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The effect of stretching exercises on the mobility of the spine in the sagittal plane in people using digital devices – preliminary observations

Wpływ ćwiczeń rozciągających na ruchomość kręgosłupa w płaszczyźnie strzałkowej u osób korzystających z urządzeń cyfrowych – obserwacje wstępne

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Abstract

Introduction. Digital devices and a sedentary lifestyle pose significant health risks in today's society, further exacerbated by the regular adoption of incorrect posture. Prolonged adoption of an incorrect posture can result in pain and impaired spinal mobility.

Aim of the study. The study aims to evaluate the impact of stretching exercises on improving cervical, thoracic and lumbar spine mobility in the sagittal plane. Furthermore, it sought to examine the potential correlation between the occurrence of pain and the duration of digital equipment usage.

Study materials and methodology. The study was conducted on a sample group of 22 individuals aged 18 to 21 (20.11 ± 1.56) years. Linear measurements, including the Schober and Otto-Wurm tests, were used to examine spinal mobility in the sagittal plane. The subjects were given a 10-day programme comprising six stretching exercises to perform autonomously daily. After ten days, line measurements were retaken.

Results. Significant statistical values were observed for spinal ranges of motion in the sagittal plane; no statistically significant value was obtained for the incidence of pain and the duration of use of digital devices.

Conclusions. The subjects demonstrated improvement in cervical, thoracic, and lumbar spine mobility in the sagittal plane following the implementation of stretching exercises. Additionally, a decrease in spinal pain was observed.

Key words:

stretching exercises, sagittal plane, digital devices

Streszczenie

Wprowadzenie. Współczesnym zagrożeniem dla zdrowia są urządzenia cyfrowe i siedzący tryb życia, przy których regularnie przyjmowana jest nieprawidłowa postawa ciała. Długotrwałe przyjmowanie nieprawidłowej pozycji może nie tylko spowodować dolegliwości bólowe, ale doprowadzić do zaburzeń w zakresie ruchomości kręgosłupa.

Cel pracy. Celem pracy jest ocena wpływu ćwiczeń rozciągających na poprawę ruchomości odcinka szyjnego, piersiowego i lędźwiowego kręgosłupa w płaszczyźnie strzałkowej. Ponadto postanowiono sprawdzić, czy istnieje zależność pomiędzy występowaniem dolegliwości bólowych a czasem spędzonym przy urządzeniach cyfrowych.

Materiały i metodyka badań. Badanie zostało przeprowadzone na 22-osobowej grupie w przedziale wiekowym od 18 do 21 (20,11 ± 1,56) lat. W badaniu ruchomości kręgosłupa w płaszczyźnie strzałkowej wykorzystano pomiary linijne, między innymi test Schobera i test Otto-Wurma. Badani otrzymywali 10-dniowy pogram zawierający sześć ćwiczeń rozciągających do wykonywania samodzielnie codziennie. Po dziesięciu dniach dokonano ponownych pomiarów linijnych.

Wyniki. Uzyskano wartości istotne statystycznie dla zakresów ruchu kręgosłupa w płaszczyźnie strzałkowej, nie uzyskano wartości istotnej statystycznie dla występowania dolegliwości bólowych a czasem posługiwania się urządzeniami cyfrowymi.

Wnioski. Wykazano wśród badanych poprawę w zakresie ruchomości odcinka szyjnego, piersiowego i lędźwiowego kręgosłupa w płaszczyźnie strzałkowej po ćwiczeniach rozciągających. Zauważono również zmniejszenie dolegliwości bólowych w obrębie kręgosłupa.

Słowa kluczowe:

