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Original Article

Effect of postural training on the correction of spinal vertebrogenic disorders in women

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Abstract
Sedentary behaviour is a risk factor for increased incidence of lower back pain in adults. Women are the most sedentary group of workers, and women working in an office are thus at a high risk for lower back pain. This study was focused on evaluating the effectiveness of compensatory postural training for vertebrogenic disorders in a sample of sedentary women. The study involved four women, who all engaged in sedentary work, with an average age of 53 ± 1.75 (N = 4). The primary objective was to address the challenges associated with vertebrogenic disorders, including limited mobility and associated pain. A targeted movement program was designed as an intervention, incorporating specific exercises derived from the Animal Flow concept. This program aimed to positively impact spine mobility, enhance muscle chain functionality and ultimately alleviate the painful symptoms associated with vertebrogenic disorders. The intervention spanned 6 months. A comprehensive input diagnosis was conducted before initiating the intervention. This involved assessing spinal mobility using non-invasive SpinalMouse® technology. Additionally, the impact of pain on daily life was evaluated using The Quebec Back Pain Disability Scale, and overall quality of life was measured using the WHOQOL-BREF questionnaire. After the 6-month intervention, output diagnostics were performed, and the results were evaluated. The findings affirm the effectiveness of the exercise program for considerably improving spine mobility, and we found an improvement in spinal mobility in the frontal and sagittal planes. Using the Animal Flow program, we found improvements in sleep-related activities, long-term sitting or standing, walking, carrying heavy loads and painful symptoms associated with vertebrogenic disorders.
Keywords: Animal Flow, Spinal disorders, Sedentary women, Compensatory exercise, Spinal mouse

Introduction

Movement is perceived as one expression of human life. The World Health Organization defines physical activity as any body movement produced by skeletal muscles that requires energy expenditure. Physical activity refers to all movement during leisure time, transport to and from a place or as part of employment (WHO, 2021). Because of consistent scientific and technical developments in society, the number of people with an inactive lifestyle is increasing. It has been estimated that 31% of the world's population does not achieve the recommended level of physical activity (Kohl et al., 2012). A dramatic decrease in physical activity results in the development of various chronic diseases and can lead to an increase in musculoskeletal disorders, including pain and disability (Booth et al., 2012).

Sedentary behaviour is characterised as awake activity in a sitting or lying position, resulting in energy expenditure of less than 1.5 metabolic equivalents (Tremblay et al., 2017). Munir et al. (2015) identified women as the most sedentary group of workers, suggesting that women working in an office are a high-risk group with a large amount of sedentary time. Studies have demonstrated the role of sedentary behaviour as a risk factor for the increased incidence of lower back pain in adults, children (Baradaran Mahdavi et al., 2021; Bontrup et al., 2019; Citko et al., 2018) and women (Amorim et al., 2017). Other risk factors for back pain are muscle imbalance and a lack of physical activity. Muscle imbalance is a deterioration in balance between shortened and weakened muscles. This does not only include one muscle because muscles work as a functional unit. Muscle imbalance can be considered one of the primary causes of chronic pain in the motor system and spinal disorders. Moreover, muscle imbalance adversely affects body posture, movement stereotypes and muscle coordination, leading to increased susceptibility to injury and limited range of movement (Barcalová et al., 2017).

Back pain is one of the most common reasons patients seek emergency care (Casiano et al., 2023). Some studies have shown that up to 23% of adults worldwide suffer from chronic lower back pain (Balagué et al., 2012; Hoy et al., 2010). Several studies have indicated that more than 80% of non-athlete patients with lower back pain have nonspecific lower back pain with unknown causes (Hashimoto et al., 2023). Back pain treatment is challenging, and many established interventions have limited efficacy. In treating the spine, conservative intervention, especially exercise, is essential. Effective and early treatment of pain and neuromuscular function through exercise is critical for treating back pain (Hayden et al., 2005). However, it is difficult to determine the most appropriate type of exercise to correct vertebrogenic disorders of the spine. Exercises are suitable if they

