Central European Journal of Sport Sciences and Medicine | Vol. 45, No. 1/2024: 5–15
ISSN (print): 2300-9705 | ISSN (online): 2353-2807 | DOI: 10.18276/cej.2024.1-01

PROPRIOFOOT CONCEPT IMPLEMENTED IN PHYSICAL AND SPORTS EDUCATION CLASSES WITH THE AIM OF IMPROVING FOOT HEALTH AND BODY POSTURE IN FEMALE STUDENTS

Elena Bendíková[A, B, C, D, E]

Faculty of Education CU, Department of Physical Education and Sports, FIEP, Slovakia
Sciences and Diagnostics Research Group, Prince Sultan University, Riyadh, Saudi Arabia
ORCID: 0000-0001-5952-056X | e-mail: bendikova.elena@gmail.com

Juan Carlos Holgado[B]

FISU Sports Director, Archery Expert, Olympic Champion B92 Archery, Switzerland

Ricardo Ricci Uvinha[A, B]

University of São Paulo, School of Arts, Sciences and Humanities, Brazil
ORCID: 0000-003-2936-9453

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Abstract The quality of the musculoskeletal system in children is important in terms of primary prevention of postural disorders in adulthood. The aim of the pilot study was to assess the impact of the Propriofoot Concept exercises within the physical and sports education classes on the postural health of female students with an emphasis on the foot, joint range of the ankle, the gait, pain elimination and overall body posture as a manifestation of its functionality. The sample consisted of n = 27 high-school female students in age(x) 16.3 ±0.7 years. In terms of data collection methods, standardized procedures and methods for physical education and physiotherapy practice were applied, focusing on the selected factors (an emphasis on the foot, joint range of the ankle, the gait, pain elimination and overall body posture) of the musculoskeletal system. Diagnostics were applied before and after the 6-month program. The obtained results show that the exercise programme based on the Propriofoot Concept had a significant (Wtest, $p < 0.01$) and positive effect on the structure and function of the foot, as well as flexion and extension at the ankle joint, which resulted in the elimination of foot pain and improvement of gait. The final assessment (V2) showed that the foot structure and function improved ($p < 0.01$) and had a positive influence on the overall body posture, as well as its individual segments, in which we found significant changes between V1 and V2. At the same time, we found a relationship between foot functionality and overall body posture, as well as between other monitored factors. These findings point to the importance of targeted exercises, implemented in physical and sports education, to female students' postural health.

Key words: foot, Physical & Sports Education, "Propriofoot Concept", female students

Introduction

Healthy feet produce smooth and flexible gait. The foot's flexibility is maintained by longitudinal and transverse arches. It is made up of 26 bones and more than 30 joints. The foot arches are shaped by muscles, ligaments with articular capsules as well as the position of the femoral head in the hip joint. Proper functioning of the foot allows the heads of the first and fifth metatarsals and the heel bone to drop down to the ground (Brockett, Chapman, 2016). Apart from the three-point support, Larsen (2005) introduced also a four-point support of the foot, in which the heel is composed of its internal and external parts. In a standing position, the highest pressure is located between the 3rd and 4th metatarsals and the lowest under the 5th metatarsal head. Our foot in contact with the ground makes up the foundation of our body's balance. It is a trapezoid with a shorter posterior region. The outer edges present its lateral region and its axes' lateral deviation ranges between 15° and 20°. The forefoot, the longest region, is made up of the line that connects the bottoms of the metatarsal heads. Ligaments and muscles that connect individual bones in the foot ensure the stability of its arches and flexible support of the body (Véle, 2006). It is important to note that the supporting function of the foot reaches and ends in the diaphragm (Lewitová, 2016).

The foot is connected to other body parts by means of muscle chains. This complex system, which is controlled by the central nervous system, consists of interconnected fascial, tendinous and bone structures. Several muscle chains can work simultaneously according to certain sequence (timing). This interconnection improves adaptability and flexibility of the muscular system (Véle, 2006).

The posterior surface line forms a muscle chain that connects the sole and the head of the foot, maintaining the upright posture. The anterior surface line balances the activities of the posterior surface line. Breaking of the muscle chain in any part leads to muscular disbalances and chaining, which consequently results in limited dorsiflexion of the foot, hyperextension of knees, the shortening of hamstrings, hyperlordosis in the lumbar region and hyperextension of cervical vertebrae. In addition, pelvic anteversion deactivates the m. tibialis anterior and decreases longitudinal arch height. This means that any dysfunction or weakening of the foot affects the gait and the body posture and results in a number of orthopaedic disorders (Myers, 2009; Shtin Baňárová, 2019).

