Original Article

Educational technology of using the system of Pilates for the prevention of spine disorders of female students

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Abstract:

The paper describes the educational technology of using Pilates for the prevention of spine disorders of female students at higher educational institutions. The main stages of this technology are discussed in the paper. In the first stage, special attention should be paid to control over the movements, concentration and focus on the exercises done by the students with the low fitness level. The main goal of this stage is to strengthen the muscles and ligaments of the spine. The second stage focuses on finding the right center of gravity of the body during exercise done by the students of the middle fitness level, as well as on the accuracy and smoothness of the movements. The main goal of this stage is to improve the support and motor functions of the spinal column. In the third stage, special attention should be paid to the development of intermuscular coordination and proper breathing of the students of high fitness level. During a workout, visual images to ensure correctness of performing this exercise should be used. The main goal of this stage is to enhance significantly the functional capacity of the spine.

Key words: Pilates, students, higher educational institution, educational technology, prevention of spine disorders.

Introduction

At higher educational institutions, much attention is paid to students' health and the provision of the conditions for a healthy lifestyle [3, 8]. Good health is important for future professional activity of the graduates as well as for dealing with the current educational load. Good health is also vital for future childbirth and parenting activities of female students. Currently, the problem of motivation for a healthy lifestyle among the students is quite a challenge [1, 4-7]. This is due to the negative changes in the physical condition of female students. According to the statistics of the Committee of the Russian Federation for 2014, more than 50% of students have poor health, 80% suffer from physical inactivity and about 40% have structural and functional disorders of the spine. This is caused by the lack of physical activity of students and the lack of effective fitness programs that would be suitable for female students with different levels of physical fitness. Today, fitness includes programs aimed at training the body as well as developing the mind, which contributes to the intellectual development of students [1, 5]. Recent studies indicate that the Pilates system is effective for the prevention of spine disorders [5]. Program "Pilates" alone can not be regarded as the only means of achieving harmony of mind and body. Nevertheless, in combination with proper nutrition, positive thinking and other types of physical activity, Pilates can achieve effective and sustainable results in the physical fitness of the students. The most important aspect of the "Pilates" program is to support the mobility and flexibility of the spine. The improved condition of the spine leads to better physical condition and overall health. Therefore, Pilates can be widely used for the prevention of spine disorders of the university students. Meanwhile, the practice of physical education at higher educational institutions shows that today there are no scientific approaches to using Pilates in the system of physical education at universities.

So far, there are no educational technologies of using Pilates for the prevention of spine disorders of female students and there are no conditions for the implementation of such technologies.

Methods and materials

In the process of development of educational technologies with the of Pilates the main goal was to examine the students' health and to identify the structural disfunctions of the spine. For this purpose, the students of St. Petersburg State Polytechnic University were examined by the medical and academic staff as well as by the experts in the field of preventive physical education. The results of this study are shown in table 1.

The analysis of the study concerning the health of the students who attend the classes of physical education enable us to make the conclusion that the number of healthy students has increased in 2015 by 3.0% in comparison with the same period of 2014. Meanwhile, the number of students with health problems remains too high. In 2014, the number of students with health problems was 64.3%, while the number of such students in 2015 is 61.3%. This insignificant decrease in the number of students with health problems is due to the measures taken by academic staff at the department of physical education and sport of St. Petersburg State Polytechnic University.

Table 1. The results of the examination of students attending the classes of physical education (%)

Diseases	The year and the number of the examined students (2014-2015)	
	2014 (n = 233)	2015 (n = 237)
Apparently healthy	35,7	38,7
Scoliosis of the 1st degree	12,1	11,6
Scoliosis of the 2nd degree	9,8	9,7
Obesity	13,1	13,0
Osteochondrosis	11,3	11,6
Injuries of the spine and legs	0,1	-
Postural disorder	3,3	2,3
Other diseases	15,1	14,8

The findings suggest that the problems with health of female students are mainly associated with obesity, osteochondrosis and scoliosis. From the survey, it became clear that most students had not done any sports before, which led to structural disfunctions of the spine. The analysis of scoliosis incidence among female students in 2014 and 2015 is shown in figure 1.

Fig.1. Analysis of scoliosis incidence among female students in 2014 and 2015

Other diseases such as kyphosis, displacement of the vertebrae, etc were found in a small number of students. There were also several cases of postural disorder. In addition, the research has shown that a significant percentage of female students (5.1%) suffer from other functional disorders of the spine. Taking into account the fact that each year the number of students attending classes of physical education increases, it can be assumed that the number of students with spinal disorders will also increase. To improve the health effect of PE classes it is necessary not only to create good conditions for doing sport, but also to develop new technologies with Pilates, which should provide favorable psychological background to improve the health of students. As shown by the examination, the number of students with scoliosis, osteochondrosis and overweight is quite high, being 46.4% in 2014, and 45.9%, in 2015, respectively. Pilates exercises were recommended to all of these students. The results of the examination of the students with health problems allowed us to conclude: the average age of students with scoliosis of the 1st degree is 21 y.o. ranging between 18-22; the average age of the students with scoliosis of the 2nd degree is 22 years, ranging from 20 to 24. The study has shown that it is the 1st year students who suffer from scoliosis, and senior students mostly suffer from osteochondrosis and overweight.