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improve body posture and strengthen the deep stabilisation system. Stretching exercises also increase mobility when aimed at the lumbar part of the spinal muscles and can eliminate lower crossed syndrome when developed individually (Pajonková & Lenková, 2023). Postural correction exercises are effective in managing cervicogenic headache (Rani & Kaur, 2023), reducing hyperkyphosis curvature (Katzman et al., 2017) and relieving shoulder pain, mid-back pain, low back pain (Kim et al., 2015) and back pain in general (Toprak Çelenay & Özer Kaya, 2017). Postural exercises have a longer-term effect than other exercise therapies (Paolucci et al., 2018). The training concept called Animal Flow (AF) is an innovative, multi-planar movement concept that combines quadrupedal movement and movement on the ground with one's body weight (Buxton et al., 2022). The AF concept comprises holistic, multi-joint movement patterns (Fitch, Smith 2020). Many of these movements resemble animal postures and movements and reflect the wide range of movements that humans are capable of (Buxton et al., 2022). It is based on activating and connecting muscle chains and allows the individual to work with their current joint mobility. From the point of view of the complexity of the development of vertebrogenic disorders, a movement program containing elements of the Animal Flow concept is suitable and sustainable for improving the mobility of the spine and alleviating painful conditions of the spine (Buxton et al., 2022). Few studies have focused on the benefits of the Animal Flow concept. From this point of view, we see this study as an opportunity to expand the knowledge of the Animal Flow concept in this field.

The study aimed to elucidate the effectiveness of movement intervention with elements of the Animal Flow concept to improve spinal mobility and alleviate vertebrogenic disorders. Based on the results of studies by Buxton et al. (2022), Lemes et al. (2021) and Pyka et al. (2017), we hypothesised that the movement program would positively affect the mobility of the spines of the participants, which will significantly reduce the pain associated with vertebrogenic disorders.

Material & methods

The study included four women with a sedentary job who were an average age of 53 ± 1.75 years with symptoms of vertebrogenic disorders (headaches, migraines, mobility problems, muscle stiffness or weakness, dizziness, nausea, and neurological problems). Before assessing the mobility of individual spine sections, we measured basic somatic characteristics. Body height was determined using a stadiometer SECA 216 (Hamburg, Germany) altimeter. Body weight was determined using an Omron BF214 scale. Based on these data, we calculated the body mass index (BMI) of the subjects. The average height of the women at the beginning of the study was 175 ± 3.75 cm, the average body weight was 80 kg ± 8 kg, and the average BMI of the women was 26.81 ± 2.98 kg/m^2. We diagnosed the mobility of individual spine sections using the non-invasive SpinalMouse® method (Figure 1). SpinalMouse® is a diagnostic device used for non-invasive measurement of the spine profile in the sagittal and frontal plane and the angles between individual segments (Machino et al., 2020). Several studies have shown the reliability, validity and effectiveness of SpinalMouse® (Barrett et al., 2014; Kellis et al., 2008; Livanelioglu et al., 2016; Mannion et al., 2004). We monitored the mobility of the spinal sections in the frontal and sagittal planes. The basic position during diagnosis was for the participants to stand up straight. In the sagittal plane, we measured the curvature of the spine while standing, in trunk flexion, and extension. In the frontal plane, we measured the curvature of the spine while standing and in the lateroflexion of the trunk. Computer software analyses and signal deviations from physiological norms.

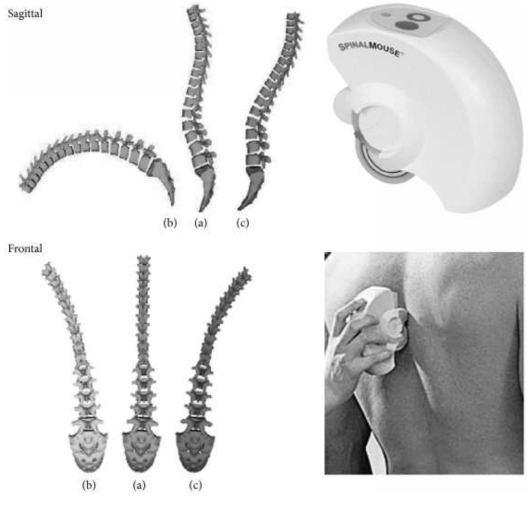

Figure 1. SpinalMouse® diagnostic device

Subjective assessment of the quality of life of the participants was carried out using a validated questionnaire, the generic WHOQOL-BREF (World Health Organization Quality of Life - Short version) (Dragomirecka & Bartoňová, 2006).

