https://doi.org/10.5272/jimab.2023292.4974

Journal of IMAB. 2023 Apr-Jun;29(2)

Journal of IMAB
ISSN: 1312-773X
https://www.journal-imab-bg.org

Original article

STRENGTH TRAINING AND POSTURE ALIGHMENT

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ABSTRACT

Purposes: The aim of the study is to design and test a comprehensive technique based on strength training for posture correction.

Materials and methods: This study was carried cohort of 37 men, aged 27,7±3,4 years old with kypholordotic posture. The program consisted of a set of exercises and exercises on a bicycle ergometer. The duration of the program was 16 weeks. Results were controlled by computer optical topography, motor tests, tests for strength endurance of abdominal muscles. For posture screening was used Posture Screen Mobile, motor tests, tests for strength endurance of abdominal muscles.

Results: According to PSM, the indices of deviation of the lumbar spine decreased from 4,3 ± 0.5 to 2.0 ± 1,1 ($p < 0.01$) mm, and indices of deviation of the shoulder decreased from 4,7 ± 0,7 to 1,8 ± 1,3 mm ($p < 0.01$), and indices of deviation of the head decreased from 3,5 ± 0,9 to 2,9 ± 1,1 mm ($p < 0.05$) The pressure force of the chest muscles after a study showed an increase in the strength capabilities of the muscles by 21,8 mm Hg. at $p < 0.01$, of the flexor muscles of the shoulder joint in the abduction, showed an increase in strength capabilities by 16 mm Hg. at $p < 0.01$, of the flexor muscles of the shoulder joint in adduction, showed an increase in strength capabilities by 17,9 mm Hg. at $p < 0.01$, strength endurance of the abdominal muscles showed an increase of 32,4 sec at $p < 0.01$.

Conclusion: Posture Screen Mobile is a non-invasive and reliable assessment of the parameters of the posture. A 16-week set of weights and stretching exercises is highly effective in correcting kypholordotic posture in young men.

Keywords: posture, hyperkyphosis, lordosis, strength training,

INTRODUCTION

Nowadays, correct posture is harder and harder to see. Correct posture contributes to the rational use of the biomechanical properties of the musculoskeletal system. Posture is defined as the relative position of parts of the human body. The anatomically neutral position of the spine is a position in which the curves of the spinal column (lumbar lordosis, thoracic kyphosis and cervical lordosis) are as close as possible to their natural anatomical position. This ensures an even distribution of the load on the intervertebral discs while the pelvis maintains anatomical tilt without excessive deflection backward or forward.

Muscle dysfunction leads to postural disorders. For example, the rhomboid muscle, which is called the main muscle of posture, moves the scapula and the entire thoracic spine forward when the function is weakened. At the same time, the pectoralis minor muscle, as an antagonist of the rhomboid muscle, spasms and compression of the neurovascular bundles begin. Deviations from the normal anatomical structure are manifested by numbness in the hands, cold palms and the inability to hold hands behind the head for a long time. When inhaling, the rhomboid muscle contracts, moving the scapula to the spine, respectively, with its weakness, incomplete exhalation occurs, the respiratory rhythm is disturbed, which, in its turn, forms the correct posture. The consequence of the listed anatomical changes is the deterioration of ventilation, restriction of the volume of inhaled air and, in addition, weakening of the abdominal muscles [1].

In complaints of patients with severe kyphosis, spinal pain dominates since the deformation of the spinal structures leads to compression of the spinal nerve roots [2, 3, 4]. Uneven load on the intervertebral discs can cause such diseases of the spine as osteochondrosis, protrusion and hernia [5]. It has been proved that the return to the anatomical norm of the curvature of the spinal column can reduce the compression

load on the intervertebral discs and reduce the neurological manifestations of degenerative changes [2, 3, 4, 5, 6, 7, 8].

In literature, posture disorders are often considered in isolation for hyperlordosis or hyperkyphosis [8, 9, 10, 11, 12, 13]. In this regard, the introduction of an accurate and safe method of posture control in all parts of the spine is relevant, as well as the substantiation and development of a set of exercises of various orientations for the correction of kypholordotic posture.

