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Elements of biomechanics correlated to the body mass index in knee osteoarthritis

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Abstract

Introduction. Osteoarthritis is considered a complex biopsychosocial condition, with consequences for the patient, the family, society and public health. Age is considered the main risk factor in the occurrence of osteoarthritis. Studies show that 2 out of 3 obese individuals associate knee osteoarthritis whereas the incidence of the latter increases at the same time with increasing body mass index. Obesity contributes to the initiation of the process of osteoarthritis by the mechanical overload of the joint, causing cartilage damage with increasing horizontal cracks and the increased incidence of the osteophites in the knee. **Purpose.** We conducted a study in patients with knee osteoarthritis and body mass index with normal and high values, evaluating pain, functional capacity and maximum travel distance by applying electrotherapy and kinesiotherapy. **Material and method.** We studied a number of 68 patients diagnosed with knee osteoarthritis, who received as therapy electrotherapy and physiotherapy. The VAS scale, the WOMAC scale, the joint balance and the Lequesne scale were used to evaluate patients.The objectives of the study were: pain reduction, improved postural control and coordination, control of the gravity center, correction of alignment at the lower limbs, re-education of gait, obtaining a body mass index as close to normal. **Results and discussions.**The total group of patients was homogeneous according to age and gender. The evaluation of patients based on scales recorded superior values in the study group, with statistically significant results, worth p <0.05, which means that the hypothesis was validated. **Conclusions.** The use of the recovery treatment was individualized and took into account the condition of the affection, the body mass index, the ability of patients' mobility and algic symptoms.

Key words: *osteoarthritis, obesity, recovery, knee biomechanics,*

Introduction

Knee osteoarthritis is one of the most common joint conditions, characterized by pain and joint dysfunction, and, in advanced stages, has misalignment of the lower limbs, contracture and muscle atrophy (1). The condition causes a significant functional deficit, affecting posture, static and dynamic balance but also gait (2). Osteoarthritis is considered a complex biopsychosocial condition, with consequences for the patient, the family, society and public health (3).

In primary knee osteoarthritis, changes occur in the articular cartilage and subchondral bone (4,5). Studies (6,7,8,9)

show that the main cause of symptoms is damage to the subchondral bone. Age is considered the main risk factor in the occurrence of osteoarthritis, however, between osteoarthritis and the phenomenon of aging there is an interconnection and not an interdependence (5). It should be taken into account that in the case of osteoarthritis there occurs the aging phenomenon of the musculoskeletal system, overload and misalignment of the load-bearing segments (5).

The overload but also the pathophysiological changes related to the biomechanical elements at the level of the knee have a special role. The articular cartilage is avascular and has no innervation (4,10), so it has a low level of metabolic activity and cell division, even if chondrocytes are capable of cell division (4,5,11,12,13).

These chondrocytes represent 1% of the volume of joint cartilage (4) wich is responsible for both the synthesis and the decomposition of the cartilaginous matrix (4,6,12).

An important role in maintaining the balance between synthesis and degradation is played by cytokines with anabolic and catabolic effect (4,6). The cartilage must be elastic and have an increased tensile strength to exercise its normal intra-articular function, and the mechanical properties of the articular cartilage depend on the extracellular matrix consisting of a fluid component and structural macromolecules (type II collagen fibers), proteoglycans, glycoproteins). Basically, the collagen matrix gives tensile strength and ensures the shape of the cartilage (4).

Disturbance of the balance between synthesis and degradation of extracellular matrix components (4,5,6,11,14) causes an increase in the amount of water and a decrease in the proteoglycan content of the extracellular matrix, affecting the collagen network by decreasing the synthesis of type II collagen, thus they are favorable factors for osteoarthritis.

At first the mechanism is compensatory and the integrity of the articular cartilage is maintained, but later the loss of chondrocytes (even their apoptosis), there are changes of the extracellular matrix and the changes characteristic of osteoarthritis.

