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Original Article

The relationship between the autonomic nervous system the deep stabilization system

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Abstract:
Problem: Problem: The deep stabilizing system (DSS) is commonly weakened in individuals due to inadequate recognition of its significance. By examining core body issues alongside assessments of autonomic nervous system function (HRV), we uncover potential direct correlations between these seemingly disparate physiological functions. Utilizing DSS tests following Kolář's methodology and HRV measurements via the VarCor PF 7 device, data collection occurred from January 2021 to February 2023. The study included 90 respondents, 48 men and 42 women, with an average age of 42 years. Upon identifying the DSS weakness, the respondent was included in the study, and an initial HRV assessment was conducted using Var Cor PF 7. The patient then underwent an average of 10 sessions to improve the DSS, and after the rehabilitation was completed, we conducted an exit HRV assessment. Data were processed in the statistical program using the One-Sample Kolmogorov-Smirnov test, followed by Descriptive Statistics, and finally, the data were evaluated using the Wilcoxon Signed Ranks Test. The aim of this study was to determine whether DSS weakness has an impact on the shift of the sympatho-vagal balance. First, we evaluated the values before and after rehabilitation using the One-Sample Kolmogorov-Smirnov test, assessing the components of power VLF, power LF, power HF, and LF/HF, and then evaluated the results.
Key Words: **dss, hrv, rehabilitation, autonomic nervous system**

Introduction

"The 'core,' also referred to as the lumbopelvic-hip complex, is a three-dimensional space with muscular boundaries: the diaphragm (superior), abdominal and oblique muscles (anterior-lateral), paraspinal and gluteal muscles (posterior), and the pelvic floor and hip girdle (inferior). The inherent nature of these muscular boundaries creates a corset-like stabilization effect on the trunk and spine (Huxel & Anderson, 2023). The core maintains the equilibrium of the vertebral column within its physiological limit by reducing postural displacement after unexpected perturbations. This requires immediate activation of the central nervous system to evoke optimal muscle recruitment for stability and mobility. Core muscles provide the necessary stability for force production in the lower limbs and effective control of body movements (Zemková & Zapletalová, 2022).

The stability (or stiffness) of the spine depends on the dynamic coordination of many synergistic and antagonistic muscles for precise control of excessive joint motion while allowing for the generation of necessary moments for desired multi-joint movement (Frank et al., 2013).

Deformations of the locomotor apparatus, especially of the spine and body, are already a serious problem in children (Rusnák et al., 2019). Incorrect body posture is recognized as a risk factor for the future development of pathological, functional, and morphological painful conditions of the spine (Kutiš et al., 2017).

The diaphragm, one of the respiratory muscles, plays a key role in the respiratory pump. Additionally, it influences respiratory function in controlling breathing, as well as the human figure. Breathing performed by contraction of the diaphragm is called diaphragmatic breathing. To date, there are many studies related to diaphragmatic breathing; diaphragmatic breathing is used in various areas including Pilates, yoga, and core stability exercises. Specifically, diaphragmatic breathing can support lung function and trunk stability (Yong et al., 2017).

There is compelling evidence that some of the protective and therapeutic effects of exercise training are significantly associated with effects on the autonomic nervous system (Joyner & Green, 2009).

Physical or mental stress is characterized by prevailing sympathetic activity, which promotes adaptation to stressors by increasing arousal levels, resulting, among other things, in increased heart rate. Conversely, parasympathetic activity is primarily responsible for reduced arousal levels and relatively low heart rate, ensuring safe and stable conditions. This depends on the extent to which an individual can reasonably regulate

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their arousal level and the ability of the autonomic nervous system to adapt to changing environmental conditions (Eszter et al., 2022).

The autonomic nervous system has a wide reach and extends to most organ systems in the body. Therefore, the study of autonomic function is often associated with a specific target organ of interest (Gibbons, 2019). Physical exercise stimulates the autonomic nervous system to varying degrees. Heart rate variability (HRV) has been used to assess the effect of physical exercise on autonomic nervous system activity. However, a wide range of results regarding the effect of physical exercise on the autonomic nervous system, as measured by HRV, has been reported (Yamanaka et al., 2015).

