PHYSICAL EDUCATION STUDENTS' KNOWLEDGE OF SELECTED SAFE AND NON-RECOMMENDED EXERCISES STRENGTHENING THE ABDOMINAL MUSCLES

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Abstract

Introduction. The aim of the study was to assess final-year physical education (PE) students' knowledge of exercises strengthening the abdominal muscles which are used in the introductory part of a PE lesson. ***Material and methods.*** The research involved 467 final-year physical education students. The group examined included undergraduate (Bachelor) and postgraduate (Master) students from four universities in Poland. A knowledge test with photographs was used to conduct the study. The students completed the knowledge test with one of the authors present. If the students had any questions regarding the exercises included in the test, they were demonstrated by the person in the photographs. The data were analysed using the Mann-Whitney-Wilcoxon test. Kendall's concordance coefficient was used to assess reliability and measure the agreement between the opinions of a group of experts who were asked to rate the exercises in terms of their safety and effectiveness. The calculations were made with the use of statistical and calculation software (SPSS 9.0 for Windows). An alpha value < 0.05 was accepted as the level of significance of differences between the groups of undergraduate and postgraduate students. ***Results.*** Eighty-two participants (17.6%) performed the task correctly, selecting all the safe exercises, 139 students (29.8%) made one error, while 110 marked all the overloading and ineffective exercises as safe. ***Conclusions.*** The students' knowledge of safe exercises strengthening the abdominal muscles was insufficient. Both undergraduate and postgraduate students demonstrated similar knowledge concerning these exercises.

Key words: exercises, strengthening of the abdominal muscles, students' knowledge

Introduction

Exercises strengthening the abdominal muscles are commonly used in training programmes of professional athletes, recreational sport, physical education, and rehabilitation [1, 2, 3]. If selected and performed properly, such exercises serve as a basis for preventing injuries of the musculoskeletal system, stabilise body posture, and protect the spine from overload or pain [4, 5, 6, 7, 8, 9, 10].

In the past, exercises strengthening the abdominal muscles which maximised the activity of these muscles were recommended [11, 12]. However, in the 1970s, the safety of these programmes started to be questioned since when such exercise is performed, tissues may be damaged due to the shear and compressive forces acting on the lumbar segment of the spine. Biomechanical and electromyographic (EMG) tests also revealed that certain exercises were not effective in increasing the strength of the abdominal muscles [9, 10, 11, 12, 13, 14, 15, 16]. It is more beneficial to strengthen the abdominal muscles with the use of exercises which put minimal load on the lumbar segment of the spine [1, 2, 3].

Physical exercises applied during PE lessons should be both effective and safe, as some of them, despite being effective in strengthening the abdominal muscles, may increase the shear and compressive forces acting on the spine. Some sources of loads acting on the spine include increased activity of the iliopsoas [17, 18] and failure to maintain the lumbo-pelvic-hip complex in a neutral position [19].

Since future PE teachers, coaches, and other persons who organise physical activity should be specialists in the field of safe and recommended exercises, the aim of the work was to assess final-year physical education students' knowledge of exercises strengthening the abdominal muscles which can be used in the introductory part of a PE lesson.

Material and methods

Diagnostic tool

On the basis of an analysis of the available literature, the authors selected a range of exercises strengthening the abdominal muscles. The exercises were assessed with regard to their effectiveness and the level of risk of musculoskeletal system overload they posed [1, 2, 3, 4, 9, 13, 14, 15, 16, 20, 21, 22, 23, 24, 25, 26, 27, 28]. The literature review was performed using data bases such as MEDLINE, EBSCO, SPORTDiscus, ScienceDirect, Web of Knowledge, and Lippincott electronic journals. Only original works were taken into account. The terms used to find relevant

publications included "exercises strengthening rectus abdominis muscle", "exercises strengthening abdominal external/internal oblique muscle", and other phrases connected with the risk of spine overload.

The selected exercises strengthening the abdominal muscles were later used as a basis for designing the research form. A knowledge test with photographs was applied as a research tool. The research purpose and instructions were presented in the introductory part of the test. The test included photographs of 3 groups of exercises strengthening the abdominal muscles with detailed descriptions (initial position, movement, and final position). Group 1 included exercises strengthening the rectus abdominis controlled by an upper part of the body, group 2 consisted of exercises strengthening the rectus abdominis controlled by a lower part of the body, while group 3 comprised exercises strengthening the abdominal oblique muscles. Each of the three groups included 3 subgroups of exercises (A, B, and C). Subgroup A included safe exercises, subgroup B was comprised of risky exercises, and subgroup C consisted of ineffective and overloading exercises (tab. 1). Exercises were included in particular subgroups (A, B, and C) on the basis of the level of overload they cause.