MATERIALS AND METHODS

At the first stage, in order to identify violations of posture, 124 men, aged 27,5±3,1, the office workers with the low level of physical activity during the day, were diagnosed. The study was approved by the decision of the Interuniversity Ethics Committee of the Russian State University of physical culture, sports, youth and tourism (protocol No. 4 of April 10, 2020). The aim of the study was explained to the potential participants, and the signed consents were obtained from the patients before their enrolment in the study. In the next stage, an experimental group of 37 men aged 27,7±3,4 years old with kypholordotic posture, was formed. Posture diagnostics, motor tests and strength endurance tests were performed by the physical therapist. All manipulations were provided at RSUPE.

Posture Screen Mobile (PSM) PostureScreen Mobile® (PostureCo Inc., Trinity, FL, USA) is a novel, commercially sold mobile photographic application that enables the identification of deviations from the ideal standing posture. The PostureScreen Mobile® (PSM) application facilitates the assessment of posture in a variety of settings. e. PSM appears to be a reliable and user-friendly tool for characterizing static standing posture. For correct results, assessments should be conducted with the subject wearing minimal clothing so as to better identify anatomical landmarks [14,15]. The PostureScreen Mobile® app was used to assess baseline posture during standing. This app was specifically designed for health professionals who are interested in objectively evaluating the posture posture, movement and body composition of patients. The app calculates posture variables using digitized anatomical landmarks from either 2 or 4 pictures of the individual, depending on the number of variables of interest. The device camera is used within the app to take pictures of subjects from various directions—anterior and posterior (coronal plane), left and right (sagittal plane). When taking the picture, the app shows a target-like display that turns green when the tablet is level. This helps ensure each image is taken at a level and consistent angle. After the picture is taken, the user is directed to crop each picture at the subject's head and feet, giving a full view of the body. This ensures that the proportions of the subject are consistent between images. Once each picture is captured, the app takes the user through the process of digitizing specified anatomical landmarks in order to produce anterior and lateral translations and angular displacements. During digitization, a grid is laid over the picture, and an image of the anatomical landmark is inset into the picture to assist with landmark location. Following digitization, the app calculates the translations and angulations. This app presents a cost-effective alternative for both clinics and research laboratories for measuring and describing baseline posture. The initial cost to purchase the app is nominal in comparison to traditional biomechanics instrumentation. While the app costs more than traditional clinical measures of posture, such as goniometers and inclinometers, it offers an analysis in multiple views and increased quantity of variables with additional posture variables not available with clinical tools (e.g., joint segment translations). Beyond the affordable cost, another benefit of using this app is its relative ease of use. The raters in this study found this mobile application to be a user friendly method to assess posture. The company's website provides background and instructional information regarding the app's uses. Once installed and opened, the user interface is intuitive, and the process for taking the client pictures is easy to follow [14, 15].

Motor tests using the Stabilizer Pressure Biofeedback.

It is generally accepted that the functional state of the muscles changes in case of posture disorders. Evaluation of muscle strength capabilities in movement tests was carried out using a Stabilizer device (Chattanoga, USA). These tests provide information on muscle condition and muscle imbalance in digital terms. The force of muscle pressure is estimated by the amount of pressure (mm Hg) that is created in the cushion of the device during 5 seconds of muscle tension [5, 16, 17, 18, 19].

The cushion of the modified sphygmomanometer is located under different segments of the limbs and has an initial pressure of 20 mm Hg. Motor test were perfomed for assess the strength of the pressure of the muscles performing movements in the hip joint, thoracic and lumbar spine (Table 1).

Table 1. Motor tests

Joint	Location of the sphygmomanometer pad:	
Hip	Extension	Under heel.
	Flexion	On the front of the lower leg, just above the ankle.
The tested is lying down in a spine position. One leg is bent at the knee at a 90 degree angle. The second leg lies on the floor, extended at the knee and hip joints. Hands along the body.		
Shoulder	Extension in the abduction under the elbow	The arm is bent at a right angle and set aside.
	Extension in adduction under the elbow	The arm is bent at a right angle and brought to the body
The tested is lying down in spine position:		
Shoulder	Flexion	Under the elbow
The tested is in a prone position with an arm bent at the elbow at a right angle to the side.		

Shirado. O test for assessing the strength endurance of the abdominal muscles.

