ISSN 2522-1906 (Print) ISSN 2522-1914 (Online)
Fizicna Reabilitacia ta Rekreacijno-Ozdorovci Tehnologii
Original article
Vol. 7 No 4

Comparative features of the immediate impact of manual therapy traction manipulations on the cardiorespiratory system of men and women

Oleksandr Romanchuk

Lviv State University of Physical Culture named after Ivan Bobersky, Lviv, Ukraine

DOI: 10.15391/prrht.2022-7(4).24

Received: 16.10.2022
Accepted: 30.10.2022
Published: 30.12.2022

Citation:

Romanchuk, O. (2022). Comparative features of the immediate impact of manual therapy traction manipulations on the cardiorespiratory system of men and women. *Physical rehabilitation and recreational health technologies*, 7(4), 130-142. https://doi.org/10.15391/prrht.2022-7(4).24

Corresponding author:
Oleksandr Romanchuk
Lviv State University of Physical Culture named after Ivan Bobersky, Lviv, Ukraine
orcid.org/0000-0001-6592-2573
e-mail: doclfc@ua.fm

Abstract

Purpose: the aim of this study was to determine the principal differences of changes in the cardiorespiratory system activity under the influence of traction manipulations in the thoracic spine of men and women.

Material & Methods: the 26 adults were involved in the study, including 18 women aged 39.6±12.1 years and 8 men aged 36.3±8.3 years. All patients were diagnosed with osteochondrosis of the thoracic spine, which was confirmed by radiographic examination. The study of the cardiorespiratory system was conducted in the first procedure of SMT before and after the use of traction manipulations directly in the physician office. The integrated method of studying the cardiorespiratory system defined as spiroarteriocardiorhythmography (SACR) was used. It simultaneously records the heart rate, rhythms of systolic and diastolic pressure at each heartbeat and respiratory rhythms, which provides significant time savings to determine the functional state of the heart, vessels and respiration, as well as to identify the important parameters of their interaction.

Results: characterizing the changes in the cardiorespiratory system as a whole under the influence of traction manipulations on the thoracic spine, it should be noted that men and women had some significant unidirectional changes in HR (min^{-1}), CO (dm^3), CI (dm^3/m^2), IH (n. u.), which are determined primarily by the decrease in HR (min^{-1}) under the influence of traction manipulations. As to the men, the significant effects were more related to the impact on the contractile function of the heart, which was confirmed by the improvement of the electrical systole of the ventricles (QTC, s), the increase in the activity of the effects of the parasympathetic branch of the ANS on the cardiac rhythm (HF, ms^2) and a certain increase in the stroke index within the normative values (SI, cm^3/m^2), then to the women the significant effects were more related to the influence on the breathing pattern and vascular tone. Thus, characteristic and positive effects in women can be considered a decrease in the variability of diastolic blood pressure in the very-low-frequency range (VLFDBP, $mmHg^2$), which is combined with a decrease in the total power of diastolic pressure variability (TPDBP, $mmHg^2$) and an increase in the total peripheral vascular resistance (GPVR, $dyn/s/cm^{-5}$).

Conclusions: summarizing the results of the impact of traction manipulations in the thoracic spine on the cardiorespiratory system of men and women, it can be stated that their effect is different and has features associated with the use of different mechanisms. For men, the predominant effect is on the heart contractile function, and for women it is on the respiratory system and autonomous regulation of vascular tone.

Key words: manual therapy, heart rate variability, blood pressure variability, respiration variability, respiratory pattern, hemodynamics.

Анотація

Олександр Романчук. Порівняльні особливості безпосереднього впливу тракційних маніпуляцій мануальної терапії на кардіореспіраторну систему чоловіків і жінок. **Метою** даного дослідження було визначення відмінностей змін діяльності кардіореспіраторної системи за впливу тракційних маніпуляцій у грудному відділі хребта у чоловіків та жінок. **Матеріал і методи:** у дослідженні взяли участь 26 дорослих, у тому числі 18 жінок віком 39,6±12,1 року та 8 чоловіків віком 36,3±8,3 роки. У всіх хворих діагностовано остеохондроз грудного відділу хребта, що підтверджено рентгенографічними дослідженнями. Дослідження кардіореспіраторної системи проводили на першій процедурі мануальної терапії до та після застосування тракційних маніпуляцій безпосередньо в кабінеті лікаря. Використовували комплексний метод дослідження кардіореспіраторної системи – спіроартеріокардіоритмографію (САКР). Він одночасно реєструє частоту серцевих скорочень, ритми систолічного і діастолічного тиску на кожному серцевому скороченні і ритми дихання, що забезпечує значну економію часу для визначення функціонального стану серця, судин і дихання, а також визначення важливих параметрів їх взаємодії. **Результати**: характеризуючи зміни в кардіореспіраторній системі в цілому під впливом тракційних маніпуляцій на грудному відділі хребта, слід зазначити, що у чоловіків і жінок спостерігалися достовірні односпрямовані зміни ЧСС (хв$^{-1}$), ХОК (дм^3), СІ (дм^3/м^2), ІХ (н. о.), які визначаються переважно зниженням ЧСС (хв$^{-1}$) під впливом тракційних маніпуляцій. У чоловіків достовірні ефекти більше пов’язані із впливом на скоротливу функцію серця, що підтверджується покращенням електричної систоли шлуночків (QTC, s), підвищенням активності ефектів парасимпатичної гілки ВНС на серцевий ритм (HF, мс^2) та певне підвищення ударного індексу в межах нормативних значень (УІ, см^3/м^2), то у жінок достовірні впливи більш пов’язані з впливом на характер дихання і тонус судин. Таким чином, характерним і позитивним ефектом у жінок можна вважати зниження варіабельності діастолічного АТ в дуже низькочастотному діапазоні ($VLF_{ДТ}$, мм рт. ст^2), яке поєднується зі зниженням сумарної потужності варіабельності діастолічного тиску ($TP_{ДТ}$, мм рт. ст.^{2}) і збільшення загального периферичного опору судин (ЗПОС, дин/с/см$^{-5}$). **Висновки:** узагальнюючи результати впливу тракційних маніпуляцій у грудному відділі хребта на кардіореспіраторну систему чоловіків і жінок, можна констатувати, що їх ефект неоднаковий і має особливості, пов’язані з використанням різних механізмів. У чоловіків переважає вплив на скорочувальну функцію серця, у жінок – на дихальну систему та автономну регуляцію тонусу судин.

Ключові слова: мануальна терапія, варіабельність серцевого ритму, варіабельність артеріального тиску, варіабельність дихання, паттерн дихання, гемодинаміка.

Introduction

Among the methods of physical rehabilitation used at the stage of providing rehabilitation services, along with massage, various mobilization and manipulation techniques are used, which are related to spinal manual therapy (SMT). SMT is a method of physical therapy, which involves direct contact between a physical therapist and a patient, when through the use of massage, manipulation and mobilization techniques, passive physical exercises he affects different parts of the human body. Current research considers, first of all, the effects of SMT, associated with the impact on pain intensity and the patient’s motor functions. These include hypoalgesia, sympathicotonia, decreased spinal rigidity, increased muscle strength and endurance (Wirth, B. et al., 2019). On the other hand, there are a number of scientific publications that describe and systematize the total effects of SMT associated with peripheral, spinal and supraspinal mechanisms (Hinkeldey, N. et al., 2020). Emphasis is placed on the fact that SMT significantly reduces the level of cytokines in the blood and serum during joint manipulations (Teodorczyk-Injeyan, J. et al., 2006), provides the changes in blood level of β-endorphin, anandamide, N-palmitoylethanolamide, serotonin (Degenhardt, B. et al., 2007), endogenous cannabinoids (McPartland, J. et al., 2005), activates the muscles proprioceptors (Espí-López, G., et al, 2018), reducts pain (Denneny, D. et al., 2019), improves the afferentation (Colloca, C., et al, 2000), changes the muscle activity (Herzog, W. et al., 1999), reducts a supraspinal areas activation responsible for central pain (Malisza, K. et al., 2003). A number of authors have shown the improvement of autonomic and opioid reactions (Moulson, A., & Watson, T., 2006; Sterling, M. et al., 2001), dopamine synthesis (de la Fuente-Fernández, R. et al., 2006), and the CNS condition (Matre, D. et al., 2006). The positive effect on the psycho-emotional state of patients was also observed (Williams, N. et al., 2007). Some studies have shown that SMT improves athletic performance, reduces spasticity of the athletes with cerebral palsy, increases forced vital lung capacity and forced exhalation, improves lung function and exercise activity of the patients with chronic obstructive pulmonary disease, moreover it is even included into the treatment protocols (Cerqueira, M., 2019; Kachmar, O. et al., 2018; Halili, A., 2021; Simonelli, C. et al., 2019). Some attention was paid to the autonomic effects of SMT, which include the changes in heart rate variability (HRV), peripheral blood flow and skin conduction (Alsayani, K., et al 2021; Benjamin, J. et al., 2020; Amoroso Borges, B. et al., 2018). Our research showed a significant impact of Yumeiho therapy manual techniques on the cardiovascular system of adults, the respiratory system and the morphofunctional state of adolescents (Romanchuk, O., &

Hanitkevych, V., 2022). At our last study we received the results which shown that traction manipulations in the thoracic spine have the effects on the system hemodynamics (Romanchuk, O., & Hanitkevych, V., 2022) and a respiratory pattern. These effects are associated with a decrease in the activity of the cardiovascular system, which is realized through a decrease in HR (min^{-1}), improved contractile function of the heart QTC (s), a decrease in CO (dm^3), SI (dm^3/m^2) during an increase in GPVR (dyn/s/cm^{-5}) and also a decrease in Texp (s), which is accompanied by an increase in Vexp (L/s) and RR (min^{-1}), the changes in the synchronization of the cardiorespiratory system by parameters IH (n. u.) and IVS (dm^3/L) (Romanchuk, O., 2022).This study is a logical continuation of the last one.