Vařeka & Vařeková (2009) claim that the foot provides two basic functions – static and dynamic. The static function ensures proper positioning of the foot and postural stability of the body in a standing position. The dynamic function, on the other hand, provides locomotion that is based on the ability of the foot to lift off the ground. The postural stability in a standing position is provided mainly by heels in the sagittal plane and hips in the latero-lateral plane.

The foot is the basic connection between our body and the ground, to which it can adapt thanks to its great flexibility. The contact between the foot and the ground surface is the source of proprioceptive and exteroceptive stimuli transmitted to the central nervous system, which controls all our movements (Palaščáková Špringrová, 2018). This means the interdependence of centripetal (sensory) and centrifugal (motor) information in the control of CNS movement.

Sensorimotor stimulation (SMS) is nowadays used to treat various musculoskeletal disorders. It is mainly designed to improve coordination and balance, fix poor posture, treat impaired proprioception, improve postural stability of the thoracic spine, and combine acquired motor skills with everyday activities. SMS can be applied to treat a large number of musculoskeletal disorders. Sensorimotor stimulation helps to subconsciously involve in movement also those muscles and muscle groups that are difficult to influence by will and thus to automate their activity. The Propriofoot Concept is a physiotherapeutic tool based on sensorimotor activation of the foot

(Palaščáková Špringrová, 2018). The SMS methodology places great emphasis on the facilitation (arousal) of the foot, using a set of balance exercises performed in various postural positions. The exercises are aimed at improving muscle coordination, accelerating the onset of muscle contraction by means of proprioceptive activation induced by a change in joint position, influencing proprioception disorders that accompany neurological diseases, correcting balance disorders, improving posture and stabilizing the trunk when standing and walking, incorporating new movement programs into normal daily activities. Correction of the body - legs, knees, pelvis, head, neck, and shoulders - is important in exercise. Exercise is best done barefoot. It is ideal to first practice without balance surfaces, on the ground, and practice until the first signs of fatigue.

Sensorimotor stimulation methodology derives from a two-stage model of motor learning. In the first stage, a man tries to repeat a new movement, subsequently working out a basic motor programme. This phase is very exhausting because this stage of learning is controlled by the cerebral cortex. The brain, however, attempts to simplify the regulation circuit and gradually shifts sensorimotor control towards subcortical regions. This opens a new phase of learning – automatization. Subcortical control enables fast motor performance (for example, necessary for fall prevention). It has been proven that good proprioception combined with balance exercises accelerates and facilitates muscle contractions (Biancalana et al., 2020). This is an essential prerequisite for quick reactions when the body unexpectedly loses balance. The first phase of learning requires very precise motor performance as it is very difficult to change a motor programme that has once been acquired. Sensorimotor stimulation is used for both treatment and prevention.

In this regard, physical and sports education is the only school subject that promotes students' active health. Nowadays, diversification of its syllabus facilitates support for active health, and it has beneficial effects on students' overall health-oriented fitness, which demonstrates their general performance. Physical and sports education in Slovakia currently places emphasis on associations between health care and the development of a positive attitude towards health through an active and healthy lifestyle pursued later in adulthood. Physical and sports education is a primary and ancillary prerequisite for developing habits, stimulating interest in sports activities, encouraging positive behaviour, and acquiring skills and knowledge of the importance of regular physical activity for students' health (Bendíková, 2018).

Suitably conceived and focused programmes of exercises are very up-to-date as part of physical and sports education lessons in the current hypokinetic way of students' life. They are inevitable for good quality of postural health (Bendíková, 2020, Bendíková, Balkó, 2022).

The aim of the study

Postural health problems related to feet often cause passive presence/absence of students in physical and sports education classes and lead to various musculoskeletal disorders caused also by insufficient primary prevention.

The aim of the pilot study was to assess the impact of the Propriofoot Concept exercises within the physical and sports education classes on the postural health of female students with an emphasis on the foot, joint range of the ankle, the gait, pain elimination and overall body posture as a manifestation of its functionality.

Material and methods

Participants

Following our goals, we set up an experimental group (Σ n = 27) which comprised 27 adolescent female students whose average age was (x) 16.3 ±0.7 years. Table 1 presents the primary characteristics of the group (body height 169.7 ±4.9 cm, body weight 59.7 ±6.9 kg).

Table 1. Characteristics of the sample of girls (n = 27)

Sample/factors	Experimental sample ($ES_{n = 27}$)		
Measurements/values	Body height/(cm)	Body weight/(kg)	BMI/(kg/m^2)
x	169.7	59.7	21.9
s	4.9	6.9	0.77
min.	164.1	53.6	21.34
max.	175.3	64.8	22.33

Measurements and organization

The aforementioned type of research study design was conducted in order to provide an introduction to a larger intervention study, as well as to identify the healthcare needs of the school environment for students by diversifying the content of physical and sports education and health prevention. What is more, the institutional Ethics Committee of the university approved this research and its design.