The tested had to lie on his back, raise his folded arms and legs bent at the knees. On command, he had to raise the pelvis and upper body, his elbows touching knees. The time after which the elbows were detached from the knees, or there was a tremor, was recorded [20].

After screening, a posture correction program was developed. We recommend using only symmetrical exercises that are performed with both limbs at the same time. In this case, weaker muscles will receive an increased load, ensuring the correction of the lateral curvature of the spine. Shortened and spasmodic muscles, on the other hand, need to be relaxed to equalize the balance of muscle traction in the agonist-antagonist system. The program consisted of a set of exercises and exercises on a bicycle ergometer. The set of exercises was performed 2 times a week. Bicycle ergometer sessions were performed 2 times a week. The duration of one lesson was 30-60 minutes. The duration of the program was 16 weeks. Three groups of exercises included: the use of simulators to overcome the opposing force with the flexor muscles of the hip joint and thoracic spine; overcoming the gravity of the body to correct the imbalance of the flexor and extensor muscles of the lumbar spine; lengthening muscles by stretching them (Table 2). The entire program was implemented in 2 periods: adaptation and correctional development. In the adaptation period: when working with dumbbells, the weight of the projectile was 3-6 kg, when working on simulators, the weight was 15-20 kg. In the correctional developmental period, exercises should be performed until a sensation of "burning" in the muscles, weights, and weightings may start to be increased from the 4th week (Table 3).

Table 2. Groups of experimental method exercises and target muscles

	Exercises on stimulators	Target muscles:
Flexion		
I	Hip joint	Rectus femoris,comb,tailor
II	Thoracic spine	Large and small pectorals, deltoid (front part)
Extension		
III	Hip joint	Gluteus maximus, biceps, semitendinosus, semimembranous
IV	Thoracic spine	Trapezoidal (middle part), diamond-shaped (large and small), round (large and small), broadest
Body weight Exercise		
V	Flexion of the lumbar spine	The straight of abdominal muscle and oblique muscles
Stretching exercise		
VII	Flexion of the hip joint	Iliopsoas muscle, rectus femoris, comb, tailor
VIII	Thoracic Spine Flexion Exercise	The pectoralis major and minor, the anterior part of the deltoid muscle
IX	Extension of the lumbar spine	Square muscles of the lower back, longest, spinous and iliocostal muscles

Table 3. Exercise methodology

	Adaptive (8 weeks)	Correctional (8 weeks)
Exercises with weights muscle groups.	12-14 reps, 2 sets. All muscle groups. 2 times a week	12-14 repetitions for shortened muscle groups, 3-4 sets, 6-8 reps for weakened muscle groups, 3-4 sets
Stretching	30-60 seconds, 2 times a week	60-120 seconds 2 times a week
Bicycle ergometer exercises	20 minutes at a heart rate of 50% of max. Two times a week.	30 minutes at a heart rate of 60% of max. Two times a week.

Methodical recommendations: it is necessary to avoid straining and holding the breath. Starting position: lying, reclining on an inclined plane up to 45 degrees, sitting, with the neutral alignment of the bends of the spinal column, it is permissible to stand while maintaining a neutral position. In the initial position, it is necessary to approach the anatomical norm as much as possible in the sagittal and frontal planes. In the sagittal plane, lumbar lordosis, thoracic kyphosis and cervical lordosis are leveled through the use of auxiliary devices (step platforms, pillows, rollers). In the frontal plane, a decrease in the deviation of the ribs and chest relative to the pelvis, shoulders relative to the body and head relative to the shoulders is provided with the help of an instructor. Lesson on a horizontal bicycle ergometer is carried out with the back while maintaining the neutral position of the spine. It is recommended to avoid overextension of the legs in the knee joints so that during the extension phase, the knee remains slightly bent.

Statistical analysis.