The purpose of this study was to determine the principal differences of changes in the cardiorespiratory system activity under the influence of traction manipulations in the thoracic spine at men and women.

Material and methods of research

Participants

The study was conducted on the basis of the clinical sanatorium V.P. Chkalov (Odesa, Ukraine) during 2003-2005. 26 adults were involved in the study, including 18 women aged 39.6±12.1 years and 8 men aged 36.3±8.3 years. All patients were diagnosed with osteochondrosis of the thoracic spine, which was confirmed by radiographic examination. A number of patients that had concomitant diseases was 9 women who had autonomic dystonia syndrome, 2 men had stage 1 hypertension. Most patients complained of intermittent pain in the thoracic spine associated with both physical activity and prolonged sitting. The characteristics of morphometric parameters of patients are presented in table 1.

Table 1. Morphometric parameters of patients

Parameters	Men (n=8)	Women (n=18)
Body length, cm	172,0 (171,0; 173,0)	164,0 (160,0; 168,0)
Body mass, kg	82,0 (70,0; 90,0)	61,0 (50,0; 68,0)
BMI, kg/m^2	28,4 (23,7; 30,4)	23,1 (19,4; 26,6)

The study of the cardiorespiratory system was conducted in the first days of a resort treatment during the first procedure of SMT before and after the use of traction manipulations directly in the physician office.

Methods

Our attention was drawn to the integrated method of studying the cardiorespiratory system defined as spiroarteriocardiorhythmography (SACR), which simultaneously records the heart rate, rhythms of systolic and diastolic pressure at each heartbeat and respiratory rhythms, which provides significant time savings to determine the functional state of the heart, vessels and respiration, as well as to identify the important parameters of their interaction. (Pivovarov, V, 2006). ECG recording in 1 lead allowed to determine the indicators of heart rate variability (HRV) according to the spectral analysis of the sequence of RR intervals is total power (TP, ms^2), power in the very low frequency range (VLF, ms^2), power in the low frequency range (LF, ms^2) and power in the high frequency range (HF, ms^2) and their derivatives (LFn, n. u., HFn, n. u., LF/HF) (Guzii, O., & Romanchuk, A., 2017, 2018); according to cardiointervalometry it is possible to define the heart rate (HR, min^{-1}), durations and intervals of PQRST-complex – P (s), PQ (s), QRS (s), QT (s), QTC (s), ST (n. u.); indicators of systemic hemodynamics (Kim, T., et al, 2005; Romanchuk, A., & Pisaruk, V., 2013) – end-diastolic volume (EDV, cm^3), end-systolic volume (ESV, cm^3), stroke volume (SV, cm^3), cardiac output (CO, dm^3), stroke index (SI, cm^3/m^2), cardiac index (CI, dm^3/m^2), general peripheral vascular resistance (GPVR, dyn/s/cm^{-5}). According to the pulse wave recording with the help of a photoplethysmographic sensor on the finger by the Penaz method (Penáz, J., 1992), blood pressure (SBP, mmHg; DBP, mmHg) and its variability (SBPV and DBPV) in the ranges similar to HRV were determined as a total power of SBPV and DBPV (TP_{SBP}, mmHg^2 and TP_{DBP}, mmHg^2), power in the very low-frequency range (VLF_{SBP}, mmHg^2 and VLF_{DBP}, mmHg^2), power in the low-frequency range (LF_{SBP}, mmHg^2 and LF_{DBP}, mmHg^2) and power in the high-frequency range (HF_{SBP}, mmHg^2 and HF_{DBP}, mmHg^2) and their derivatives – LF_{SBP}n, n. u., HF_{SBP}n, n. u., LF/HF_{SBP}, LF_{DBP}n, n. u., HF_{DBP}n, n. u., LF/HF_{DBP} (Wesseling K., 1990; Papaioannou, T., et al, 2020, Picone, D. et al., 2017; Pinna, G., 1996). Additionally by using the spectral method we determined the index of arterial baroreflex sensitivity (BRS, ms/mmHg) – α-coefficient, that was calculated in high (BRS_{HF}) and low (BRS_{LF}) frequencies ranges (Guzii, O. et al., 2021; Tkaczyszyn, M. et al., 2013, Papaioannou, T. et al., 2019).

$$BRS_{LF}=\sqrt{LF_{HRV}\ (ms^2)/LF_{SBP}\ (mmHg^2)} \quad (1)$$

$$BRS_{HF}=\sqrt{HF_{HRV}\ (ms^2)/HF_{SBP}\ (mmHg^2)} \quad (2)$$

The ultrasonic sensor of the SACR device allows to measure flows of air on inspiration and expiration and to define the average parameters of a respiration pattern (PR): duration of inspiratory (Tin, s), duration of expiratory (Tex, s), tidal volume (V_T, L), volumetric inspiratory velocity (Vin, L/s), volumetric expiratory velocity (Vex, L/s), the fraction of inspiration in the respiratory cycle (Ti/(Ti+Te) (c.u.)), as well as the volume of minute respiration (V_E); and calculate the parameters of respiration variability (RV): total power of respiration (TP_R, (L/min)^2), respiration power in the very low-frequency range (VLF_R (L/min)^2), respiration power in the low-frequency range (LF_R (L/min)^2) and respiration power in the high frequency range (HF_R (L/min)^2) and their derivatives – LF_Rn, HF_Rn, LF/HF_R – in n. u. (Bazhora, Y., & Romanchuk, O, 2018; Romanchuk, A., & Guzii, O., 2020).

Indicators of frequency and volume synchronization of the cardio-respiratory system were also calculated – Hildebrandt index (IH) and the ratio of CO to V_E (IVS) (Noskin, L., et al, 2018).

$$IH=HR\ (min^{-1})/RR\ (min^{-1}) \quad (3)$$

$$IVS=CO\ (dm^3)/V_E\ (L) \quad (4)$$

All studies were carried out in a sitting position; the duration of registration of the cardiorespiratory system parameters was 2 minutes before and 2 minutes after manipulation.

Procedure

This study involved the determination of changes in the cardiorespiratory system in the SMT procedure, which had several parts. In the first part of the procedure, acupressure was performed in a supine position on the abdomen and back, taking into account muscle tension and pain points. In the second part of the procedure, mobilization and manipulation techniques were performed, which involved the use of manipulations and mobilizations in the supine and sitting positions. In one of part the procedure, after the transition from the supine position to the sitting position and a minute break to adjust the device, the first recording of the indicators of the cardiorespiratory system using the SACR device. After registration, a manipulative effect was performed on the thoracic spine, which involved the use of traction manipulations for the upper, middle and lower thoracic spine according to the method of Yumeiho (Saionji, M., 1990). After the manipulations and adjustment of the device, the cardiorespiratory system parameters were re-registered using SACR. Then the SMT procedure continued. In general, the duration of the SMT procedure was about one hour.

Statistical analysis

The processing of the received results was carried out with the help of STATISTICA program for Windows (version 10.0), Microsoft Excel 2012. The comparison of quantitative indices in studied groups was realized using non-parametric criterion of Wilcoxon.

Results of the study

Analyzing the data of changes in cardiointervalometry, it should be noted that in both men and women the previously obtained results (Romanchuk, 2022) about a decrease in HR (min^{-1}) from 89.5 (77.6; 106.3) to 77.3 (70.7; 86.0) are confirmed, p=0.012, and from 85.1 (72.8; 90.6) to 81.8 (69.8; 89.3), p=0.003, respectively. As for QTC (s), its decrease is significant for men from 0.419 (0.409; 0.442) to 0.409 (0.391; 0.424), p=0.025, but not so for women, although it decreases from 0.419 (0.403; 0.434) to 0.413 (0.405; 0.432), p=0.267. Other indicators do not change significantly (Table 2).