In terms of time plan and intervals, the study was conducted in several consecutive stages (selection of a group of female students at school, selection of methodology, entrance diagnosis by a physiotherapist, implementation of exercises carried out by female students and exit diagnosis, data analysis among other things).

The selection of the study participants was deliberate concerning the aim of the study as well as the willingness to participate in the research and complete the exercise program. That is, after an initial assessment (V1) of the musculoskeletal system by the physiotherapist, the schoolgirls were suggested, recommended and selected by their parents to participate in the health-oriented program within the framework of physical and sports education aimed at prevention and improvement of their postural health. Participation in the research was voluntary and secured by written consent from the school institution and the pupils' legal guardians, in accordance with the GDPR anchored in the legislative guidelines of the participating school.

In terms of data collection methods, standardized methods for exercise and physiotherapy practice (see below) were used to assess the status of selected factors (general posture, foot position, ankle joint mobility, gait and pain).

In the first stage, we diagnosed the selected factors of the musculoskeletal system. At first, we used the body posture assessment method for schools developed by Thomas & Klein and modified by Mayer. This method evaluates body posture by totalling up points for the monitored segments and divides posture into four categories: the 1st category – perfect (5 points); the 2nd category – good (6 to 10 points); the 3rd category – poor (11 to 15 points) and the 4th category – bad (16 to 20 points). Each posture category comprises five segments: 1. Head and neck posture; 2. Thoracic shape; 3. Abdominal shape and pelvic tilt; 4. Overall curvature of the spine; 5. Position of scapulae and shoulders. Each segment is assessed and given a score ranging from 1 to 4 (Bendíková, 2017). Note: the above-mentioned method is suitable in school practice in terms of the first contact with the physical and sports education teachers, who assess the posture, its quick availability and application. It is also used in physiotherapy practice alongside others as a method of first contact and awareness of postural status of a functional nature.

Then we used a non-invasive instrument called podoscope Namrol PD 300, which complies with the Medical Devices Regulations 2017/45 in Slovakia, to quickly evaluate the shape of the foot. We also assessed the shape of the foot from the rear, focusing on the ankle joint: a) (1 point) – slim ankles touching each other, good upright stance, b) (2 points) – ankles are slightly turned inward, c) (3 points) – ankles roll excessively inwards, overpronated feet, poor posture. Feet were assessed in both static and dynamic forms: (walking pattern: 1 point – proper gait, 2 points – slight changes, 3 body – unsteady/abnormal gait).

We measured the ankle joint's range of motion (increased or decreased) using a digital goniometer Easy Angel. Physiological range – standard supine position: flexion of the ankle joint - 20^0 and ankle extension - 45^0, in the frontal plane in position on the back (Vojtaššák, 2000).

Pain intensity was assessed by means of the visual analogue scale (VAS), which is an 11-point Likert scale: 0 = no pain, 10 = pain as bad as it could possibly be (Vojtaššák, 2000).

The initial assessment (V_1) was followed by the preventive and therapeutic balance instrument called Propriofoot Concept (Baicry, Paris, 2017), which was applied during initial phases of physical and sports education classes 3 x 10 minutes per week for the period of six months. Note: the students did not attend any organised or unorganised activity of interest during the movement programme, related to the implementation of physical activity in relation to postural health or health in general, whether in or out of the school environment. Nor were they taking any medication. They performed 20 consecutive exercises (Baicry, Paris, 2017). Emphasis was placed on following the recommended sequence (from the easiest to the most difficult ones). Exercising in proper positions (fixation and initial) was aimed at improvement of the assessed segments. The Propriofoot Concept exercises are performed with the help of four plates (10 x 10 cm) of different colour and shape (3 unstable and 1 stable) (Baicry, Paris, 2017); Palaščáková Špringrová, 2018). The green plate is stable, and it has two parallel half cylinders on the sides of its base. The yellow and the blue plates have two half cylinders placed in the centre, which makes them unstable in two planes. The red plate has a half sphere in the centre, which makes it unstable in all directions. It is important to note that the exercise programme was supervised by a physical and sports education teacher, who was certified to use the aforementioned tools in schools. During the last phase, we conducted final measurements and assessments (V_2) of the monitored segments and processed the acquired qualitative and quantitative data.

