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Original scientific paper

BIOMECHANICAL STATUS OF MODEL EXERCISES FOR THE PREVENTION AND CORRECTION OF FUNCTIONAL STADIUM AND THE FIRST STAGE OF KYPHOSIS

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Abstract

The aim of this research was to find an ideal model of set of exercises from an initial position lying on chest, that would be used for prevention and correction of a functional stage and the first stage of kyphosis as most frequent health and sociable issue among children in development that have this deformity as a result of various external and internal factors affecting their growth and development. The research is conducted on 12 entities (exercises) for establishing their homogeneity as well as their connectivity the method of qualitative mechanical analysis was applied. The results of the biomechanical analysis from the binary matrix were processed by algorithm ALPROBI HERACLIT and SPSS 18.0. All the provided condensed data. *The proposed complexof exercises has a coefficient of full biomechanical similarity (**CFBS= .829**).*The greatest values were obtained at the exercises.No1.Moving of the shoulders, scapula and the head backwards towards the spine. (MOVSHOUHBACKSP., No3. Moving of the shoulders with the clasped hands behind the nape towards the spine while moving the scapulas towards the spine. (MOVSHUINTHBEHNTOWSPSCS) and No 4. Moving of the shoulders backwards by arms spreading perpendicularly to the floor. (MOVSHOBCKARSPRPERFL). For the effect as well as the improvement of the muscle contraction in the future the electromyographic method would be applied through which we would have a concise preview of the efficiency of the exercises from the suggested set of exercises and particularly the exercises that showed the highest coefficient of force of connectivity that would be frequently repeated in the treatment.

Keywords: kyphosis, prevention, correction, biomechanicalanalysis, spine, x-ray

1. Introduction

Kyphosis is deformity of the spine with a posterior rounding mostly in the thoracic part of the spine (Rathod el al., 2021). The most frequent causes of this deformity are unknown. There are various theories such as the constitutional weakness of the spine, traumatic damage of the growing area of the vertebrae, as a result of inflammatory, endocrines, metabolic and other factors (Roghani et al., 2016). This deformity appears most frequently in the period of growth and development, so we can distinguish three periods when a child goes through pathological changes of the spine (Radzevičienė at al., 2016). A stage of standing up (stages of walking of a child), the whole process of a child's standing up should happen naturally and not as a result of a premature desire of impatient parents. (Katzman et al., 2010). Every premature standing up of a child could contribute to one of such deformities. The period of a child attending school, a great amount of the time is spent in specific positions such as a sedentary position on a chair at a desk which is most frequently very hard and leads towards incorrect posture and posture deformity such as the kyphosis. (Henryet al.,2018). The puberty period, period in which a turbulent changes occur and the swift development of the bones and the lack of the muscle strength, which easily leads to deformity. (Boyd-Clark et al.,2002). Rounding of the spine which occurs as a result of rachitis or other malformations in the period of childhood is in a shape of an arch while the tuberculosis humps have more triangular shape (Levy et al.,2018). Such bent posture is called kyphotic posture. Such hump is a result of insufficient ability of the ligaments and muscles under certain mechanical influences to hold the spine in a correct position. (Geiger et al.,2007). The diagnosis of this deformity is being made by clinical examination and x-ray (Harrison et al., 2000). The functional kyphosis disappears when one is in a lying position, but the structural kyphosis persists. The x-ray is made in a profile position, mostly standing. (Geiger er al.,2007). The correct posture requires long term and controlled exercising in order to strengthen the postural muscles which should take the role of stabilizers of the posture (Tarasi et al.,,2019).In the hardest phases of the kyphosis malformations, a kyphosis corset or a plaster is suggested while in the hardest cases a surgical intervention is necessary.(Yoon er al.,2017)No matter the stage of the deformity including the hardest cases, exercises are indispensable and without them the curing protocol is impossible. (Hrysomallis et al.,2001) Exercise therapy related to the postural muscles should be precisely and correctly defined, through planning and programming of selected set of exercises. (Naderi et al.,2019) EffectFor creation of an ideal set of exercises that would provide the required results in the overall kinesiological protocol, a method of qualitative biomechanical analysis should be applied, by which an ideal set of exercises would be made for kyphosis treatment as one of the most frequent malformation of the spine among the youth. (Busscheret al.,2010).