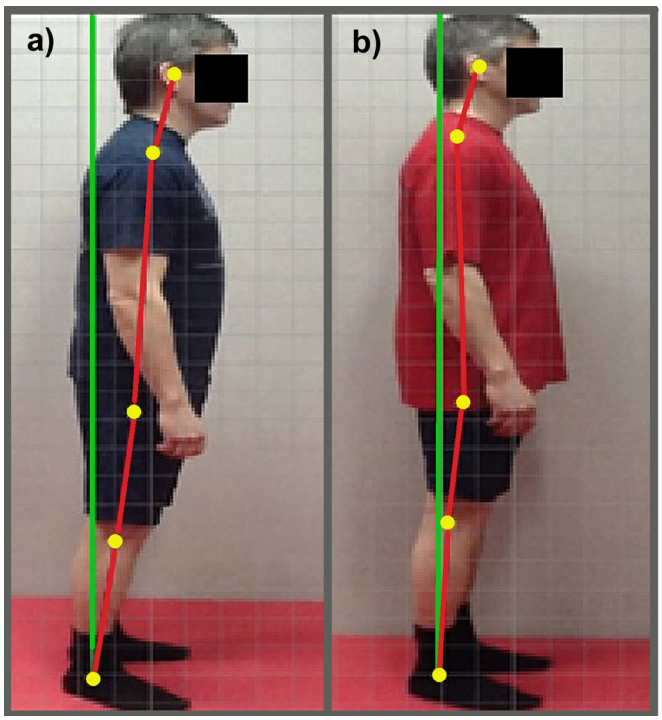
The processing of the research results was carried out using the "STATISTICA 10" package. In the course of parametric statistical analysis, all initial data were checked for normal distribution using the methods of mathematical statistics included in this package. In particular, based on the analysis of the histogram parameters, the correspondence of the distribution of the initial information to the normal (Gaussian) law was assessed. If the histograms of the distributions of the original data were close to the bell-shaped figure of the normal distribution or completely corresponded to it, the distribution was considered normal. This correspondence was necessarily confirmed by the Shapiro-Wilk test, which made it possible to assess the statistical significance of the null hypothesis, indicating that the observed empirical distribution did not differ from the theoretical, expected normal distribution in small samples. With the probability of this (null) hypothesis P> 0.05, it was concluded that it was indeed true. The data were then analyzed using parametric methods for dependent groups. To process the research results, the arithmetic mean M and the standard deviation "σ" were chosen. The average value of the indicators before and after classes was compared by the t criterion for related samples. Differences were considered statistically significant at pd"0.05. This criterion was chosen due to the fact that the indicators are subject to the law of normal distribution, and the measurement scale is parametric.

RESULTS.

Posture Screen Mobile.

According to PSM, the indices of deviation of the lumbar spine decreased from 4,3 ± 0.5 to 2.0 ± 1,1 (p <0.01) mm, and indices of deviation of the shoulder decreased from 4,7 ± 0,7 to 1,8 ± 1,3 mm (p <0.01), and indices of deviation of the head decreased from 3,5 ± 0,9 to 2,9 ± 1,1 mm (p <0.05) The dynamics of changes in posture according to the PSM data in male V. is presented in the figures (Figure 1 a, b).

Fig. 1. Graphical representation of changes in posture: **a)** at the first examination, **b)** after correction)



Results of movement tests using the Stabilizer Pressure Biofeedback. motor tests were used for assess the pressure strength of the pectoral muscles, flexor and extensor muscles of the hip joint and muscles, shoulder extensors in abduction and adduction.The tests were carried out before the start of the study and at the end of the correctional and developmental period (Table 4).

Table 4. Dynamics of the pressure force indicators of the flexor muscles and the extensor muscles of the hip joint (mm Hg)

	Before the course		After the course		Comparison of the groups
Indicator (mm Hg)	*Mcp*	±	*Mcp*	±	t cr
Extensors of hip joint	41,3	1,2	62,1*	2,1	54,5
Hip flexors	54,8	1,3	67,1*	2,2	33,4
Chest muscles	61,4	1,4	83,2*	1,4	53,4
Muscles – extensors of the shoulder joint in abduction	71,7	1,8	87,7*	2,1	39,2
Muscles- extensors of the shoulder joint in adduction	45,1	1,0	63,0*	2,3	30,3

Note: * p <0.01 compared with baseline, with t cr = 3.25 in intragroup comparison

Assessment of the strength endurance of the abdominal muscles.

For correction hyperlordosis in the lower back, it is necessary to increase the strength endurance of the abdominal muscles, which will counteract the increase in lordosis caused by the shortened extensor muscles of the lumbar spine. The strength endurance of the abdominal muscles increased from 21,1 ± 1.3 to 53,5 ± 2.3 sec., at p <0.01, tcr = 3.25.