Data analysis

The statistical analysis was done using MS Excel 2016 and IBM SPSS 22 software with significance levels of $p \leq 0.05$ and $p \leq 0.01$. The collected data were analysed by means of descriptive statistics, means (M) and standard deviations (SD). The Shapiro-Wilk test for normality was performed on all variables. Except for the overall body posture and ankle flexion and extension before the experimental program, deviation from normality was identified in all the data sets. The significance of the difference between the two compared groups was calculated by the Wilcoxon signed ranks test in two related groups. To compute an effect size for the signed-rank test, the rank-biserial correlation was applied. Pearson's correlation (r) was used to determine the relationships between the results of individual tests.

Results

Individual segments of the musculoskeletal system were selected and measured with regard to longitudinal and cross-sectional aspects of our studies that are focused on postural health in students. Our findings were as follows:

In our experimental group, we found significant changes in overall body posture (W_{test} = -4.573, p < 0.01) between initial (V_1) (11.667 ±2.038) and final (V_2) (8.0 ±1.593) assessments with an average difference (x) 3.667 ±0.445. The extent of variation in (V_1) was minimally 8.0 and max. 16.0, with the difference $R_{max-min}$ 8.0 ±1.0 and in (V_2) it was $R_{max-min}$ 8 ±1.593. As far as the overall body posture is concerned, we observed an improvement by 3.67 points, which amounts to 31.43 % (p < 0.01). These findings prove that the quality of body posture in the experimental group members was higher during final measurements (Table 2).

Other individual segments of body posture improved subjectively or objectively in all the female students (Table 2). As far as head and neck posture is concerned, the difference between the initial and final measurements was (V_1) (2.667 ±0.784) and (V_2) (1.667 ±0.620), the difference 1 ±0.164, statistical significance (W_{test} = –4.838, p < 0.01). The abdominal region and the pelvic tilt improved as well, with the difference between the initial (V_1) (2.778 ±0.641) and final (V_2) assessments (1.630 ±0.629), the difference (1.148 ±0.012) was statistically significant (W_{test} = –4.767, p < 0.01). We found significant changes also in the thoracic region; the difference between the initial (V_1) and the final (V_2) assessments was (W_{test} = –2.449, p < 0.05). In addition, significant improvements (W_{test} = –4.472, p < 0.01) were observed in the physiological curvature of the spine: (V_1) (2.379 ±0.629) and (V_2) – (1.630 ±0.594), the difference was 0.74 ±0.035. The improvement in the position of scapulae and shoulders was also significant (W_{test} = –3.5; p < 0.01), with the difference between the initial (V_1) (2.259 ±0.594) and the final (V_2) assessments was (1.741 ±0.594), 0.518 ±0.00.

The neck and head posture score decreased by 1 point, which amounts to 37.5%, the thoracic shape improved by 0.22 point, which presents 14.63%, the score of the abdominal and pelvic regions decreased by 1.15 point, which accounts for 41.33%, the curvature of the spine improved by 0.74 point, which equals 31.25% and the position of scapulae and shoulders improved by 0.51 points, which amounts 22.95%. These changes were significant at the one-percent level of statistical significance (p < 0.05). The score for the shape of the foot changed by 1.04 point, which amounts to 42.42% (p < 0.01). A great effect of significance represented by the rank-biserial correlation was confirmed in all the monitored segments (Table 2).

Table 2. Overall body posture and posture of its segments in female students (n = 27)

Test	pre-test		post-test		Wilcoxon		rank-biserial
	M	SD	M	SD	Z	p	correlation r
Overall body posture	11.667	2.038	8.000	1.593	–4.573	< 0.001	–0.880
Head - neck	2.667	0.784	1.667	0.620	–4.838	< 0.001	–0.931
Thoracic region	1.519	0.509	1.296	0.465	–2.449	0.014	–0.471
Abdomen - pelvis	2.778	0.641	1.630	0.629	–4.767	< 0.001	–0.917
Spinal curvature	2.370	0.492	1.630	0.629	–4.472	< 0.001	–0.861
Position of shoulders and scapulae	2.259	0.594	1.741	0.594	–3.500	< 0.001	–0.674

Table 3 presents the data related to feet assessments. As far as the foot arches (V_1 2.444 ±0.505), podogram evaluations (V_1 2.630 ± 0.492) and the gait (V_1 2.519 ±0.509) are concerned, we found that the subjects' feet turned inward and that their footprints were wide (without a typical arch in the middle of the inner edge) rather than long. In addition, we assessed the subjects' feet in both static and dynamic forms, and we found out that their ankles were turned either slightly or significantly inward and their feet rolled inwards as well. This affected the flexion (V_1 15.963 ±1.911) and the extension (V_1 37.593 ±2.664) at the ankle joint. The experimental group subjects experienced pain related to all evaluated regions (V_1 2.778 ±0.751). The Propriofoot Concept led to significant changes ($p < 0.01$) in all the segments we assessed during the V_2 evaluation (See Table 3).

