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Acral Coactivation Therapy method in terms of improving the musculoskeletal system in pupils in physical and sport education

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Abstract
Introduction. **The quality of the musculoskeletal system in children is important in terms of primary prevention of postural health in adulthood.** **Aim of Study.** **The pilot study focused on the implementation of the Acral Coactivation Therapy (ACT) method in the teaching of physical and sport education in terms of improving the postural health of pupils with an emphasis on the muscular system and overall posture as a manifestation of its functionality.** **Material and Methods.** **The sample consisted of n = 16 pupils (14.21 ± 0.71 years; 54.25 ± 4.25 kg; 161.09 ± 4.56 cm) attending primary school. In terms of ensuring longevity and cross-sectionality in the surveys, available and standardized methods for physical education practice were applied.** **Results.** **The obtained results point to the followeing findings. While in control period V (1-2) we did not notice significant changes (p > 0.05) in the area of body posture and muscular system, in experimental period V (3-4), after applying the ACT method, we noticed overall significant (Wtest p < 0.05, r = 0.69) changes in the overall body posture of pupils with a high effect size, as well as in the muscular system (p < 0.05). In terms of difference and comparison of changes between control V (1-2) and experimental V (3-4) period ES (n = 16) in body posture and muscle groups, we noticed significant differences in favor of experimental period V (3-4), (Mann–Whitney test p < 0.05).** **Conclusions.** **These findings point to the importance of the application of targeted exercises in relation to the pupil's postural health, implemented in physical and sport education. At the same time, there is a significant need to improve the content of the subject physical education and sport in terms of diversification and towards the health of pupils.**

KEYWORDS: ACT method, physical education and sport, musculoskeletal system, pupils.

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Introduction

In the modern world of computer and electronics development, from the youngest years children and teenagers choose sedentary leisure time activities (sitting in front of a computer, TV). Passive mobility becomes the cause of muscular disbalance, which may be a risk factor for abnormalities in body posture [9, 22]. The 21st century is marked on the one hand by modern digitalization and on the other hand by the elimination of physical activity in the lives of children and young people, which results in incorrect body posture and malfunctioning of the musculoskeletal system. Children often experience pain during this period and there is an increase in changes and disorders of a functional and structural character in the musculoskeletal system [3, 7, 11, 18, 30]. Low levels of physical activity undertaken by children and adolescents have an impact on the posturogenesis process, that is the development of the osteoarticular system, and thus future development

of the body. Postural defects in both children and adolescents are an important public health problem and a challenge for the primary care and education system. Some studies point to the fact that the problem of postural defects applies to 20-40% of children and adolescents, but there are also publications giving much higher values [27].
Spinal deformity as well as defects of feet and knees are the most common health problem of children and youth, even more common than allergies, eye disorders of refraction and accommodation, obesity, or other diseases. According to various sources, 50-60% of pupils suffer from postural defects. These problems develop during the so-called growth spurts (ages 6-7 and 12-16) when the development of the muscular system does not keep up with the fast growth of bones [15].
Postural defects may result in serious diseases in adult life, such as e.g., cardiorespiratory disorders, physical performance impairment, back pains, and gynecological issues in women. Spinal stability means the ability to fix the spinal configuration, which is given by the shape of the vertebrae and the curvature of the spine, and subsequently to maintain this basic position within the physiological range of motion. We recognize the static, i.e. resting, and dynamic stability of the spine, which occurs during movement. In terms of the involvement of muscle chains, we speak of the vertical stabilization in the static and the spiral stabilization in the dynamic position. With the right synergy of muscle chains, we can observe the application of movement patterns of the spine in its stabilization. The failure of the stabilization function is manifested by a violation of the alternation of vertical and spiral stabilization, with static stabilization still prevailing in the dynamics [28].
The deep stabilization system plays an important role in the musculoskeletal system. The deep stabilization system is formed by muscles, which are embedded in deep layers of the muscular corset, more tightly around the spine, in the belly and the underbelly. These muscles stabilize the spine, thus markedly influencing the body posture and forming a fixed support for the movement of the extremities. Muscles of the deep stabilization system participate in each targeted movement, activate themselves at any static loading. For their activity it is not strength that is important, but the quality of their engagement, which is automatic, without conscious influence. Malfunctions of the deep stabilization system are the substance of malfunctions of the motion system, which originate because of natural movement. Each malfunction in internal forces of the deep stabilization system leads to problems, which are reflected in movement activity. Therefore, targeted influencing of the stabilization function of the spine is the foundation for good quality of movement performance [25].
At present, active health and active rest in the exercise regime of the school population are increasingly being put into the foreground, as they contribute to the quality of postural health, the musculoskeletal system, as one of the factors of health-oriented fitness with a sense of posture and movement stereotypes, as stated by Bendíková [6]. Prevention through physical activity and healthy lifestyles, based on strong medical evidence, is the most cost effective and sustainable way to tackle these problems and to support positive social development [12].
Regular and quality physical education and sport can help children and adolescents achieve the recommended amount of daily vigorous-or moderate-intensity physical activity and improve fitness and body posture as well [4]. In this context, it is important to say that prophylaxis of bad posture in children requires knowledge concerning prevention itself and the role of correct body posture, as well as motivation, abilities, and prophylaxis implementation. It is also important to undergo screening and prophylactic medical examination for early diagnosis. Schools should provide conditions fostering healthy development, which also covers preventive healthcare.

