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THE EFFECT OF OXYGEN-OZONE TREATMENT ON POSTURE

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Abstract
The way we step, the functioning of the oculomotor muscles, the dental occlusion and the mobility of the temporomandibular joint influence our posture and balance.

A dysfunction at one of these levels or the presence of skin scars affects the kinematic chain of movement, generating muscle contractions, decreased joint mobility, vertebral static disorders and, finally, bone changes. A large number of the adult population, but also of children, due to sedentary lifestyle and inadequate nutrition, in the absence of sustained physical activity, face postural disorders. Sometimes, excessive physical activity (physical exertion) or incorrect exercise results in the accumulation of lactic acid and muscle contractions, leading to postural disorders.

Oxygen-ozone therapy administered in the form of periarticular subcutaneous infiltrations or along the spine, reduces muscle contractions, relieves pain, having a beneficial effect on posture and balance.

A study of 20 patients with vertebral static disorders (argued by three-dimensional vertebral measurements with the Spine 3D system, Sensor Medica Italy) and balance disorders (recorded on the baropodometric and stabilometric platform), treated with an oxygen-ozone mixture, in low concentrations (8-10µg/ml), shows the immediate effects of this therapy on pain and posture (balance, vertebral statics, etc.).

The lack of allergic reactions and side effects of oxygen-ozone therapy recommends it in the treatment of musculoskeletal disorders, caused by vertebral static disorders. Of course, to this should be added the correction of the posture disorder, which was the basis of the illness.

Keywords: posture, balance, ozone therapy, vertebral statics

Introduction

Posture is how we manage to maintain a bipedal position in close harmony with balance to ensure the body functions properly. It is influenced by the way we walk, the quality of dental occlusion, the functionality of the temporomandibular joint and, not least, oculomotor function.

Impaired posture is frequently accompanied by balance disorders and the development of various musculoskeletal disorders, from muscle contractures to herniated discs, joint and ligament disorders.

Ozone therapy is used in the treatment of musculoskeletal disorders because of its positive effects on increasing the supply of oxygen to the tissues: combating muscle contractures, reducing pain, increasing joint mobility.

Methodology

Using the Free Step baropodometric platform and the Spine 3D spinal statics investigation system, both produced by Sensor Medica Italy, we were able to evaluate the effect of ozone, administered in the form of local infiltrations, on posture and balance.

We used a group of 20 patients, 10 with knee arthrosis and 10 with lumbar damage (herniated or protruded discs, non-traumatic cause), who followed the baropodometric, stabilometric and spinal statics investigation protocol, before and after 10 sessions with ozone, administered as local subcutaneous infiltrations, comparing the results obtained. We chose subcutaneous infiltrations, not intra-articular or deep intramuscular infiltrations, in order not to change the posture or vertebral statics very much. We also analysed the evolution of pain (using the numerical pain scale) before, 30 minutes after the first ozone administration and after 10 sessions.

The baropodometric examination included: static, dynamic and stabilometric examination.

For the static examination, three measurements were taken in orthostatic position, with the feet apart, in a position assumed spontaneously by each patient, so as not to cause pain. The aim was to position the soles at an equal distance from the landmark marking the centre of the balance polygon. The static examination was followed by the dynamic examination and, finally, the balance analysis.

The following were analysed: foot type (flat/hollow/valgus/normal), CoF angle, foot angle, right or left, anterior or posterior foot loading, average forefoot and heel pressures, balance disorders, (translated by the amplitude of the oscillations, the area of the equilibrium ellipse, the angle formed between the projection of the equilibrium centre and the balance on the two pelvic limbs).

All the data obtained was collected and analyzed by the Free Step software, showing in real-time all the pressure changes in the two soles.

After examining the foot and balance, the analysis of spinal statics was performed using non-invasive [4] LIDAR technology, following:

- in sagittal plane: the VPDM spinal tilt (between the C7 proeminens vertebra and the mid-distance DM, between the two right/left lumbosacral fossae - DR/DL), the lumbar and cervical sag, the kyphotic and lordotic angle
- in coronal plane: pelvic obliquity, spinal deviation – RMS
- in cross-sectional plane, the evolution of the maximum angle of rotation was followed.