Table 3. Evaluation of the selected segments of the students' feet (n = 27)

Test	pre-test		post-test		Wilcoxon		rank-biserial
	M	SD	M	SD	Z	p	correlation r
Foot	2.444	0.506	1.407	0.501	–5.112	<0.001	–0.984
Pain intensity	2.778	0.751	0.148	0.362	–4.646	<0.001	–0.894
Flexion of the ankle joint	15.963	1.911	19.852	0.456	–4.568	<0.001	–0.879
Extension of the ankle joint	37.593	2.664	44.778	0.577	–4.549	<0.001	–0.875
Gait	2.519	0.509	1.519	0.509	-5.196	<0.001	–1.000
Podogram	2.630	0.492	1.630	0.492	-5.196	<0.001	–1.000

Pain intensity changed the most significantly, e. i. by 2.63 points, which accounts for as many as 94.67 %. Flexion and extension at the ankle joint improved by 3.89 (and 7.19 points), which equals 24.36% and 19.11%. The gait and podogram tests showed an improvement by 1 point in both cases, which amounts to 39.71 and 38.03%. As we have already mentioned, all these changes were significant.

When evaluating relations between individual tests before the application of the Propriofoot Concept, we found statistically significant correlations. The overall body posture was correlated with all the assessed segments, except for the thoracic region. Head and neck posture mostly affects the posture of the abdomen and the pelvis, spinal curvature and flexion at the ankle joint. It slightly influences the shape of the foot, pain intensity and the gait as well.

Strong correlations were found in relation to the spine curvature, which affects flexion at the ankle joint, the gait and the podogram footprints. All these segments together with the extension at the ankle joint have an impact on pain intensity. There are significant correlations between ankle flexion and extension as well as between the gait and the podogram footprint. The abdomen and the pelvis are less significantly influenced by the spine curvature, the podogram footprint and flexion at the ankle joint. The position of scapulae and shoulders is greatly correlated with the gait and extension at the ankle joint. The gait also correlates with the foot test (Table 4).

Table 4. Correlation coefficients between individual tests before application of the programme

Variable	Overall body posture	Head-neck	Thorax	Abdomen-pelvis	Spine curvature	Position of shoulders and scapulae	Foot	Pain intensity	Flexion at the ankle joint	Extension at the ankle joint	Gait
Head-neck	0.87**										
Thoracic region	0.28	0.06									
Abdomen-pelvis	0.71**	0.69**	–0.11								
Spine curvature	0.74**	0.53**	0.13	0.39*							
Position of shoulder and scapulae	0.58**	0.36	0.05	0.26	0.32						
Foot	0.56**	0.48*	0.27	0.44*	0.24	0.37					
Pain intensity	0.45*	0.39*	0.31	0.29	0.23	0.22	0.17				
Flexion at the ankle joint	–0.67**	–0.60**	–0.26	–0.45*	–0.48**	–0.33	–0.34	–0.78**			
Extension at the ankle joint	–0.49**	–0.38	–0.18	–0.28	–0.35	–0.39*	–0.15	–0.64**	0.78**		
Gait	0.69**	0.45*	0.41*	0.25	0.59**	0.56**	0.41*	0.51**	–0.53**	–0.55**	
Podogram	0.64**	0.47*	0.49*	0.34	0.59**	0.21	0.38	0.60**	–0.63**	–0.38*	0.77**

Note: * $p < 0.05$, ** $p < 0.01$

The number of correlations significantly decreased after application of the exercise programme. Overall body posture was correlated with head-neck, abdomen-pelvis, spine curvature, position of shoulders and scapulae as well as the podogram test results. The shape of the foot assessed by the podogram test was correlated with better head posture and gait. The spine curvature correlates with the position of shoulders and scapulae, which affects the foot test results. There is also a correlation between flexion and extension at the ankle joint, which have an influence on the pain intensity test results. Assessments of the thoracic region did not show any significant correlations (Table 5).