Description of exercises strengthening the abdominal muscles (tab. 1)

1) Exercise 1A – lying in a supine position, lower limbs bent in knees and hips, feet flat on the floor, upper limbs straightened against the sides of the body. Movement – diaphragm inhalation followed by slow exhalation combined with lifting the head and shoulders (with shoulder blades touching the ground) and pulling the navel in towards the spine.
2) Exercise 1B – lying in a supine position, lower limbs straightened in knees and hips. Upper limbs straightened in elbows against the sides of the body. Movement – lifting the head, shoulders, and trunk to a sedentary position. Returning to the initial supine position.
3) Exercise 1C – sitting on a gymnastic bench, lower limbs bent in knees and hips, feet stabilised, upper limbs lifted straight behind the head. Movement – straightening the trunk and upper limbs to the maximum. Returning to the initial position.
4) Exercise 2A – lying in a supine position, lower limbs straight in knees and bent in hips at a 90° angle to the floor, calves joined. Upper limbs against the sides of the body (the back of the hand touching the floor). Movement – lifting sacrum from the floor and holding this position for 3 seconds. Returning to the initial position.
5) Exercise 2B – lying in a supine position with the trunk supported on forearms. Lower limbs straightened in knees and lifted 20 cm above the floor. Movement – scissoring lower limbs vertically.
6) Exercise 2C – lying in a supine position, lower limbs straightened in knees and lifted 20 cm above the floor. Upper limbs straightened in elbows at a 90° angle to the trunk lying flat on the floor. Movement – scissoring lower limbs vertically.
7) Exercise 3A – lying in a supine position, lower limbs bent in knees and hips, feet flat on the floor. Upper limbs straightened in elbows at a 90° angle to the trunk lying flat on the floor. Movement – diaphragm inhalation followed by exhalation while pulling the navel in towards the spine and shifting calves 20 cm in a lateral plane. Returning to the initial position and changing the exercised side.
8) Exercise 3B – lying in a supine position, lower limbs straightened in knees and hips lying flat on the floor. Upper limbs straightened in elbows, at a 90° angle to the trunk lying flat on the floor. Movement – lifting the head, trunk, right and left upper limb, and right and left lower limb simultaneously and then, while bending the body, touching the left knee with the right hand. Returning to the initial position and changing the exercised side.
9) Exercise 3C – lying flat on the floor, lower limbs straightened in knees and bent in hips at a 90° angle to the floor. Upper limbs straightened in elbows at a 90° angle towards the trunk and lying flat on the floor. Movement – shifting lower limbs to the right side until the limbs touch the floor. Returning to the initial position and changing the exercised side.

The terminology which was used to describe the exercises is applied in physical education.

Table 1. Abdominal muscle exercises included in the knowledge test

Group \ Subgroup	A	B	C
Group 1 Exercises strengthening the rectus abdominis controlled by an upper part of the body			
Group 2 Exercises strengthening the rectus abdominis controlled by a lower part of the body			
Group 3 Exercises strengthening the abdominal oblique muscles			

Tool verification

In order to verify the selection of the exercises, the method of expert assessment was applied. The group of experts included 24 physiotherapists and 21 physicians. The experts were given a form showing the exercises with their detailed descriptions. The task of every expert was to select the exercises which, according to their knowledge and experience, were (1) safe, (2) risky, and (3) ineffective and overloading the spine and assign them to each group and subgroup. In order not to suggest any answers, exercises from subgroups A, B, and C in particular groups (1, 2, and 3) were presented in a random order. If there were any questions regarding the way in which the exercises included in the test were performed, these exercises were demonstrated by the person who can be seen in the photographs.