We assessed the impact of back pain resulting from vertebrogenic problems on everyday life using The Quebec Back Pain Disability Scale (Kopec et al., 1995). This questionnaire consisted of the following items: Q1 – Get out of bed; Q2 – Sleep through the night; Q3 – Turn over in bed; Q4 – Ride in a car; Q5 – Stand up for 20–30 min; Q6 – Sit in a chair for several hours; Q7 – Climb one flight of stairs; Q8 – Walk a few blocks (300–400 m); Q9 – Walk several kilometres; Q10 – Reach up to high shelves; Q11 – Throw a ball; Q12 -Run one block (approximately 100 m); Q13 – Take food out of the refrigerator; Q14 – Make the bed; Q15 – Put on socks (pantyhose); Q16 – Bend over to clean the bathtub; Q17 – Move a chair; Q18 – Pull or push heavy doors; Q19 – Carry two bags of groceries; Q20 – Lift and carry a heavy suitcase. The questionnaire has a 0- to 5-point scale for each item.

For basic descriptive statistics, we used non-parametric tests due to the small size of the research sample ($n = 4$). For measures of central tendency, we used the median ($\tilde{x}$), and for measures of dispersion, we used quartile deviation (QD), with the minimum and maximum. Comparison of differences was assessed using the Wilcoxon test for dependent sets. The significance of the differences was assessed at $p < 0.05$.

We used the statistical program STATISTICA for statistical processing. We evaluated the data individually. Each subject represented an individual case study. During the evaluation, we monitored the causality of the exercise program. The study aimed to expand the knowledge of the effectiveness of movement intervention using the Animal Flow concept to improve spinal mobility and thus alleviate vertebrogenic disorders.

Intervention

The participants completed a 6-month intervention using the Animal Flow exercise program. The intervention consisted of 60-minute training units (TUs) three times a week under our guidance. Each TU was divided into an introductory, main and final part. In the introductory part, we focused on warming up the body. The main part of TU consisted of compensatory and mobilisation exercises. The final part of the TU consisted of relaxation exercises focused on calming the body.

Figure 2. Photographs of exercises in the Animal Flow intervention program

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Results

Using the answers provided by the participants in the WHOQOL-BREF questionnaire and with the help of the questionnaire manual, we calculated scores on each topic in the questionnaire (Figure 3). We entered the input and output scores of the questionnaires into a table for comparison.

At the beginning of the experiment, subjective evaluations of the quality of life and satisfaction with general and physical health were significantly affected. All participants in our research group noted improvements in quality of life and general, physical and physiological health after our exercise intervention.

Table 1. Results of the WHOQOL-BREF questionnaire

	Subject 1		Subject 2		Subject 3		Subject 4	
Domains	Input	Output	Input	Output	Input	Output	Input	Output
Quality of Life	2	4	3	5	3	5	3	5
General Health	2	4	3	4	2	4	3	4
Physical Health	19	33	24	26	27	31	23	24
Psychological	24	29	25	26	25	27	25	26
Social Relationships	14	14	12	13	14	14	15	15
Environmental Health	33	33	35	35	36	36	33	33

We observed an improvement in subjective feelings when several activities were performed after the participants completed the movement intervention (Figure 3). All participants observed reduced back pain while getting out of bed, during the night, when turning over in bed, during sitting, walking, pushing, pulling and running and during common daily activities. These activities had caused difficulties before our Animal Flow movement intervention.