ćwiczenia rozciągające, płaszczyzna strzałkowa, urządzenia cyfrowe

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Introduction

The average person spends 10-14 hours a day sitting, or up to 85% of the time. Unfortunately, various factors have contributed to a rise in the prevalence of individuals with musculoskeletal disorders. The detrimental consequences are not exclusive to adults; they also impact children and young people born in the fully digital age. As stated in the "Digital 2023" report, 36 million people use the internet in Poland [1]. The duration of internet use on various devices is typically seven hours, on average [2]. The human body adjusts to the predominant posture assumed throughout the day. Biomechanical analysis provides an understanding of the dynamics of the spine, its stabilisation and the loads exerted on individual structures. The spine is a modular structure with a functional unit comprising two vertebrae and an intervertebral disc. These components overlap and collaboratively form a biomechanical system that functions harmoniously [3]. The biomechanical functions of the spine encompass supporting the body and facilitating movement, absorbing external forces, safeguarding the spinal cord, upholding body balance and postural stability, and transmitting forces between the lower and upper limbs, thus enabling motor coordination throughout the entire body [4-7]. The human spine is distinguished by curvatures such as cervical and lumbar lordosis and thoracic and sacral kyphosis [8]. Properly formed curvature of the spine, along with the alignment of the pelvis and lower limbs, profoundly influence the development of the antigravity muscles. This, in turn, determines the stabilisation of the spine and its axial load [9, 10]. Flexibility is defined as the degree of motion around a joint, accomplished through various methods, such as stretching exercises. When the muscles acting on the joint have an equal degree of stretch, the joint can be moved freely in all ranges [11]. The main task of stretching is to increase the range of mobility around the joints [12]. The most commonly described muscle stretching methods in the literature include static stretching, dynamic stretching and neuromuscular techniques [12-17]. We assume a sedentary position during the day at work, on our commute home in the car or public transport, during meals and as forms of relaxation, such as reading books and watching television. Children are restricted in their movement from an early age, depriving them of opportunities for spontaneous, unrestrained movement [18]. Prolonged sitting can contribute to dysfunctions such as cognitive decline, postural disorders, upper crossed syndrome, respiratory and gastrointestinal dysfunction, overweight and obesity, type 2 diabetes, cancer, the development of cardiovascular disease, lipid disorders, depression and anxiety disorders, as well as sleep disorders and mental fatigue [19-26]. More than 80% of Poles use a computer or laptop at least several times a week, and more than half of the population spends more than four hours a day in front of a screen [27]. According to research conducted by the CBOS Institute for Market, Opinion and Society Research, in 2021, as many as 96% of Poles used a mobile phone, with more than half spending over two hours daily on their phones [28]. Over 70% of the subjects spent more than three hours a day in front of screens on digital devices, and 48% experienced back pain [29]. 50% of Americans experience back pain associated with

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the use of digital devices [30], and nearly 70% of Japanese suffer from pain associated with the use of digital devices [31]. The most common health problems among people who use digital devices are headaches, cervical spine pain and carpal tunnel syndrome [32]. In addition, postural disorders can also be a consequence, related to reduced extension of the cervical region and trunk, which can lead to back pain, scoliosis, hyperkyphosis or flat feet [33]. The use of digital devices before bed can disrupt the diurnal rhythm and affect sleep quality [34]. Extended periods of device screen exposure can cause eye fatigue, dryness, burning, and dry eye syndrome. Additionally, they can contribute to addiction to the internet, video games, or social media and affect stress levels. The phenomenon known as 'text neck', 'texting neck', or 'tech neck' is becoming a more prevalent problem. It refers to the forward head posture (FHP) and is a defining problem that can result in injury and tension pain in the cervical spine and shoulder joint. This is caused by excessive and prolonged staring at a handheld device [38, 39]. Patients diagnosed with spinal diseases may be eligible for conservative treatment and/or surgical intervention [40]. A programme designed to prevent overload during work, physical activity, and rest involves learning and reinforcing proper movement patterns daily, removing equipment and objects from the surrounding environment that cause spinal overload, and adopting correct physical activity and rest practices. [41]. Interrupting prolonged sitting with activities unrelated to sitting is a recommended strategy [42]. A crucial preventive measure is to incorporate exercise gymnastics into daily routines to enhance muscle strength and improve overall fitness [43]. It is essential to adhere to the recommendations for correctly assuming the neutral position in standing and sitting [44]. Proper posture is characterised by a straight head, a straight spine in the frontal plane with physiological curves, a correctly arched chest, aligned shoulders, tightened shoulder blades, a slightly retracted abdomen, a neutral pelvic position, tight gluteal muscles, parallel positioning of the lower limbs, and correct positioning and arched feet [45-48].

Aim of the study

Before the study, the following research hypothesis was established: a sedentary lifestyle causes reduced mobility in the cervical, thoracic and lumbar regions of the sagittal plane.

The study aims to evaluate the impact of stretching exercises on improving cervical, thoracic and lumbar spine mobility in the sagittal plane. Furthermore, it sought to examine the potential correlation between the occurrence of pain and the duration of digital equipment usage.

Material and methodology

The study included a cohort of 22 subjects aged 18-21 years (20.11 ± 1.56), comprising 11 women and 11 men. The study was conducted with the approval of the Bioethics Committee of the Poznan University of Medical Sciences No. 559/23 and the subjects' written consent.