Table 5. Correlation coefficients between individual tests after application of the programme

Variable	Overall body posture	Head-neck	Thorax	Abdomen-pelvis	Spine curvature	Position of shoulders and scapulae	Foot	Pain intensity	Flexion at the ankle joint	Extension at the ankle joint	Gait
Head-neck	0.66**										
Thoracic region	0.05	–0.04									
Abdomen-pelvis	0.58**	0.36	–0.27								
Spine curvature	0.69**	0.26	–0.14	0.13							
Position of shoulders and scapulae	0.69**	0.17	–0.13	0.25	0.56**						
Foot	0.53**	0.33	0.12	0.25	0.25	0.50*					
Pain intensity	–0.07	0.23	–0.27	0.25	–0.26	–0.17	–0.13				
Flexion at the ankle joint	0.16	-0.18	0.22	-0.20	0.34	0.28	0.11	–0.79**			
Extension at the ankle joint	0.17	–0.11	0.26	–0.24	0.29	0.27	–0.07	–0.76**	0.89**		
Gait	0.24	0.33	0.14	–0.10	0.14	0.21	0.34	–0.02	0.18	0.02	
Podogram	0.29	0.46*	0.16	0.04	0.16	0.05	0.32	0.10	–0.08	–0.17	0.8**

Note: * $p < 0.05$, ** $p < 0.01$

Discussion

The presented results cannot be generalized. They should be perceived as the basis for development of syllabi for physical and sports education in relation to students' postural health.

This empirical research study helps expand the knowledge of how exercises focused on the musculoskeletal system can be used in physical and sports education classes and how motor skills can be learned and acquired. The initial assessments and tests V_1 showed that the overall body posture and its segments as well as the shape of the foot and pain intensity were worse in comparison to final evaluations V_2. These findings prove that there are correlations in terms of functional disorders, which are interrelated and the symptom of which is pain. Appropriate diagnostics and intervention can be used as primary prevention of students' postural health disorders.

Furthermore, the results show and confirm the relationships that exist in the musculoskeletal system and influence each other, either in a positive way as we have observed in the output assessment (V2), or in a negative way, as we have observed in the input assessment (V1) between the overall posture, the individual posture segments, and the foot itself. We found that foot functionality influences overall posture, which is a manifestation of the functionality of the muscular system, as well as gait. Hence, improper foot functionality causes a number of orthopaedic impairments (improper spinal curvature in both the lateral and sagittal directions, scapular alignment, improper pelvic tilt, improper head posture) and also affects the status of locomotor abilities, which include gait itself.

In this context, Hillstrom et al. (2013), Zambojová (2013) and Shtin Baňárová (2019) state that the foot is the first source of information for postural stabilisation. Foot deformities lead to changes in muscle tension and motor patterns. In addition, they lead to a muscular imbalance that subsequently results in the development of musculoskeletal disorders. Kolář et al. (2010) also state that flat feet are often symptoms of bad body posture. This means that foot motions can fully activate muscles of the lower limb and contribute to stabilisation of the body as a whole. Motions of the foot do not involve only isolated muscle activity but also coordination between muscles, the cerebellum, and the ear along with conscious control of movements. Foot disorders can also disrupt stability of the thorax (McKeon et al., 2015). According to Lewit, Lepšíková (2008), foot problems can be predictors of mobility impairment. The shape of the foot is closely correlated with the pelvic floor, the deep stabilisation system as well as the superior thoracic aperture and the floor of the oral cavity (McKeon et al., 2015).

Healthy feet and proper gait patterns contribute to overall postural health of students in the long term (Adamec, 2005; Lynn et al., 2012; Kim, Kim, 2016; Kinclová, 2016; Skaličková-Kováčiková, 2016; Unver et al., 2019; Bendíková et al., 2020; Nemček, Ladecká, 2020; Okamura, Ladecká, 2020; Okamura et al., 2020; Kisacik et al., 2016, 2021; Park et al., 2021). Application of health-oriented exercises, procedures, and programmes within physical and sports education classes in physically active schools seems to be an appropriate tool for prevention of bad body posture in students (Černický et al., 2018; Bendíková, Balint, 2023).

In conclusion, we add, that increasing the popularity and interest in physical and sports education can be achieved through the possibility of creating an education program, with its own program structure and curriculum, which is approved by the subject commission within the School Education Program (Bendíková, 2018, 2020).

Conclusion

We regard our findings to be very important for pedagogical and clinical practice. We managed to bring about positive changes in the students' overall body posture and foot functions in a relatively short time and space that physical and sports education offers. We proved that the correct intervention resulted in better functionality of the foot and improvements in the overall posture and the posture of individual segments of the body. At the same time, we have demonstrated the relationships between the foot and the observed factors, which confirms the existence of the interplay of the different areas of the muscular system as a whole.

These findings prove that it is necessary to diversify the syllabus of this school subject and focus more on the prevention of postural disorders among pupils and students.

Acknowledgments A pilot cross-sectional study in the framework of longitudinal research, through which we point out that insufficient primary prevention of postural health in childhood causes serious health problems of the musculoskeletal system in adulthood. The study was conducted according to the guidelines of the Declaration of Helsinki. This study was supported by a member of the SSDRL research group of Prince Sultan University.

