with degenerative disorders. The inclusion criteria were JSO diagnosis confirmed by a medical doctor (according to ICD-10 Version: 2016 - M 42.0), female, age 16-17 years, back pain for at least 12 weeks and subjects who had not received treatment specific to this condition, within the last 3 months. Exclusion criteria were severe postural or skeletal abnormalities and traumas, neuromuscular disorders, neuropathic pain. To avoid sex-specific differences in the tempo of maturation of bones [8], boys were excluded from the study.

Forty adolescent girls who were diagnosed with JSO were randomly assigned into two groups: Group 1 Sling Suspension Therapy (SST, n=20), Group 2 Gym Ball exercises (GBE, n=20). The groups had no statistically significant differences at the start of the study in age, height, weight and body mass index (BMI) (Table 1).

2.3. Procedures

All subjects from both groups participated in a 3-week individual physiotherapy programme supervised by senior physiotherapist consisting of 15 sessions 30 minutes each for back pain management, posture improvement, and trunk muscles strengthening exercise.

The SST program consisted of open and closed kinetic chain exercises aiming to stabilize and activate trunk muscles using single and multi-point suspension [9].

The other group performed GBE: inclined press-up, upper body roll-out, single-leg hold, and quadruped exercise with a contralateral arm and leg raise. Gym balls used in this study were in sizes of 45-55 cm according to the height of the subjects.

Both interventions aimed to activate weak trunk muscles, relieve pain and muscle spasm, prevent deformities, reduce stress across the joints, and enable relaxation. One of the most important aspects during each intervention was to maintain correct body mechanics and posture, i.e., the relationship of the head, shoulders, spine, hips, knees and ankles to each other. Exercises using different positions and planes were used to make these interventions not only effective but also interesting and variable. Balance pads, and palm dumbbell weights (0.5 or 1 kg) were also used during procedure. Physical load was increased gradually up to the limit when the patient could not maintain correct body alignment or felt pain; each set of exercises was followed by a 1-minute rest.

2.4. Outcome measures

Back pain in subjects was evaluated using the Visual Analog Scale (VAS**)** [10]. The participants were asked to report the ‘current’ pain intensity. A higher score indicates greater pain intensity: no pain (0–4 mm), mild pain (5–44 mm), moderate pain (45–74 mm), and severe pain (75– 100 mm).

Endurance of trunk muscles was tested as suggested by McGill [11] and the duration was recorded in seconds.

Trunk extensors were tested in the prone position with the upper body cantilevered out over the end of a test bench and with pelvis, knees, and hips secured (Fig.1A). The upper limbs were held across the chest with the hands resting on the opposite shoulders. The subject was asked to hold the isometric posture at the level of the bench as long as possible. Failure occurred when the upper body dropped from the horizontal position.

Trunk flexors were tested in a sit-up position with the back at 60° from the floor when both knees and hips were flexed to 90°, the arms were folded across the chest with the hands placed on the opposite shoulder, and feet were secured (Fig.1B). The subject was asked to hold the isometric posture as long as possible. Failure was determined when the participant could no longer maintain this position.

Lateral trunk musculature was tested with the person lying in full side - bridge position. Lower limbs were extended, and the top foot was placed in front of the lower foot for support (Fig.1C). The subjects supported themselves on one elbow and on their feet while lifting their hips off the floor to create a straight line along their body length. The uninvolved arm was held across the chest with the hand placed on the opposite shoulder. The subject was asked to hold the isometric posture as long as possible. Failure was determined when the participant could no longer maintain this position.

Posture was evaluated by a commonly used clinical assessment technique - the New York Posture Rating Chart (Fig. 2) [12]. In an attempt to minimize the data collection error and avoid bias in measurements, one experienced examiner evaluated all the study participants' postures both in pre- and post -intervention assessment. The examiner was blind to the scope of the study and to the group that the subjects belonged to. For positioning, the subjects were instructed to stand comfortably barefooted in a normal standing position in front of a posture evaluation grid (160×70 cm), placed on the wall, calibrated into squares (5×5 cm) with a plumb line suspended overhead. They were dressed in shorts or swimsuits for better recognition of observed body landmarks. The participants had to face the screen, the plumb line had to pass directly up the middle of the back, and from the side view, through the ear lobe and the shoulder joint. The participants were instructed not to touch the grid or the plumb line but to look straight ahead. Alignment of head, shoulders, spine, hips, and ankles was visually evaluated in a frontal plane from the subject's back; alignment of neck, upper back, trunk, abdomen, and lower back was evaluated in a sagittal plane from the subject's left side. The observer stood at 2.8 m from the standing subject. Each body segment was rated on a scale from 1 to 5 with 1 corresponding to poor body alignment, 3 to fair, and 5 to good/perfect according to New York Posture Rating Chart. A final score was obtained by adding up the points given for each body segment and looking at the posture evaluation standards, where a score of more than 45 meant an excellent posture, between 40–44 – good, 30–39 – average, 20–29 – fair, and 19 or less– poor posture [13].