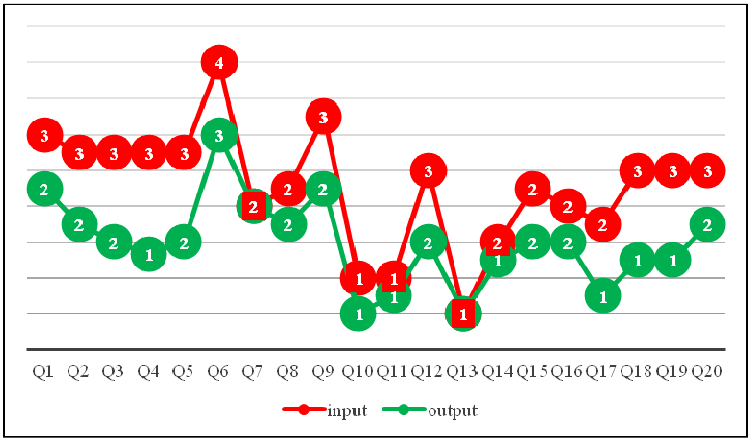

Figure 3. Results of The Quebec Back Pain Disability Scale questionnaire (Kopec et al., 1995).

Results of spinal mobility in the sagittal plane

Figure 4 shows the graphical results of the mobility of the spine of subject 1 in the sagittal plane. We established that subject 1 had a flat back, especially in the lumbar area. Even though the subject's input values were in the range of reference values, we observed an improvement in the mobility of the spine in trunk flexion and extension after the end of the intervention.

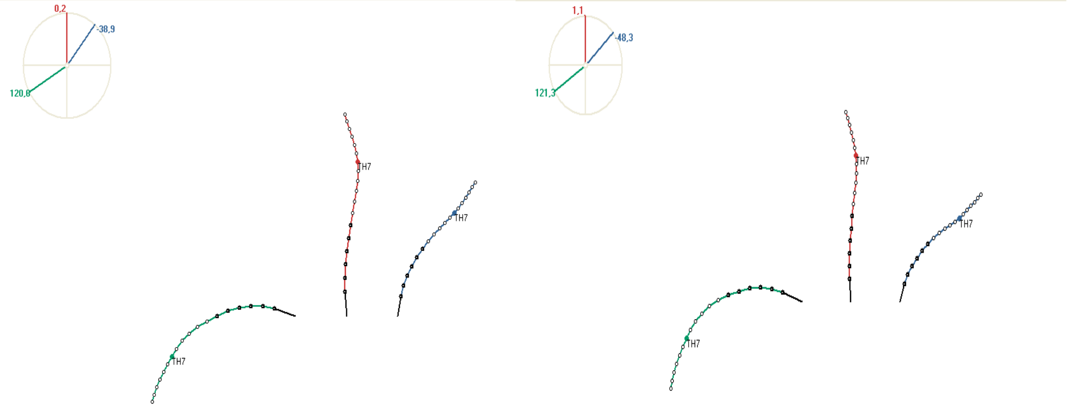

Figure 4. Mobility of the spine in the sagittal plane of subject 1

Figure 5 shows the graphical results of the mobility of the spine of subject 2 in the sagittal plane before and after the exercise program. Before the program began, we observed a slight instability in the standing position in this subject. Subject 2 tended to lean back. However, trunk extension in the sagittal plane was limited and insufficient, and we observed instability in the thoracolumbar part of the spine. After the end of the program, we noticed slightly impaired mobility in terms of trunk flexion and extension towards hypomobility, and there was an improvement in the stability and curvature of the spine while standing. The centre of gravity of the subject's body approached the central axis. Regarding the causes of this state, please see the Discussion below.