Results and discussions

It is well known that with the passage of time, our posture undergoes changes [2], both through musculoskeletal and nervous system degradation.

Knee osteoarthritis is a problem of adulthood, through weight gain and lack of movement. Due to joint instability, many patients with knee osteoarthritis have significant balance disorders and are exposed to precipitation trauma [3]. Because knee damage is often secondary to a podiatric disorder, plantar pressure changes are frequently encountered in the context of flat, hollow or valgus foot.

Non-traumatic, disc-related spinal damage is accompanied by significant podiatric pressure disorders and spinal static disorders, often in multiple segments. Frequently, there is co-injury to the knees and spine.

The wide range of treatments is aimed particularly at the pain and reduced mobility which bring the patient to the consultation and, very rarely, at inadequate posture. As most patients with knee osteochondritis or spinal damage are over 50 years of age and frequently have multiple co-morbidities, treatment of these conditions must take into account contraindications and adverse effects.

Ozone therapy, in addition to the fact that it does not come with side effects (the only reaction reported by most patients is discomfort in the form of painful discomfort when injected, which disappears in 30 to 60 seconds), has multiple advantages, which recommends it as a first-line treatment for musculoskeletal disorders. At the low concentrations used in subcutaneous administration (10-20 µg/ml), ozone therapy:

- modulates oxidative stress, by activating Nrf2 (nuclear erythroid factor 2) and HIFα (hypoxia-inducing factor) preparing the body for confrontation with reactive oxygen species (ROS) [6,7],
- fights inflammation, by reducing IL-6, IL1, TNFα levels [6,7], resulting in a rapid decrease of pain
- increases ATP and 2,3-DPG levels, shifting the HbO_2 dissociation curve to the right, increasing ozone delivery to tissues [7,8,9,10]
- increases joint mobility [8,9,11]

Regardless of the site of administration (spine and/or knee), the effect on spinal statics was obvious, bringing changes in the initially measured values, most of the time in a positive direction. Therefore, we statistically analysed the measurements made using IBM SPSS Statistics 23. The t-test was used for paired samples in order to compare the means of the tests administered to the group of patients, observed at two points in time, before and after treatment, in order to check whether the differences between the mean values of the parameters at the two points in time were significant.

The Friedman test was used to test for differences in rank for a variable measured repeatedly (more than twice) on the same group of subjects. We used this test to test for differences in pain scale at baseline, 30 minutes after the first administration and after 10 treatment sessions. We tried to determine whether there were differences in pain scale between women and men using the independent samples t-test. We also calculated the Pearson coefficient to test for correlation between variables.

A significance threshold $\alpha = 0.05$ was considered for all tests.

Analyzing various parameters, initially and after 10 ozone treatments, we observe differences, often significant, between measurements, especially in obliquity, shoulder slope and pelvic tilt, balance and pain scale. As a general observation, in the patients examined and treated with ozone, there were postural disorders, argued by values outside the normal spectrum.

Reference points:

- CA = cervical apex- maximum curvatum of the cervical lordosis
- ITL = thoraco- lumbar inversion
- ILS = lumbo-sacral inversion
- KA = apex kyphosis – maximum curvatum of the dorsal kyphosis
- LA = apex lordosis - maximum curvatum of the lumbar kyphosis
- DM = midpoint between DR (right lumbar dimple) and DL (left lumbar dimple)
- VP = proeminents vertebra – spinous process of C7
- SL = midpoint calculated between the axilary cavity and the left shoulder apex
- SD = midpoint calculated between the axilary cavity and the right shoulder apex
- SP = S4

Calculated parameters:

- Trunk inclination VPDM- angle between the straight line passing through VP and DM and the vertical plane (along the sagittal section)
- Sagital imbalance VPDM = horizontal distance, along the sagittal plane, between VP and the vertical passing through DM
- Cervical lordosis depth CA- ‖ KK = distance between CA and the tangent to KA wich is parallel to the VPDM line
- Lumbar lordosis LA- ‖ KA = distance between LA and the tangent to KA wich is parallel to the VPDM line
- Cervical arrow CArr = forward protraction of the head
- Lumbar arrow LArr = lordosis depth
- Coronal imbalance VPDM – distance between DM and the vertical passing through VP
- Trunk imbalance VPDM – lateral deviation between VP and DM angle formed between the joining of VP and DM and the vertical axis.
- Shoulder obliquity SLSR- distance between the horizontal axis passing through SR
- Schoulder titl SLSR – lateral deviation between SL and SR angle, formed between the joining of SL and the SR and the horizontal axis.
- Vertebral deviation RMS – on the frontal plane, quadratic mean of the horizontal lateral deviation of the centers of the vertebral bodies with respect to the connecting line VP-DM
- Vertebral deviation max left (-) = maximum convexity to the left
- Vertebral deviation max right +-) = maximum convexity to the right
- Surface rotation RMS – quadratic mean of the angle formed between the straight line passing through the center of the vertebral body and the apex of the corresponding spinous process and the perpendicular to the frontal plane
- Surface rotation max right (+) – angle formed between the straight line passing through the center of the vertebral body and the apex of the corresponding spinous process and the perpendicular to the frontal plane, displacement of the surface to the right and then left vertebral rotation
- the appearance of the foot
- podiatric loading
- average foot pressure
- global CoF
- Foot angle

- Lung sway
- the surface of the ellipse
- numerical scale of pain

	Medium value		
	Initial	Final	Different percentages
VPDM spinal tilt	3,6315	3,2035	-11,79%
Lumbar arrow Larr	43,8	43,4	-0,91%
Cervical arrow Carr	52,45	50,4	-3,91%
ICT ITL kyphotic angle	49,2735	48,618	-1,33%
ITL ILS lordotic angle	41,3765	44,449	7,43%
VPDM coronal imbalance	-7,7	-6,8	-11,69%
SLSR shoulders obliquity	2	2,35	17,50%
DLDR pelvic obliquity	1,6	-0,6	-137,50%
VPDM torso imbalance	-0,932	-0,9165	-1,66%
SLSR shoulder slope	0,3055	0,381	24,71%
DLDR titl pelvis	0,8035	-0,405	-150,40%
RMS vertebral deviation	4,35	3,8	-12,64%
Flat right foot	0,7	0,65	-7,14%
Right foot hollow	0,1	0,1	0,00%
Right foot valgus	0,4	0,45	12,50%
Normal right foot	0,2	0,25	25,00%
Flat left foot	0,7	0,65	-7,14%
Left hollow foot	0,15	0,15	0,00%
Left leg valgus	0,4	0,5	25,00%
Normal left foot	0,15	0,15	0,00%
Anterior right podiatric loading	25,55	25,3	-0,98%
Posterior right podiatric loading	25,35	25,75	1,58%
Anterior left podiatric loading	24,35	24,35	0,00%
Posterior left podiatric loading	24,75	24,6	-0,61%
Anterior right mean pressure	237,4	248,5	4,68%
Posterior right mean pressure	306,85	318,8	3,89%
Anterior left mean pressure	235,9	261,8	10,98%
Posterior left mean pressure	306,5	318,1	3,78%
Global Right CoF	83,25	83,5	0,30%
Global Left CoF	79,45	81,2	2,20%
Right Foot angle	11	11,9	8,18%
Left Foot angle	10,45	8,75	-16,27%
Lung sway cervical test, straight head	441,048	468,054	6,12%
Lung sway, cervical test,retroflex head	509,075	498,848	-2,01%
The surface of the ellipse, cervical test, straight head	56,3905	77,2095	36,92%
The surface of the ellipse, cervical test, retroflex head	122,5775	68,809	-43,86%
Numerical scale of pain	7,3	1,65	-77,40%

Paired samples t-test - used for testing the difference between the mean of a variable at different times, reveals very strong correlations between the initial and final values of the variables for:

- VPDM spinal tilt ($r = 0.828$, $p < 0.001 < \alpha = 0.05$),
- ITL ILS lordotic angle ($r = 0.781$, $p < 0.001 < \alpha = 0.05$),
- SLSR shoulder slope ($r = 0.666$, $p = 0.001 < \alpha = 0.05$),
- DLDR pelvic tilt ($r = 0.611$, $p = 0.004 < \alpha = 0.05$),

with no correlation between initial and final values of:

- ICT ITL kyphotic angle (r = 0.295, p = 0.206 > α = 0.05)
- VPDM torso imbalance (r = 0.063, p = 0.973 > α = 0.05).