All recordings were performed at baseline and after the 3-week intervention period by the same assessor.

2.5. Statistical analysis

All analyses were performed using SPSS version 19 for Windows. Quantitative variables were expressed as mean ± standard deviation (SD). Differences in baseline characteristics between the two groups were assessed using the Mann-Whitney *U* test, and any changes between before and after the intervention were assessed using the Wilcoxon test. All subjects completed the study, so no adjustments were needed for drop-outs. Significance was set at an alpha level of 0.05. Effect sizes were calculated using Cohen's *d*. The absolute values of effect sizes were classified as follows: d = 0.20 to 0.49 for a small effect, d = 0.50 to 0.79 for a medium effect, and d 0.80 for a large effect.

3. Results

Forty adolescent girls participated in the study, and their mean age was 16.3 ± 0.47 years. Results of the analysis of outcome measures are summarised in Table 2. There were no statistical differences in the pre-intervention outcome measures between two randomly assigned groups.

The back pain decreased after both types of intervention ($p < 0.05$). SST was more effective in reducing pain as compared with the GBE group ($p = 0.013$, $d = 0.94$) (Table 2).

SST and GBE had a great impact on the endurance of trunk musculature, which increased significantly ($p < 0.05$). After the intervention in the SST group, all outcome measures improved significantly, while in the GBE group no statistical difference was found in endurance of left side muscles before and after intervention ($p > 0.05$). However, comparing the effectiveness of both interventions, significantly better results were found in the SST group ($p < 0.05$, $d = 0.79 – 1.01$).

We also compared alignment of different body segments between the groups and found that after both interventions most of the body segments improved their alignment (Table 3); however, comparison of the groups after interventions demonstrated that only two body segments (shoulders and spine) in the SST group had better alignment when compared with the GBE group (shoulders $p = 0.048$, $d = 1.12$, spine $p = 0.046$, $d = 0.78$).

4. Discussion

The purpose of this study was to analyse and compare the changes in back pain, endurance of trunk muscles, and posture, by applying two different exercise modalities to adolescent girls with juvenile spinal osteochondrosis (JSO) in an inpatient rehabilitation unit. One study group received physiotherapy sessions using Sling suspension therapy other exercised on Gym balls. The groups matched for age, height, weight, and BMI as well as measures of back pain, posture, and endurance of trunk muscles before intervention.

Scheuermann's disease is a deformity of the spine that develops prior to puberty and becomes most prominent during the adolescent growth spurt [14], thus to avoid sex differences in growth spurt timing, we excluded males from the study.

Back pain was a symptom of JSO in all 40 participants. As pain relief is one of the most important factors in the rehabilitation process [14], it ought to be stated that both interventions helped to reduce it significantly from moderate to mild. Pain decrease was more evident in the SST group ($p = 0.013$) as compared to the GBE group. This result is supported by previous research, which has demonstrated the effectiveness of sling suspension therapy in reducing back pain and improving activation of local spinal stabilizers [9, 15].

Chronic pain frequently leads to abnormal posture [16], which can be defined as an imbalance between muscle groups. The analysis of our pre-intervention posture evaluation showed that more than half of the evaluated body segments were not in correct alignment. Increased thoracic kyphosis occurs in a great number of cases [1] and it was visible in evaluating posture of shoulders in our study. After both interventions, the total posture score increased in both groups ($p < 0.05$), but in the SST group, the posture score was higher ($p = 0.005$) as compared to the GBE group. This might have been due to better activation of trunk muscles during SST sessions. SST is shown to be an effective method for the training of muscles by facilitating selective strengthening and activation [17]. Analysis of the changes in separate body segments demonstrated that after SST alignment of only one body segment – lower back – did not improve significantly, while in GBE group two segments – head posture and neck – did not improve. Poor lower back alignment after the intervention might be associated with lower central activation and increased inhibition of muscle activity related to chronic low back pain [18]. As we compared alignment of each body segment after intervention between the two groups, we found that the alignment of shoulders and spine were significantly better (shoulders $p = 0.048$, spine $p = 0.046$) in the SST group. We assume that better alignment of shoulders and spine has a great clinical importance for health status of adolescents with JSO, as postural disorders of above-mentioned body regions and associated orthopaedic conditions are registered in most cases [14].

