

The influence of the intervention program on the prevention of functional disorders of the musculoskeletal system in children

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Abstract

Physical activity is essential to children's lives, particularly in preventing and eliminating musculoskeletal disorders. This study aims to present the effectiveness of an engaging movement program integrated into primary education to address functional muscle system disorders in pupils. The research sample comprised 63 pupils, including boys (n=30) aged 10.21±0.42 years and girls (n=32) aged 10.32±0.37 years. The intervention program, comprising music-based movement and dance activities, was implemented over 18 weeks, twice a week for 45 minutes, as part of Physical Education classes. Data collection methods included a standardized frontal test for assessing postural and phasic muscles according to Jurašková, Junger & Junger (2019). The evaluation focused on eight muscles prone to shortening (postural) and five muscles prone to weakness (phasic). Based on the statistical evaluation, the Wilcoxon signed-rank test was used to verify the effect of the implemented movement program at a significance level of 0.05. The research results confirmed the occurrence of muscle imbalance in 69.4% of the tested primary school pupils at the beginning of the study, with a higher prevalence in boys (76.6%) compared to girls (62.5%). The most shortened muscle in both genders was the musculus rectus femoris, with a prevalence of 60% in boys and 40.6% in girls. The most weakened muscles were the hip extensors. The applied intervention program significantly reduced muscle shortening in both genders in the following segments: m. triceps surae, m. rectus femoris, knee flexors, hip adductors, m. quadratus lumborum, m. erector spinae, and m. trapezius (p>0.05). A positive effect was also confirmed in strengthening muscles that tend to weaken hip extensors, neck flexors, m. abdominis, hip abductors, and lower scapular fixators (p>0.05). The results of our study confirmed the importance of incorporating an intervention program, including music-movement and dance activities, into school physical education to prevent muscle imbalances and reduction of functional muscular system disorders in the observed pupils.

Keywords: Dance, Intervention Movement Program, Muscle Imbalance, Physical Education, Pupils

Introduction

The decline in physical activity among children as a global trend with significant impacts on their health has been documented by numerous authors (Nemček, 2016; Aghyppo, et al., 2016; Wafa et al., 2016; Kuzmenko, 2017; Brzek et al., 2018; Izrael & Holdoš, 2020; WHO, 2020; Slováková, et al. 2022). These studies uniformly argue that movement is a fundamental prerequisite for the healthy development of a child's personality (Jurášková & Bartík, 2010; Kanásová, 2008), and its absence leads to the disruption of the musculoskeletal system, increased BMI and the loss of physical fitness and resilience in children, even at younger school age (Bendíková et al., 2020; Bendíková, 2022). Musculoskeletal system disorders rarely occur in isolation, typically accompanied by disruptions in other areas and at various levels (Vařeka & Dvořák, 2001). Prolonged sitting in school can lead to painful conditions in the back (Murphy, Buckle & Stubbs, 2004). Authors (Grimmer & Williams, 2000; Masiero et al., 2020) observed a decline in children's ability to maintain an upright posture without increased muscle effort, often accompanied by spinal pain. According to the National Report on Youth Policy in the Slovak Republic for the Council of Europe, there has been an increase in chronic health conditions among children and adolescents aged 0–18, highlighting the need for intensive preventive care (Sobihardová et al., 2005). One potential solution is a high-quality educational process within physical education classes focusing on preventing and correcting musculoskeletal disorders.

Movement programs have been developed to proactively influence and enhance the appeal of physical activities in physical education. These programs emphasize health-oriented exercises to increase physical fitness and address musculoskeletal imbalances. Health-oriented exercises generally target strengthening the inner stabilization system, correcting muscle imbalances, and improving coordination, flexibility and balance. However, it is also essential that the content of these exercises is not monotonous but engaging for pupils. An exciting study in the prevention and correction of musculoskeletal disorders in children aged 11–12 was conducted (Grygus et al., 2020). They implemented a program of dance activities in physical education tailored to the functional status of the children's muscular and cardiovascular systems. The analysis of the program's