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	VPDM initial spinal titl - VPDM final spinal titl	0,42800	2,24613	0,50225	-0,62322	1,47922	0,852	19	0,405
Pair 2	ICT ITL inițial kyphotic angle ICT ITL final kyphotic angle	0,65550	14,85570	3,32183	-6,29718	7,60818	0,197	19	0,846
Pair 3	ITL ILS inițial lordotic angle- ITL ILS final ordotic angle	-3,07250	8,08232	1,80726	-6,85514	0,71014	-1,700	19	0,105
Pair 4	VPDM initial torso imbalance -VPDM final torso imbalance	-0,01550	11,50845	2,57337	-5,40162	5,37062	-0,006	19	0,995
Pair 5	SLSR inițial shoulder slope - SLSR final shoulder slope	-0,07550	1,57135	0,35136	-0,81091	0,65991	-0,215	19	0,832
Pair 6	DLDR inițial pelvic tilt - DLDR final pelvic titl	1,20850	2,21423	0,49512	0,17221	2,24479	2,441	19	0,025

The Paired Samples Test table shows the results of the t-test as follows:

- difference between means (Mean),
- the standard deviation of the difference (Std. Deviation),
- confidence interval of the difference (95% Confidence Interval of the Difference)

with:

- lower limit and upper limit,
- the calculated value of the t-test,
- degrees of freedom (df),
- p probability associated with the test (Sig. 2-tailed).

The results obtained from the application of the test show that there are statistically significant differences between the initial and final values of the parameters analysed only in the case of the data for DLDR pelvic tilt (difference between means = 1.20850, t = 2.441, p = 0.025 < α = 0.05, and the confidence interval limits (0.17221, 2.24479) for the difference between the means of the two groups do not contain the value zero).

There are no statistically significant differences between the means of the baseline and the means of the final parameter values, according to the paired samples t-test in the case:

- VPDM spinal tilt (difference between means = 0.428, t = 0.852, p = 0.405 > α = 0.05),

- ICT ITL kyphotic angle (difference between means = 0.6555, t = 0.197, p = 0.846 > α = 0.05),
- ITL ILS lordotic angle (difference between means = -3.0725, t = -1.700, p = 0.105 > α = 0.05),
- VPDM torso imbalance (difference between means = -0.0155, t = -0.006, p = 0.995 > α = 0.05),
- SLSR shoulder slope (difference between means = -0.0755, t =-0.215, p = 0.832 > α = 0.05).

We note that:

- VPDM spinal tilt decreased by 11.79%,
- ICT ITL kyphotic angle decreased by 1.33%,
- ITL ILS lordotic angle increased by 7.43%,
- VPDM torso imbalance decreased by 1.66%,
- SLSR shoulder slope increased by 24.71%,
- DLDR pelvic tilt decreased by 150.40%.

Very strong correlations are observed between the initial and final values of the variables in the case of:

- posterior right podiatric loading (r = 0.793, p < 0.001 < α = 0.05),
- anterior left podiatric loading (r = 0.814, p < 0.001 < α = 0.05),
- posterior left podiatric loading (r = 0.466, p = 0.038 < α = 0.05),
- anterior right mean loading (r = 0.892, p < 0.001 < α = 0.05),
- posterior right mean pressure (r = 0.721, p < 0.001 < α = 0.05),
- anterior left mean pressure (r = 0.817, p < 0.001 < α = 0.05),
- posterior left mean pressure (r = 0.567, p = 0.009 < α = 0.05),
- right foot angle (r = 0.533, p = 0.015 < α = 0.05),
- left foot angle (r = 0.771, p < 0.001 < α = 0.05).