We used static endurance tests in this study, because these are considered as safe and reliable core stability related measurements [19]. In a study of Carter et al. [20], the results of a 10-

week core stability Gym ball exercise programme applied twice a week for 30 minutes showed significant improvement in back muscle endurance test. Although our study lasted for three weeks, we found significant improvement in trunk muscle endurance. The results of our study were in line with the previous research revealing significant improvements in back endurance tests in addition to decreased lower back pain [21].

Various rehabilitation and exercise programs have been developed to increase lower back muscle strength and correct imbalanced muscle strength in patients with back pain [22]. Our study demonstrated an increase of trunk muscle endurance related to a decrease of back pain.

It ought to be noted that to date there are no publications in the literature comparing the effect of Sling suspension therapy and Gym ball exercise programmes. SST has been shown to improve functional movement patterns more effectively than traditional exercise by creating a challenging and pain free environment for movement retraining [17]. In our study SST had a greater effect on measured outcomes compared to GBE. Benefits of Gym ball core training exercises that facilitate spinal stability and balance have often been emphasized by researchers in the development of strength and endurance, flexibility, and neuromuscular control as a cost effective and enjoyable way to treat and prevent back pain [21, 23, 24]. However, literature is scarce in regard to SST training.

Rehabilitation is recommended to relieve pain and improve posture by reducing kyphosis [14]. In our study, we were not able to take accurate measures, e.g. by imaging, of the angle of kyphosis, but relied on a widely used clinical observational measurement of the whole spinal posture [12]. These results therefore, may be useful for the clinicians when monitoring the effects of their intervention in everyday rehabilitation practice, where the support of X-ray and other imaging are not available and justified [25].

The small number of subjects in the groups and the short follow-up period can be considered as the main limitations of the study, but the intensity of the interventions seems to compensate for that factor to achieve statistically significant results.

5. Conclusion

The findings of this study may be helpful for daily clinical rehabilitation practice in order to develop effective and attractive treatment programs for adolescents with juvenile spinal osteochondrosis. The present study showed that Sling suspension therapy is more effective than Gym ball exercises in the treatment of juvenile spinal osteochondrosis in adolescent girls in terms of back pain, posture and endurance of the trunk muscles.

Statement

No commercial party having a direct financial interest in the results of this research has or will confer a benefit upon the authors or upon any organization with which the authors are associated.

Conflict of interest

None to report.

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Table 1

Anthropometric characteristics of subjects

Group	Age (yrs. ± SD)	Height (cm ± SD)	Weight (kg ± SD)	BMI (kg/m2 ± SD)
Sling suspension therapy, n=20	16.3 ± 0.47	162.6 ± 5.83	51.7 ± 3.50	18.0 ± 0.0
Gym ball exercises, n=20	16.4 ± 0.49	163.5 ± 5.91	53.9 ± 4.42	19.3 ± 0.96
Total, n=40	16.3 ± 0.47	163.0 ± 5.81	52.8 ± 4.08	18.7 ± 0.95

Table 2

Outcome measures before and after intervention

Outcome measures	Intervention – SST		Intervention - GBE		*p*	*Cohen's d*
	Before	After	Before	After		
Back pain (mm ± SD)	57.0±13.80	28.0±10.05*	58.5±14.24	35.5±5.10*#	0.013	0.94
Endurance of back extensors (s ± SD)	82.8±22.35	110.1±17.69*	82.3±22.16	93.0±21.23*#	0.007	0.88
Endurance of trunk flexors (s ± SD)	78.0±18.31	107.3±15.68*	77.8±12.89	95.05±6.82*#	0.002	1.01
Endurance of right side muscles (s ± SD)	39.2±13.22	61.9±20.37*	42.1±14.47	48.05±13.82*#	0.038	0.79
Endurance of left side muscles (s ± SD)	44.2±20.83	60.0±10.36*	43.9±19.87	49.2±11.68#	0.027	0.97
Posture (score ± SD)	39.0±3.34	47.5±1.93*	39.7±4.32	45.1±2.86*#	0.005	0.98

* – $p<0.05$, within groups; # − $p < 0.05$ between groups after intervention; *Cohen's d* − effect sizes between groups; abbreviations: SST, Sling suspension therapy; GBE, Gym ball exercises.