results demonstrated its effectiveness in improving body proportionality, correct posture, spinal flexibility, and reducing shoulder blade asymmetry. Andrieieva et al. (2021) also noted statistically significant improvements ($p < 0.05$ in biogeometric posture profiles, muscle strength ($p < 0.05$), and foot positioning ($p < 0.05$) following the implementation of dance into pupils' fitness training. Their study also recorded a 41.9% increase in back muscle strength and a 57.1% increase in abdominal muscle strength. The range and frequency of postural sway decreased significantly by 38.6% and 31.1% in the medial/lateral direction and by 43.6% and 37.0% in the anterior/posterior direction. Additionally, pupils exhibited enhanced spinal flexibility and balance abilities. Fong et al. (2018) reviewed the available literature on the effectiveness of dance interventions compared to exercise programs, examining dance interventions lasting over four weeks that included physical health outcomes. They compared various dance genres and movement interventions across 1,276 participants. Meta-analyses revealed that dance interventions significantly improved body composition, blood biomarkers, musculoskeletal function, and cardiovascular health, recommending dance as a safe and effective alternative in educational content. Other studies (Fong et al., 2021; Pantelić et al., 2019) confirmed the effectiveness of dance programs in developing pupils' motor abilities. However, there is still a lack of studies addressing the positive effects of music movement and dance activities on the musculoskeletal system of 9–10-year-old pupils, as highlighted by Mishenko et al. (2023). In this context, Kashuba et al. (2021) emphasizes the need to incorporate innovative means into school physical education with a high level of pupil motivation.

The main objective of this study was to reduce the incidence of muscle shortening and weakness through music, motion and dance activities in elementary school pupils.

Material & methods

Participants

Following the stated aim, a total of $\Sigma n=62$ pupils ($n=30$ boys, $n=32$ girls) of the Banska Bystrica region, Slovak Republic, aged 9–10 years, i.e. pupils of early school age who were willing to participate in the research with the consent of their parents and school, were included in the sample. The measurements were carried out in accordance with the moral standards of the Declaration of Helsinki. Ethical approval was obtained from the ethical committee at the Matej Bel University under project number 42/2026. The basic characteristics of the groups are presented in Table 1.

Table 1. The primary characteristics of the research group ($n=62$)

Measured values	Boys ($n=30$)	Girls ($n=32$)
Age/years	10.21 $\pm$ 0.42	10.32 $\pm$ 0.37
Body weight/kg	43.21 $\pm$ 7.54	35.41 $\pm$ 7.11
Body height/cm	145.37 $\pm$ 6.54	138.1 $\pm$ 6.24
BMI kg/m ²	20.45 $\pm$ 2.21	18.57 $\pm$ 2.11

Measurement organization

The research occurred in 2021/2022 at a primary school in Banska Bystrica. After thoroughly preparing the research to achieve the goal, initial diagnostics of somatometric indicators were carried out in February, and a diagnostic of body posture was evaluated using a standardized test used in school practice. Subsequently, an exercise program aimed at health promotion about the correct posture of the pupils, was included in the teaching content of compulsory physical education (supported by studies: Andrieieva et al., 2021; Mischenko et al., 2023; Kashuba et al., 2021; Gao et al., 2013) twice a week for 45 minutes, for 18 weeks, a total of 36 lessons. Each lesson of the exercise program included music-implementing exercise and dance activities, containing a 10-minute warm-up, a 25-minute central part, and a 5-minute Cool-Down. Every lesson included a 10-minute warm-up with stretching.

The central part included 30-minute continuous musical-movement and dance activities, such as aerobics, dances (modern, folk), dance aerobics, dance games and skipping rope games. The intensity of the main program was 60%–75% of the maximum heart rate in the first six weeks.

After six weeks, from week seven to week eleven, the intensity was increased to 75%–85% of the maximum heart rate. In the next seven weeks, the program's intensity was variable, and rest weeks were 75–85%. In the last part of the lesson, the participants were given 5 min. cool down. It included muscular strength exercises. A qualified teacher with years of experience led the process of teaching. Subsequently, output testing of the same indicators was performed.