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The subjects constituted one study group. Subjects eligible for the study declared that they had no health problems and no history of injury, trauma, or surgery in the spinal area. Before the study began, points were marked on the subjects' skins with a marker, which would subsequently be used to measure a particular section of the spine. The following were measured in the sagittal plane: cervical spine [49], thoracic spine with the Otto-Wurm test [50], and lumbar spine with the Schober test [50]. The subjects' weights were determined using a medical scale (SECA 799 electronic column scale), body height was measured, and BMI was calculated. The subjects' waist and hip circumferences were measured to ascertain the WHR ratio and determine the presence of gynoid or android obesity. The subjects were asked about the time they spent on their digital devices daily, with the results showing the aggregated time over 10 days. During the baseline and endline measurements, the subjects were questioned if they had any complaints of back pain. The subjects were instructed on how to perform the exercises, which included a training plan consisting of seven stretching exercises performed for 10 days, once a day in two series, one after the other. The stretching exercise plan included the following exercises: cervical spine flexion, thoracic spine flexion, forward flexion in a straight sitting position, forward lunge, thoracic spine extension in a two-legged kneeling position, trunk extension in a one-legged kneeling position. Each exercise was repeated 10 times, holding each position for 5-10 seconds. Descriptive statistical analysis, Shapiro-Wilk test, Spearman's rho correlation analysis, Wilcoxon rank-sum sign test, McNemar test and Student's t-test for independent samples were utilised. The statistical results were analysed using the statistical package IBM SPSS Statistics version 26. The classic threshold of $\alpha = 0.05$ was used as the significance level.

Results

The first step in the analysis encompassed the computation of basic descriptive statistics, accompanied by the application of the Shapiro-Wilk test to assess the normality of the distribution (improvement in mobility based on differences in measurement before and after 10 days of exercise, table 1).

Table 1. Basic descriptive statistics with the Shapiro-Wilk test result

	M	Me	SD	Sk.	Kurt.	Min.	Max.	W	p
Time spent on digital devices	108.45	110.00	32.00	0.44	−0.09	60.00	176.00	0.96	0.432
for lack of improvement	100.00	101.50	32.07	−0.26	0.49	60.00	137.00	0.96	0.982
for improvement	122.63	118.50	37.36	0.33	−1.01	77.00	176.00	0.92	0.416
Cervical section Flexion									
Before	1.95	2.00	0.43	0.67	−0.10	1.50	3.00	0.84	0.002
After 10 days	2.61	2.50	0.38	−0.41	−1.04	2.00	3.00	0.80	< 0.001
Improvement	0.66	0.50	0.36	−0.57	−0.76	0.00	1.00	0.78	< 0.001

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	M	Me	SD	Sk.	Kurt.	Min.	Max.	W	p
Cervical section Extension									
	7.77	7.75	0.81	0.68	1.28	6.50	10.00	0.92	0.095
	8.36	8.50	0.49	1.27	5.55	7.50	10.00	0.72	< 0.001
	0.59	0.50	0.48	−0.04	−1.33	0.00	1.50	0.83	0.001
Otto-Wurm Flexion Test									
	2.82	2.50	0.82	0.51	−1.38	2.00	4.00	0.80	< 0.001
	3.64	4.00	0.44	−0.60	−1.48	3.00	4.00	0.72	< 0.001
	0.82	1.00	0.61	−0.09	−0.92	0.00	2.00	0.87	0.008
Otto-Wurm Extension Test									
	1.39	1.75	0.77	−0.96	−0.53	0.00	2.00	0.75	< 0.001
	1.68	2.00	0.52	−1.92	3.90	0.00	2.00	0.67	< 0.001
	0.30	0.00	0.43	0.95	−0.92	0.00	1.00	0.66	< 0.001
Schober Flexion Test									
	14.70	15.00	0.43	−0.95	−0.92	14.00	15.00	0.66	< 0.001
	14.95	15.00	0.15	−3.06	8.09	14.50	15.00	0.33	< 0.001
	0.25	0.00	0.37	1.16	−0.02	0.00	1.00	0.68	< 0.001
Schober Extension Test									
	8.05	8.00	0.74	0.80	1.02	7.00	10.00	0.91	0.037
	8.16	8.00	0.70	0.53	1.48	7.00	10.00	0.86	0.004
	0.11	0.00	0.21	1.40	−0.06	0.00	0.50	0.52	< 0.001

M: Mean, Me: Median, SD: Standard Deviation, Sk.: Skewness, Kurt.: Kurtosis, Min.: Minimum, Maks.: Maximum,

W: Test statistic from the Shapiro-Wilk test, p: p-value

It was checked whether the subjects still experienced back pain after the relaxation exercises. Measurements before and after 10 days were compared using the McNemar test (table 2, fig. 1).