2. Methods

Sample of entities

1. Moving of the shoulders, scapulas and the head backwards towards the spine. (MOVSHOUHBACKSP).

2. Moving the scapulas and the arms behind back towards the spine. (MOVSCARMBBCKSP).

3. Moving of the shoulders with the clasped hands behind the nape towards the spine while moving the scapulas towards the spine. (MOVSHUINTHBEHNTOWSPSCS).

4. Moving of the shoulders backwards by arms spreading perpendicularly to the floor. (MOVSHOBCKARSPRPERFL).

5. Raising of the part of the thoracic spine with bent elbows by 90 degrees and moving the scapulas towards the spine. (RAIPTHOSPBELB90MOVSCTOWSP).

6. Moving of the elbows backwards with clasped hands behind nape. (MOVELBBACKINTHN).

7. Moving of the shoulders and the hands backwards. (MOVSHOUHBACK),

8. Moving the head backwards with great resistance with the hands behind the nape. (MOVHBACKGRRESHBEHN),

9. Moving of the torso backwards, arms are in an initial position by torso and lifting them with rotation of the palms up. (MOVTORBACKAINIPOSTORLIFROTPALUP).

10. Moving of the torso backwards with the arms stretched above the head with clasped hands. (MOVTORBACKASTRABHINTH).

11. Positioning of the arms above head in parallel position as an initial position and moving them towards the nape of the head with bent elbows and clasped hands. (POSAAHPARAINIPOSMOVTOWNHBELBINTH).

12. Moving of the thoracic part of the spine with arms along the torso initial position and moving the arms backwards to the position of 90 degrees bent elbows with palms up. (MOVTHOPSPAALTORINIPOSMOVBACKPOS90ELBPALUP).

Data processing

The basic motor stereotypes are analyzed by the method of qualitative biomechanical analysis, while the results will be given in an ordinary matrix that provides information about the basic biomechanical characteristics of each entity (exercise). (Tufekchievski el al.,2012). The entity represents a vector, where the numeric value 1 indicates the possessiveness of a biomechanical characteristic, and 0 indicates the non-possessiveness of a biomechanical characteristic in that entity. The rows represent the vectors of the entities while the columns represent the vectors of the biomechanical variables. From the basic matrix, primarily, the coefficients of biomechanical similarity are determined among the analyzed entities. Then full biomechanical similarity is determined i.e homogeneity as well as the force of the biomechanical similarity among the entities. (Aliu, 2021). This procedure is described in the ALPROBI Heraclitus algorithms and SPSS 18.0.

3. Results and Discussion

Table1. Biomechanical characteristics of a sample of complex exercises from initial position lying on the chest (kyphosis)