Another element involved in the occurrence of osteoarthritis and its interrelation with the aging phenomenon is oxidative stress through the chronic production of "free radicals" (5,12,15).

They can damage mitochondrial DNA, influence cell viability and disrupt extracellular matrix homeostasis (16,17) causing decreased chondrocyte sensitivity to IGF-1 (18). Articular and cartilage overload influences the mechanism of chondrocyte production, quality and functionality of proteoglycans or collagen (4).

A normal synovial joint can cope with repetitive loading for normal activities without developing osteoarthritis (14).

However, if the mechanical action exceeds the ability of the cartilage to remain in a normal functional state (repair or recovery ability), then a process of joint degeneration occurs (4,14). In this context, the mechanical factor will cause the damage of the articular cartilage, of the subchondral bone, affecting the function of chondrocytes (14).

For a normally aligned knee, the center of pressure for femur -tibial force passes through the middle of the knee (19). In knee flexion, the center of pressure is medial. For varus or valgus changes, the load in the medial compartment will increase by up to 20% (20). The biomechanical consequences in patients are especially while walking (21,22)

but also for persons with an increased body mass index (23).

Studies (24) show that 2 out of 3 obese individuals associate knee osteoarthritis whereas the incidence of the latter increases at the same time with increasing body mass index. There are studies (25,26) that evaluated the impact of mechanical stress and systemic factors associated to the knee obesity and showed that mechanical stress is more important.Other studies (27,28) showed that mechanical stress played a role in the onset of osteoarthritis, whereas inflammation was a secondary consequence of the mechanical process.

The Guide published in 2018 presents the effects of the biomechanical factors and of obesity upon the development of the knee osteoarthritis and the management possibility in this context (29).

Obesity contributes to the initiation of the process of osteoarthritis by the mechanical overload of the joint (30), causing cartilage damage (small degradation in the superficial area) with increasing horizontal cracks (28) and the increased incidence of the osteophites in the knee (31). At the level of infrapatellar fat, larger adipocytes and the presence of M2 type macrophages were observed (32). Cartilage has a low coefficient of friction and enables slipping and compressibility (33). In the early stages of osteoarthritis there is a proliferation of chondrocytes and an increase in the number of proteins specific to the extracellular matrix (33,34), but once the disease progresses, there is a deep deterioration of the cartilage with changes at this level and also at the level of the subchondral bone (35).

A 2009 study (36) showed that cartilage defects are associated with an increased body mass index, results confirmed by another study (37) that associates the severity of changes in cartilage with obesity and body mass index.

In patients with high body mass index, the cartilage was thicker on the intercondylar fossa and on the back of the patella (lateral and medial) and thinner on the tibia, in the medial region, compared to people who have a normal body mass index (38).

The body mass index (BMI) is a parameter that is taken into account in maintaining health, for prophylactic or therapeutic purposes. According to the value, BMI may indicate to a patient a normal status (BMI = 18.5-24.99), overweight (25-29.99), 1st degree obesity (30-34.99), 2nd degree obesity (35-39.99), 3rd degree obesity with value> 40.

The body mass index also plays a role in pathological changes in the subchondral bone (39,40). One study (39)showed in obese individuals the association between increased body mass index and changes in the subchondral trabecular bone. Mechanical overload during physical activity or walking plays a key role in the progression of osteoarthritis. Increased body mass index correlates with increased mechanical stress, especially when walking (41). International guidelines suggest the importance of exercising to tone muscles (42) and increase muscle strength to relieve painful symptoms.

Another study (43) showed that exercise improved muscle strength, decreased pain, and increased functional capacity in people with knee osteoarthritis. It is also useful in proprioception, coordination, postural control.

In osteoarthritis it is also indicated to do electrotherapy with anti-inflammatory, analgesic, vasodilator, hyperemic role. Low, medium and high frequency ultrasound currents can be applied.

Purpose.