Long-term participation in exercise training induces resting bradycardia accompanied by reduced sympathetic activity and/or increased parasympathetic activity and a significant decrease in resting heart rate. Furthermore, increasing evidence suggests that regular exercise can reduce individual stress levels and also increase well-being. Based on this principle, regular physical exercise can potentially create optimized HRV for psychosomatic well-being and alleviate stress (Zou et al., 2018).

Heart rate (HR) in healthy individuals is influenced by physical, emotional, and cognitive activities, and physiological oscillations leading to variable fluctuations in heart rate between individual beats are known as HRV (Tyagi & Cohen, 2016).

The heart has the ability to change the RR interval in different situations. This is due to the close mutual dependence of the autonomic nervous system and its two components, the sympathetic (SNS) and parasympathetic (PNS) nervous systems with the cardiovascular system (Martínez-González-Moro et al., 2022). Heart rate is the number of heartbeats per minute. Heart rate variability (HRV) represents the fluctuation in time intervals between adjacent heartbeats. HRV indexes neurocardiac function and is generated by interactions between the heart and brain and dynamic nonlinear processes of the autonomic nervous system (ANS). HRV is the resultant property of interconnected regulatory systems that operate on different time scales to help us adapt to environmental and psychological challenges. HRV reflects the regulation of autonomic balance, blood pressure (BP), gas exchange, intestinal activity, heart and vascular tone, which refers to the diameter of blood vessels that regulate blood pressure, and probably also facial muscles (Shaffer & Ginsberg, 2017).

Material & Methods

The data were collected in a private rehabilitation facility in northern Slovakia, in the Orava region. All participants agreed to be included in the study. Initially, all participants were assessed for the weakness of the deep stabilizing system, and subsequently, heart rate variability (HRV) measurements were conducted using the VarCor PF 7 device. Each participant then underwent rehabilitation focused on strengthening the lower back, abdominal, and gluteal muscles to improve the core of the body. Participants were also provided with a home rehabilitation exercise plan to enhance the effectiveness of rehabilitation. The rehabilitation plan used the DNS (Dynamic Neuromuscular Stabilization) method, which incorporates elements of ontogenetic development. After 10 sessions, a follow-up HRV measurement was performed. The study included 90 participants with an average age of 42 years.

Each measurement lasted an average of 12-15 minutes, involving 3 positions. Firstly, the patient lay down, then stood up, and in the third position, the patient lay down on the bed again and performed deep breathing. For our measurements, the relevant values were obtained from the third position, where the patient attempted diaphragmatic breathing. The device evaluates 300 representative RR intervals from the EKG. RR intervals, which are short-term recordings, are transformed into cycles in Hz.

The spectrum is divided into several components, expressed as spectral power density (PSD) in ms^2/Hz. Components VLF, LF, and HF are evaluated. The assessment of VFS was conducted using the non-invasive VarCor PF7 diagnostic system. The EKG signal is recorded using a chest strap of the Polar type, connected via a cable to a UHF transmitter located on the left arm. The signal is then transmitted wirelessly (via radio) to a UHF receiver, which is connected to the computer via a USB port. The transmitted information is processed using a specialized computer program.

Statistical analysis first involved a non-parametric test, the One-Sample Kolmogorov-Smirnov Test, to assess the normality of individual measured values before and after rehabilitation. Subsequently, we analyzed all the data together using descriptive statistics. The Wilcoxon Signed Ranks Test helped determine positive and negative ranks, allowing us to evaluate the research goal. The test statistic indicated the level of significance.

Results

In the tables numbered 1, 2, 3, and 4 shown below, we can observe the assessment of individual data obtained from VarCor PF 7 using non-parametric tests. Table number 1 evaluates the Power VLF (Very Low Frequency), which indicates sympathetic activity.

Table number 2 assesses Power HF (High Frequency), which is responsible for parasympathetic activity. Furthermore, in table number 3, we analyze the LF/HF data, which means we are evaluating low-frequency range versus high-frequency range, reflecting sympathetic and parasympathetic activity.