Calculations of a weight-height index indicate that it is below the norm for students with the diseases of the musculoskeletal system and scoliosis of the 1st and 2nd degree. It is normal (0.43) for the students suffering from osteochondrosis, and above the norm (0.52) for those who are overweight.

Weight of students with osteochondrosis is 70 kg on the average, with an average height of 172 cm, which is much higher than normal. The heart rate of all students examined at rest is normal (70-72 beats / min).

The heart rate was registered as normal after physical exercises of 20 sit-ups. The recovery time of heart rate after the exercise was slightly higher than the norm, and it was 0.8 minutes higher than the norm for the students who are overweight.

An examination of students attending PE classes enabled us to make conclusions about their level of physical fitness, functional state, and problems with their health. This made it possible to develop several specific methods and programs to improve their health status with the use of Pilates. The main goal of Pilates was to train the muscles and ligaments of the spine. When choosing health programs we took into account the individual capabilities of students with functional disorders of the spine basing on the analysis of the spine functional disorders. The system of Pilates for preventing and correcting functional disorders of the spine were chosen according to the nature of the symptoms of spine structural and functional disorders. Such an approach to the system of Pilates will be possible if the teacher of physical education knows the physiological mechanisms contributing to the development of spine structural and functional disorders. The problem of spine structural and functional disorders has been drawing the attention of specialists in physical education for a long time. The question remains: should the prevention of spine diseases with the use of Pilates be successful if the reason for pain syndromes remains unknown?

The answer to this question lies in the contemporary theories and concepts of development of spine structural and functional disorders. Critical review of existing views on the nature and physiological mechanisms of spine diseases allows us to find the scientific approach to the development of fitness complex with the use of Pilates for the compensation of structural and functional disorders of the spine. There are several theories explaining the development of various structural and functional disorders of the spine, such as the theory of premature aging; autoimmune theory; traumatic theory; muscle theory; endocrine theory; metabolic theory; theory of heredity; Rheumatoid theory; theory of visceral disease, and others.

Theories of premature aging appeared in the 30s of XX century. These theories are based on the assumption that the cause of structural and functional disorders of the spine is premature aging and degeneration of discus intervertebralis. However, in practice x-rays very often show marked changes in the spine, but the patient does not feel any discomfort and makes no complaints, and vice versa. Therefore, the degree of the disease is not directly associated with the so-called "aging" (degeneration) of the discus intervertebralis. The process of aging is latent and almost symptom-free. In contrast to aging spine disorders always develop with periodic relapses of varying severity [10].

Furthermore, the theories mentioned above do not give any explanation why "aging" of the cartilage develops in different places: in the lumbar, in the cervical spine, etc. They do not give any reasons for the development of spinal disorders in childhood, adolescence and student's age. Finally, it is unclear what is the cause of "aging" of the intervertebral cartilage? Hence, the conclusion is that "aging" (degeneration) of the intervertebral cartilage is not the cause of spine disorders but one of the most painful syndrome. Autoimmune theory is based on the assumption that autoimmune phenomena, in varying degrees of severity, are present in almost any disease, including rheumatoid arthritis. From this respect, the autoimmune theory has very much in common with the rheumatoid theory. But there is no explanation to the selectiveness of clinical manifestations of functional disorders of the spine. For instance, these theories do not explain why primarily the cervical, thoracic or lumbar spines are affected in similar conditions. The development of the traumatic theory is due to the attempts to understand the role of traumatic mechanical factor in the etiopathogenesis of spine functional disorders. It demonstrated the role of mechanical stress as a pathogenetic component with the disorders having been developed. In the case of explicit trauma, the etiology of functional disorders of the spine is quite obvious. The development of symptoms of various spine diseases without trauma is inexplicable in terms of the impact of only physical factors, such as microtraumas from static-dynamic loads, hard physical work, constrained posture, etc. [9].