Measurement Taking

Frontal muscle testing was employed during physical education classes to assess the pupils' postural and phasic muscles, following the recommendations for primary education by Jurašková, Junger & Junger, (2019). Participating pupils were assessed by the same method.

The evaluation focused on eight muscles prone to shortening and five muscles prone to weakness.

Frontal Testing of 8 Shortened Postural Muscles:

1. M. triceps surae – Mild stance in a wide position, performing a slow squat with the entire foot flat on the ground. Shortening: Heels do not touch the surface.
2. M. rectus femoris – Prone position, knees bent. Shortening: Heels are more than 10 cm away from the gluteal muscles.
3. Flexors of the knee joint – Supine position, left leg bent, right leg extended forward. Shortening: The extended leg does not reach a 90° angle.
4. Adductors of the hip joint – Supine position, legs widely abducted—shortening: Less than a 90° angle in abduction.
5. M. quadratus lumborum – Wide stance with lateral trunk flexion. Shortening: The perpendicular line from the armpit does not reach the groove between the gluteal muscles.
6. M. erector spinae – Sitting on a bench, trunk flexion. Shortening: No natural curve is formed; the back remains straight.
7. M. pectoralis major – Supine on a bench, with arms raised laterally. Shortening: Extended arms do not go below the level of the bench.
8. M. trapezius, pars superior – Supine position, touch the left ear with the right hand around the head, with lateral flexion to the right. Shortening: Head flexion is limited.

Frontal Testing of 5 Muscles Susceptible to Weakness:

1. Extensors of the hip joint – Prone position, hands placed under the chin, leg extended backwards, hold for 20 seconds. Norm: The individual can maintain the position unchanged for 20 seconds.
2. Deep flexors of the neck – Supine position, head flexed with the chin to the chest, hold for 20 seconds. Norm: The individual cannot maintain the position for 20 seconds; the head drops.
3. Abdominal muscles – Supine position, knees bent, slow transition to a seated position. Norm: Smooth transition to a seated position.
4. Abductors of the hip joint – Lying on the left side, left knee bent, right leg abducted at a 45° angle. Norm: Maintain the 45° angle without external rotation of the leg or forward movement.
5. Lower fixator of the scapula – Kneeling position with a forward-leaning plank for a push-up. Norm: The back remains straight, and the scapulae do not protrude.

Garmin heart rate monitor was used to measure pulse rate.

Data Analyses

In terms of data processing methods, mathematical and statistical methods were used to process the collected data and to calculate basic descriptive statistics: arithmetical mean ($\bar{x}$), selective standard deviation (SD), and percentage frequency analysis (%). To ascertain the statistical significance of achieved results in the level of body posture, the Wilcoxon signed-rank test was used, $p < 0.05$ –statistically significant on the level of 5%.

Results

The findings of our study confirmed the presence of muscular imbalance in 69.4% of the primary school pupils evaluated at the start of the research. The prevalence of muscular imbalance was higher in boys (76.6%) compared to girls (62.5%). This trend aligns with previous studies (Jurašková & Bartík, 2010; Jurašková, Junger & Junger, 2019) which also reported a higher occurrence of muscle shortening in boys.

Occurrence Frequency of Muscle Shortening and Muscle Weakness in the Experimental Group of Boys

Among the boys, the most frequently shortened muscle was the rectus femoris, with a prevalence of 60% at baseline testing, followed by the knee flexors and quadratus lumborum (see Figure 1). The least commonly shortened muscle was the pectoralis major, with only 13.3% prevalence in the initial assessment.

Following the 18-week program an exit evaluation was performed to assess the program's impact on the level of muscle shortening. The results indicated a statistically significant improvement in boys' muscle shortening levels across five monitored segments (see Table 2).