Sample selection

The research included 473 final-year undergraduate (Bachelor) and postgraduate (Master) students of physical education from 4 universities in Poland. All the participants of the study were over 18 years of age. The method of two-stage cluster sampling was applied. In the first stage, universities that offer physical education programmes in particular regions of the country were randomly selected. In the second stage, groups of students (final year of studies) were selected from particular faculties (cluster stratified sampling). The numbers of students were selected with probability proportional to the numbers of final-year students at particular faculties. The analysis included students who gave written consent, i.e. 467 students (239 undergraduate Bachelor students and 228 postgraduate Master students) of physical education from the following universities: Rzeszów University, the Józef Śniadecki University of Physical Education and Sport in Gdańsk, the Józef Piłsudski University of Physical Education in Warsaw, and Holy Cross University in Kielce.

Knowledge test

The research form, i.e. the knowledge test including photographs with detailed descriptions, was presented to the students. Each subject received the same form. The task was to indicate one exercise in each group which, according to the subject, was safe for the spine and thus is recommended for use in the introductory part of a PE lesson. If, according to the respondents, the group did not include a safe exercise, the students were not to mark any exercise and were allowed to describe in detail their own version of the exercise which could be qualified as safe. In order not to suggest any answers, exercises from subgroups A, B, and C in particular groups (1, 2, and 3) were presented in a random order. The respondents knew about the division into groups 1, 2, and 3, but they were not informed about the subgroups, i.e. symbols A, B, and C. The symbols were added so that the results of the research could be better presented and interpreted.

All the students completed the knowledge test during their classes or lectures at the university with one of the authors present. If there were any questions regarding the way in which the exercises included in the test were performed, these exercises were demonstrated by the person seen in the photographs. The knowledge test was anonymous and voluntary, and the study was approved by the Senate Research Ethics Committee of the Józef Piłsudski University of Physical Education in Warsaw.

Statistical methods

The collected data were analysed statistically. In order to compare the knowledge of undergraduate and postgraduate students, a non-parametric Mann-Whitney-Wilcoxon test was applied. Kendall's concordance coefficient was used to assess reliability and measure the agreement between the opinions of the experts. The calculations were made using statistical and calculation software (SPSS 9.0). The value of alpha < 0.05 was accepted as the level of significance of differences.

Results

Selection of exercises by experts

According to 95.6% of the experts, exercise 1C was the most ineffective and overloaded the lumbar segment of the spine the most out of the exercises strengthening the rectus abdominis controlled by an upper part of the body (group 1). In group 2 (exercises strengthening the rectus abdominis controlled by a lower part of the body), the exercise which was the most ineffective and most conducive to overload was exercise 2C, which was chosen by 97.8% of the experts, while in group 3, it was exercise 3C, indicated by 91.1% of the experts. The exercises that the experts identified as risky were as follows: exercise 1B in group 1 (nearly 95.6%), exercise 2B in group 2 (nearly 97.8%), and exercise 3B in group 3 (91.1%). In turn, the safe exercises in particular groups, according to the experts, were: exercise 1A in group 1, exercise 2A in group 2, and exercise 3A in group 3. The percentage of experts who selected these exercises as safe in each of the groups was 100% (fig. 1).

The concordance coefficient in particular groups was equal to or higher than W = 0.91 (0.96; 0.98; 0.91, respectively).

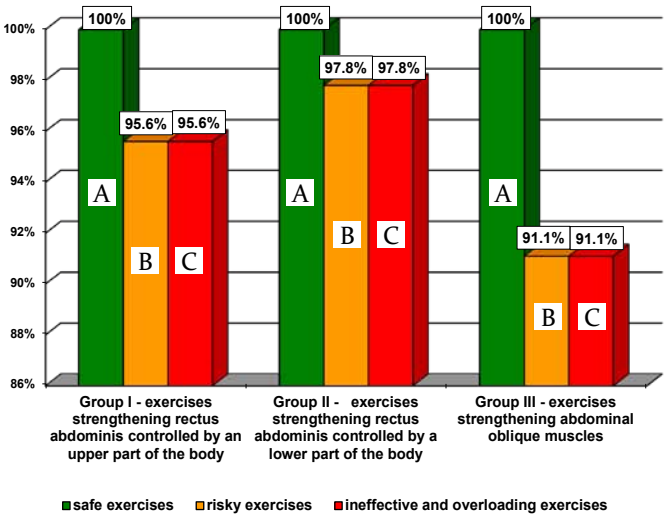

Figure 1. Percentage of experts who selected a given exercise for the following subgroups: A – safe exercises, B – risky exercises, and C – ineffective and overloading exercises

Selection of exercises by students

Both the undergraduate and postgraduate students most often (177 times) selected exercise 1A as a safe one from among the exercises strengthening the rectus abdominis controlled by an upper part of the body. In turn, 113 students saw exercises 1B and 1C (risky and ineffective exercises, respectively) as safe. No statistically significant differences (p > 0.05) were noted in the selection of the safe exercise strengthening the rectus abdominis controlled by an upper part of the body made by undergraduate and postgraduate students (tab. 2).