КИФОЗА

5.2.	*Примерок на комплекс вежби*		*Цел на вежбањет*			*Почетна положба*				*Завршна положба*				*Варијабли за одредување на анатомсо-функционалната структура на движењата*																	*Варијабли за одредување на механичката структура на движењата*													
5.2.1.	*Комплекс на вежби за превенција и корекција на лошото кифотично држење на телото (функционален стадиум) и прв степен (**кифоза**)*	*Примерок на варијабли*	Истегнување	Јакнење	Издржување	Лежење на гради	Лежење на бок	Опирање во клек	На справи и со реквизити	Лежење на гради	Лежење на бок	Опирање во клек	На справи и со реквизити	Изометриска контракција на екстензорите во зглобот на главата	Концентрчна контракција на екстензорите во зглобот на главата со централен потпор	Концентрична контракција на екстензорите во рбетниот столб вратен дел со централен потпор	Концентрична контракција на екстензорите во рбетниот столб слабинско-граден дел со централен потпор	Изометриска контракција на флексорите во зглобовите на прстите од шаката симетрично	Концентрчна контракција на флексорите во зглобовите на прстите од шаката со централен потпор симетрично	Изометриска контракција на екстензорите во зглобовите на прстите од шаката симетрично	Концентрчна контракција на флексорите во зглобот на шаката со централен потпор симетрично	Изометриска контракција на екстензорите во зглобот на шаката симетрично	Концентрична контракција на екстензорите во зглобот на шаката со централен потпор симетрично	Изометриска контракција на флексорите во зглобот на лактот симетрично	Концентрична контракција на флексорите во зглобот на лактот со централен потпор симетрично	Изометриска контракција на екстензорите во зглобот на лактот симетрично	Концентрчна контракција на екстензорите во зглобот на лактот со централен потпор симетрично	Концентрична контракција на антефлексорите во зглобот на раменото централен потпор симетрично	Концентрична контракција на ретрофлексорите во зглобот на раменото централен потпор симетрично	Концентрична контракција на хоризонталните екстензори во зглобот на раменото централен потпор симетрично	Голема потпорна површина	Ниско ниво на тежиштето на телото	Лабилна рамнотежна положба	Затворен кинематички синџир рака-рамenski појас-рака	Отворен кинематички синџир со потпор на труп	Движење во фронтална рамнина	Движење во сагитална рамнина	Движење во хоризонтална рамнина	Куса траекторија на актуелната точка	Праволиниска траекторија на актуелната точка	Мала брзина	Умерено мускулно напрегање на агонистите на рацете	Големо мускулно напрегање на агонистите на рацете	Умерено мускулно напрегање на агонистите на трупот
5.2.1.1.	*Комплекс на вежби од почетна положба **ЛЕЖЕЊЕ НА ГРАДИ***		**ИСТЕГ**	**ЈАКНЕ**	**ИЗДРЖ**	**ППЛЕЖГРА**	**ППСЕД**	**ППОКЛЕК**	**ППСПР-РЕК**	**ЗПЛЕЖГРА**	**ЗПСЕД**	**ЗПОКЛЕК**	**ЗПСПР-РЕК**	**ИКЕЗГ**	**ККЕЗГЦП**	**ККЕРСВДЦП**	**ККЕРССГДЦП**	**ИКФЗПРШС**	**ККФЗПРШЦПС**	**ИКЕЗПРШС**	**ККФЗШЦПС**	**ИКЕЗШС**	**ККЕЗШЦПС**	**ИКФЗЛС**	**ККФЗЛЦПС**	**ИКЕЗЛС**	**ККЕЗЛЦПС**	**ККАФЗРЦПС**	**ККРФЗРЦПС**	**ККХЕЗРЦПС**	**ГОЛПОТПОВ**	**НИСНИТТ**	**ЛАБРП**	**ЗАКИНСИРППР**	**ОТВКИСИПТР**	**ДВИФОРАМ**	**ДВИСАГРАМ**	**ДВИХОРРАМ**	**КУСТРААТ**	**ПРАТРААТ**	**МАЛБРЗ**	**УМЕМНАР**	**ГОЛМНАР**	**УМЕМНАТ**
			1	2	3	1	2	3	4	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Подигнување на рамениците и главата со доближување на лопатките врз РС	(ПОДРИГДОБЛПРС)	1			1				1					1	1	1													1	1	1	1		1	1	1		1	1	1			1
2	Подигнување на рамениците со раце во задрачување и доближување на лопатките врз РС	(ПОДРИРАЗРАЧЛПРС)	1			1				1					1	1	1												1	1	1	1	1		1	1	1		1	1	1			1
3	Подигнувањена рамениците со раце во задрачување со вкрстени раце и доближување на лопатките врз РС	(ПОДРАМРАЗАДВРАДЛРС)	1			1				1					1	1	1	1												1	1	1	1		1	1	1		1	1	1			1
4	Подигнување на рамениците со рацете во одручување и дланки свртени кон подот и со доближување на лопатките на РС	(ПОДАМРОДДЛПЛРС)	1			1				1					1	1	1													1	1	1	1		1	1	1		1	1	1			1
5	Подигнување на рамениот дел од `рбетниот столб со свиткани лакти под агол од 90° зад тилот и припојување на лопатките на РС	(ПОДРРССЛКА90ЛРС)	1			1				1					1	1	1			1		1		1						1	1	1	1		1	1	1		1	1	1			1
6	Подигнување на свиткани лакти зад тил	(ПОССВЛЗАДТ)	1			1				1				1		1	1	1						1						1	1	1	1		1	1	1		1	1	1			1
7	Подигнување на рамениот појас и рацете	(ПОДРПР)	1			1				1					1	1	1			1			1			1		1		1	1	1	1		1	1	1		1	1	1	1		1
8	Подигнување на глават од тло со силен отпор со раце поставени зад тил	(ПОДГТЛОТПРЗАДТ)		1		1				1					1	1	1	1			1			1							1	1	1	1	1		1		1	1	1		1	
9	Подигнување на трупот со раце во узрачување и движење на дланките кон горе	(ПОДТРУЗРДВДЛГ)	1			1				1					1	1	1			1			1			1		1			1	1	1		1	1	1		1	1	1	1		1
10	Подигнувње на трупот и рацете пред глава со испреплетени вкрстени прсти	(ПОДТРПРГИСППР)	1			1				1					1	1	1		1			1			1		1	1		1	1	1	1	1	1	1	1		1	1	1			1
11	Подигнување на исправени раце од тло во свиткани лакти поставени на тил	(ПОДРСВЛЗАДТ)	1			1				1					1	1	1			1		1			1		1	1	1	1	1	1	1		1		1		1	1	1	1		1
12	Подигнување на градниот дел на рбетниот столб со раце во узрчување до свиткување на лактите	(ПОДРДРСРУЗСВЛ)	1			1				1					1	1	1			1		1			1			1		1	1	1	1		1		1	1	1	1	1	1		1