Table 1

One-Sample Kolmogorov-Smirnov Test

			Power VLF before	Power VLF after
N			90	90
Normal Parameters	Mean		342,05	418,38
	Std. Deviation		500,996	978,294
Most Extreme Differences	Absolute		,284	,343
	Positive		,284	,324
	Negative		-,262	-,343
Test Statistic			,284	,343
Asymp. Sig. (2-tailed)			<,001	<,001
Monte Carlo Sig. (2-tailed)	Sig.		<,001	<,001
	99% Confidence Interval	Lower Bound	,000	,000
		Upper Bound	,000	,000

Table 2

One-Sample Kolmogorov-Smirnov Test

			Power HF before	Pover HF after
N			90	90
Normal Parameters	Mean		1277,00	1203,93
	Std. Deviation		3891,250	2814,549
Most Extreme Differences	Absolute		,375	,337
	Positive		,349	,320
	Negative		-,375	-,337
Test Statistic			,375	,337
Asymp. Sig. (2-tailed)			<,001	<,001
Monte Carlo Sig. (2-tailed)	Sig.		<,001	<,001
	99% Confidence Interval	Lower Bound	,000	,000
		Upper Bound	,000	,000

Table 3

One-Sample Kolmogorov-Smirnov Test

			LF/HF before	LF/HF after
N			90	90
Normal Parameters	Mean		1,28	1,67
	Std. Deviation		1,182	2,623
Most Extreme Differences	Absolute		,148	,266
	Positive		,145	,250
	Negative		-,148	-,266
Test Statistic			,148	,266
Asymp. Sig. (2-tailed)			<,001	<,001
Monte Carlo Sig. (2-tailed)	Sig.		<,001	<,001
	99% Confidence Interval	Lower Bound	,000	,000
		Upper Bound	,000	,000

Table number 4 provides an overview of collective phenomena that exhibit the influence of randomness. It evaluates all the variables individually, displaying each variable separately. This table shows the minimum and maximum values measured, average values, and the standard deviation for each variable.

Table 4 Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Power VLF before	90	22,87	3191,63	342,05	501,00
Power LF before	90	17,80	5914,72	456,34	784,83
Power HF before	90	35,31	26905,85	1277,00	3891,25
LF/HF before	90	,0429	5,3325	1,28	1,18
Power VLF after	90	23,37	8748,84	418,38	978,29
Power LF after	90	23,20	12418,75	768,94	1666,14
Pover HF after	90	18,76	21824,68	1203,93	2814,55
LF/HF after	90	,0236	20,6523	1,67	2,62
Valid N (listwise)	90				

In the table below (Table 5), it is evident that for each parameter, there are approximately 40-49 subjects with "negative ranks," indicating a decrease, and approximately the same number with an increase in the parameter value. Since the number of subjects with a positive change is similar to those with a negative change, the change is not statistically significant. "On average, it is zero." This is confirmed by the p-values in Table 6 below. If the p-value is higher than the significance level (0.05), the difference was not confirmed.

Table 5 Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Power VLF after - Power VLF before	Negative Ranks	44	42,18	1856,00
	Positive Ranks	45	47,76	2149,00
	Ties	1		
	Total	90		
Power LF after - Power LF before	Negative Ranks	40	40,05	1602,00
	Positive Ranks	49	49,04	2403,00
	Ties	1		
	Total	90		
Pover HF after - Power HF before	Negative Ranks	42	45,67	1918,00
	Positive Ranks	48	45,35	2177,00
	Ties	0		
	Total	90		
LF/HF after - LF/HF before	Negative Ranks	44	44,34	1951,00
	Positive Ranks	45	45,64	2054,00
	Ties	1		
	Total	90		

Table 6

Test Statistics[a]

	Power VLF after - Power VLF before	Power LF after - Power LF before	Pover HF after - Power HF before	LF/HF after - LF/HF before
Z	-,599	-1,639	-,521	-,211
Asymp. Sig. (2-tailed)	,549	,101	,602	,833

Discussion

No one has directly addressed the direct impact of the deep stabilization system and the autonomic nervous system. Typically, the ANS is assessed with specific diseases, stress, and cardiovascular diseases, rather than in direct relation to the physiotherapy of the core. Therefore, we can only discuss the influence of breathing on the ANS, the exercise methods we used, and the results we found.