Table 2. Changes in cardiointervalometry indicators under the influence of traction manipulations

Parameters	sex	Before	After	T	Z	p-value
HR, min^{-1}	m	89.5 (77.6; 106.3)	77.3 (70.7; 86.0)	**0.0**	**2.52**	**0.012**
	f	85.1 (72.8; 90.6)	81.8 (69.8; 89.3)	**18.0**	**2.94**	**0.003**
P, s	m	0.106 (0.097; 0.120)	0.103 (0.090; 0.116)	16.0	0.28	0.779
	f	0.088 (0.086; 0.100)	0.090 (0.086; 0.101)	64.5	0.57	0.570
PQ, s	m	0.145 (0.123; 0.158)	0.147 (0.129; 0.159)	15.0	0.42	0.674
	f	0.118 (0.105; 0.125)	0.117 (0.105; 0.130)	58.0	0.88	0.381
QR, s	m	0.033 (0.032; 0.033)	0.032 (0.032; 0.035)	13.5	0.08	0.933
	f	0.033 (0.030; 0.034)	0.033 (0.030; 0.034)	45.0	0.47	0.638
QRS, s	m	0.094 (0.087; 0.103)	0.093 (0.087; 0.103)	6.0	0.94	0.345
	f	0.084 (0.076; 0.092)	0.081 (0.079; 0.092)	66.0	0.50	0.619
QT, s	m	0.349 (0.325; 0.369)	0.357 (0.321; 0.372)	11.0	0.98	0.327
	f	0.351 (0.329; 0.377)	0.355 (0.338; 0.384)	**14.5**	**2.93**	**0.003**
QTC, s	m	0.419 (0.409; 0.442)	0.409 (0.391; 0.424)	**2.0**	**2.24**	**0.025**
	f	0.419 (0.403; 0.434)	0.413 (0.405; 0.432)	60.0	1.11	0.267
ST, n. u.	m	-0.022 (-0.190; 0.093)	-0.059 (-0.145; 0.079)	14.0	0.56	0.575
	f	0.053 (0.011; 0.110)	0.058 (0.030; 0.102)	80.0	0.24	0.811

According to the analysis of changes in HRV (Table 3), it is possible to confirm the results obtained earlier regarding the significant variability of the effects caused by traction manipulations on the thoracic spine, both for men and women. These effects concern both the total HRV power (TP, ms^2) and its individual components – VLF (ms^2) and LF (ms^2). Only one of the indicators (HF, ms^2), which indicates the activity of the parasympathetic part of the nervous system, significantly increased in men from 209.9 (88.8; 811.6) to 665.2 (67.7; 2964.6), p=0.049. In women, this indicator was fairly stable up to 617.8 (166.4; 1361.6) and after 512.1 (144.0; 1310.4), p=0.679. Certain, but

ISSN 2522-1906 (Print) ISSN 2522-1914 (Online)

Fizicna Reabilitacia ta Rekreacijno-Ozdorovci Tehnologii

Vol. 7 No 4

Table 3. Changes in HRV indicators under the influence of traction manipulations

Parameters	sex	Before	After	T	Z	p-value
TP, ms^2	m	1117.7 (617.9; 2879.6)	2369.2 (567.1; 9528.3)	9.0	1.26	0.208
	f	1684.3 (818.0; 3422.3)	1180.8 (924.2; 2787.8)	65.0	0.89	0.372
VLF, ms^2	m	400.2 (339.4; 685.0)	675.6 (158.2; 1765.5)	13.0	0.70	0.484
	f	339.2 (225.0; 640.1)	357.4 (132.3; 750.8)	82.0	0.15	0.879
LF, ms^2	m	398.6 (198.3; 1235.1)	490.7 (194.2; 3447.9)	10.0	1.12	0.263
	f	387.0 (185.0; 702.3)	379.2 (153.8; 697.0)	85.0	0.02	0.983
LFn, n.u	m	64.7 (50.4; 77.1)	56.5 (46.2; 64.0)	6.0	1.68	0.093
	f	40.8 (27.2; 56.7)	42.5 (24.6; 59.2)	85.0	0.02	0.983
HF, ms^2	m	209.9 (88.8; 811.6)	665.2 (67.7; 2964.6)	**4.0**	**1.96**	**0.049**
	f	617.8 (166.4; 1361.6)	512.1 (144.0; 1310.4)	60.0	0.41	0.679
HFn, n. u.	m	33.4 (19.5; 42.4)	35.6 (25.5; 50.2)	7.0	1.54	0.123
	f	54.0 (28.9; 70.6)	46.2 (33.1; 68.5)	65.0	0.89	0.372
LFHF, ms^2/ms^2	m	1.96 (1.21; 4.01)	1.57 (0.91; 2.75)	8.0	1.40	0.161
	f	0.81 (0.36; 2.25)	0.91 (0.36; 1.69)	54.0	0.34	0.733

not likely, changes in men were characterized by an increase in the relative indicators of regulatory effects on cardiac rhythm in the high-frequency range (HFn, n. u., p=0.123) and a decrease in the low-frequency range (LFn, n. u., p=0.093).

That is, it can be assumed that HRV changes under the influence of traction manipulations on the thoracic spine have significant individual variability, including gender. In this group of patients, the propensity of men to increase parasympathetic effects was determined.

The study of BPV at each cardiac contraction by the Penaz method is a sensitive registration method that requires sufficiently strict compliance with the conditions. At the same time, it makes it possible to estimate not only the absolute values of BP, but also their variability associated with a number of hemodynamic effects. According to other authors, the results of such BPV registration are related to the activity of the sympathetic link of the central nervous system, a number of baro- and chemoreceptor reflexes, humoral, rheological factors, and also depend on the influence of surrounding, behavioral, emotional factors, age, activity. Breathing also affects the results of BP measurement (Karemaker, J., & Wesseling, K., 2008; Rosei, E. et al., 2020). This was also demonstrated by us on the example of changes in BP during controlled breathing (Guzii, O. et al., 2019). In our opinion, BP registration at each heart contraction can be considered as a method that allows characterizing the general (autonomic, hemodynamic, baroreflex) provision of the pumping function of the heart and blood vessels (their tone) (Guzii, O. et al., 2021). From these positions, an increase in the variability of SBP may indicate the instability of maintaining the pumping function of the heart, and an increase in the variability of DBP may indicate a violation of vascular tone. It is quite useful to determine SBP at each heart contraction in case of heart rhythm disturbances, primarily atrial fibrillation, which has an important prognostic value (de la Sierra, A. et al., 2020; Schillaci, G. et al., 2012; Casali, K. et al., 2018; Tian, G. et al., 2019). On the other hand, the variability of DBP is related to the stiffness of blood vessels (Kishi, T., 2018) and the lability of their tone.

Analyzing data on changes in SBPV and DBPV (Table 4) for men and women under the influence of traction manipulations, attention is drawn to the difference in changes in some indicators. First of all, for women, changes in TP_{DBP} ($mmHg^2$) were significant, which decreased from 11.2 (5.8; 16.8) to 6.5 (3.2; 10.2), p=0.022, and VLF_{DBP} ($mmHg^2$), which decreased from 5.1 (2.6; 9.6) to 2.9 (1.7; 5.8), p=0.025. In addition, according to many indicators, changes at the trend level are noted for women. Namely, a decrease in TP_{SBP} ($mmHg^2$), p=0.052, VLF_{SBP} ($mmHg^2$), p=0.199, HF_{DBP} ($mmHg^2$), p=0.074, $HF_{DBP}n$ (n. u.), p=0.071 and an increase in $LF_{DBP}n$ (n. u.), p=0.145. No significant changes were found for men, but an increase in TP_{DBP} ($mmHg^2$), p=0.123, and LF_{SBP} ($mmHg^2$), p=0.161 was noted at the level of an insignificant trend.

That is, the effect of traction manipulations in the chest area has more significant effects for women. Perhaps this is due to the fact that half of the women showed signs of autonomic dystonia. In this case, a significant decrease and a tendency to decrease of the indicators mentioned above may indicate a positive effect of traction manipulations. First of all, taking into account the reduction of suprasegmental effects on vascular tone (VLF_{DBP}). At the same time, the tendency to increase the above-mentioned indicators in men may indicate the possibility of increased sympathetic influences on the contractile function of the heart, as well as an increase in the stiffness of the vascular wall, which should be characterized as a negative effect (Schillaci, G. at al., 2012; Tian, G. et al., 2019). On the other hand, these effects require further study with proper randomization of groups.