Aim of Study

The pilot study focused on the implementation of the Acral Coactivation Therapy (ACT) method in the teaching of physical and sport education to improve the postural health of pupils with an emphasis on the muscular system and overall posture as a manifestation of its functionality.

Material and Methods

Participants

The sample consisted of pupils of pubescent age (14.21 ± ± 0.71 years) in the total number n = 16, who attended primary school. The experimental group consisted of pupils with an average body height of 161.09 ± 4.56 cm, body weight of 54.25 ± 4.25 kg and a BMI of 20.53 ± ± 2.85. The pupils were included in the pilot research based on established research conditions (participation in the research with the consent of legal representatives, problems in the musculoskeletal system, regularity of participation in physical education classes and sport activities. The primary characteristics of the experimental sample (ES) are presented in Table 1.

Table 1. Characteristics of the sample of pupils

Sample/factors	$ES_{n = 16}$		
Measurements/ values	Body height (cm)	Body weight (kg)	BMI (kg/m^2)
x	161.09	52.21	20.53
s	4.56	4.25	2.85
min.	152.12	45.32	18.32
max.	164.55	54.86	22.21
$R_{max–min}$	12.43	9.54	3.89

Note: ES – experimental sample, (n) – number, (x) – average, (s) – standard deviation, (min.) – minimal value, (max.) – maximal value, R($_{max–min)}$ – range of variation

Procedure and measurements

In terms of ensuring longevity and cross-sectionality in the surveys, we applied a standardized aspect method of body posture assessment for school practice to determine the condition of the musculoskeletal system (Thomas and Klein as modified by Mayerom). Body posture is evaluated in four levels: 1. Correct (5 points), 2. Good (6 to 10 points), 3. Bad (11 to 15 points), 4. Incorrect (16 to 20 points). Each degree of body posture has five characters: 1. Posture of the head and neck, 2. Shape of the chest, 3. Shape of the abdomen and pelvic inclination, 4. Total spine curvature, 5. Height of the shoulders and position of the shoulder blades. Each character is evaluated by mark 1-4. Subsequently, we applied the method of evaluating the muscular system. We evaluated the group of muscles with a tendency to shorten: m. trapezius, pars superior, m. levator scapulae, m. pectoralis major, m. iliopsoas, m. rectus femoris, m. tensor fasciae latae, hip joint adductors, knee joint flexors, m. quadratus lumbrorum, m. erector spinae, and triceps surae. Subsequently, we evaluated a group of muscles with a tendency to weaken: deep neck flexors, mm. abdominis, lower scapular fixators, hip joint extensors, hip joint abductors, and shoulder abductors [5].

The said exercise program was based on applied targeted health-oriented exercises, which were based on the ACT method, which has copyright and a protection license, authored by Palaščáková Špringrová [25]. The ACT method is based on the application of a set of support exercises, which lead to muscle coactivation in order to positively affect the stabilization and straightening of the axial organ, spine, as well as the activation of the internal stabilization system. From a neurophysiological point of view, the basis of the acral coactivation therapeutic method is the use of the positions of human motor ontogenesis and the principles of motor learning. It follows from the above that the basis of the method is to correct incorrect movement stereotypes through motor learning and to achieve its re-acquisition. The exercises were based on the current functional status of the observed factors of the musculoskeletal system ($V_{1–2}$, $V_{3–4}$) of ES pupils [25].