Our results indicate that we cannot clearly confirm whether exercise focused on the deep stabilization system has a direct impact on the autonomic nervous system. We can evaluate that there is a group of respondents whose values improved due to such exercises, but an equal group whose values did not improve. From our perspective, improvement in half of the respondents is a success, but when evaluating statistical significance, the change came out as statistically insignificant. In the study, we focus on diaphragmatic breathing and DNS exercise as a form of core strengthening.

Hamasaki (2020) highlights diaphragmatic breathing, describing it as a slow and deep breathing method involving slow and deep breathing through the nose, using the diaphragm with minimal chest movement. It also points out that recent systematic reviews suggest that mind-body exercise can alleviate stress by modulating the sympatho-vagal balance. The reason we emphasize diaphragmatic breathing is that we used it as a primary component in the DNS method. We used this method to strengthen the deep stabilization system. Ricoy et al. (2019) further describe that the diaphragm has other functions besides breathing, controlling postural stability, defecation, urination, and childbirth by modulating intra-abdominal pressure. Additionally, its function is associated with metabolic balance and cardiovascular and intraperitoneal lymphatic systems. Thus, there is a significant association with diaphragm dysfunction and dysautonomia.

Magnon et al. (2021) point out that breathing can indeed directly influence the activity of the autonomic nervous system, including heart rate. Heart rate is regulated by a dynamic balance between the sympathetic nervous system and the parasympathetic nervous system. This means that the relationship between diaphragmatic breathing as a form of deep stabilization system strengthening and the autonomic nervous system is one of the possibilities to improve health conditions related to various dysautonomias. DNS as a method used to strengthen the core is also very effective according to Abadi Marand et al. (2022), who emphasize that with DNS, the individual must maintain intra-abdominal pressure and voluntarily perform movements. According to evidence, DNS is an effective protocol for significant improvement in respiratory functions directly linked to the autonomic nervous system.

Conclusions

Overall, this study sheds light on the potential relationship between the deep stabilizing system and the function of the autonomic nervous system, as manifested in HRV measurements. Both assessed parameters were measured, examined, and statistically evaluated to sufficiently explore the relationship between these different systems. While there is a connection between these two factors, our findings suggest that the impact of targeted DSS rehabilitation on HRV is not statistically significant. Statistical tests assessed that approximately half of the subjects stabilized their autonomic nervous system status, indicating an improvement in values, although an equal number of respondents showed no change. I dare say that in physiotherapy, any improvement is a victory, especially if it enhances the respondent's quality of life. The deep stabilizing system is just one of many components of the human body through which we can improve overall patient health. This means that the mutual relationship between musculoskeletal health and the function of the autonomic nervous system is complex and may involve multiple factors. However, it is important to recognize that our study has certain limitations, such as a relatively small sample size and the need for further research to explore these relationships in more detail.

Conflicts of Interest - The authors declare no conflicts of interest related to this research. This study was conducted with the aim of advancing knowledge in the field of musculoskeletal health and autonomic nervous system function, without any external influences or conflicts that could affect the results or interpretation of the findings.

References

Abadi Marand L, Noorizadeh Dehkordi S, Roohi-Azizi M, Dadgoo M.(2022). Effect of dynamic neuromuscular stabilization on balance and trunk function in people with multiple sclerosis: protocol for a randomized control trial. Trials. Jan 21;23(1):69. Doi : DOIhttps://doi.org/10.1186/s13063-022-06015-3

Eszter Horvath , Martin Tamas Kovacs , Daniel Toth , Laszlo Toth. (2022). A study of the relationship between anxiety, cognitive emotion regulation and heart rate variability in athletes. Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 2), Art 66, pp. 528 – 534. Doi:10.7752/jpes.2022.02066

Frank C, Kobesova A, Kolar P. (2013). Dynamic neuromuscular stabilization & sports rehabilitation. Int J Sports Phys Ther. Feb;8(1):62-73. PMID: 23439921; PMCID: PMC3578435

Gibbons CH.(2019). Basics of autonomic nervous system function. Handb Clin Neurol. 160:407-418. Doi: 10.1016/B978-0-444-64032-1.00027-8

Hamasaki H.(2020). Effects of Diaphragmatic Breathing on Health: A Narrative Review. Medicines (Basel). Oct 15;7(10):65. Doi: 10.3390/medicines7100065.