Having analyzed, the indicators of RV, first of all, it should be noted that in the cohort of men they

Table 4. Changes in blood pressure variability indicators under the influence of traction manipulations

Parameters	sex	Before	After	T	Z	p-value
SBP, mmHg	m	139.6 (112.1; 149.5)	129.4 (107.1; 153.1)	13.0	0.70	0.484
	f	124.2 (109.4; 129.2)	117.3 (114.1; 134.5)	54.5	1.04	0.298
DBP, mmHg	m	89.4 (71.9; 99.4)	84.5 (72.0; 100.5)	13.0	0.17	0.866
	f	74.5 (64.8; 79.3)	74.5 (66.2; 79.6)	54.0	1.37	0.170
TP_{SBP}, $mmHg^2$	m	24.1 (14.2; 33.8)	24.5 (13.2; 96.4)	11.0	0.98	0.327
	f	23.5 (17.6; 44.9)	22.6 (15.2; 38.4)	35.5	1.94	0.052
TP_{DBP}, $mmHg^2$	m	10.2 (5.8; 11.2)	14.5 (6.0; 45.3)	7.0	1.54	0.123
	f	**11.2 (5.8; 16.8)**	**6.5 (3.2; 10.2)**	**28.0**	**2.30**	**0.022**
VLF_{SBP}, $mmHg^2$	m	7.1 (3.6; 17.3)	12.1 (4.6; 44.3)	8.0	1.01	0.310
	f	10.6 (7.8; 17.6)	8.7 (4.8; 11.6)	56.0	1.28	0.199
VLF_{DBP}, $mmHg^2$	m	2.9 (2.1; 6.0)	5.8 (3.3; 18.3)	7.0	1.54	0.123
	f	**5.1 (2.6; 9.6)**	**2.9 (1.7; 5.8)**	**34.0**	**2.24**	**0.025**
LF_{SBP}, $mmHg^2$	m	7.0 (6.0; 8.7)	11.1 (2.7; 20.1)	8.0	1.40	0.161
	f	5.8 (3.2; 16.8)	7.3 (3.6; 9.0)	53.0	1.11	0.266
LF_{DBP}, $mmHg^2$	m	2.6 (1.7; 4.4)	4.7 (2.2; 7.3)	10.0	1.12	0.263
	f	2.0 (1.4; 4.8)	2.3 (1.2; 3.2)	62.5	1.00	0.317
LF_{SBP}n, n. u.	m	71.1 (55.1; 72.8)	66.4 (54.9; 75.7)	17.0	0.14	0.889
	f	48.8 (38.3; 67.8)	54.8 (38.2; 71.7)	69.0	0.72	0.472
LF_{DBP}n, n. u.	m	71.4 (54.6; 84.2)	71.1 (60.1; 81.0)	17.0	0.14	0.889
	f	68.0 (52.2; 81.1)	73.0 (67.5; 79.6)	52.0	1.46	0.145
HF_{SBP}, $mmHg^2$	m	2.7 (2.0; 6.8)	3.3 (2.0; 7.6)	13.0	0.70	0.484
	f	6.5 (2.3; 9.0)	3.8 (2.3; 10.2)	56.0	0.62	0.535
HF_{DBP}, $mmHg^2$	m	0.8 (0.5; 2.1)	2.0 (0.4; 2.1)	11.0	0.51	0.612
	f	0.9 (0.4; 1.4)	0.5 (0.4; 0.8)	33.5	1.78	0.074
HF_{SBP}n, n. u.	m	26.1 (24.7; 36.6)	25.0 (21.2; 42.8)	10.0	0.68	0.499
	f	48.2 (27.5; 60.2)	38.9 (21.0; 56.0)	66.0	0.50	0.619
HF_{DBP}n, n. u.	m	24.8 (13.1; 41.0)	23.0 (16.0; 35.3)	12.0	0.84	0.401
	f	26.5 (15.6; 41.5)	22.1 (16.0; 27.9)	44.0	1.81	0.071
$LFHF_{SBP}$, $mmHg^2/mHg^2$	m	2.70 (1.78; 2.86)	2.68 (1.30; 3.54)	13.0	0.70	0.484
	f	1.03 (0.64; 2.50)	1.51 (0.69; 3.46)	85.0	0.02	0.983
$LFHF_{DBP}$, $mmHg^2/mHg^2$	m	2.89 (1.39; 6.53)	3.10 (1.74; 5.53)	11.0	0.98	0.327
	f	2.58 (1.19; 5.20)	3.27 (2.46; 4.84)	64.0	0.94	0.349

Table 5. Changes in the variability of spontaneous breathing under the influence of traction manipulations

Parameters	sex	Before	After	T	Z	p-value
TP_R, $(L/min)^2$	m	1334.5 (755.9; 1973.6)	1494.9 (924.6; 1862.0)	17.0	0.14	0.889
	f	676.2 (475.2; 1056.3)	630.1 (571.2; 906.0)	83.0	0.11	0.913
VLF_R, $(L/min)^2$	m	26.4 (10.3; 70.9)	14.4 (9.6; 28.3)	12.0	0.34	0.735
	f	7.6 (2.3; 14.4)	7.6 (2.9; 13.7)	79.0	0.28	0.777
LF_R, $(L/min)^2$	m	77.9 (35.8; 533.7)	63.1 (16.4; 296.2)	10.0	1.12	0.263
	f	16.8 (12.3; 57.8)	16.0 (7.8; 27.0)	53.0	1.42	0.157
LF_Rn, n. u.	m	10.5 (2.8; 27.0)	4.2 (1.6; 25.7)	12.0	0.84	0.401
	f	2.1 (1.3; 7.7)	2.1 (1.1; 3.9)	46.5	1.42	0.156
HF_R, $(L/min)^2$	m	934.7 (575.4; 1279.9)	813.5 (580.9; 1365.5)	17.0	0.14	0.889
	f	578.5 (222.0; 1004.9)	527.0 (331.2; 595.4)	76.0	0.41	0.679
HF_Rn, n. u.	m	70.9 (58.6; 84.6)	65.4 (51.7; 94.0)	16.0	0.28	0.779
	f	86.8 (69.8; 95.2)	85.5 (69.3; 93.7)	81.0	0.20	0.845
$LFHF_R$, $(L/min)^2/(L/min)^2$	m	0.140 (0.034; 0.437)	0.064 (0.016; 0.433)	11.0	0.98	0.327
	f	0.029 (0.014; 0.152)	0.032 (0.017; 0.063)	40.0	1.45	0.148

were significantly higher than in women, in all frequency ranges. Unfortunately, there is no data on gender differences in these indicators. Therefore, at this stage, we will limit ourselves to their comparative analysis before and after traction effects (Table 5). No significant changes in RV parameters were observed. At the same time, in women there was a noticeable tendency to decrease in low-frequency effects, for absolute LF_R, $(L/min)^2$ from 16.8 (12.3; 57.8) to 16.0 (7.8; 27.0), p=0.157, and for relative LF_Rn, n. u. from 2.1 (1.3; 7.7) to 2.1 (1.1; 3.9), p=0.156, values. In men, this ten-

ISSN 2522-1906 (Print) ISSN 2522-1914 (Online)
Fizicna Reabilitacia ta Rekreacijno-Ozdorovci Tehnologii
Vol. 7 No 4

dency was less pronounced LF_R, $(L/min)^2$ from 77.9 (35.8; 533.7) to 63.1 (16.4; 296.2), p=0.263, and LF_Rn, n. u. from 10.5 (2.8; 27.0) to 4.2 (1.6; 25.7), p=0.401, respectively. At the same time, there were no changes in activity in the high-frequency range even at the trend level.

The obtained data on changes in the function of the respiratory system are significantly supplemented by the results of the breathing pattern analysis (Table 6). They were observed for both men and women. They were at the trend level for men, and for women they were significant. There was a decrease in the duration of exhalation (Texp,s) – for men from 2.0 (1.7; 2.5) to 1.8 (1.3; 2.5), p=0.123, for women from 1.8 (1.6; 2.1) to 1.5 (1.4; 1.8), p=0.000; increase in expiratory volume velocity (Vexp, L/s) – for men from 0.26 (0.23; 0.31) to 0.36 (0.25; 0.48), p=0.161, for women from 0.30 (0.21; 0.35) to 0.30 (0.25; 0.36), p=0.102; increase in the share of inhalation in the respiratory cycle (Ti/(Ti+Te)) – for men from 0.44 (0.43; 0.49) to 0.51 (0.42; 0.53), p=0.093, for women from 0.41 (0.38; 0.45) to 0.43 (0.41; 0.45), p=0.008. An increase in RR (min^{-1}) was similar in terms of significance – for men from 16.4 (13.8; 19.4) to 17.4 (14.5; 22.1), p=0.208, for women from 18.8 (16.6; 21.9) to 20.6 (18.4; 23.9), p=0.006.