There is no correlation between initial and final values for:

- anterior right foot loading (r = 0.370, p = 0.109 > α = 0.05),
- global right CoF (r = 0.003, p = 0.989 > α = 0.05), global left CoF(r = 0.189, p = 0.425 > α = 0.05),
- cervical with straight head lung sway (r = 0.442, p = 0.051 > α = 0.05), or retroflex (r = 0.290, p = 0.214 > α = 0.05).

The results obtained from the application of the test show that there are statistically significant differences between the initial and final values of the parameters analyzed for:

- anterior right mean pressure (difference between means = -11.10, t = -2.724, p = 0.013 < α = 0.05, confidence interval limits for the difference between the means of the two groups - (-19.629, -2.571))
- anterior left mean pressure (difference between means = -25.90, t = -3.489, p = 0.002 < α = 0.05, confidence interval limits for the difference between the means of the two groups - (-41.436,-10.364)).

As for the evolution of pain, we performed t-test for two paired samples, in order to check if there are significant differences in the mean obtained for the pain scale at baseline and after 10 treatment sessions.

According to Pearson's correlation test, the initial values of the pain scale are directly correlated with those obtained after 10 treatment sessions (r = 0.704, p = 0.001 < α = 0.05). The difference between the two means is 5.650, the test value is t = 19.305, and p < 0.001 < α = 0.05.

Paired Samples Statistics

Pair 1	Initial pain scale	7,30	20	1,838	0,411
	After 10 treatment sessions	1,65	20	1,387	0,310

Paired Samples Correlations

	N	Correlation	Sig.
Pair 1 Initial pain scale & after 10 treatment sessions	20	0,704	0,001

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 Initial pain scale & after 10 treatment sessions	5,650	1,309	0,293	5,037	6,263	19,305	19	0,000

Friedman test for repeated measures to test differences in pain scale at baseline, 30 minutes after first administration and after 10 treatment sessions:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Initial pain scale	20	7,30	1,838	4	10
Pain scale 30 minutes after first administration	20	6,20	1,542	3	9
Pain scale after 10 treatment sessions	20	1,65	1,387	0	4

Ranks

	Mean Rank
Initial pain scale	2,85

Pain scale 30 minutes after first administration	2,15
Pain scale after 10 treatment sessions	1,00

Test Statistics[a]

N	20
Chi-Square	36,737
df	2
Asymp. Sig.	0,000

a. Friedman Test

In the Ranks table, the average of the ranks of the tested variable for each time point is calculated. Recall that rank 1 is given to the lowest value. The data in the table show that the mean ranks decrease with increasing number of treatment sessions.

The test result is displayed in the Test Statistics table and is expressed as a CHI^2 value with two degrees of freedom. The conclusion is that the pain experienced is in a strong relationship with the number of treatment sessions ($p < 0.001 < \alpha = 0.05$, df = 2, $CHI^2 = 36.737$). The mean of the pain scale 30 minutes after the first administration is 15.06% lower than the mean at baseline, and after 10 treatment sessions the mean of the pain scale decreased by 77.40% compared to the mean of the variable at baseline.

Conclusions

1. Spinal and knee disorders are accompanied by postural disorders.
2. Examination of plantar pressures and balance disorders using the Free Step Sensor Medica Italia platform reveals postural disorders.
3. Examination of spinal statics using the innovative non-invasive Spine 3D Sensor Medica Italy system has the advantage of multiple scans without the risk of irradiation.
4. Ozone therapy applied in the form of local paravertebral (in case of spinal disc damage) or periarticular (in case of knee osteoarthritis) infiltrations using low concentrations of ozone (8-20 µg/ml) improves posture.
5. There are differences, often significant, between initial measurements and those made after 10 sessions of ozone treatment, particularly in obliquity, shoulder slope and pelvic tilt, anterior/posterior podiatric loading, balance and pain scale.
6. we observe differences, often significant, between measurements, especially in obliquity, shoulder slope and pelvic tilt, balance and pain scale.
7. The mean of the pain scale 30 minutes after the first administration is 15.06% lower than the mean at baseline, and after 10 treatment sessions the mean of the pain scale has decreased by 77.40% compared to the mean of the variable at baseline.
8. Ozone therapy is a safe procedure and can be applied in the treatment of postural disorders accompanied by pain.