In the group of exercises strengthening the rectus abdominis controlled by a lower part of the body (group 2), the students (85 undergraduate and 101 postgraduate students) perceived exercise 2C as safe. Also, 102 undergraduate and postgraduate students selected exercise 2B as a safe one (tab. 2). No significant differences ($p > 0.05$) were noted between undergraduate and postgraduate students as far as their choice regarding the exercises strengthening the rectus abdominis controlled by a lower part of the body is concerned.

overloading exercise (3C) were identified as safe by 167 undergraduate and postgraduate students. No significant differences ($p > 0.05$) were found between undergraduate and postgraduate students for the third group of exercises (tab. 2).

In the group of 467 students included in the research, 82 (17.6%) made no errors and identified all the safe exercises, 139 students (29.8%) made one error, while 110 marked all the overloading and ineffective exercises as safe (tab. 3).

Table 2. Opinions of undergraduate and postgraduate students concerning safe exercises strengthening the rectus abdominis controlled by an upper (group 1) and lower (group 2) part of the body as well as the abdominal oblique muscles (group 3) (n = 467)

Subgroup of exercises / Subgroup of students	A		B		C		Sum of ranks	Z-test	p
	n	%	n	%	n	%			
Exercises controlled by an upper part of the body (group 1)									
UG (n = 239)	177	74.1	32	13.4	30	12.5	56548.50	0.42701	0.67
PG (n = 228)	177	77.6	15	6.6	36	15.8	52729.50		
Exercises controlled by a lower part of the body (group 2)									
UG (n = 239)	98	41.0	56	23.4	85	35.6	53560.50	−1.62265	0.1
PG (n = 228)	81	35.5	46	20.2	101	44.3	55717.50		
Exercises strengthening the abdominal oblique muscles (group 3)									
UG (n = 239)	161	67.4	43	18.0	35	14.6	53946.00	−1.35821	0.17
PG (n = 228)	139	61.0	43	18.8	46	20.2	55332.00		

UG – undergraduate students, PG – postgraduate students, n – number of respondents, A – safe exercises subgroup, B – risky exercises subgroup, C – ineffective and overloading exercises subgroup, Z-test – test for comparing two independent proportions.

In the group of exercises strengthening the abdominal oblique muscles, exercise 3A was selected as a safe one most often (300 indications). The risky exercise (3B) and ineffective and

An analysis of the responses in the test revealed that in the majority of cases (group 1 – 75.8%, group 2 – 38.3%, group 3 – 64.2%), the respondents indicated the safe exercises correctly. However, it is worth noting that when it comes to both risky and ineffective and overloading exercises in group 1, over 24% of students selected these exercises as safe ones. In groups 2 and 3 this percentage was 61% and 35%, respectively (fig. 2).

Table 3. Number of errors made by the students in the knowledge test (n = 467)

Number of errors / Number and percentage of students	0	1	2	3	Total
UG					
n	43	68	75	53	239
%	17.9	28.5	31.4	22.2	100
PG					
n	39	71	61	57	228
%	17.1	31.1	26.8	25.0	100
UG and PG					
n	82	139	136	110	467
%	17.6	29.8	29.1	23.5	100

UG – undergraduate students, PG – postgraduate students, n – number of respondents, % – percentage value.

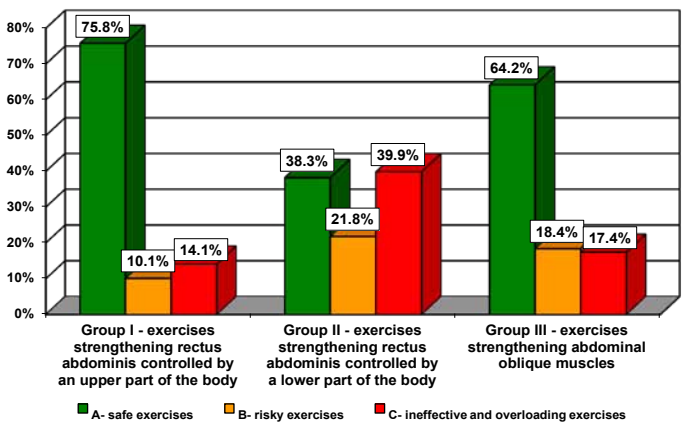

Figure 2. Results of the knowledge test: percentage of students who identified safe exercises, risky exercises, and ineffective and overloading exercises as safe (n = 467)

Discussion

The aim of the work was to assess the final-year physical education students' knowledge of exercises strengthening the abdominal muscles used in the introductory part of a PE lesson. To the authors' knowledge, such research has not been carried out yet.