Table 1. Age of respondents.

	Perception of spine pain	Decline	p
Before	54.5%	36.3%	0.008
After	18.2%		

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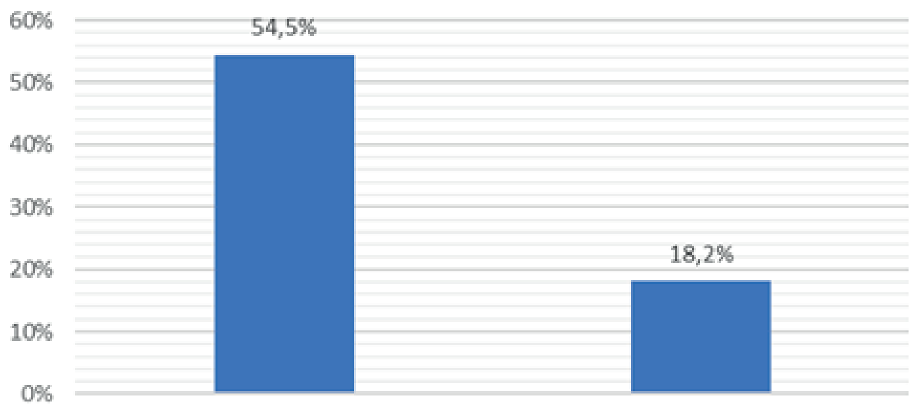

Figure 1. Distribution of pain sensations before and after exercises

The results of the test conducted proved to be statistically significant. During the initial measurement, over half of the subjects (54.5%) reported experiencing spine pain, whereas in the final measurement, only 18.2% of the group reported experiencing pain. In the subsequent step, a series of Wilcoxon rank-sum sign tests were conducted to determine whether there was a discernible increase in spinal mobility after completing the stretching exercises with a 10-day gap (as indicated in tab. 3).

Table 3. Comparison of cervical, thoracic and lumbar spine mobility in the sagittal plane after stretching exercises

Dependent variable	Before		After 10 days		Z	p	r
	Mdn	IQR	Mdn	IQR			
Cervical section Flexion	2.00	0.63	2.50	0.50	−3.94	< 0.001	0.59
Cervical section Extension	7.75	1.50	8.50	0.50	−3.51	< 0.001	0.53
Otto-Wurm Flexion Test	2.50	2.00	4.00	1.00	−3.60	< 0.001	0.54
Otto-Wurm Extension Test	1.75	1.00	2.00	0.50	−2.60	0.009	0.39
Schober Flexion Test	15.00	0.63	15.00	0.00	−2.60	0.009	0.39
Schober Extension Test	8.00	1.00	8.00	0.50	−2.24	0.025	0.34

Mdn: median, IQR: interquartile range, Z: distance of a score from the mean, p: p-value, r: effect size

The analysis revealed statistically significant variances in the measurements before and after a 10-day interval of stretching exercises for each spinal segment in the sagittal plane. All effects were strong, except for the Schober test score at extension (moderate effect). The results indicate that the subjects showed an improvement in cervical, thoracic, and lumbar spine mobility in the sagittal plane after the stretching exercises.
The Wilcoxon repeated measures test was utilised to determine the significance of variations between the outcomes of the two measurements (tab. 4).

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Table 4. Wilcoxon repeated measures test results - the significance of differences between the first and second measurements

Variable	W		p	r_{rb}	95% CI Lower	95% CI Upper
Cervical section Flexion	0.00	***	0.001	−0.51	−0.72	−0.21
Cervical section Extension	0.00	***	< 0.001	−0.71	−0.84	−0.50
Otto-Wurm Flexion Test	0.00	*	0.012	−0.19	−0.49	0.15
Otto-Wurm Extension Test	0.00	***	< 0.001	−0.55	−0.75	−0.27
Schober Flexion Test	0.00	*	0.037	−0.13	−0.44	0.21
Schober Extension Test	0.00	*	0.012	−0.29	−0.57	0.04

** p < 0.05, ** p < 0.01, *** p < 0.001*

Subsequently, a test was conducted to determine if there was any difference in the time spent with digital devices between the subjects who experienced improvement in their perceived back pain and those who did not. The analysis was conducted using the Student's t-test for independent samples. The test results were found to be statistically insignificant, suggesting that there were no significant differences between the compared groups (tab. 5, fig. 2).