Huxel Bliven KC, Anderson BE.(2013). Core stability training for injury prevention. Sports Health. Nov;5(6):514-22. Doi: 10.1177/1941738113481200. PMID: 24427426; PMCID: PMC3806175.

Joyner M, Green D. (2009). Exercise protects the cardiovascular system: effects beyond traditional risk factors. The Journal of Physiology, 2009; 587 (23): 5551-5558. PMID: 19736305; PMCID: PMC2805367

Kutis, P., Kolarova, M., & Hudakova, Z. (2017). Assesment of the posture with the students of the first grade of primary school. *International Journal of Developmental and Educational Psychology. Revista INFAD De Psicología.*, *3*(1), 457–464. Doi: 10.17060/ijodaep.2017.n1.v3.1015

Magnon V, Dutheil F, Vallet GT. (2021). Benefits from one session of deep and slow breathing on vagal tone and anxiety in young and older adults. Sci Rep. Sep 29;11(1):19267. Doi: 10.1038/s41598-021-98736-9

Martínez-González-Moro I, Albertus Cámara I, Paredes Ruiz MJ. (2022). Influences of Intense Physical Effort on the Activity of the Autonomous Nervous System and Stress, as Measured with Photoplethysmography. Int J Environ Res Public Health. Nov 30;19(23):16066. Doi 10.3390/ijerph192316066

Ricoy J, Rodríguez-Núñez N, Álvarez-Dobaño JM, Toubes ME, Riveiro V, Valdés L. (2019). Diaphragmatic dysfunction. Pulmonology. Jul-Aug ;25(4):223-235. Doi: 10.1016/j.pulmoe.2018.10.008

Rusnák R, Kolarová M, Aštaryová I, Kutiš P. (2019). Screening and Early Identification of Spinal Deformities and Posture in 311 Children: Results from 16 Districts in Slovakia. Rehabil Res Pract. Mar 17;2019.

Tyagi A, Cohen M. (2016). Yoga and heart rate variability: A comprehensive review of the literature. Int J Yoga. Jul-Dec;9(2):97-113. Doi: 10.4103/0973-6131.183712.

Shaffer F, Ginsberg JP (2017) . An Overview of Heart Rate Variability Metrics and Norms. Front Public Health. Sep 28;5:258. Doi: 10.3389/fpubh.2017.00258

Yamanaka Y, Hashimoto S, Takasu NN, Tanahashi Y, Nishide SY, Honma S, Honma K. (2015). Morning and evening physical exercise differentially regulate the autonomic nervous system during nocturnal sleep in humans. Am J Physiol Regul Integr Comp Physiol. 2015 Nov 1;309(9):R1112-21.

Yong MS, Lee HY, Lee YS. (2017). Effects of diaphragm breathing exercise and feedback breathing exercise on pulmonary function in healthy adults. J Phys Ther Sci. 2017 Jan;29(1):85-87.

Zemková E, Zapletalová L. (2022). The Role of Neuromuscular Control of Postural and Core Stability in Functional Movement and Athlete Performance. Front Physiol. 2022 Feb 24;13:796097. Doi: 10.3389/fphys.2022.796097

Zou L, Sasaki JE, Wei GX, Huang T, Yeung AS, Neto OB, Chen KW, Hui SS.(2018). Effects of Mind⁻Body Exercises (Tai Chi/Yoga) on Heart Rate Variability Parameters and Perceived Stress: A Systematic Review with Meta-Analysis of Randomized Controlled Trials. J Clin Med. Oct 31;7(11):404. Doi: 10.3390/jcm7110404.