That is, traction manipulations on the thoracic

Table 6. Changes in breathing pattern indicators under the influence of traction manipulations

Parameters	sex	Before	After	T	Z	p-value
Tinsp, s	m	1.5 (1.3; 2.2)	1.6 (1.3; 2.0)	13.0	0.70	0.484
	f	1.3 (1.1; 1.5)	1.2 (1.0; 1.5)	63.5	0.62	0.538
Texp, s	m	2.0 (1.7; 2.5)	1.8 (1.3; 2.5)	7.0	1.54	0.123
	f	1.8 (1.6; 2.1)	1.5 (1.4; 1.8)	**2.0**	**3.64**	**0.000**
V_T, L	m	0.570 (0.455; 0.680)	0.635 (0.500; 0.860)	17.0	0.14	0.889
	f	0.510 (0.450; 0.690)	0.495 (0.420; 0.570)	58.0	1.20	0.231
Vexp, L/s	m	0.26 (0.23; 0.31)	0.36 (0.25; 0.48)	8.0	1.40	0.161
	f	0.30 (0.21; 0.35)	0.30 (0.25; 0.36)	48.0	1.63	0.102
Vinsp, L/s	m	0.33 (0.27; 0.47)	0.44 (0.26; 0.54)	14.0	0.56	0.575
	f	0.40 (0.29; 0.45)	0.38 (0.30; 0.50)	79.0	0.28	0.777
Ti/(Ti+Te)	m	0.44 (0.43; 0.49)	0.51 (0.42; 0.53)	6.0	1.68	0.093
	f	0.41 (0.38; 0.45)	0.43 (0.41; 0.45)	**25.0**	**2.63**	**0.008**
RR, min^{-1}	m	16.4 (13.8; 19.4)	17.4 (14.5; 22.1)	9.0	1.26	0.208
	f	18.8 (16.6; 21.9)	20.6 (18.4; 23.9)	**12.0**	**2.73**	**0.006**
V_E, L	m	8.5 (7.2; 11.2)	12.2 (8.1; 14.3)	11.0	0.98	0.327
	f	10.2 (7.3; 12.4)	10.0 (7.7; 12.1)	57.0	1.24	0.215

Table 7. Changes in indicators of systemic hemodynamics under the influence of traction manipulations

Parameters	sex	Before	After	T	Z	p-value
EDV, cm^3	m	104.3 (90.8; 127.5)	112.6 (94.7; 123.1)	10.0	1.12	0.263
	f	88.0 (71.3; 106.5)	82.4 (77.6; 100.4)	85.0	0.02	0.983
ESV, cm^3	m	41.2 (34.4; 47.4)	43.2 (40.2; 45.7)	17.0	0.14	0.889
	f	30.1 (22.1; 36.0)	26.0 (22.8; 34.2)	62.0	1.02	0.306
SV, cm^3	m	66.8 (55.1; 75.1)	70.7 (57.5; 76.2)	5.0	1.82	0.069
	f	60.3 (49.7; 66.1)	57.7 (51.3; 68.5)	66.0	0.85	0.396
CO, dm^3	m	6.0 (5.2; 6.5)	5.8 (4.8; 6.0)	**0.0**	**2.37**	**0.018**
	f	5.1 (4.3; 5.4)	4.6 (4.2; 5.2)	**19.5**	**2.51**	**0.012**
SI, cm^3/m^2	m	36.6 (26.8; 40.6)	36.6 (31.3; 42.2)	**4.0**	**1.96**	**0.049**
	f	36.2 (30.8; 40.4)	36.2 (32.4; 40.2)	65.0	0.89	0.372
CI, dm^3/m^2	m	3.1 (2.8; 3.3)	3.0 (2.7; 3.1)	**0.0**	**2.37**	**0.018**
	f	3.0 (2.7; 3.3)	2.8 (2.6; 3.4)	**21.0**	**2.43**	**0.015**
GPVR, $dyn/s/cm^{-5}$	m	1363.5 (1181.0; 1486.0)	1357.2 (1273.2; 1641.9)	10.0	1.12	0.263
	f	1435.0 (1298.6; 1685.2)	1493.7 (1358.6; 1775.8)	**35.0**	**2.20**	**0.028**
BRS_{LF}, ms/mmHg	m	7.8 (5.3; 10.8)	10.1 (5.1; 15.3)	13.0	0.70	0.484
	f	8.3 (5.4; 11.6)	8.0 (6.1; 10.9)	68.0	0.76	0.446
BRS_{HF}, ms/mmHg	m	8.2 (3.7; 12.9)	10.5 (5.8; 19.0)	5.0	1.82	0.069
	f	11.4 (7.7; 15.7)	8.9 (7.0; 12.7)	76.0	0.41	0.679
IH, n. u.	m	5.15 (4.26; 7.65)	4.66 (3.66; 5.55)	**4.0**	**1.96**	**0.050**
	f	4.43 (3.89; 5.02)	3.90 (3.54; 4.42)	**2.0**	**3.64**	**0.000**
IVS, dm^3/L	m	0.609 (0.511; 0.914)	0.439 (0.383; 0.840)	11.0	0.98	0.327
	f	0.494 (0.406; 0.634)	0.461 (0.414; 0.515)	45.0	1.76	0.078

spine lead to a more significant restructuring of breathing patterns for women than for men. Probably, such an effect for women can be related to the differences in the types of breathing for men and women, which for women is mainly thoracic, and for men it is abdominal. Therefore, the manipulative effect on the costovertebral joints of the women chest can cause greater activation of exhalation muscles against the background of improving their mobility.

In the table 7 presents the data determining central hemodynamic indicators for men and women under the influence of traction manipulations. A significant decrease in CO (dm^3) for men from 6.0 (5.2; 6.5) to 5.8 (4.8; 6.0), p=0.018, and for women from 5.1 (4.3; 5.4) to 4.6 (4.2; 5.2), p=0.012, respectively, is characteristic. For both cases, this is ensured by a decrease in HR (min^{-1}) (Table 2), however, in men, this occurs against the background of a trend towards an increase in SV (cm^3) from 66.8 (55.1; 75.1) to 70.7 (57.5; 76.2), p=0.069 , and for women only due to HR (min^{-1}) – SV probably does not change 60.3 (49.7; 66.1) before and 57.7 (51.3; 68.5) after, p=0.396. For both men and women, the SI index (dm^3/m^2) significantly decreases from 3.1 (2.8; 3.3) to 3.0 (2.7; 3.1), p=0.018 and from 3.0 (2.7; 3.3) to 2.8 (2.6; 3.4), p=0.015, respectively, which indicates a tendency to decrease blood circulation kinetics. On the other hand, for men, a significant increase in SI (cm^3/m^2) is noted, which, taking into account the above-established trends in the autonomous provision of BPV, can be considered as a negative effect. However, the absolute values of the SI indicator (cm^3/m^2) are within the normative values, which can probably be characterized as optimization of the hemodynamics kinetics.

The increase in GPVR ($dyn/s/cm^{-5}$) for women from 1435.0 (1298.6; 1685.2) to 1493.7 (1358.6; 1775.8) was sufficiently informative, p=0.028. For men, this indicator changed insignificantly, but had a slight tendency to increase from 1363.5 (1181.0; 1486.0) to 1357.2 (1273.2; 1641.9), p=0.263.

As expected, taking into account the decrease in HR, the Hildebrandt index decreased, both for men from 5.15 (4.26; 7.65) to 4.66 (3.66; 5.55), p=0.050, and for women from 4.43 (3.89; 5.02) to 3.90 (3.54 ; 4.42), p=0.000. Changes in the volumetric synchronization index (IVS, dm^3/L) were interesting, but not significant, which proved sufficient stability of the hemodynamic support of breathing.

Discussion

Analyzing the successively investigated changes in the parameters of cardiointervalometry, HRV, BPV, RV, breathing pattern and central hemodynamics, we should pay attention to the fact that a significant part of them remains intact. However, it is expedient to discuss them, because different results were obtained in a number of studies by other authors.

We did not find changes in cardiointervalometry with the analysis of the PQRST-complex indicators in literary sources. Most of them analyze the HR, which is a reflection of the R-R interval, or HRV indicators, as derivatives of this interval variability. At the same time, the changes in the standardized QT (QTC) we established for men allow us to assume an improvement in the contractile function of the heart during traction manipulations on the thoracic spine. Unfortunately, we did not investigate the stability of this effect. At the same time, its mechanism remains not entirely clear, especially from the standpoint of the absence of similar significant changes for women. The most likely factor is an increase in parasympathetic effects for men.

Quite a lot, especially in recent years, have published publications characterizing changes in HRV under the influence of manual therapy. Most of them testify to different effects on HRV, taking into account the section of the spine on which the manipulations are carried out. A number of researchers who analyzed changes in HRV due to the impact on the cervical spine in patients with headache showed that among the immediate effects of reducing tension and pain, there is a significant increase in HRV indicators (Araujo, F. et al., 2019) due to an increase in the low-frequency component (LF, ms^2). Such effects were short-term, which prompted the authors to conclude that more procedures are appropriate. Other authors conducted a study of manual effects on the thoracic spine. It made it possible to draw a conclusion about the increase of vagotonic effects on the cardiac rhythm (Minarini, G. et al., 2018). The same effect was obtained by us for men. No such changes were found in women. In this case, we should mention the results of previously conducted studies, which showed the peculiarities of changes in the autonomic regulation of the HR for women under the influence of long-term aerobic exercises (Romanchuk, A., & Dolgier, Y., 2017), which had a different direction than for men.