Funding The study is part of the research project VEGA „1/0427/22" Prevention of pupils' postural health by physical activity".

References

Adamec, O. (2005). Plochá noha v dětském věku - diagnostika a terapie = [Flat foot in childhood - diagnosis and therapy]. *Pediatrie pro praxi,* 6(4), 194–196.

Baicry, J., & Paris, L. (2017). *Propriofoot.* [online]. [cited 30.03.2020]. Available on: <http://www.propriofoot.com/proprioception-cheville/home.html>

Biancalana, V., Massimo, M., Lucchetti, C., & Nart, A. (2020). Balance and posture: effects of proprioceptive training on a group of sedentary people. *Journal of Physical Education and Sport,* 20(S3), 2196–2204. https://doi.org/10.7752/jpes.2020.s3295

Brockett C. L., & Chapman, G. J. 2016. Biomechanics of the ankle. *Orthop. Traumatol.*, 30(3), 232–238. https://doi.org/10.1016/j.mporth.2016.04.015

Bendíková, E. (2017). *Theory of health, movement and lifestyle of human beings.* 1st ed. Debrecen: University of Debrecen, 2017, 164 p.

Bendíková, E. (2018). Health-oriented education in Slovakia related to physical and sport education. *Hungarian educational research journal,* 8(2), 39–49.

Bendíková, E., Novotná, B., Rozim, R., Tomková, Š., Fyodorov, A., & Palaščáková Špringrová, I. (2020). Analysis of physical activity status and functional posture in Slovakia's young school-aged children with different body weight. *Zdravotnícke listy*, 8(2), 71–81.

Bendíková, E. (2020). Diversification of the physical and sport education syllabi and its effects on the musculoskeletal system in young female students. *Trends in Sport Science,* 27(3), 149–155. https://doi.org/10.23829/TSS.2020.27.3-5

Bendíková, E., & Balkó, I. (2022). Acral coactivation therapy method in terms of improving the musculoskeletal system in pupils in physical and sport education. *Trends in Sport Sciences*, 29(3), 107–114. https://doi.org/10.23829/TSS.2022.29.3-4

Bendíková, E., & Balint, G. (2023). Selected factors influencing the qualitative level of postural health of students in Slovakia. *European Journal of Contemporary Education,* 12(3),756–756.

Černický, M., Ratulovská, Z., Pavlíkova, L., Vomela J., & Klein, J. (2018). Škola chrbta ako primárna prevencia chybného držania tela u detí v školskom veku = [Back school as primary prevention of defective posture among school children]. *Zdravotnícky listy*, 6(2), 80–86.

Hillstrom, H. J., Song, J., & Kraszewski, A. P. Hafer, J. F., Mootanah, R., Dufour, A. B., Chow, B. S., & Deland, J. T., 3rd (2013). Foot type biomechanics part 1: structure and function of the asymptomatic foot. *Gait Posture*, 37(3), 445–451. https://doi.org/10.1016/j.gaitpost.2012.09.007

Kim, E., & Kim, J. (2016). The effects of short foot exercises and arch support insoles on improvement in the medial longitudinal arch and dynamic balance of flexible flatfoot patients. *Journal of Physical Therapy Science,* 8(11), 3136–3139. https://doi.org/ 10.1589/jpts.28.3136

Kisacik, L. (2016). Aktivní cvičení dětské ploché nohy = [Active exercise of the children's flat foot]. *Umění fyzioterapie,* 1(1), 32–35.

Kisacik, P., Tunay, V. B., Bek, N., Atay, O. A., Selfe, J., & Karaduman, A. A. (2021). Short foot exercises have additional effects on knee pain, foot biomechanics, and lower extremity muscle strength in patients with patellofemoral pain. *J. Back Musculoskelet. Rehabil.*, 34(6), 1093–1104. https://doi.org/10.3233/BMR-200255

Kolář, P., Bitnar, P., Calta, J., Čakrt, O., Čech, Z., Druga, R., Dyrhonová, O., Hyšperská, V., Knotek, P., Kobesová, A., Kříž, J., Lepšíková, M.,Lewit, K., Marčišová, M., Smékal, D., Šafářová, M., Tomanová, M., Valouchová, P., Vařeka, I., Zedka, M., Zounková, I., ... Zumrová, A. (2010). *Rehabilitace* v *klinické praxi* = [Rehabilitation in clinical practice]. Praha: Galén, 2010. 713 p.

Larsen, Ch. (2005). *Zdravá chůze po celý* život = [Healthy walking for life]. Poznání, 2005, 154 p.