We conducted a study in patients with knee osteoarthritis and body mass index with normal and high values, evaluating pain, functional capacity and maximum travel distance by applying electrotherapy and kinesiotherapy.

Material and method.

We studied a number of 68 patients (48.52% women and 51.48% men) diagnosed with knee osteoarthritis, who received as therapy electrotherapy and physiotherapy.

Electrotherapy consisted in the application of low frequency (TENS), medium frequency (interferential) and high frequency (ultrasound) currents.

TENS uses rectangular currents, has an analgesic role and is based on presynaptic inhibition and endorphin release, with a frequency between 15-200 Hz.

The medium frequency current has as main actions analgesia, hyperemia and vasomotor effect, but also secondary actions of trophic type, muscle relaxant and vasodilation. The 0-100 Hz modulation was used which ensures inhibitory / excitatory effects. Ultrasound, as a form of coupling - ultrasonophoresis (using an anti-inflammatory gel) for analgesic, muscle relaxant, hyperemic purposes. Ultrasound parameters: 1 MHz frequency, 0.6W / cm² intensity, duration 4 minutes, pulse application to reduce the thermal effect (44).

Physiotherapy sessions were performed for 40 minutes/ day, 3 times/ week, for 4 weeks. The evaluation of the patient was performed at the beginning of the recovery treatment and at the end of it.

Patients were divided into two groups, namely the control group L1 (patients underwent electrotherapy) and the study group L2 (patients received electrotherapy and physiotherapy).

The inclusion criteria were: patients diagnosed clinically and radiologically with knee osteoarthritis, age 35 -75 years old, without decompensated diseases, without neurological diseases and who gave their consent to participate in the study.

The exclusion criteria were: patients aged <35 years and >75 years, with decompensated heart and respiratory disorders, with neuro-psychic disorders, non-compliant, and who did not give their consent to participate in the study.

The study complies with the norms of ethics and deontology according to the legislation.

The VAS scale (for the assessment of the pain syndrome), the WOMAC scale (for the assessment of the pain and functional capacity), the joint balance (for the assessment of the mobility) and the Lequesne scale (for the assessment of the arthritic involvement in the lower limbs) were used to evaluate patients.

The objectives of the study were: pain reduction, improved postural control and coordination, control of the gravity center, correction of alignment at the lower limbs, re-education of gait, obtaining a body mass index as close to normal.

The L1 witness group included 33 patients, of which 16 (48.48%) were women and 17 (51.52%) were men, whereas the L2 study group had 19 (54.28%) women and 16 (45.72%) men. The distribution by age groups is shown in Table no. 1

Table no. 1. Distribution of patients on study groups and on age groups

Group	Gender	35-44 years	45-54 years	55-64 years	65-75 years	Total
witness lot	Female	2	4	5	5	16
L1	Male	1	5	4	7	17
study lot	Female	1	5	6	7	19
L2	Male	2	5	5	4	16
	Total	6	19	20	23	68

Statistical analysis

The data obtained from the initial and final evaluations were
statistically processed by using Microsoft Excel 10. In addition to the median and standard deviation, the t-student test was calculated, which is useful in verifying the working hypothesis. The level of statistical significance is 5%, i.e. the value of p <0.05.

Results

The pain assessment by using the VAS scale shows statistically significant results in both groups, with a reduction of 28.57% in the witness group and 37.5% in the study group. The mobility of the knee joint quantified by the joint testing registered an increase of 13.63% in the witness group compared to 27.27% in the study group.

The body mass index increased by 0.74% in the witness group, and in the study group it registered an increase of 6.21%.

Table no.2. Evolution of the parameters pain, mobility and body mass index in the witness group

Scale/	Witness lot	
Index	Initial	Final
VAS	7 ± 1.25	5 ± 0.95
Joint testing	88 ± 26.45	100 ± 23.43
BDI	29.41 ± 4.43	29.63 ± 4.45

Table no.3. Evolution of the parameters pain, mobility and body mass index in the study group

Scale/	Study lot	
Index	Initial	Final
VAS	8 ± 1.64	5 ± 1.09
Joint testing	88 ± 23.59	121 ± 21.06
BDI	28.2 ± 3.54	26.45 ± 3.81

As for the WOMAC scale, representative for the arthritic process, the results are statistically significant in both groups and there is a decrease in pain and joint stiffness.