Table 2. Normed measures of biomechanical similarity (inter-similarity), coefficient of full biomechanical similarity and coefficients of biomechanical connection force of a sample of complex exercises from initial position lying on the chest (kyphosis)

	Cosine of Vectors of Values											
	(ПОДРИГДО	(ПОДРИРАЗІ	(ПОДРАМРА	(ПОДАМРОД	(ПОДРРССЛ	(ПОССВЛЗА	(ПОДРПР)	(ПОДГТЛОТ	(ПОДТРУЗР	(ПОДТРПРГІ	(ПОДРСВЛЗ	(ПОДРДРСРУЗСВЛ)
(ПОДРИГДО	1.000	.972	.972	1.000	.922	.890	.879	.723	.847	.860	.809	.827
(ПОДРИРАЗІ	.972	1.000	.944	.972	.896	.865	.854	.703	.823	.836	.836	.804
(ПОДРАМРА	.972	.944	1.000	.972	.896	.919	.854	.757	.823	.836	.786	.804
(ПОДАМРОД	1.000	.972	.972	1.000	.922	.890	.879	.723	.847	.860	.809	.827
(ПОДРРССЛ	.922	.896	.896	.922	1.000	.872	.858	.718	.830	.839	.839	.858
(ПОССВЛЗА	.890	.865	.919	.890	.872	1.000	.783	.737	.751	.765	.718	.734
(ПОДРПР)	.879	.854	.854	.879	.858	.783	1.000	.636	.977	.800	.845	.864
(ПОДГТЛОТ	.723	.703	.757	.723	.718	.737	.636	1.000	.651	.670	.622	.636
(ПОДТРУЗР	.847	.823	.823	.847	.830	.751	.977	.651	1.000	.774	.819	.837
(ПОДТРПРГІ	.860	.836	.836	.860	.839	.765	.800	.670	.774	1.000	.870	.845
(ПОДРСВЛЗ	.809	.836	.786	.809	.839	.718	.845	.622	.819	.870	1.000	.934
(ПОДРДРСР	.827	.804	.804	.827	.858	.734	.864	.636	.837	.845	.934	1.000
КЦБС	.829											
КСБП	(ПОДРИГДО	(ПОДРИРАЗІ	(ПОДРАМРА	(ПОДАМРОД	(ПОДРРССЛ	(ПОССВЛЗА	(ПОДРПР)	(ПОДГТЛОТ	(ПОДТРУЗР	(ПОДТРПРГІ	(ПОДРСВЛЗ	(ПОДРДРСРУЗСВЛ)
	.882	.864	.869	0.882	.859	.811	.839	.689	.816	.814	.808	.815
	1	4	3	1	5	10	6	12	7	9	11	8