Analyzing BP indicators, it should be noted that there is currently little data on short-term BPV. There are certain caveats regarding the informativeness of this analysis. However, there are already recommendations for its practical application (Rosei, E. et al., 2020). On the other hand, in our researches, an analysis of a large number of healthy and physically fit men (Guzii, O. et al., 2019) was carried out, which made it possible to determine the characteristics of changes in BP indicators taking into account the state of somatic health, the influence of training loads (Romanchuk, A, & Guzii, O., 2017), the development of cardiovascular system overstrains (Guzii, O. et al., 2021). We did not analyze the data on the study of BPV for women. At the same time, summarizing the obtained data for men, it was suggested to consider BP indicators from the standpoint of general regulatory effects on the contractile function of the heart (according to SBP indicators) and vascular tone (according to DBP indicators) (Guzii, O. et al., 2021). Considering the obtained results of changes in regulatory effects on SBP, it can be stated that for men, manual effects on the thoracic spine do not significantly change the regulation of the contractile function of the heart and vascular tone. As for women, there is a significant effect on the regulation of vascular tone, which is characterized by a decrease in suprasegmental (central) effects. There are several possible mechanisms, but they require appropriate proof in further research.

The analysis of RV indicators was proposed not so long ago. There are different options for analysis. Some scientists analyze the variability of the time intervals of the respiratory cycle. We proposed an analysis of the variability of inhalation volumes, which became achievable using the ultrasonic measurement of air flows implemented in the SACR device (Romanchuk, O. et al., 2022). From this point of view, we should mention the results obtained by us during the examination of highly qualified athletes with different types of heart rhythm regulation, which indicated the importance of differentiating low-frequency influences during the development of overstrain according to the sympathetic type (Romanchuk, A. & Guzii, O., 2020), when the activity of low-frequency influences on breathing was significantly reduced. Differences in RV indicators were also significant when testing patients with different courses of bronchial asthma (Bazhora, Y., & Romanchuk, O., 2018), with traumatic injuries of the spinal cord (Ternovoy, K. et al., 2012), under the influence of physical load. In view of the informativeness of these parameters, it is unequivocally possible to affirm their connection with respiratory volumes, which, when the indicators decrease, determines the economization of external breathing. On the other hand, the frequency characteristics of the volume variability of breathing may have other regulatory prerequisites that require further research. Especially taking into account the differences that we obtained during the study of changes in the cardiovascular system during controlled breathing with different frequency and volume characteristics (Guzii, O. & Romanchuk, A., 2018). Analyzing the differences and changes in RV indicators in this study, it should be said that there are the significant differences between men and women in terms of RV indicators in the initial condition, which can be explained by differences in lung capacity. The RV in response to the influence of manipulations on the thoracic spine did not differ significantly in any of the parameters.

The differences in changes in the pattern of breathing turned out to be quite significant. As a rule, breathing pattern research is not widely used in practice. This is more connected, in our opinion, with insignificant diagnostic value in determining restrictive and obstructive disorders of external breathing, which are the basis of most diseases of the pulmonary system. They are examined using spirometry. Pattern research requires spirography, which is of very limited use. In this case, spirography is performed in combination with the registration of indicators of the cardiovascular system, which provides an opportunity to characterize the indicators of patterned breathing. As it turned out, they have a special value for characterizing the state of the body, especially dynamic changes during spontaneous breathing, when for one reason or another the duration, volumetric rate of inhalation and exhalation, and their ratio changes. A decrease in the duration of exhalation and its share in the respiratory cycle, which lead to increased breathing after performing traction manipulations for women, can be considered from the standpoint of exhalation muscle activation against the background of improving the mobility of costovertebral joints under the influence of manual therapy traction manipulations. There are no such changes for men. This is probably due to the peculiarities of the type of breathing for women, which is mainly chest breathing. Accordingly, it is more sensitive to changes in the mobility of the chest under the influence of traction manipulations.

As for the differences in changes in central hemodynamics, the changes independent of gender, which were combined with a decrease in heart rate, turned out to be quite informative. Its mechanism is difficult to explain as a reaction to traction manipulations. The most likely, in our opinion, is its decrease due to an increase in the suction function of the chest. In this case, the SV of the heart should increase. However, it remains unchanged. For men, this could be explained by an increase in vagotonic effects. Then there is the question of women. The involvement of baroreflex mechanisms is also in question, because the sensitivity of the arterial baroreflex remains unchanged both in the high- and low-frequency range. The GPVR index (dyn/s/cm^{-5}) in women, which significantly increases after traction, deserves special attention. Given the decrease in DBPV observed for women, it is most likely optimization of peripheral vascular tone that leads to an increase in GPVR.

Characterizing the changes in the cardiorespiratory system as a whole under the influence of traction manipulations on the thoracic spine, it should be noted that for men and women there were significant unidirectional changes in HR (min^{-1}), CO (dm^3), CI (dm^3/m^2), IH (n. u.), which are determined primarily by the decrease in HR (min^{-1}) under the influence of traction manipulations. Given the changes in other indicators, there are certain gender differences that should be taken into account both when evaluating the effectiveness of manipulations and taking into account the prediction of possible negative reactions (Table 8). If for men, the significant effects were more related to the impact on the contractile function of the heart, which was confirmed by the improvement of the

Table 8. Significant differences in indicators of the cardiorespiratory system changes in men and women under the influence of traction manipulations in the thoracic spine

Parameters	Men	Women
QTC, s	↓	=
HF, ms^2	↑	=
TP_{DBP}, $mmHg^2$	=	↓
VLF_{DBP}, $mmHg^2$	=	↓
Texp, s	=	↓
Ti/(Ti+Te)	=	↑
RR, min^{-1}	=	↑
SI, cm^3/m^2	↑	=
GPVR, $dyn/s/cm^{-5}$	=	↑

electrical systole of the ventricles (QTC, s), the increase in the activity of the effects of the parasympathetic branch of the ANS on the heart rhythm (HF, ms^2) and a certain increase in the stroke index within the normative values (SI, cm^3/m^2), then for women the significant effects were more related to the influence on the breathing pattern and vascular tone. Thus, characteristic and positive effects for women can be considered a decrease in the variability of diastolic blood pressure in the very-low-frequency range (VLF_{DBP}, $mmHg^2$), which is combined with a decrease in the total power of diastolic pressure variability (TP_{DBP}, $mmHg^2$) and an increase in the total peripheral vascular resistance (GPVR, $dyn/s/cm^{-5}$). Such changes testify to a decrease in the lability of blood vessels and optimization of their tone.

Analyzing all the differences in a complex, it should be noted that men and women are characterized by changes associated with a decrease in HR under the influence of traction manipulations. At the same time, for men, the improvement of the contractile function of the heart is informative, the further study of which with use the different methods of a manual influence may be useful in cardiology practice. First of all, with the initial symptoms of coronary heart disease, the development of prolonged QT syndrome, Brugada syndrome, etc. A positive effect for men is also associated with an increase in the contribution of the high-frequency component of HRV and may indicate the effectiveness of a manual therapy in the disorders associated with excessive activity of the sympathetic nervous system. At the same time, for women, it is possible to increase the effectiveness of preventive and therapeutic effects when using manual therapy in the clinic of the lung diseases and dystonic disorders.

Conclusion

Summarizing the results of the impact of traction manipulations in the thoracic spine on the cardiorespiratory system for men and women, it can be stated that their effect is different and has features associated with the use of different mechanisms. For men, the predominant effect is on the heart contractile function, and for women – on the respiratory system and autonomous regulation of vascular tone. Further research in this direction should be aimed at determining the criteria for the use of various manipulation and mobilization methods of manual therapy in different diseases of the cardiovascular, respiratory and autonomic nervous systems, which can be useful not only at the rehabilitation stage, but also within the scope of inclusion in treatment protocols.

Conflicts of Interest

The author declares no conflict of interest.

Funding

This article didn’t receive financial support from the state, public or commercial organizations.

References

Alsayani, K.Y.A., Aslan, U.B., Büker, N., Şavkın, R., & Yağcı, A.B. (2021). The immediate effect of harmonic therapy on peripheral blood flow in young males: A cross-over pilot study. *International Journal of Osteopathic Medicine*, 42, 51-55. https://doi.org/10.1016/j.ijosm.2021.11.001.