Table no.4. Evolution of the WOMAC and Lequesne scales in the witness group

Scale/	Witness lot	
Index	Initial	Final
Womac	52 ± 15.01	46 ± 5.57
Womac pain	14 ± 1.06	7 ± 0.51
Womac stiffness	7 ± 0.51	5 ± 0.97
Womac functional capacity	30 ± 14.59	30 ± 5.34
Lequesne	6 ± 0.98	4 ± 1.13

As for the functional ability, only in the study group there is an increase of 6%.

When assessing the arthritic damage with the help of the Lequesne scale, there is an improvement of 13.63% in the witness group, whereas in the study group the result is 27.27%.

Table no.5. Evolution of the WOMAC and Lequesne scales in the study group

Scale/	Study lot	
Index	Initial	Final
Womac	52 ± 11.42	41 ± 7.57
Womac pain	14 ± 0.86	8 ± 0.75
Womac stiffness	7 ± 0.17	5 ± 0.56
Womac functional capacity	30 ± 11.78	25 ± 9.81
Lequesne	6 ± 0.98	4 ± 1.02

Discussions

The total group of patients was homogeneous according to age and gender. The evaluation of patients based on scales recorded superior values in the study group, with statistically significant results, worth p <0.05, which means that the hypothesis was validated.

Table no.6. T-student test values in patient group

GROUP	Witness lot	Study lot
Scala/test t-student	initial-final	initial-final
VAS	0.0201	0.0391
Womac pain	0.0155	0.0383
Womac stiffness	0.0181	0.0156
Womac functional capacity	0.0247	0.0125
Womac	0.0101	0.0119
Lequesne	0.0295	0.0285
Joint testing	0.0039	0.0191
BDI	0.0009	0.0006

As for the body mass index, the results are extremely statistically significant, with more important values in the study group, p <0.0006. So in the group that made kinesiotherapy, the results are better, as it is also apparent from the literature, which indicates the physical exercise done by the patient as a means of reducing the body mass index and a way of increasing mobility Thus, in the witness group, the number of overweight people decreased whereas the number of people with normal weight increased. In the study group the number of people with obesity and overweight decreased whereas the number of people with normal weight increased.(Table no.7)

Table no.7 The evolution of the patients of the groups according to BMI

Group (no. of patients)	Normal		Overweight		1st degree obesity		2nd degree obesity		3rd degree obesity	
MOMENT	initial	final	initial	final	initial	final	initial	final	initial	final
Witness group	2	4	18	16	10	10	1	1	2	2
Study group	5	9	20	17	8	9	2	0	0	0

As for the WOMAC and Lequesne scales, the recorded results show a pain relief, rigidity and functional ability increase, especially in the study group. And the VAS scale that assesses the evolution of pain recorded significant decrease in both groups.

Conclusions

The use of the recovery treatment was individualized and took into account the condition of the affection, the body mass index, the ability of patients' mobility and algic symptoms. The use of electrotherapy and kinesiotherapy was beneficial for patients who had decrease in the algic syndrome and increase in the joint mobility and a reduction of the body mass index, even if it was only 6.21%. The latter can also be diminished if patients keep a diet adapted to their functional status. I will continue my research on the correlation between the biomechanical elements of the knee with the body mass index by using the baropodometric test with sensors to identify the faulty segmentation positions and to analyze the pressures exerted in the soles in the static position.

Authors' contributions.
The authors had an equal contribution while writing this article.

Declaration of conflict of interest
The authors declare that there are no conflicting interests related to the publication of this article.

Informed consent
The informed consent was obtained from all the patients who were included in this study.

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