ES pupils in the first stage of the research (control period) $V_{(1–2)\ 2022}$ completed the entrance $V_{(1)\ 2022}$ evaluations of the monitored factors and subsequently for 8 weeks 2 times/week they took part the physical education and sport lessons in compliance with the content (TC) of the school curriculum. Subsequently, they completed the final $V_{(2)\ 2022}$ evaluation, on the basis of which we incorporated exercises of ACT methods with a health focus into the content of teaching physical education and sport. ES performed ACT exercises (experimental period) for 8 weeks $V_{(3–4)\ 2022}$ 2 times/ week, 15 minutes during the preparatory and final part of the physical education and sport lessons. The realized experiment was pedagogical, one-group, non-parallel and multifactor (called quasi-experiment). The experimental factor was a set of ACT exercises, thanks to which we created a consequential dependent experimental factor, which formed the functional state of the musculoskeletal system in pupils ($V_{1–2}$, $V_{3–4}$). This research was conducted during the Covid-19 pandemic.

Statistical analyses

In terms of data processing, we applied descriptive statistics procedures – arithmetic mean (x), standard deviation (s), percentage frequency analysis (%), frequency (n) and range of variation ($R_{max–min}$). We assessed the practical and material significance using the effect size (r). Furthermore, we processed the obtained qualitative-quantitative data using theoretical methods of induction, deduction, logical analysis, and synthesis. To determine the statistical significance of the difference between the input and output evaluations for the observed indicators in the sample, we used the Wilcoxon test $W_{(test)}$ ($p < 0.05$) and to compare the difference between $V_{(1–2)}$ and $V_{(3–4)}$ we applied the Mann–Whitney test ($p < 0.05$).

Results

In the first phase of the experimental period $V_{(1–2)}$ (the control phase) we observed no significant changes in the total body posture in the ES between $V_{1–2}$ (W_{test} = = 0.598, $p > 0.05$), while the difference between the input (V_1 12.31 ± 1.63) and the output (V_2 12.94 ± 1.60) evaluation was at a level of 0.63 ± 0.03.

During the second phase of the experimental period $V_{(3–4)}$, we applied ACT exercises within physical education and sport lessons with a focus on the overall complex body posture of pupils. Comparing the quality of ES body posture during $V_{(3–4)}$, we found that the average difference between the input (V_3 11.69 ± ± 1.82) and output (V_4 6.23 ± 1.35) scores was 5.46 ± ± 0.47, indicating an overall improving body posture in pupils after the application of our ACT exercises. In ES, we noticed significant changes in body posture between input V_3 and output V_4 (W_{test} = 0.002, $p < 0.05$, r = 60). Between periods $V_{(1–2)}$ and $V_{(3–4)}$ ES, we noticed significant changes (Mann–Whitney test = 0.00004, $p < 0.05$) in the monitoring of total body posture (Table 2).

In the muscular system, as well as in total body posture, in the control period $V_{(1–2)}$ in the $ES_{(n = 16)}$, no significant differences were recorded in monitored muscle groups of postural (W_{test} $p > 0.05$) and phasic character (W_{test} $p > 0.05$). During the control period $V_{(1–2)}$, we noticed a muscle imbalance in the ES, which also manifested itself in III quality level in overall body posture. The postural muscle groups at the greatest risk of disorders included m. trapezius pars superior (1.46 ±

Table 2. Total body posture in pupils ES

Sample	$ES_{(n = 16)}$ $V_{(1–2)}$			$ES_{(n = 16)}$ $V_{(3–4)}$		
Factors/measurements	V_1	V_2	R_1	V_3	V_4	R_2
x	12.31	12.94	0.63	11.69	6.23	5.46
s	1.63	1.60	0.03	1.82	1.35	0.47
min.	8	7	-1	5	2	3
max.	15	14	1	14	8	6
$R_{max–min}$	7	5	2	9	6	3
Wilcoxon test		0.598, $p > 0.05$			0.002, $p < 0.05$	
Mann–Whitney test			$p < 0.05$			

Note: ES – experimental sample, n – number, x – average, s – standard deviation, min. – minimal value, max. – maximal value, $R_{max–min}$ – range of variation, V_1, V_3 – input, V_2, V_4 – output, R_1 – difference $V_{(1–2)}$, R_2 – difference $V_{(3–4)}$