From the analysis of the obtained results in the inter-similarity matrix from tab. 2, it can be determined that the greatest similarity is observed between the exercises No.1Moving of the shoulders, scapulas and the head backwards towards the spine. (MOVSHOUHBACKSP) and No.4 Moving of the shoulders backwards by arms spreading perpendicularly to the floor. (MOVSHOBCKARSPRPERFL)**.990**. The largest similarity coefficients range from **.922** to **990.** The smallest similarity is present between exercises No.8. Moving the head backwards with great resistance with the hands behind the nape (MOVHBACKGRRESHBEHN) **.622** and No. 11 Positioning of the arms above head in parallel position as an initial position and moving them towards the nape of the head with bent elbows and clasped hands. (POSAAHPARAINIPOSMOVTOWNHBELBINTH)**.**The smallest similarity coefficients range from **.622** to**.718**.The coefficient of full biomechanical similarity is **CFBS= .829**. According to the obtained results, the highest values of the **CBCF** coefficient of biomechanical connection force of one exercise with all other highest values were obtained in exercises No1.Moving of the shoulders, scapulas and the head backwards towards the spine. (MOVSHOUHBACKSP)**.882**.No.4.Moving of the shoulders backwards by arms spreading perpendicularly to the floor. (MOVSHOBCKARSPRPERFL) **.882** and . No.3 Moving of the shoulders with the clasped hands behind the nape towards the spine while moving the scapulas towards the spine. (MOVSHUINTHBEHNTOWSPSCS) **.869**.

4. Conclusion

Analysis of the data provided direct towards the statement that the suggested exercises possess great homogeneity. According to the obtained results the highest values of one exercise with all the other of the exercises (**CBCF**), the highest values of are obtained in the following exercises No1. Moving of the shoulders scapulas and the head backwards towards the spine (MOVSHOUHBACKSP) **.882**, No3.Moving of the shoulders with the clasped hands behind the nape towards the spine while moving the scapulas towards the spine (MOVSHUINTHBEHNTOWSPSCS) **.869** and. No 4. Moving of the shoulders backwards by arms spreading perpendicularly to the floor (MOVSHOBCKARSPRPERFL) **.882**.The obtained results from the research are a quality example in the planning and programming that would be used in the prevention and correction of the kyphosis(functional stadium and the first stage). For the establishing of the effect of the above mentioned exercises on the postural muscles in an individual as well as in groups that have the functional and the first stage of kyphosis, not excluding the ones that are in more serious phase of malformation. In the future, the electromyographic method would be applied that would precisely define the effect of the chosen exercises as well as the duration of the improvement of the muscle contraction. (Lim et al.,2022). By application of these exercises in one treatment by physicians who more efficiently and for less time would contribute to solve the issues referring to this deformity including the possibility this to be applied in the exercises which are used for different deformities of the spine.