Lewit, K., & Lepšíková, M. (2008). Chodidlo: významná část stabilizačního systému = [Sole – an important part of stabilisation system]. *Rehabilitace a fyzikální lékařství*, 15(3), 99–104. https://www.medvik.cz/link/bmc07516611

Lewitová, C-M. H. (2016). O dětských nohách = [About children's feet]. *Umění fyzioterapie,* 1(1), 5–7.

Lynn, S. K., Padilla, R. A., & Tsang, K. K. (2012). Differences in static- and dynamic-balance task performance after 4 weeks of intrinsic-foot-muscle training: the short-foot exercise versus the towel-curl exercise. *J Sport Rehabil*, 21(4), 327–333. https://doi.org/10.1123/jsr.21.4.327

Myers, T. W. (2009). Anatomy trains: myofascial meridians for manual and movement therapists, (2nd ed.), Edinburgh, Churchill Livingstone: Elsevier. [online]. Av. on: https://www.academia.edu/43890178/Anatomy_Trains_Myofascial_Thomas_W_Myers

McKeon, P. O., Hertel, J., Bramble, D., & Davis, I. (2015). The foot core system: A new paradigm for understanding intrinsic foot muscle function. *Br. J. Sports Med*., 49(5), 290. https://doi.org/10.1136/bjsports-2013-092690

Nemček, D., & Ladecká, P. (2020). Úroveň osobnej pohody stredoškolákov s poruchami muskuloskeletálneho systému = [The level of subjective well-being of high school students with musculoskeletal disorders]. *Zdravotnícke listy*, 8(2), 16–21.

Okumara, D., & Ladecká, P. (2020). Úroveň osobnej pohody stredoškolákov s poruchami muskuloskeletálneho systému. *Zdravotnícke listy*, 8(2), 16–21.

Okamura, K., Fukuda, K., Oki, S., Ono, T., Tanaka, S., & Kanai, S. (2020). Effects of plantar intrinsic foot muscle strengthening exercise on static and dynamic foot kinematics: A pilot randomized controlled single-blind trial in individuals with pes planus. *Gait Posture*, 75, 40–45. https://doi.org/10.1016/j.gaitpost.2019.09.030

Park, D. J., Lee, K. S., & Park, S. Y. (2021). Effects of two foot-ankle interventions on foot structure, function, and balance ability in obese people with pes planus. *Health care,* 9(6), 667. https://doi.org/10.3390/healthcare9060667

Palaščáková Špringrová I. (2018). *Akrální koaktivační terapie* = [Acral coactivation therapy]. NmČelakovice: ACT centrum s.r.o., 2018. 143 p.

Shtin Baňárová, P. (2019). Vplyv tvaru pozdĺžnej klenby nohy na vybrané statické parametre dolnej končatiny = [The impact of the longitudinal foot arch shape on the selected static parameters of the lower limb]. *Zdravotnícke listy*, 7(3), 31–36.

Skaličková-Kováčiková, V. (2016). Ďetská noha a její problémy, principy rehabilitace = [Children's foot and its problems, principles of rehabilitation]. *Umění fyzioterapie,* 1(1), 21–23.

Unver, B., Erdem, E. U., & Akbas, E. (2019). Effects of short-foot exercises on foot posture, pain, disability, and plantar pressure in pes planus. *J. Sport Rehabil*., 29(4), 436–440. https://doi.org/10.1123/jsr.2018-0363

Vařeka, I., & Vařeková, R. (2009). *Kineziologie nohy* = [Kinesiology of the foot]. Olomouc: UP v Olomouci, 2009. 189 p.

Zambojová, I. (2013). Úloha nohy pri chôdzi posturálnej stabilizácií = [The role of the foot in postural stabilization during walking]. *Physiotherapia Slovaca*, 20(1), 24–30.

Véle F. (2006). *Kineziologie: Přehled klinické kineziologie a patokineziologie pro diagnostiku a terapii poruch pohybové soustavy* = [Overview of clinical kinesiology and pathokinesiology for the diagnosis and therapy of movement system disorders]. 2nd edition, Praha: Triton, 2006, 375 p.

Vojtaššák, J. (2000). *Ortopédia* = [Orthopedics]. Bratislava: Slovak Academic Press, 2000, 783 p.

Cite this article as: Bendíková, E., Holgado, J. C., & Uvinha, R. R. (2024). Propriofoot Concept Implemented in Physical and Sports Education Classes with the Aim of Improving Foot Health and Body Posture in Female Students. *Central European Journal of Sport Sciences and Medicine*, *1*(45), 5–15. https://doi.org/10.18276/cej.2024.1-01