Table 3. Evaluation of postural muscle groups in pupils

Sample/research phase	$ES_{(n = 16)}$ $V_{(1–2)}$		$ES_{(n = 16)}$ $V_{(3–4)}$	
Muscle groups	$R_1 x \pm s$	W_{test}	$R_2 x \pm s$	W_{test}
1. m. trapezius, pars superior	0.09 ± 0.05	$p > 0.05$	0.92 ± 0.11	$p < 0.05$
2. m. levator scapulae	0.04 ± 0.02	$p > 0.05$	0.72 ± 0.17	$p < 0.05$
3. m. pectoralis major	0.02 ± 0.02	$p > 0.05$	0.79 ± 0. 34	$p < 0.05$
4. m. iliopsoas	0.05 ± 0.03	$p > 0.05$	0.78 ± 0.27	$p < 0.05$
5. m. rectus femoris	0.03 ± 0.01	$p > 0.05$	0.65 ± 0.22	$p < 0.05$
6. m. tensor fasciae latae	0.00 ± 0.00	$p > 0.05$	0.36 ± 0.25	$p < 0.05$
7. m. hip joint adductors	0.00 ± 0.00	$p > 0.05$	0.29 ± 0.22	$p < 0.05$
8. m. knee joint flexors	0.07 ± 0.06	$p > 0.05$	0.64 ± 0.28	$p < 0.05$
9. m. quadratus lumbrorum	0.02 ± 0.02	$p > 0.05$	0.50 ± 0.23	$p < 0.05$
10. m. erector spinae	0.07 ± 0.03	$p > 0.05$	0.43 ± 0.29	$p < 0.05$
11. m. triceps surae	0.08 ± 0.04	$p > 0.05$	0.65 ± 0.22	$p < 0.05$

Note: ES – experimental sample, n – number, x – average, s – standard deviation, W_{test} – Wilcoxon test, $V_{(1–2)}$ – control phase, $V_{(3-4)}$ – experimental phase, R_1 – difference $V_{(1–2)}$, R_2 – difference $V_{(3–4)}$

Table 4. Evaluation of phasic muscle groups in pupils

Sample/research phase	$ES_{(n = 16)}\ V_{(1–2)}$		$ES_{(n = 16)}\ V_{(3–4)}$	
Muscle groups	$R_1 x \pm s$	W_{test}	$R_2 x \pm s$	W_{test}
1. deep neck flexors	0.00 ± 0.00	p > 0.05	0.62 ± 0.19	p < 0.051
2. mm. abdominis	0.19 ± 0.03	p > 0.05	0.99 ± 0.19	p < 0.05
3. mm. lower scapular fixators	0.8 ± 0.03	p > 0.05	0.40 ± 0.19	p < 0.05
4. hip joint extensors	0.03 ± 0.03	p > 0.05	0.85 ± 0.19	p < 0.05
5. hip joint abductors	0.05 ± 0.02	p > 0.05	0.41 ± 0.19	p < 0.05
6. shoulder abductors	0.6 ± 0.03	p > 0.05	0.87 ± 0.21	p < 0.05

Note: ES – experimental sample, n – number, x – average, s – standard deviation, W_{test} – Wilcoxon test, $V_{(1–2)}$ – control phase, $V_{(3–4)}$ – experimental phase, R_1 – difference $V_{(1–2)}$, R_2 – difference $V_{(3–4)}$

± 0.27), m. pectoralis major (1.40 ± 0.22), and hip flexors (1.39 ± 0.24). The abdominal area (1.48 ± 0.09), shoulder abductors (1.44 ± 0.07), and lumbar extensors (1.41 ± 0.09) dominated in the group of phasic muscle groups. No changes were noticed in the input assessments V_3 in the $ES_{(n = 16)}$.

We noticed significant changes after the experimental period $V_{(3–4)}$ by applying the ACT method, which was significantly (W_{test} $p < 0.05$) manifested in individual muscle groups (Tables 3, 4).

The functional quality of muscle groups and the correct execution of movement stereotypes manifested itself after the experimental period in controlled body posture, which we evaluate positively in terms of education promoting the postural health of pupils. The development in $ES_{(n = 16)}$ occurred in $V_{(4)}$, by the improvement from III quality grade to II quality of overall body posture.

In terms of differences and comparison of changes between the control $V_{(1–2)}$ and experimental $V_{(3–4)}$ periods (n = 16) in muscle groups, we noticed significant differences in favour of the experimental period $V_{(3–4)}$, which was also confirmed by the results of the Mann–Whitney test ($p < 0.05$).

This fact shows that even a controlled and conscious stabilization of body posture resulted in the functionality and improvement of the musculoskeletal system. This is because body posture is one of the basic postural stereotypes within the movement patterns, from which others derive and are related to.

Discussion

Diseases of civilization (also called lifestyle diseases) are non-communicable, usually have a long duration, progress slowly, and are usually the result of genetics, the environment, or a bad lifestyle. Diseases of the musculoskeletal system are also among the diseases of civilization. Body posture is defined as the ideal position adopted by human beings for their daily activities through their body structures and function in order to have better biomechanical efficiency with lesser energy expenditure. However, this is not always possible, as habits are often adopted which may disregard this pattern and lead to postural changes [1, 16].