The research included final-year physical education students (n = 467) who should already be prepared for their future work. The participants of the research presented their knowledge of exercises strengthening the abdominal muscles which they gained during their classes. Additionally, during their studies, the subjects did a teaching apprenticeship, which is an obligatory part of their study programme. Over 24% of the respondents revealed a lack of knowledge of safe exercises strengthening the rectus abdominis controlled by an upper part of the body (group 1). In the group of exercises strengthening the rectus abdominis controlled by a lower part of the body (group 2) and exercises strengthening the abdominal oblique muscles (group 3), the percentage of wrong answers was over 61% and 35%, respectively. In the group of 467 students, as many as 110 participants of the research identified risky as well as ineffective and overloading exercises as safe ones in all the groups. The analysis of the results revealed that both undergraduate and postgraduate students demonstrated a similar level of knowledge of exercises strengthening the rectus abdominis controlled by an upper and lower part of the body and exercises strengthening the abdominal oblique muscles ($p > 0.05$).

The findings of the study show that the knowledge of future PE teachers concerning safe exercises strengthening the abdominal muscles is insufficient. Therefore, there is a risk that they will apply risky and inefficient exercises while conducting PE classes with children and youth.

It should be highlighted that the questions the students were asked regarded the selection of exercises which they would apply during the introductory part of a PE lesson. According to the methodology of teaching physical education, the introductory part of a lesson is aimed, among others, at preparing the body for more intensive physical effort during the main part of the lesson.

Kędra, Czaprowski, and Rutkowska [29] observed 60 PE lessons in schools at three levels of education focusing on safe, risky, and overloading exercises that were performed. The results of the research revealed that only four lessons included safe exercises. The teachers most frequently selected overloading, ineffective, and risky exercises.

Exercises strengthening the abdominal muscles are a significant element of training programmes both in professional and amateur sports as well as of rehabilitation programmes and PE lessons. Properly performed and selected exercises of the abdominal muscles are a key stabilising element [8, 27]. It is recommended that the abdominal muscles be strengthened with exercises that exert minimum load on the lumbar segment of the spine [1, 2, 3].

While performing exercises which strengthen the abdominal muscles, it is necessary to maintain a neutral position of the lumbo-pelvic-hip complex. It is indispensable for the proper functioning of local and global muscles and simultaneously for providing the lumbar spine with support when loads are applied [31, 32]. Additionally, in order to increase the stiffness of the sacroiliac joints, it is necessary to activate the multifidus and transversus abdominis muscles [32].

Czaprowski and Kędra [19] carried out research on a group of final-year physical education students concerning their knowledge of the role of maintaining the lumbo-pelvic-hip complex in a neutral position. Over 60% of the respondents demonstrated a lack of knowledge or insufficient knowledge regarding this issue. What is particularly significant is that, according to the results of the study, over 90% of the respondents were unable to teach a child how to control the proper position of the lumbo-pelvic-hip complex.

Recommendations for the future

The obtained results indicate that there is a need to adequately prepare physical education students so that they are able to select proper physical exercises at the initial stage of teaching and especially before the teaching apprenticeship, which is an obligatory element of their programme of studies. A lack of proper knowledge among future teachers may result in them organising exercises which may cause students participating in PE lessons to experience mechanical overload on spinal motion segments and spinal pain. The research has indicated how crucial it is to adequately prepare PE teachers to implement tasks connected with promoting health and preventing diseases of affluence including spine injuries and disorders.

Conclusions

1. The final-year physical education students' knowledge of safe exercises strengthening the rectus abdominis and abdominal oblique muscles was insufficient.
2. Both undergraduate and postgraduate students of physical education demonstrated a similar level of knowledge of exercises strengthening the abdominal muscles.

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