The musculoskeletal system is capable of withstanding constant static-dynamic load throughout life, including those of the same type. Experts in the field of physiology and sports medicine proved that the same type of static-dynamic loads trigger adaptation processes and have an effective training effect. There is no direct relationship between the amount of physical work and the spine disorder degree of severity. However, studies undertaken to this end, testify to the contrary. They show independence of the location and degree of the clinical manifestations of spine disorders from the working conditions and social status. The steady increase in the cases of disorders accompanied by the decrease of physical loads and the rise of technical equipment worldwide is another concern. These data allow us to consider so-called "microtrauma" as one of many components of the pathogenesis having a clinical significance after the start of the degeneration process of the intervertebral cartilage. It should be noted that the search for etiologic exogenous influences is just one of the directions of research into the causes of morbidity of the human body. The absence of a clear picture of etiopathogenetic mechanisms of the vast majority of diseases defined as well as of a coherent system of ideas about the laws of interaction of the organism and environment leads us to the factors prone to quantitative and qualitative classification.

Supporters of the "muscle theory" identify the reason for the development of functional disorders of the spine in the constant tension of muscles, muscle hypotension and inflammation of muscles and ligaments. They believe that the development of functional disorders of the spine is due to improper muscle movement patterns,

which leads to a mechanical overload of the relevant components of the intervertebral segment and, eventually, to the emergence of processes of degeneration and involution [9]. However, some researchers are inclined to believe that the changes in the muscles is a consequence of disturbances in the spine, rather than its cause. Changes in the muscle tone become quite serious at certain stages of spine diseases [1,2,3]. There are quite a number of theories and assumptions that have much in common with those mentioned above. Each of them has strengths and weaknesses, explaining to a certain extent the registered pathogenic elements in the development of spine functional disorders. Meanwhile, the main unresolved problem faced by the researchers is to determine the etiological factor as well as the main cause of development of spine functional disorders.

Results and analysis

The study found that the lack of support and motor functions of the spine tend increase (Table 2). Thus, in the first year the lack of the support function of the spine of female students was 17.3%, 30.5% of the motor function and these figures increased to 18.5% and 32.1% by the graduation year. This indicates a lack of motor activity and low effectiveness of the current program of physical education (Table 2).

Table 2. The main types of functional disorders of the spine (n = 271)

№	Types of disorders	Number of students with the year of study (%)				
		I	II	III	IV	V
1.	Disorders of support function of the spine	17,3	17,4	17,8	18,0	18,5
2.	Muscular blockade of disc	25,5	25,3	25,0	25,1	24,6
3.	Spinal disease and movement disorders	14,4	14,2	14,1	14,4	14,0
4.	The lack of motor function of the spine	30,5	30,7	31,0	31,3	32,1
5.	Dysfunction of interspinous ligaments	12,3	12,4	12,1	11,2	10,8

In the absence of any special physical exercises to strengthen the spine, a state of functional failure of the spine occurs, indicating the the loss (full or partial) of its bearing capacity. To better understand the causes of the loss of the spine bearing capacity and to identify the main determinants of pathological pain, manifesting itself in static-dynamic loads, we turn to the theory of biomechanical instability.

The main drawback of the program is the underestimation of the role of physical exercise aimed at strengthening the muscles and ligaments of the spine, which results in poorer health of female students in the graduating year. It is well-known that disc degeneration may not manifest itself for a long time. The disease manifests itself only when the adaptive mechanisms in the form of rectification of the physiological lumbar bending (lordosis) replaced by the local curvature of the spine the back (kyphosis) accompanied by the bone growths (which increases footprint, thereby reducing the load per unit area) are no longer able to compensate for the progressive spinal instability. According to this theory, the main carrier function in the spine is performed by vertebral bodies and spinal discs (the main power line), reinforced by longitudinal ligaments. Elements of the rear supporting complex (vertebral arch, vertebral joints and ligaments) play a supportive role in the maintenance of the support function of the spine. Their main purpose is to provide the spine motor function. As already mentioned, the instability in the affected segment of the spine is formed by the scheme of accumulated changes in the spinal disc. In the first stage of this process the nucleus pulposus (assuming a significant portion of external loads and ensuring their portability) loses its central location in the disc and starts to move along the disc. Due to this, the resultant external load ceases to pass through the location of pulpose nuclei. This reduces the efficiency of their damping effect, and later leads to a complete cessation. The load is carried then by the elements of the vertebral segment, which are not involved under normal conditions. The more explicit is the abnormal mobility of the vertebrae, the clearer is the manifestation of symptoms of lack of spine support function (fatigue, discomfort, moderate pain). These symptoms occur in response to pressure on the fragments of the collapsed core fabric of the fibrous ring. It is possible to identify the failure of the spine support function only on the basis of establishing the fact of its lowered endurance to a vertical load. This is usually done by the students' examination allowing us to pay attention to subtle signs and symptoms being usually neglected. In the early diagnosis of this disorder we should take into account that the first signs of instability of the spine appear long before it (instability) can be detected.

Movements with the participation of the disc are normally carried out simultaneously with the movements in the vertebral joints. It should be noted that vertebral joints tend to "wear and tear" rapidly. According to the studies, destructive changes in the joints occur at the age of 20-25 years (80%) with no signs of osteochondrosis. Age-related changes in the joints together with the manifestation of osteochondrosis accelerate the development of osteoarthritis, thus confirming a special role in the nature of joint pain syndrome.