DISCUSSION

The following steps are being carried out for diagnose posture disorders,: visual assessment, ultrasound scanning, X-ray examination, multispiral computer topography. Some authors, to assess the effectiveness of posture correction techniques, use visual diagnostics using questionnaires for fixing the identified deviations. C.M. Norris, in the study "Back stability: integrating science and practice", recommends the use of a motor learning algorithm to correct postural disorders. The algorithm consists of three stages: at the first stage, the patient receives information about the correct posture and his violations through images. At this stage, the patient is not able to take the correct posture on his own, so the methodologist helps him to correctly align the body segments relative to each other. The second stage involves the use of physical exercise. The patient is more coordinated can identify errors in the performance of exercises. At the final stage, the patient independently controls the posture without focusing on maintaining it while maintaining optimal alignment of body segments relative to each other. He is also able to maintain a rational posture during exercise. Thus, to assess the effectiveness of the correction of posture disorders, only visual diagnostics were used using special questionnaires for fixing the identified deviations [21].

A method of systemic analysis of radiographs of the spine (ARPA) is proposed for visualize the processes occurring in the spine at different age periods. A systematic analysis of radiographs of the spine, due to the integrity of its approach, is able to reflect the spatial static and morphological changes that occur in the spine with age. ARPA accurately records the individual X-ray picture of the patient's spine, reflecting the tensions, stresses and compressions that each part of this complex skeleton system experiences. However, the method has limitations for assessing changes in the spine over time due to radiation exposure [22].

In the work of Skvoznova TM., devoted to biomechanical studies of the spine, the strength and tone of the disturbing imbalance of the flexor and extensor muscles of the neck and trunk, the stabilizing muscles of the scapula, the stabilizing muscles of the pelvis and feet were restored. A dynamometer was used to determine the value of isometric muscle tension, and ultrasound scanning was used to diagnose posture [23]. The difference in our approach is that not only weakened but also shortened muscle groups were worked out. Evaluation of changes in the spine using the PSM, in contrast to ultrasound scanning, allows obtaining a complex quantitative assessment of posture.

In the methods for the correction of kypholordotic posture, it is proposed to use taping, exercises and massage. Exercises are selected to build "postural endurance." However, not all the exercises eliminate uneven muscle traction between the flexor and extensor muscles of the hip joint, between the flexor and extensor muscles of the lumbar spine, the extensor muscles and flexors of the thoracic spine as a whole. In addition, all techniques are designed for standing or hanging exercises. Based on our experience, it is impossible to correctly align all body segments relative to each other in a standing position, and strong muscles will take on more load, compensating for the lack of traction of weakened muscles.

CONCLUSION

Posture disorders are especially widespread among young people leading a sedentary lifestyle, whose work activity involves prolonged sitting. The problems of postural disorders without their timely correction become a predisposing factor for the development of structural changes in the spine and diseases of internal organs, which are the cause of a decrease or disability in adulthood. The solution to this problem lies in further improvement in the development and implementation of non-invasive methods of diagnostics, monitoring and posture restoration.

Posture Screen Mobile allows a non-invasive and reliable assessment of the parameters of posture disorders. The main advantages of the method of PSM: high accuracy in determining posture disorders; great information content.

A 16-week set of weights and stretching exercises is highly effective in correcting kypholordotic posture in young men. The technical result, which can be obtained by using the proposed method of posture correction, consists in restoring the imbalance in the muscles that are opposite in function, namely, flexor and extensor muscles of the hip joint, flexor and extensor muscles of the lumbar spine, muscles extensors and flexors of the thoracic spine for posture correction in the sagittal plane and muscles of the left and right half of the body in the frontal plane.

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Please cite this article as: Babydov E, Zaborova V, Tkachenko S, Kotovskiy S, Erokhin I, Fesyun A, Shestakov D, Vicheva D, Stavrev V. Strength training and posture alighment. *J of IMAB.* 2023 Apr-Jun;29(2):4974-4979. [Crossref - https://doi.org/10.5272/jimab.2023292.4974]

Received: 13/08/2022; Published online: 13/06/2023

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