Amoroso Borges, B.L., Bortolazzo, G.L., & Neto, H.P. (2018). Effects of spinal manipulation and myofascial techniques on heart rate variability: A systematic review. *Journal of Bodywork and Movement Therapies*, 22(1), 203-208. https://doi.org/10.1016/j.jbmt.2017.09.025

Araujo, F.X., Ferreira, G.E., Angellos, R.F., Stieven, F.F., Plentz, R.D. M., & Silva, M.F. (2019). Autonomic Effects of Spinal Manipulative Therapy: Systematic Review of Randomized Controlled Trials. *Journal of Manipulative and Physiological Therapeutics*, 42(8), 623-634. https://doi.org/10.1016/j.jmpt.2018.12.005

Bazhora, Y.I., & Romanchuk, O.P. (2018). Variability and Respiration Pattern of Patients with Persistent Asthma and Obesity. *Ukraïns'kij Žurnal Medicini, Bìologìï Ta Sportu*, 3(7), 74-83. https://doi.org/10.26693/jmbs03.07.074

Benjamin, J.G., Moran, R.W., Plews, D.J., Kilding, A.E., Barnett, L.E., Verhoeff, W.J., & Bacon, C.J. (2020). The effect of osteopathic manual therapy with breathing retraining on cardiac autonomic measures and breathing symptoms scores: A randomised wait-list controlled trial. Journal of Bodywork and

Movement Therapies, 24(3), 282-292. https://doi.org/10.1016/j.jbmt.2020.02.014

Casali, K.R., Schaan, B.D., Montano, N., Massierer, D., Neto, F.M.F., Teló, G.H., Ledur, P.S., Reinheimer, M., Sbruzzi, G., & Gus, M. (2018). Correlation between Very Short and Short-Term Blood Pressure Variability in Diabetic-Hypertensive and Healthy Subjects. *Arquivos Brasileiros de Cardiologia*, 110(2), 157-165. https://doi.org/10.5935/abc.20180020

Cerqueira, M.S. (2019). Response to "Spinal Manipulative Therapy and Sports Performance Enhancement: A Systematic Review." *Journal of Manipulative and Physiological Therapeutics*, 42(5), 382. https://doi.org/10.1016/j.jmpt.2018.03.008.

Colloca, C.J., Keller, T.S., Gunzburg, R., Vandeputte, K., & Fuhr, A.W. (2000). Neurophysiologic response to intraoperative lumbosacral spinal manipulation. *Journal of Manipulative and Physiological Therapeutics*, 23(7), 447-457. https://doi.org/10.1067/mmt.2000.108822.

Degenhardt, B.F., Darmani, N.A., Johnson, J.C., Towns, L.C., Rhodes, D.C.J., Trinh, C., McClanahan, B., & DiMarzo, V. (2007). Role of osteopathic manipulative treatment in altering pain biomarkers: a pilot study. *The Journal of the American Osteopathic Association*, 107(9), 387-400. http://www.ncbi.nlm.nih.gov/pubmed/17908831.

Denneny, D., Frawley, H.C., Petersen, K., McLoughlin, R., Brook, S., Hassan, S., & Williams, A.C. (2019). Trigger Point Manual Therapy for the Treatment of Chronic Noncancer Pain in Adults: A Systematic Review and Meta-analysis. *Archives of Physical Medicine and Rehabilitation*, 100(3), 562-577. https://doi.org/10.1016/j.apmr.2018.06.019.

de la Fuente-Fernández, R., Lidstone, S., & Stoessl, A.J. (2006). Placebo effect and dopamine release. *Journal of Neural Transmission. Supplementum*, 70, 415-418. https://doi.org/10.1007/978-3-211-45295-0_62.

de la Sierra, A., Banegas, J.R., Bursztyn, M., Parati, G., Stergiou, G., Mateu, A., Vinyoles, E., Segura, J., Gorostidi, M., & Ruilope, L.M. (2020). Prognostic Relevance of Short-Term Blood Pressure Variability: The Spanish ABPM Registry. *Hypertension (Dallas, Tex.: 1979)*, 5 Suppl 1, HYPERTENSIONAHA11914508. https://doi.org/10.1161/HYPERTENSIONAHA.119.14508

Espí-López, G.V., López-Martínez, S., Inglés, M., Serra-Añó, P., & Aguilar-Rodríguez, M. (2018). Effect of manual therapy versus proprioceptive neuromuscular facilitation in dynamic balance, mobility and flexibility in field hockey players. A randomized controlled trial. *Physical Therapy in Sport*, 32, 173-179. https://doi.org/10.1016/j.ptsp.2018.04.017

Halili, A. (2021). Physical therapy for the treatment of respiratory issues using Systemic Manual Therapy protocols. *Journal of Bodywork and Movement Therapies*, 27, 113-126. https://doi.org/10.1016/j.jbmt.2021.02.009

Herzog, W., Scheele, D., & Conway, P.J. (1999). Electromyographic responses of back and limb muscles associated with spinal manipulative therapy. *Spine*, 24(2), 146-152; discussion 153. https://doi.org/10.1097/00007632-199901150-00012.

Hinkeldey, N., Okamoto, C., & Khan, J. (2020). Spinal Manipulation and Select Manual Therapies. *Physical Medicine and Rehabilitation Clinics of North America*, 31(4), 593-608. https://doi.org/10.1016/j.pmr.2020.07.007.

Guzii, O., & Romanchuk, A. (2017). Heart rate variability during controlled respiration after endurance training. *Journal of Physical Education and Sport ® (JPES)*, 17(203), 2024-2029. https://doi.org/10.7752/jpes.2017.03203

Guzii, O., & Romanchuk, A. (2018). Determinants of the functional state of sportsmen using heart rate variability measurements in tests with controlled respiration. *Journal of Physical Education and Sport ® (JPES)*, 18(2), 715-724. https://doi.org/10.7752/jpes.2018.02105.

Guzii, O., Romanchuk, A., Mahlovanyi, A., & Trach, V. (2019). Polyfunctional express-evaluation criteria of the sportsman organism state. *Journal of Physical Education and Sport ® (JPES)*, 19(4), 2352-2358. https://doi.org/10.7752/jpes.2019.04356

Guzii, O., Romanchuk, A., Mahlovanyi, A., & Trach, V. (2021). Post-loading dynamics of beat-to-beat blood pressure variability in highly trained athletes during sympathetic and parasympathetic overstrain formation. *Journal of Physical Education and Sport*, 21(5), 2622-2632. https://doi.org/10.7752/jpes.2021.05350.

Kachmar, O., Kushnir, A., Matiushenko, O., & Hasiuk, M. (2018). Influence of Spinal Manipulation on Muscle Spasticity and Manual Dexterity in Participants With Cerebral Palsy: Randomized Controlled Trial. *Journal of Chiropractic Medicine*, 17(3), 141-150. https://doi.org/10.1016/j.jcm.2018.03.004

Karemaker, J.M., & Wesseling, K.H. (2008). Variability in Cardiovascular Control: The Baroreflex Reconsidered. *Cardiovascular Engineering*, 8(1), 23-29. https://doi.org/10.1007/s10558-007-9046-4

Kim, T.H., Hur, J., Kim, S.J., Kim, H.S., Choi, B.W., Choe, K.O., Yoon, Y.W., & Kwon, H.M. (2005). Two-Phase Reconstruction for the Assessment of Left Ventricular Volume and Function Using Retrospective ECG-Gated MDCT: Comparison with Echocardiography. *American Journal of Roentgenology*, 185(2), 319-325. https://doi.org/10.2214/ajr.185.2.01850319.

Kishi, T. (2018). Baroreflex failure and beat-to-beat blood pressure variation. *Hypertension Research: Official Journal of the Japanese Society of Hypertension*, 41(8), 547-552. https://doi.org/10.1038/s41440-018-0056-y.

Malisza, K.L., Stroman, P.W., Turner, A., Gregorash, L., Foniok, T., & Wright, A. (2003). Functional MRI of the rat lumbar spinal cord involving painful stimulation and the effect of peripheral joint mobilization. *Journal of Magnetic Resonance Imaging*, 18(2), 152-159. https://doi.org/10.1002/jmri.10339.

Matre, D., Casey, K.L., & Knardahl, S. (2006). Placebo-induced changes in spinal cord pain processing. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, 26(2), 559-563. https://doi.org/10.1523/JNEUROSCI.4218-05.2006.

McPartland, J.M., Giuffrida, A., King, J., Skinner, E., Scotter, J., & Musty, R.E. (2005). Cannabimimetic effects of osteopathic manipulative treatment. *The Journal of the American Osteopathic Association*, 105(6), 283-291. http://www.ncbi.nlm.nih.gov/pubmed/16118355

Minarini, G., Ford, M., & Esteves, J. (2018). Immediate effect of T2, T5, T11 thoracic spine manipulation of asymptomatic patient on autonomic nervous system response: Single-blind, parallel-arm controlled-group experiment. *International Journal of Osteopathic Medicine*, 30, 12-17. https://doi.org/10.1016/j.ijosm.2018.10.002

Moulson, A., & Watson, T. (2006). A preliminary investigation into the relationship between cervical snags and sympathetic nervous system activity in the upper limbs of an asymptomatic population. *Manual Therapy*, 11(3), 214-224. https://doi.org/10.1016/j.math.2006.04.003.