Thus, the analysis of the nature and complexity of pain with the functional insufficiency of the spine shows the need for a differentiated approach to the prevention of spine diseases with the use of Pilates. Important role in the individual approach to the prevention of spine functional disorders is given to the complex of sports and wellness with the extensive use of Pilates. The fitness program with the use of Pilates should be selected depending on the functional readiness of the muscles and ligaments of the students' spine. The technology of using Pilates for the prevention of female students' spine diseases developed in the course of the study is presented in Figure 2.

Stages	Goals	Exercises	Methods
First stage (low fitness level) Time: at 6-8 weeks with regular workouts 2-3 times a week	Strengthening the muscles and ligaments of the spine	Basic exercises, lying on the back and stomach on the floor. Training complex consists of 10 exercises	Particular attention is paid to control over the movement, concentration and focus to do the exercises
Second stage (middle fitness level) Time: at 8-12 weeks with regular workouts 3-4 times a week	Improved support and motor function of the spine	Added training exercises, lying on the side and stomach. Training complex consists of 25 exercises	Control of the recision and smoothness of the exercises. Particular attention is paid to finding the correct center of gravity of the body during exercise
Third stage (high fitness level) Time: at 30-36 weeks of regular workouts 4-5 times a week	A significant expansion of the functionality of the spine	Training exercises are added with an emphasis on lying and sitting on hands. Significantly increases the omplexity of the exercises	Use of visual images. Particular attention is paid to the intermuscular coordination and proper breathing

Fig.2. Educational technology of using Pilates for the prevention of female students' spine diseases of the spine

Meanwhile, it is obvious that physical activity itself does not provide fitness effect if used not properly. Physical activity should be chosen individually for each person. In order to determine the pedagogical conditions necessary for the effective use of Pilates to prevent spine diseases a survey with 72 experts was conducted. The survey results are presented in Figure 3.

Figure 3. The rank structure of the pedagogical conditions necessary for the effective use of Pilates for the prevention of female students' spine diseases (n = 72)

In the process of systematic trainings with the use of Pilates, fitness of the students improves. A trained body of students is different not only in terms of functional reserves and adaptation but also in terms of the ability to quickly use the reserves, with their proper coordination. The conditioned reflex patterns of fitness during the training process with are the physiological prerequisites of fitness continuity. Long breaks in training lead to the extinction of temporary connections that underlie motor skills. In this regard, most subtle and lately developed skills, especially fine motor coordination skills fade away first of all. The changes in the female students body developing under the influence of Pilates have a phase character and are retained only for a while.

For the development of fitness it is necessary that the period of rest between Pilates workouts would be not too long. It is important that "results" of the previous workout be reinforced by the subsequent workout.

The results of health compensations of the disorders of the spine support function and articular syndrome and syndrome interspinous ligaments are shown in tables 3, 4.

Table 3. Improving compensation for the disorders of the female students' support function

The level of fitness	The effectiveness					
	No changes		Partial recovery		Full recovery	
	n	%	n	%	n	%
«High» (n=15)	-	-	-	-	15	100
«Middle» (n=30)	-	-	7	24,2	23	75,8
«Low» (n=11)	2	18,1	4	36,4	5	45,5

Table 4. Improving compensation of the spine functional state for the students with articular syndrome and interspinous ligament syndrome

The level of fitness	The effectiveness					
	No changes		Partial recovery		Full recovery	
	n	%	n	%	n	%
«High» (n=15)	-	-	-	-	15	100
«Middle» (n=30)	-	-	4	19,1	26	80,9
«Low» (n=11)	4	35,5	4	35,5	3	29,0

The data show that in groups with a high level of fitness the remission occurs in full. For the mid-level of students' fitness when the fixation of the spine increases dramatically the effectiveness of the proposed technology is somewhat lower, and in the group with a low level of fitness the partial and complete recovery remains close to 75%. Presumably, the compensation method of training with the use of Pilates should be further developed. The incidence of this type of variation in the health status of students is low. In the group with a higher level of fitness the successful compensation amounts to 80-100%, while in the group with a low level of fitness the success of the compensation is reduced to 54%, making it difficult to gain exposure to the spine.

Thus, our pedagogical experiments have provided a sufficiently high level of partial or complete recovery of physical condition and health of students suffering from various structural and functional disorders of the spine, which indicates the high efficiency of the technology with the use of Pilates.

Conclusion

The proposed educational technology with the use of Pilates for the prevention of spine disorders of the students at higher educational institutions enables us to improve the functional state of the spinal column and of the body as a whole. Variations in the health status of the students, including the spine disorders, are largely due to the lack of motor activity of the students.

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