9. In non-traumatic musculoskeletal disorders there is postural disorder, and the aim of treatment should be, in addition to combating pain and increasing joint mobility, to correct posture.

References

1 Correale L, Carnevale Pellino V, Marin L, Febbi M, Vandoni M. Comparison of an Inertial Measurement Unit System and Baropodometric Platform for Measuring Spatiotemporal Parameters and Walking Speed in Healthy Adults. Motor Control. 2020 Nov 18;25(1):89-99. doi: 10.1123/mc.2020-0060. PMID: 33207319.
2 Herssens N, Verbecque E, Hallemans A, Vereeck L, Van Rompaey V, Saeys W. Do spatiotemporal parameters and gait variability differ across the lifespan of healthy adults? A systematic review. Gait Posture. 2018 Jul; 64:181-190. doi: 10.1016/j.gaitpost.2018.06.012. Epub 2018 Jun 12. PMID: 29929161.
3. Taglietti M, Dela Bela LF, Dias JM, Pelegrinelli ARM, Nogueira JF, Batista Júnior JP, Carvalho RGDS, McVeigh JG, Facci LM, Moura FA, Cardoso JR. Postural Sway, Balance Confidence, and Fear of Falling in Women with Knee Osteoarthritis in Comparison to Matched Controls. PM R. 2017 Aug;9(8):774-780. doi: 10.1016/j.pmrj.2016.11.003. Epub 2016 Nov 19. PMID: 27876656.
. 4. Kleinerman RA. Cancer risks following diagnostic and therapeutic radiation exposure in children. Pediatr Radiol. 2006 Sep;36 Suppl 2(Suppl 2):121-5. doi: 10.1007/s00247-006-0191-5. PMID: 16862418; PMCID: PMC2663653.
5. Truszczyńska A, Dobrzyńska M, Trzaskoma Z, Drzał-Grabiec J, Tarnowski A. Assessment of postural stability in patients with lumbar spine chronic disc disease. Acta Bioeng Biomech. 2016;18(4):71-77. PMID: 28133382.
6. de Sire, Alessandro et al. “Oxygen-Ozone Therapy for Reducing Pro-Inflammatory Cytokines Serum Levels in Musculoskeletal and Temporomandibular Disorders: A Comprehensive Review.” International journal of molecular sciences vol. 23,5 2528. 25 Feb. 2022, doi:10.3390/ijms23052528
7. Sagai M, Bocci V. Mechanisms of Action Involved in Ozone Therapy: Is healing induced via a mild oxidative stress? Med Gas Res. 2011 Dec 20;1:29. doi: 10.1186/2045-9912-1-29. PMID: 22185664; PMCID: PMC3298518.
8. Bocci V. Biological and clinical effects of ozone: Has ozone therapy a future in medicine? Br J Biomed Sci. 1999;56:270–9. [PubMed]
9, Viebahn-Hänsler R. The use of ozone in medicine: Mechanisms of action. Munich. 2003. May 23-25, [cited in 2003]. Available from: http://www.oxidation-therapy. Com / pdfs / MechanismofAction.pdf
10, I L.Valdenassi, M. Franzini, V. Simonetti, G. Ricevuti; Oxygen-ozone therapy: paradoxical stimulation of ozone, DOI: 10.4081/ozone.2016.5837
11. Seyam O, Smith NL, Reid I, Gandhi J, Jiang W, Khan SA. Clinical utility of ozone therapy for musculoskeletal disorders. Med Gas Res. 2018 Sep 25;8(3):103-110. doi: 10.4103/2045-9912.241075. PMID: 30319765; PMCID: PMC6178642.