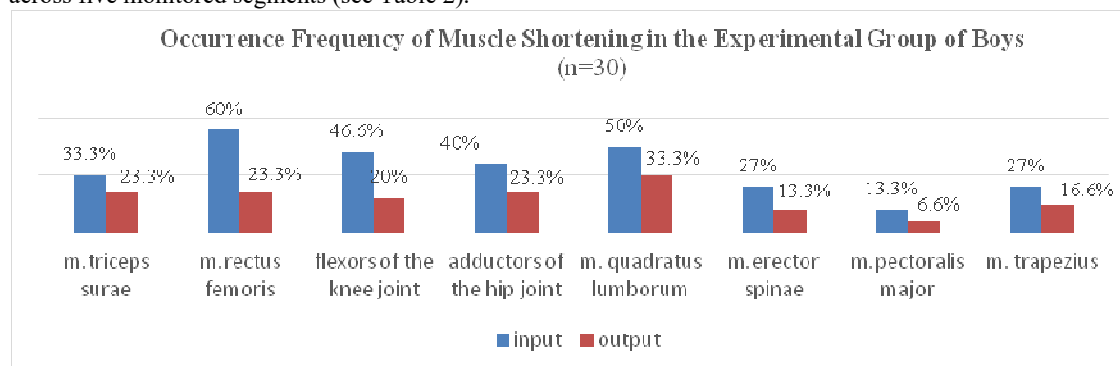


Figure 1. Occurrence Frequency of Muscle Shortening in the Experimental Group of Boys (n=30)

The highest occurrence of muscle weakness in boys was recorded in the hip extensors, both in the initial and final measurements, with a frequency of 30% of boys (see Figure 2). The positive impact of the intervention program was statistically significant in reducing the weakness of the hip extensors and abdominal (see Table 2). There was also a slight improvement in the weakness of the lower scapular stabilizers, with boys improving by 6.7% in the final assessment, indicating that weakness persists in 26% of pupils.

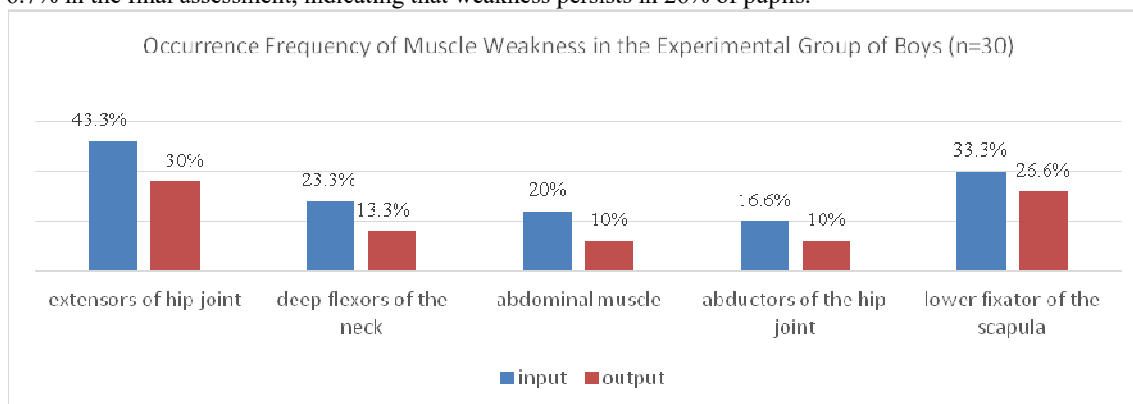


Figure 2 Occurrence Frequency of Muscle Weakness in the Experimental Group of Boys (n=30)

Table 2. The Effect of the Intervention Program on the Occurrence of Muscle Shortening and Muscle Weakness in the Experimental Group of Boys

Muscle Shortening								
Boys	m.triceps surae	m.rectus femoris	flexors of the knee joint	adductors of the hip joint	m. quadratus lumborum	m. erector spinae	m.pectoralis major	m. trapezius
p<0,05	0.07446	0.0005447	0.002981*	0.01844*	0.01844*	0.03593*	0.1729	0.07446
Muscle Weakness								
Boys	Extensors of the hip joint	Flexors of the neck		Abdominal muscles		Abductors of the hip joint		Lower fixators of the scapula
p<0,05	0.03593	0.07446		0.03593*		0.1729		0.1729