Table 5. Differences in time spent on digital devices according to the occurrence of improvement in back pain (a subject was considered an improvement if they fulfilled two conditions: a) had pain at the initial measurement; b) had no pain at the final measurement. Individuals who initially reported no pain were therefore excluded from the analyses (n = 10)

Dependent variable	No improvement (n = 4) M	No improvement (n = 4) SD	Improvement (n = 8) M	Improvement (n = 8) SD	t(10)	p	95% CI LL	95% CI UL	Cohen's d
Time spent on devices	100.00	32.07	122.63	37.36	−1.03	0.327	−71.55	26.30	0.63

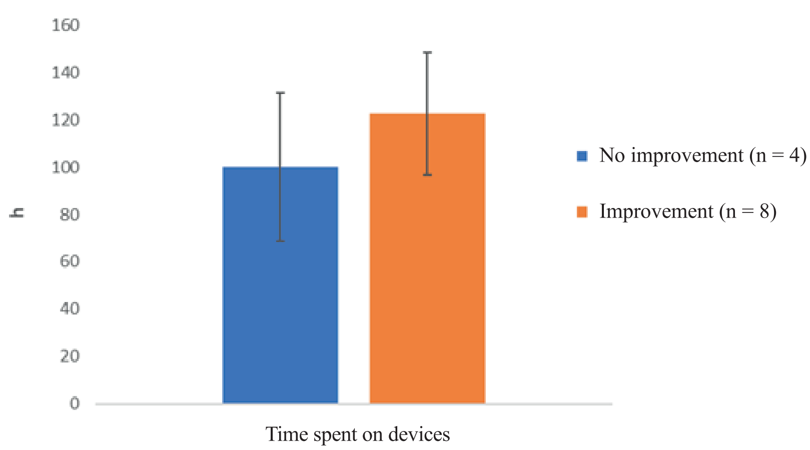

Figure 2. Mean values with a 95% confidence interval for time spent on digital devices when broken down by the occurrence of improvement in back pain

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Table 6. Correlations between time spent on digital devices and changes in mobility

Improvement	Time spent on devices	
	Spearman's rho	p
ΔC flexion	0.11	0.619
ΔC extension	−0.12	0.609
ΔTest Otto-Wurm Flexion	0.23	0.307
ΔTest Otto-Wurm Extension	0.11	0.631
ΔTest Schobert Flexion	−0.36	0.102
ΔTest Schobert Extension	0.06	0.791

Discussion

According to research by Ipsos for Huawei, 67% of subjects reported an increase in time spent in front of the computer compared to before the pandemic, with 40% of people indicating an increase of 1-2 h per day, 31% of subjects claiming an increase of up to 3-4 h per day, while 16% opted for 4 h or more [51]. It's not the digital devices that are the problem, but rather the incorrect posture adopted when using them. It is worth noting the importance of diagnosing posturogenesis at the age of 7-10, the first critical stage [52, 53]. Children are most susceptible to spinal disorders during the development phase and puberty [54]. Neglecting initial spinal disorders can cause function deterioration and increased cardiopulmonary conditions [55-58]. The study showed that appropriately selected stretching exercises resulted in a statistically significant improvement in ranges of motion for both flexion and extension in the cervical, thoracic and lumbar regions after just 10 days. A significant improvement in back pain was also observed. Flexibility is now acknowledged as a crucial factor influencing human health [59-63]. Flexibility is the ability to perform high-amplitude movements [60-64]. The significance of the sagittal plane in the spine lies in its impact on the spine's mobility and stability in terms of rotational movement and lateral tilt [65, 66]. Maintaining proper spinal mobility is paramount in promoting spinal health and preventing back pain [67]. Regular stretching can help decrease work-related pain and improve joint range of motion [68]. Stretching exercises can enhance joint mobility by increasing the range of motion [69-75]. It has also been noted that inappropriate stretching exercises can cause or exacerbate skeletal disorders [68]. Yoga can be an excellent complement to stretching exercises in treating musculoskeletal disorders [76]. Stretching and strengthening exercises for the abdominal and trunk muscles have a beneficial effect on reducing pain and improving function in people with chronic lower back pain [77]. It has also been observed that these effects are more pronounced when exercise is performed regularly [77]. Stretching exercises are also recommended for people with scoliosis [78]. It has been found that there is an association between smartphone use and spinal posture in young people [79]. It was observed that individuals who used their phones while lying down had significantly better spinal posture than

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those who used their phones while sitting or standing [79]. Prolonged screen time can adversely affect spinal posture [80]. Extended use of digital devices is linked to text neck syndrome and the development of pain in the neck and thoracic region [81].

Conclusions

The subjects demonstrated improved cervical, thoracic, and lumbar spine mobility in the sagittal plane. Stretching exercises help to reduce back pain. No correlation was observed between pain and the time spent on digital devices.

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