Noskin, L., Rubinskiy, A., Romanchuk, A., Marchenko, V., Pivovarov, V., Cherepov, A., & Zarovkina, L. (2018). Study of cardiovascular and respiratory synchronization in different types of breathing. *Patogenez*, 4(), 90-96. https://doi.org/10.25557/2310-0435.2018.04.90-96

Papaioannou, T.G., Fasoulis, R., Gialafos, E., & Tousoulis, D. (2019). Methodological and computational insights on the assessment of arterial baroreflex sensitivity. *Experimental Physiology*, 104(5), 779-780. https://doi.org/10.1113/EP087298

Papaioannou, T.G., Protogerou, A.D., Stamatelopoulos, K.S., Alexandraki, K.I., Vrachatis, D., Argyris, A., Papaioannou, V., Vavuranakis, M., Stefanadis, C., & Tousoulis, D. (2020). Very-short-term blood pressure variability: complexities and challenges. *Blood Pressure Monitoring*, 25(5), 300. https://doi.org/10.1097/MBP.0000000000000464.

Penáz, J. (1992). Criteria for set point estimation in the volume clamp method of blood pressure measurement. *Physiological Research*, 41(1), 5-10. http://www.ncbi.nlm.nih.gov/pubmed/1610779.

Picone, D.S., Schultz, M.G., Otahal, P., Aakhus, S., Al-Jumaily, A.M., Black, J.A., Bos, W.J., Chambers, J.B., Chen, C.-H., Cheng, H.-M., Cremer, A., Davies, J.E., Dwyer, N., Gould, B.A., Hughes, A.D., Lacy, P.S., Laugesen, E., Liang, F., Melamed, R., … Sharman, J.E. (2017). Accuracy of Cuff-Measured Blood Pressure. *Journal of the American College of Cardiology*, 70(5), 572-586. https://doi.org/10.1016/j.jacc.2017.05.064

Pinna, G.D., Maestri, R., & Mortara, A. (1996). Estimation of arterial blood pressure variability by spectral analysis: comparison between Finapres and invasive measurements. *Physiological Measurement*, 17(3), 147-169. https://doi.org/10.1088/0967-3334/17/3/002

Pivovarov, V.V. (2006). [A spiroarteriocardiorhythmograph]. *Meditsinskaia Tekhnika*, 1, 38–40. http://www.ncbi.nlm.nih.gov/pubmed/16610287.

Romanchuk, A., & Dolgier, Y. (2017). Effects of long-term training experience of aerobic exercises on middle-aged women. *Journal of Physical Education and Sport ® (JPES)*, 17(102), 680-687. https://doi.org/10.7752/jpes.2017.02102.

Romanchuk, A., & Pisaruk, V. (2013). Change of central hemodynamics of qualified athletes for testing the use of controlled breathing and evaluation. *Pedagogics, Psychology, Medical-Biological Problems of Physical Training and Sports*, 11, 77-84. https://doi.org/10.6084/m9.figshare.817930

Romanchuk, O.P. (2022). The Immediate Effects of the Manual Therapy Traction Manipulations on Parameters of Cardiorespiratory System Functioning. *International Journal of Human Movement and Sports Sciences*, 10(5), https://doi.org/10.13189/ saj.2022.100424

Romanchuk, A., & Guzii, O. (2020). Variability and Pattern of Spontaneous Respiration in Different Types of Cardiac Rhythm Regulation of Highly Trained Athletes. *International Journal of Human Movement and Sports Sciences*, 8(6), 483-493. https://doi.org/10.13189/saj.2020.080622

Romanchuk, O., & Hanitkevych, V. (2022). Influence of Yumeiho therapy on morphometric parameters of adolescents with postural disorders. *Physical Rehabilitation and Recreational Health Technologies*, 7(2), 43-47. https://doi.org/10.15391/prrht.2022-7.10

Romanchuk, O.P., & Hanitkevych, V.I. (2022). [The influence of Yumeiho-therapy on the adolescent's respiratory system functional state with posture disorders]. *Rehabilitation and Recreation*, 11, 47-57. https://doi.org/10.32782/2522-1795.2022.11.5

Romanchuk, O.P., & Hanitkevych, V.I. (2022). The influence of the Yumeiho therapy procedure on central hemodynamics and its assessment. *Physical rehabilitation and recreational health technologies*, 7(3), 96-103. https://doi.org/10.15391/prrht.2022-7.20

Rosei, E.A., Chiarini, G., & Rizzoni, D. (2020). How important is blood pressure variability? *European Heart Journal Supplements: Journal of the European Society of Cardiology*, 22(Suppl E), E1-E6. https://doi.org/10.1093/eurheartj/suaa061

Saionji, M. (1990). Hipbone yumeiho therapy. Beijing: Xue Yuan (Academia).

Schillaci, G., Bilo, G., Pucci, G., Laurent, S., Macquin-Mavier, I., Boutouyrie, P., Battista, F., Settimi, L., Desamericq, G., Dolbeau, G., Faini, A., Salvi, P., Mannarino, E., & Parati, G. (2012). Relationship Between Short-Term Blood Pressure Variability and Large-Artery Stiffness in Human Hypertension. *Hypertension*, 60(2), 369-377. https://doi.org/10.1161/HYPERTENSIONAHA.112.197491

Simonelli, C., Vitacca, M., Vignoni, M., Ambrosino, N., & Paneroni, M. (2019). Effectiveness of manual therapy in COPD: A systematic review of randomised controlled trials. *Pulmonology*, 25(4), 236-247. https://doi.org/10.1016/j.pulmoe.2018.12.008.

Sterling, M., Jull, G., & Wright, A. (2001). Cervical mobilisation: concurrent effects on pain, sympathetic nervous system activity and motor activity. *Manual Therapy*, 6(2), 72-81. https://doi.org/10.1054/math.2000.0378

Teodorczyk-Injeyan, J.A., Injeyan, H.S., & Ruegg, R. (2006). Spinal Manipulative Therapy Reduces Inflammatory Cytokines but Not Substance P Production in Normal Subjects. *Journal of Manipulative and Physiological Therapeutics*, 29(1), 14-21. https://doi.org/10.1016/j.jmpt.2005.10.002.

Ternovoy, K.S., Romanchuk, A.P., Sorokin, M.Y., & Pankova, N.B. (2012). Characteristics of the functioning of the cardio-respiratory system and autonomic regulation in para-athletes with spinal injury. Human Physiology, 38(4), 410-415. https://doi.org/10.1134/S0362119712040147

Tian, G., Xiong, L., Leung, H., Soo, Y., Leung, T., & Wong, L.K.-S. (2019). Beat-to-beat blood pressure variability and heart rate variability in relation to autonomic dysregulation in patients with acute mild-moderate ischemic stroke. *Journal of Clinical Neuroscience: Official Journal of the Neurosurgical Society of Australasia*, 64, 187-193. https://doi.org/10.1016/j.jocn.2019.03.003

Tkaczyszyn, M., Rydlewska, A., Ponikowska, B., Borodulin-Nadzieja, L., Banasiak, W., Ponikowski, P., & Jankowska, E.A. (2013). [Arterial baroreflex--physiological role and assessment of functioning]. Polski Merkuriusz Lekarski: Organ Polskiego Towarzystwa Lekarskiego, 35(206), 104-110. http://www.ncbi.nlm.nih.gov/pubmed/24052991

Wesseling K. (1990). *Finapres, continuous noninvasive finger arterial pressure based on the method of Peňáz*. In: Meyer-Sabellek, W,. Gotzen, R., Anlauf, M., Steinfeld, L., editors. Blood Pressure Measurements. Steinkopff.

Wirth, B., Gassner, A., de Bruin, E.D., Axén, I., Swanenburg, J., Humphreys, B.K., & Schweinhardt, P. (2019). Neurophysiological Effects of High Velocity and Low Amplitude Spinal Manipulation in Symptomatic and Asymptomatic Humans: A Systematic Literature Review. *Spine*, 44(15), E914-E926. https://doi.org/10.1097/BRS.0000000000003013.

Williams, N.H., Hendry, M., Lewis, R., Russell, I., Westmoreland, A., & Wilkinson, C. (2007). Psychological response in spinal manipulation (PRISM): a systematic review of psychological outcomes in randomised controlled trials. *Complementary Therapies in Medicine*, 15(4), 271-283. https://doi.org/10.1016/j.ctim.2007.01.008