Occurrence Frequency of Muscle Shortening and Muscle Weakness in the Experimental Group of Girls

The most frequently shortened muscle among girls during the initial testing was the rectus femoris, with a prevalence rate of 40.6%, followed by the knee flexors (28% of girls) and the triceps surae (25%). Like the boys, the least shortened muscle among the girls was the pectoralis major, with no signs of shortening observed in any of the girls after the intervention program (see Figure 3). The pectoralis major is directly involved in various upper limb movements and plays a role in essential daily physiological activities such as breathing. Therefore, maintaining its functional integrity is crucial (Bueno et al., 2017; Choudhari et al., 2012). Following the application of the intervention program, a statistically significant reduction in the prevalence of muscle shortening was observed in four monitored muscle groups among the girls (Table 3). The least shortened muscle in girls was the trapezius, occurring in only one participant during the final assessment.

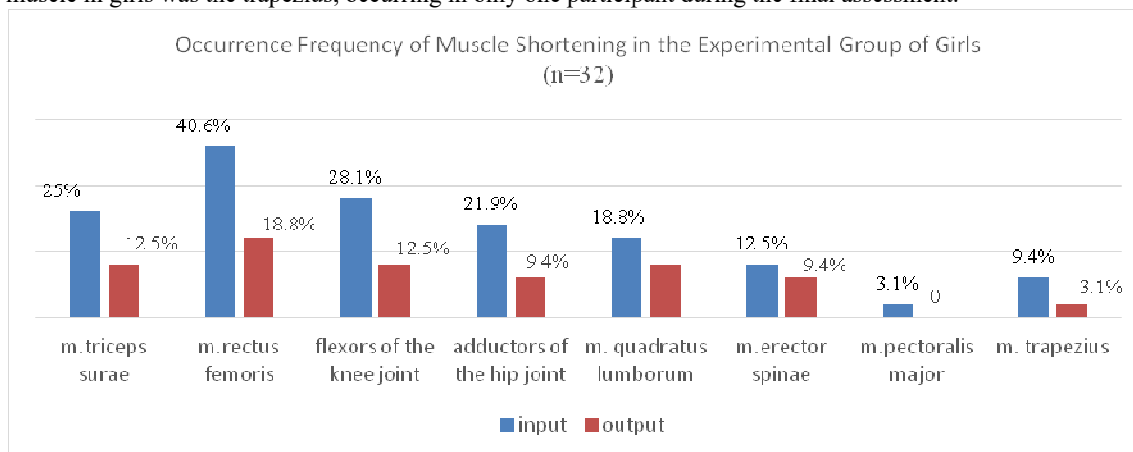


Figure 3. Occurrence Frequency of Muscle Shortening in the Experimental Group of Girls (n=32)

From the research results, it can be concluded that there is a higher occurrence of muscles showing a tendency towards weakness in girls than in boys. Similar to boys, the most weakened muscles the most of muscle weakness occurred in were the hip extensors (see Figure 4), which showed a statistically significant reduction in weakness due to the intervention program ($\lambda=0.03593$; $p>0.05$). Statistically significant changes were also observed in the level of weakness in the deep neck flexors and lower scapular stabilizers among girls after the application of the intervention program ($\lambda=0.01844$; $p>0.05$; see Table 3). Neck flexors are part of the deep stabilization system of the human body; they play a role in stabilizing the spine and are essential to proper posture (Lenková et al., 2018). Exercising these muscles improves head and neck posture stability and helps maintain an upright position. Otherwise, it may lead to deformities in the neck area, such as forward head posture, and cause pain in this region (Lin et al., 2022).