References

[1]. Aliu.D, Biomechanical status of exercise for prevention and treatment of scoliotic body posture. Research in Physical Education, Sport and Health,2022, Vol,11, No.1, pp43-47.

[2]. Boyd-Clark LC, Briggs CA, Galea MP. Muscle spindle distribution, morervicalphology and density in longuscolli and multifidus muscle of the c spine. Spine. 2002, Vol,27, pp,694–701

[3]. Busscher I, van derVeen AJ, van Dieën JH, et al. In vitro biomechanical characteristics of the spine: a comparison between human and porcine spinal segments, Spine 2010, Vol,5, pp,35-42.

[4]. Geiger E, Müller O, Niemeyer T, Kluba T. Adjustment of pelvispinal parameters preserves the constant gravity line position. International Orthopaedics. 2007, Vol,31, No.2, pp,253–8.

[5]. Harrison DE, Harrison DD, Cailliet R, Troyanovich SJ, Janik TJ, Holland B. Cobb method or Harrison posterior tangent method: which to choose for lateral cervical radiographic analysis. Spine. 2000, Vol, 25, pp, 2072-8.

[6]. Henry BM, Skinningsrud B, Vikse J, Pękala PA, Walocha JA, Loukas M, et al. Systematic reviews versus narrative reviews in clinical anatomy: methodological approaches in the era ofevidence-based anatomy. Clin Anat. 2018, Vol,31, No,3, pp,364–7.

[7]. Hrysomallis C, Goodman C. A review of resistance exercise and posture realignment. J Strength Cond Res 2001, Vol,15, pp,385–390.

[8]. Katzman WB, Wanek L, Shepherd JA, Sellmeyer DE. Age-related hyperkyphosis: its causes, consequences, and management. J Orthop Sports Phys Ther 2010, Vol,40, No.6, pp,352–60.

[9]. Levy J, Prigent H, Bensmail D. Respiratory rehabilitation in multiple sclerosis: A narrative of rehabilitation techniques. Ann Phys Rehabil Med. 2018, Vol,61, No.1, pp,38-45.

[10]. Lim, J.Y.; Frontera, W.R. Single skeletal muscle fiber mechanical properties: A muscle quality biomarker of human aging. Eur. J. Appl. Physiol. 2022, Vol, 122, pp,1383–1395.

[11]. Naderi A., Rezvani M.H., Shaabani F., Bagheri S. Effect of kyphosis exercises on physical function, postural control and quality of life in elderly men with hyperkyphosis. Salmand.2019, Vol,13, pp,464–479.

[12]. Radzevičienė L, Kazlauskas A. Posture disorders and their causes in rural schools pupils. Soc WelfInterdiscip Approach. 2016, Vol,1, No.6,118–125.

[13]. Severe Kyphotic Deformity Involving Thoracolumbar Region -A Management Dilemma. T, Marathe N, Shende C, Jogani A, Sathe A, Mallepally AR. J Orthop Case Rep. 2021 Vol,11, No.6, pp,68-71.

[14]. Tarasi, Z.; Rajabi, R.; Minoonejad, H.; Shahrbanian, S. The Effect of spine strengthening exercises and posture training on functional thoracic hyper kyphosis in young individuals. J. Adv. Med. Biomed. Res. 2019, Vol, 27, pp, 23–31.

[15]. Tufekchiewski, A., Aceski, A.& Hristoski, R. Determining the biomechanical status of the basic motor skills. International Journal Issues in Physical Education (PESH) Sport and Health (PESH).

[16]. Yoon TL, Cynn HS, Choi SA, Lee JH, Chio BS. Effect of the craniocervical brace on craniocervical angle, thoracic kyphosis angle, and trunk extensor muscle activity during typing in subjects with forward head posture. Work 2016, Vol, 55, No.1, pp, 163-169.