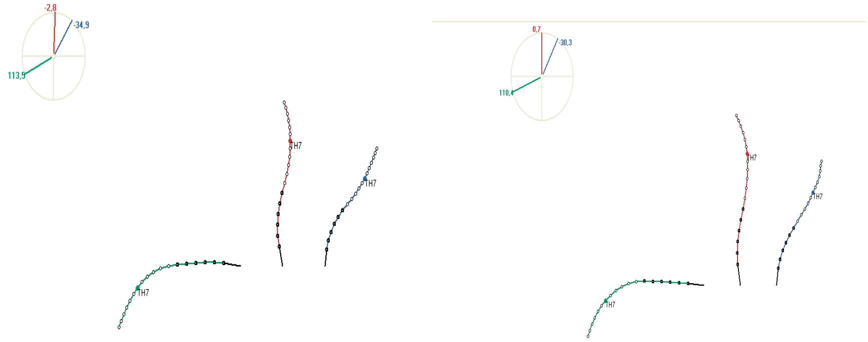

Figure 5. Mobility of the spine in the sagittal plane of subject 2

Figure 6 shows the graphical results of the mobility of the spine of subject 3 in the sagittal plane. We compared the results obtained before and after the program. Before starting the 6-month exercise program, we noted considerable instability of the spine and deviations from the reference values in subject 3. The forward shift of the centre of gravity was reflected in the standing posture with a slight forward tilt of the trunk from the central axis. Lack of mobility was diagnosed during trunk flexion. The trunk extension in the sagittal plane of subject 3 was excessive at the beginning of the study. After the exercise program, we observed significant improvements in the standing, flexion and extension of the trunk of subject 3. While standing, the spine significantly stabilised towards the central axis, and there was a slight correction of the curvature of the spine in individual sections. Trunk flexion increased significantly by 23.4°. Within the trunk extension, we observed a small improvement towards increasing spinal mobility.

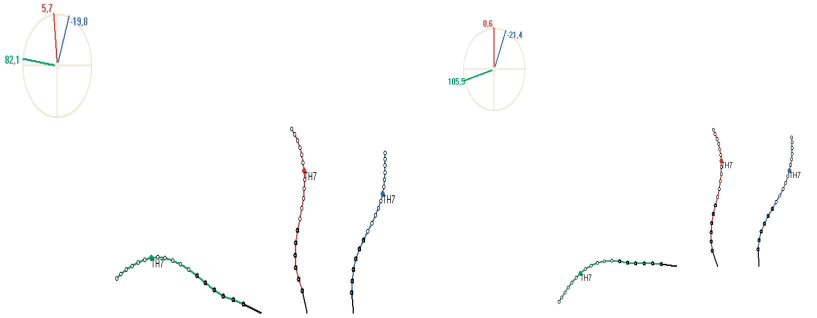

Figure 6. Mobility of the spine in the sagittal plane of subject 3

Figure 7 shows the graphical results of the mobility of the spine of subject 4 in the sagittal plane. After comparing the input and output diagnostics of the mobility of the spine, we found a slight improvement in its curvature and stability in the standing position. There was a significant improvement in trunk flexion of subject 4, up to 48.1°. During extension, we observed a slight deterioration of spinal mobility towards hypomobility.

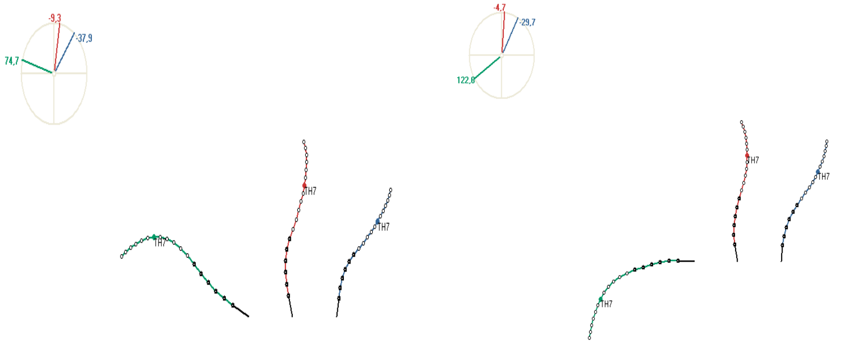

Figure 7. Mobility of the spine in the sagittal plane of subject 4

Table 2 compares the numerical parameters of spinal mobility in the sagittal plane and the differences before and after for the four subjects. Numerical values are given in degrees.