Table 3

Evaluation of posture in respect to every body segment before and after intervention

Body segments	Intervention – SST		Intervention - GBE		*Cohen's d*
	Before	After	Before	After	
Head (score ± SD)	4.0±1.03	4.8 ± 0.62*	4.5±0.89	4.7±0.73	
Shoulders (score ±SD)	3.6±1.47	5.0±0.0*#	3.5±0.89	4.2±1.01*	1.12
Spine (score ± SD)	3.7±0.98	4.7±0.73*#	3.4±1.23	4.0±1.03*	0.78
Pelvis (score ± SD)	3.7±0.98	4.5±0.89*	3.7±0.98	4.3±0.98*	
Knees, ankles (score ± SD)	3.8±1.01	4.7±0.73*	3.9±1.21	4.0±0.94*	
Neck (score ± SD)	4.0±1.03	4.8±0.62*	4.1±1.21	4.5±0.89	
Upper back (score ± SD)	4.1±1.02	4.8±0.62*	4.1±1.02	4.5±0.89*	
Abdomen (score ± SD)	4.6±0.82	5.0±0.0*	4.4±0.94	5.0±0.0*	
Lower back (score ± SD)	3.7±0.98	4.2±1.01	3.7±1.34	4.7±0.73*	
Legs (score ± SD)	3.8±1.01	5.0±0.0*	4.4±0.94	4.8±0.62*	

* – $p<0.05$, within groups; # − $p < 0.05$ between groups after intervention; *Cohen's d* − effect sizes between groups; abbreviations: SST, Sling suspension therapy; GBE, Gym ball exercises.

A


B

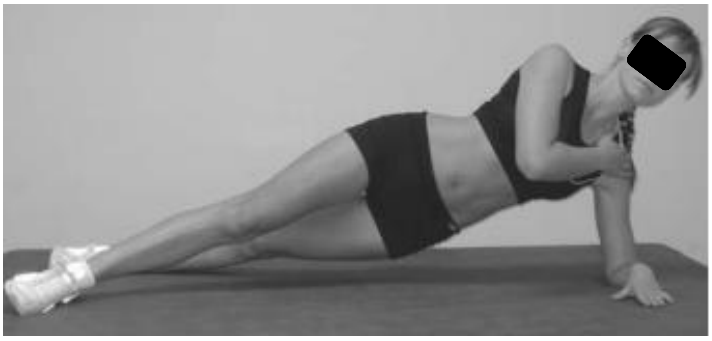

C


Fig. 1. Testing positions for muscle endurance: A – trunk extensors; B – trunk flexors; C – lateral trunk musculature

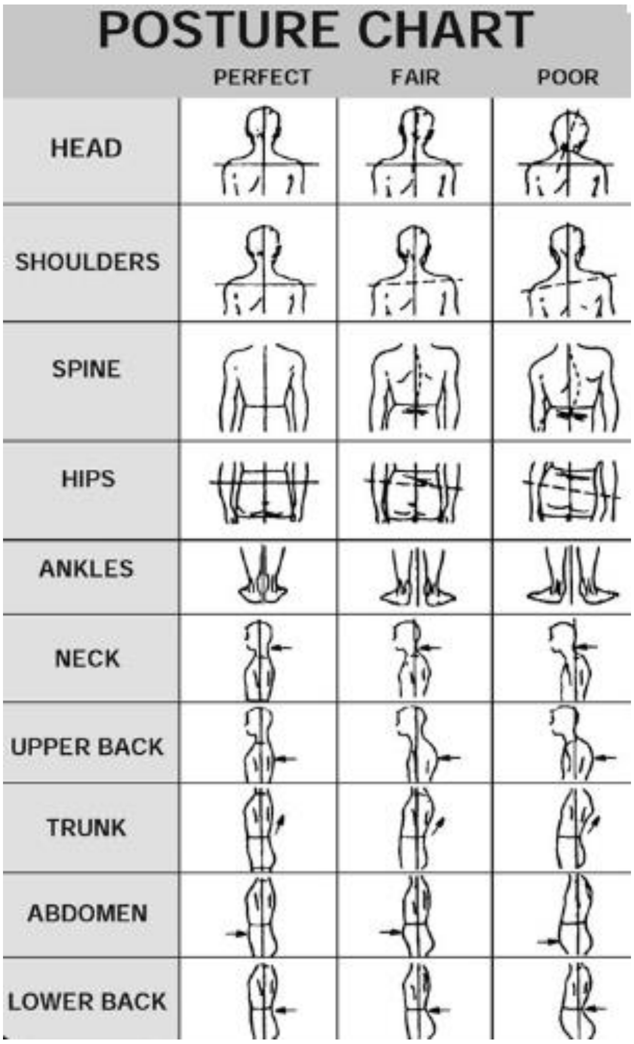


Fig. 2. Posture evaluation chart