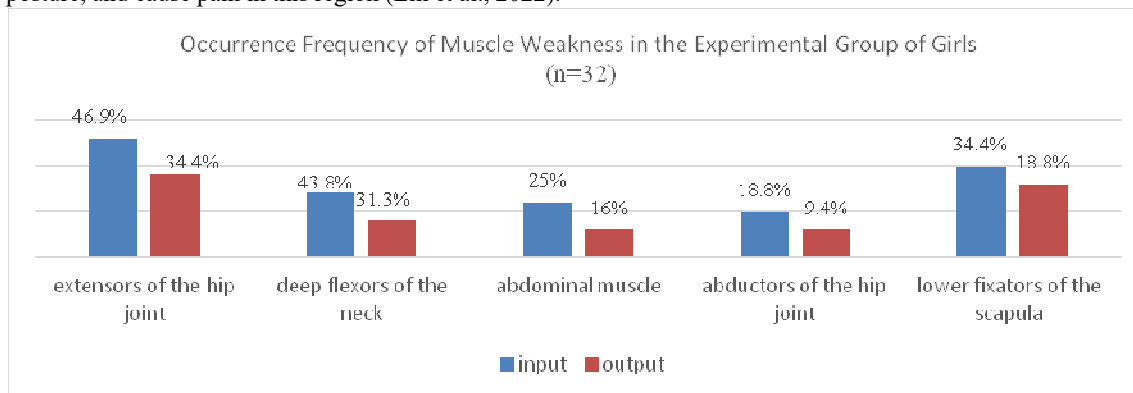


Figure 4. Occurrence Frequency of Muscle Weakness in the Experimental Group of Girls (n=32)

Table 3. The Effect of the Intervention Program on the Occurrence of Muscle Shortening and Muscle Weakness in the Experimental Group of Girls

Muscles Shortening								
Girls	m.triceps surae	m.rectus femoris	flexors of the knee joint	adductors of the hip joint	m. quadratus lumborum	m. erector spinae	m.pectoralis major	m. trapezius
p<0,05	0.03593	0.005367*	0.01844*	0.03593*	0.1729	0.5	0.5	0.1729
Muscles Weakness								
Girls	Extensors of the hip joint	Flexors of the neck		Abdominal muscles		Abductors of the hip joint		Lower fixators of the scapula
p<0,05	0.03593	0.03593*		0.07446		0.07446		0.01844*

Discussion

The study presented investigated the impact of applied music and movement activities and dance on correcting functional disorders of the musculoskeletal system in children. Many studies in recent years have pointed to a trend of decreasing physical activity, which is reflected in the increase in obesity and functional disorders of the musculoskeletal system, even in the youngest age categories (Yao et al., 2011; Rajan & Koti, 2013). Recent years have seen studies describing the phenomenon of initial muscle imbalance occurring in primary school pupils due to the sudden decrease in natural movement when children start school (Bursová & Langmajerová, 2006; Bartík, 2007). This is also evidenced by the study (Vařeková & Vařeka, 2005), which diagnosed muscle imbalance in 192 boys and 183 girls aged 6 to 14 years. A high occurrence of muscle shortening and weakness was already noted in the youngest age category. The most shortened muscle group was the knee flexors in boys and the upper scapular fixators in girls.

The most muscle weakness in both genders was in the lower scapular fixators. In our research, the muscle most shortened was the rectus femoris, at 60% in boys and 40.6% in girls. The most weakened muscles were the hip extensors, occurring in 43.3% of boys and 46.9% of girls. Based on the analysis of results, it was found that among our subjects, boys suffered more frequently from shortened muscles than girls, while the level of muscle weakness was found to occur at a higher percentage in girls than in boys. This fact corresponds with the research (Jurášková & Bartík, 2010; Bendíková & Rozim, 2020) noted similar functional disorders in postural health, indicating that up to 48% of girls and 50% of boys had poor posture and associated muscle imbalance among pupils. The most significant differences were recorded in shortened muscle groups between girls and boys in m. pectoralis major ($\chi^2 p < 0.01$) and m. tensor fasciae latae ($\chi^2 p < 0.05$). It was found that boys dominated in muscle weakness groups, such as m. abdominis, m. trapezius pars descendens, and scapular fixators ($\chi^2 p < 0.01$). Weakness of m. gluteus ($\chi^2 p < 0.05$) and deep flexors of the head and neck were characterized by increased norms in girls.