Table 2. Curvatures of the spines of the subjects in the sagittal plane

S	TFI	TFO	VD	SI	SO	VD	TEI	TEO	VD
1	120	121.3	1.3	0.2	1.1	0.9	−38.9	−48.3	9.4
2	113.5	110.4	−3.1	−2.8	0.7	3.5	−34.9	−30.3	−4.6
3	82.1	105.5	23.4	5.7	0.6	5.1	−19.8	−25.7	5.9
4	74.7	122.8	48.1	−9.3	−4.7	4.6	−37.9	−39.9	2
W	p = 0.273			p = 0.715			p = 0.273		

Note: S – subject; **TFI** – trunk flexion input; **TFO** – trunk flexion output; **VD** – value difference; **SI** – Standing input; **SO** – Standing output; **TEI** – trunk extension input; **TEO** – trunk extension output; **W** – Wilcoxon pair test

We did not find a statistically significant difference between the input and output diagnostics of the spine of the subjects in the sagittal plane.

Results of spinal mobility in the frontal plane

Figure 8 shows the graphical results of the mobility of the spine in the frontal plane of subject 1 before and after the exercise program. We observed a leftward shift of the trunk starting from the thoracolumbar part of the spine, which caused an imbalance in lateroflexion. After the program, we observed a larger shift in the trunk, which started from the same point. However, there were no significant changes in comparison to lateroflexion.

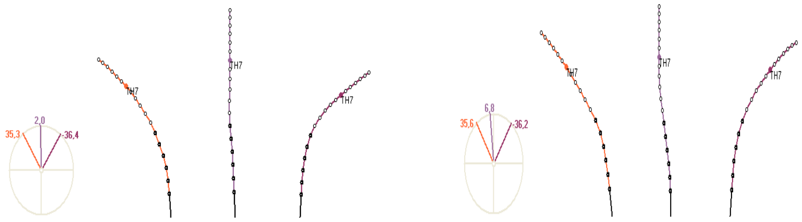

Figure 8. Mobility of the spine in the frontal plane of subject 1

Figure 9 shows the graphical results of the mobility of the spine in the frontal plane of subject 2. In this subject, we found a left-sided shift of the trunk, which also originated at the thoracolumbar part of the spine, and it straightened after the 6-month exercise program. There was a shift towards the central axis of the body. We noted a slight improvement in both lateroflexions after the program.

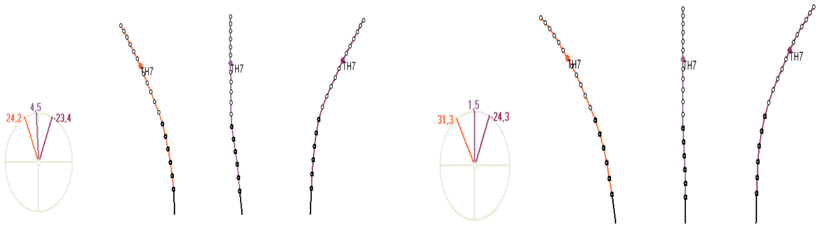

Figure 9. Mobility of the spine in the frontal plane of subject 2

Figure 10 shows the graphical results of the mobility of the spine in the frontal plane of subject 3. We found no obvious deviations from the reference values. In both left and right lateroflexions of the trunk, there was a slight increase in the extent of spine development due to the program. The difference was 4.1° in the left lateroflexion of the trunk and 7.4° in the right lateroflexion of the trunk. We did not find any other significant imbalances.