Ningthoujam [23] considered "posture" as a product of human behaviour, emphasizing that factors affecting a wrong posture are features of daily behaviour. According to that author "posture" reflects the well-being of the individual, reflects the person's activity and somehow relevant personality.

Correct posture, which represents the organization and balance of the body system, requires a position of alignment and support of the musculoskeletal structures between the various segments, which involves the adoption of a healthy lifestyle. According to Graup et al. [13], incorrect posture habits and remaining in a sitting position for long periods lead to an imbalance of the musculoskeletal system and compromise the body structure. These factors are recurrent in the school population, arising from the activity itself and the absence of mechanisms to encourage the adoption of the correct posture. Thus, the sitting posture leads to an overload on the ischial tuberosity, due to the body weight leaning forward and reducing the myofascial flexibility, while the upright torso supports the constant action of the abdominal and back muscles. Moreover, shortened ischia and ileus muscles result in painful symptoms, causing lordosis of the lumbar region, which increases the burden on the spine and the discs.

The abdominal muscles are an important muscle group which, in the event of weakness, does not fulfil its function of supporting the spine or stem. The resulting muscle imbalance affects the pelvic tilt, which can lead to an increase in lumbar lordosis and subsequent pain in the lumbar region of the spine. Correct posture is a body system that provides proper conditions for all body functions, and at the same time, enables active human behaviour towards the environment. This behaviour requires a certain state of alertness, which is associated with greater metabolism and significant energy expenditure. This is true when measuring muscle EMG for correct and improper postures. In a correct posture, EMG shows more intensive muscle work [17, 20].

Thus, the economic importance of correct posture lies not in the fact that the body is released from effort, but in the fact that it is not exposed to excessive expenditure, which occurs with incorrect body balance [26].

Kratenová et al. [14] investigated the prevalence of postural deviation among children (7, 11, 15 years old). From 3520 subjects included in their study it resulted that because of lack of physical activity (measured by PAQ-c) 50% of children were detected with protruding scapulae, 32% with lumbar and 31% with round back. The preferred leisure-time form by children was watching TV and playing video games, for which they devoted 14 hours weekly. Children reported that they spent only 4 hours per week participating in different sports activities. In this study it is underlined that 20% of those who reported no participation in sports activities were at a greater risk of poor posture than children who regularly attend sports activities.

The above facts also confirm our findings in terms of perception and improvement of the postural stereotype of posture as an external manifestation of the functionality of the muscular system. Ultimately, movement stereotypes and their proper implementation play an important role. The presented findings showed significance of care for the postural health of pupils in physical and sport education. It is the consciously controlled correct motion patterns that are the basis for their possible reprogramming. However, this requires a longer time horizon. Every positive change is evaluated positively. It follows from the above that regular physical activity has its place and position in the movement regime of pupils in terms of postural health support [8, 24].

In terms of primary prevention of musculoskeletal system diseases, which is one of the determinants of health, physical and sport education requires interventions [10] in the form of health-oriented exercise programmes, which help to improve body posture (postural stability), functions of the spine and the muscle system in school-aged children [2, 4, 19, 21, 26, 29], to support their adequate development and improve quality of their health at present and in the future.

Conclusions

Due to physical and sport lessons according to the content of the school curriculum during period $V_{(1–2)}$ there were no significant changes ($p > 0.05$) in any of the evaluated areas of the musculoskeletal system (body posture, muscular system), the changes were only minimal. However, in the experimental period $V_{(3–4)}$ applying the ACT method to physical education and sport lessons, we noticed $V_{(3–4)}$ significant changes in W_{test} ($p < 0.05$) in terms of overall body posture and the muscular system, as well as manifestation of its functionality. We also noticed a significant difference in the monitored factors between periods $V_{(1–2)}$ and $V_{(3–4)}$ as reflected in the Mann–Whitney test ($p < 0.05$). This results in the fact that correctly selected and applied health-promoting exercises had a positive effect on the overall adjustment, improvement and quality of body posture and muscular system in pupils, which we evaluate very positively.

Based on the results of the experiment, we may recommend targeted exercises for practical use in physical education and sport lessons for the static load compensation system and prevention of functional disorders of the musculoskeletal system. However, it is important for the exercises to be carried out on a long-term and regular basis. Suitable conceived and focused programmes of exercises are crucial as part of physical education and sport lessons in the current hypokinetic way of life of people. They are indispensable for good quality of body posture health.

Conflict of Interest

The authors declare no conflict of interest.

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