Postural imbalance does not only affect one body's segment but harms the entire body. Compromised health necessitates implementing special measures, such as corrective exercises and therapeutic procedures, to

stabilize, reduce, or prevent these imbalances (Acasandrei & Macovei, 2014). Nosko et al. (2016) point to the possibility of using physical education and sports to positively influence the muscle imbalance of pupils. The integration of activities aimed at correcting posture into the teaching process in schools was also observed by Kashuba et al. (2021), who involved 139 pupils aged 6 to 10 years with hearing defects. They experimentally verified the proposed implementation technology concerning the indicators of the biometric profile of posture. The preventive modules consisted of education on postural preventive exercises, exercises according to Gitman Pilates, exercises on a fit ball, and yoga.

The intervention program's effect improved the respondents' biogeometric profile index at a statistically significant level of $p < 0.05$. Similarly, Černický et al. (2018) consider it appropriate to incorporate elements of the healthy back school methodology into physical education teaching. The study found that out of a total of 260 school-age children, as many as 80 exhibited postural disorders. The authors concluded by playfully recommending physical activity using suitable motivational tools such as words, music, and colorful and engaging aids, thereby positively influencing pupils' motivation for active participation. A similar stance can be taken based on the results of our study, where a diverse and attractive movement program, incorporating music and movement activities and dance, proved effective in motivating pupils toward physical activity in a non-violent manner, as well as in addressing and eliminating initial postural disorders in pupils.

A contrasting approach to supporting postural health is presented by Johnson & Deshpande (2000) to utilize the enormous potential of schools to help pupils develop knowledge and skills aimed at health. Schools are the leading social institutions responsible for promoting health. One of the most essential tools for primary prevention is to develop educational intervention programs to acquire theoretical knowledge about health and proper movement habits (Mendez et al., 2001). The study by Miñana-Signes, et al. (2019) examined the impact of a monthly intervention program on the knowledge and postural habits of 10 to 11-year-old pupils. In terms of expertise and postural habits, the intervention scores significantly increased. Thus, physical education classes appear to be an ideal environment for developing educational intervention programs and intervention movement programs related to children's health. A strong point of the study is the presentation of unique results in the field of musculoskeletal health and its influence through music, movement, and dance activities during physical education classes in a fun and appealing manner for pupils. Another advantage is the possibility of applying to the program without high financial or material demands. The application in practice is straightforward for teachers and motivational for pupils toward physical activity.

The limitations of the presented study include the absence of a control sample, which limits the generalizability of the results, and the use of a visual method to assess shortened and weakened muscle groups in pupils, which the subjective viewpoint of the evaluator may influence. The study did not include a reassessment of the muscular imbalances of the assessed pupils; thus it is not possible to confirm the stability of the achieved improvements of the musculoskeletal system.

Conclusion

The intervention program that incorporated music and motion activities, as well as dance, applied to the content of physical education classes had immediately after the end of the intervention program significantly reduced muscle shortening in both genders in the following monitored segments: m. triceps surae, m. rectus femoris, knee flexors, hip adductors, m. quadratus lumborum, m. erector spinae, and m. trapezius ($p > 0.05$). The positive effect was also confirmed in strengthening muscles that tended to weaken hip extensors, neck flexors, m. abdominis, hip abductors, and lower scapular fixators ($p > 0.05$).

An essential factor for the success of the exercise program is student motivation. Compensatory exercises are often dull and monotonous, and especially in younger age categories, it is challenging to maintain pupils' attention, which is crucial during compensatory exercises. Our program's varied music and movement activities accompanied by musical backgrounds proved effective in keeping the pupils in physical activity.

The results of the presented study support the importance of incorporating the intervention program into the school physical education, thus contributing to the reduction of postural and phasic muscle functional disorders. The proposed intervention program can be recommended for inclusion in teaching pupils at least twice a week, utilizing appropriate musical backgrounds based on the age and preferences of the pupils involved.

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