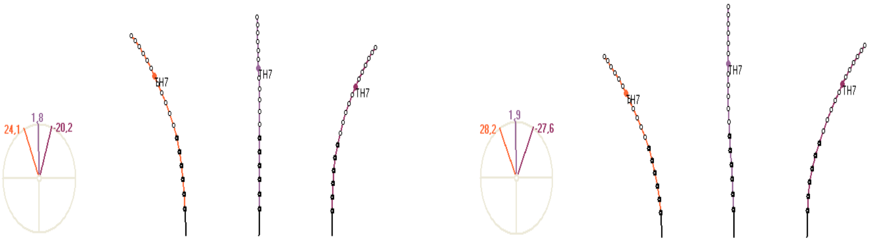

Figure 10. Mobility of the spine in the frontal plane of subject 3

Figure 11 show the graphical results of the mobility of the spine of subject 4 in the frontal plane. Before the beginning of the intervention, we diagnosed a slight left-sided shift of the trunk in subject 4, which again originated from the thoracolumbar part of the spine. During the initial diagnosis, we evaluated this imbalance more positively, as there was a centralisation of the spine and, thus, instability. We noted a slight improvement in the range of mobility of the spine in the bilateral lateroflexions of the trunk due to the exercise program.

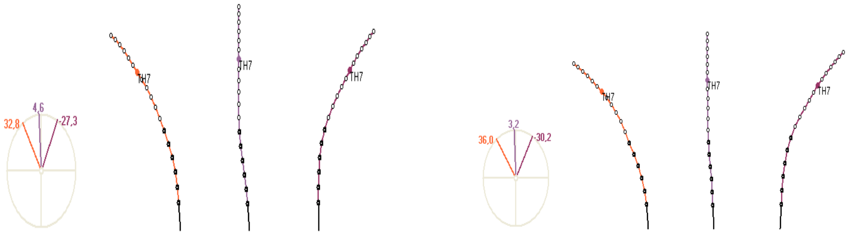

Figure 11. Mobility of the spine in the frontal plane of subject 4

Table 3 shows the range of mobility in degrees of individual positions for each subject. The parameters refer to the diagnosed values within the frontal plane. Differences in values point to a shift in mobility towards hypomobility or hypermobility, depending on the positive or negative sign.

Table 3. Curvatures of the spines of all subjects in the frontal plane

S	LLTI	LLTO	VD	SI	SO	VD	RLTI	RLTO	VD
1	35.3	35.6	0.3	2	3.2	1.2	−36.4	−36.2	−0.2
2	24.2	31.3	7.1	4.5	1.5	3	−23.4	−27.6	4.2
3	24.1	28.2	4.1	1.8	1.9	0.1	−20.2	−27.6	7.4
4	32.8	36	3.2	4.6	2.6	2	−27.3	−30.2	2.9
W	p = 0.067			p = 0.465			p = 0.144		

Note: S – subject; **LLTI** – left lateroflexion of the trunk input; **LLTO** - left lateroflexion of the trunk output; **SI** – standing input; **SO** – standing output; **VD** – value difference; **RLTI** – right lateroflexion of the trunk input; **RLTO**– right lateroflexion of the trunk output; **W** – Wilcoxon pair test

During the input and output interviews with the subjects, we investigated painful conditions in their everyday life. After 6 months of our exercise program, the subjects reported an almost complete disappearance of painful conditions of the spine based on their subjective feelings. However, upon comparison of the input and output diagnostics of their spines in the frontal plane, we did not find a statistically significant difference in left lateroflexion (p = 0.067), right lateroflexion (p = 0.144), in standing (p = 0.465).

Discussion

This study focused on women who have sedentary jobs and have vertebrogenic disorders of the spine. The exercise intervention in our study was postural training. Specifically, we used an innovative training concept based on the quadrupedal movement program Animal Flow. Diagnostics of the subjects were carried out using a relatively new wireless, non-invasive device on the surface of the skin called Spinal Mouse® that does not involve radiation. After the 6-month Animal Flow movement program, we observed an improvement in subjective feelings in all participants. All subjects experienced reduced back pain when getting out of bed, sleeping at night, turning over in bed, sitting, walking, pushing or pulling, running, and during normal daily activities that caused them difficulty before our exercise intervention. Another accompanying phenomenon after the exercise intervention was a decrease in their body weights by 3 kg ± 2 kg (median ± quartile deviation). Still, this change was not statistically significant (p = 0.14). Battaglia et al. (2014) observed that after a specific training mesocycle focused on flexibility, in the sagittal plane in flexion and extension of the spine, an increase in the mobility of the spine in the lumbar part by 29.2% and in the thoracic part by 22.5% was observed. This was similar to subject 3 in our study, who showed improved spinal mobility in flexion by 22% and extension by 23%. Subject 4 showed a significant improvement in spinal flexion by 39% and spinal extension by 5% compared to before the intervention. Spinal disorders, such as pain in the spine during trunk flexion or extension, can negatively affect the entire musculoskeletal system. In people with pain in the lower part of the spine, knee bending increases when flexing the trunk compared to healthy individuals (Gombatto et al., 2017). Reduced range of motion in the sagittal plane of the spine can lead to thoracic hyperkyphosis (Roghani et al., 2022). Spinal disorders, such as thoracic hypokyphosis, hyperkyphosis, lumbar hypolordosis and hyperlordosis, are associated with pathophysiological processes (Chun et al., 2017; Lim & Kim, 2014; Sparrey et al., 2014). Increased spinal mobility can be achieved by increasing the range of motion for trunk flexion, not by stretching the hamstrings (Mitsuda & Nakajima, 2023). The results of a systematic review and meta-analysis suggested that exercise programs may positively affect the thoracic kyphosis angle but have no clear effect on the lordotic angle. The review suggested that strengthening rather than stretching might be more relevant for kyphosis, and both properties are important for lordosis (González–Gálvez et al., 2019). In the frontal plane, subject 2 improved by 7.1° in left lateroflexion and by 4.2° in right lateroflexion, and subject 3 improved by 4.1° in left lateroflexion and by 7.4° in right lateroflexion. These findings contrast with a prior study (Topalidou et al., 2015) that observed an improvement of 7.74° ± 0.68° in left lateroflexion, and another study (Özsoy et al., 2021) observed improvements 32.55° for left lateroflexion and 31.62° for right lateroflexion. Isometric neck strengthening training, also part of the Animal Flow method, has shown that women with chronic non-specific neck pain improved neck flexion, extension, rotation and lateral flexion (Ylinen et al., 2003). Specific scoliosis correction exercises include exercises focused on postural stability and control (Negrini et al., 2015). Subjects 1, 2 and 4 alleviated the left-sided shift of the spine towards the centre of the axis. Thus, we can conclude that the Animal Flow exercise program also helps prevent or correct scoliotic posture.

Conclusion

One of the most important aspects of this study is the appropriateness of applying the new exercise program Animal Flow to improve spinal mobility and alleviate the manifestations of vertebrogenic disorders. Although the Animal Flow training program is primarily a fitness and compensatory training program for professional athletes of various disciplines, it is also a suitable aid for non-athletes. Animal Flow, with its complexity, helps to strengthen the muscles of the entire body based on the theory of muscle chains. Furthermore, its creatively designed movements provide a suitable training program for the exerciser, which is sustainable and constantly motivating in the long term. It also develops coordination skills and improves movement patterns. Given that our research subjects were non-athletes, had a predominantly sedentary lifestyle in their normal lives and suffered from certain vertebrogenic disorders, we assumed that non-physiological spinal mobility would be diagnosed as part of all initial spinal mobility measurements in these subjects. Considering our results, our assumptions were confirmed. We found improvements in the mobility of the spine in the frontal and sagittal planes. With improved mobility, we observed a subjective improvement in the quality of their lives, and the effect of pain during daily activities was reduced. We noted the greatest positive changes in activities related to their sleep, long-term sitting or standing, walking and carrying heavy loads. Over the past decades, we have encountered an increasing number of inactive people who suffer from non-specific back pain (World Health Organization, 2022). Based on statistics, there is an increasing tendency toward back pain and disorders. Importantly, after our exercise program, the subjects subjectively felt relief from back pain.

Research limitations

The low diversity of the research group was a limit of the study.

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