Original Paper

Research on the Influence of MUVON PLUS Treatment Upon the Biomechanical Behavior of the Human Osteoarthritic Knee

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ABSTRACT: Background. This study aimed to investigate the effects of MUVON PLUS, a dietary supplement containing hydrolized collagen, chondroitin sulfate, and vitamin C, on the biomechanical behavior of the knee joint in patients with second-degree osteoarthritis (OA). Material and method. The study included 15 participants who underwent biomechanical testing before and after 3 and 6 months of supplement administration. Biometrics and SimiMotion software were used to process and analyze the data. Results showed significant improvements in biomechanical parameters such as joint range of motion, joint torque, and joint stiffness for all patients during the treatment. Improvements were observed across various tests, including horizontal walking, stairs climbing and descending, sitting/standing up from a chair, and knee squats. This improvement in biomechanical performance was also reflected in the patients' reported quality of life. For the stairs climbing test, the maximum flexion-extension angle increased by approximately 7% after 3 months and 12% after 6 months. In the stairs descending test, the maximum flexion-extension angle increased by approximately 8% after 3 months and 19% after 6 months. These results highlight an improvement in mobility for the study participants. Conclusions. Significant improvements of the biomechanical parameters of the knee joint were found in all patients during the treatment with the MUVON PLUS in all tests, which indicates the clear clinical benefit, revealed by improving the quality of life reported by patients. Overall, the study demonstrated the effectiveness of MUVON PLUS in enhancing the biomechanical behavior of the knee joint in patients with OA, providing valuable insights for future research and treatment.

KEYWORDS: *Biomechanics, human knee, gonarthrosis, dietary supplements, experimental tests.*

Introduction

Osteoarthritis of the knee (OA) is a widespread degenerative condition that affects millions of people around the world [1].

Hip and knee OA is one of the leading causes of global disability.

Health professions need to prepare for increased demand in treatments for OA.

Population aging has become an important aspect of the transition underway all over the world.

Musculoskeletal diseases pose major threats to healthy aging, causing considerable economic and medical burdens.

The 5 major musculoskeletal burden remain relatively consistent, with age between 40 and 80 contributing the greatest part of the total number of incidence, prevalence, and DALYs for rheumatoid arthritis, osteoarthritis, low back pain, and neck pain, respectively [2,3].

It involves the gradual deterioration of articular cartilage, changes in the underlying bone, and growth of bony spurs [4].

Osteoarthritis of the knee can cause severe pain, stiffness, and disability, impairing patients' quality of life [5].

The biomechanical function of the knee joint is markedly altered in patients with osteoarthritis, leading to alterations in gait, muscle activity, and joint stability [5,6].

The main cause of these changes is the loss of articular cartilage, which reduces the joint's ability to bear load and increases friction and wear [5,6].

Most individuals over the age of 65 have radiographic and/or clinical evidence of osteoarthritis, which is characterized by significant functional impairment, pain, stiffness, and loss of mobility.

Multiple factors are known to affect the progression of OA, including joint instability, obesity, increasing age, and associated intra-articular crystal deposition.

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Current knowledge segregates the risk factors for development of OA into two fundamental mechanisms, aging and abnormal loading.

Aging is the primary factor contributing to this abnormal state of articular cartilage [6].

There is good evidence that conditions that produce increased load transfer and/or altered patterns of load distribution can accelerate the initiation and progression of OA [7,8].

Chondrocytes respond to mechanical perturbation by upregulating synthetic activity or by increasing the production of inflammatory cytokines, which are also produced by other joint tissues.

Activation of integrins and Discoidin domain receptor-2 (DDR-2) stimulates the production of matrix-degrading proteinases and inflammatory cytokines [9].

Gait analysis has been used to investigate the actual joint moments in OA, but has not been able to assess impulsive loadings, which may be co-factors in the initiation and progression of OA [10,11].

Skin-mounted accelerometers are used to evaluate gait-related movement patterns and to evaluate tibial acceleration [12].

They have been used to investigate the possible differences between healthy and knee OA subjects [13,14].

OA alters joint biomechanics, leading to abnormal load distribution and subsequent cartilage degeneration [15].

Thus, evaluating joint loading during different activities can provide valuable insights into disease progression and the effects of various treatments [16].

Biomechanical measurements can be used to quantify joint forces, moments, and pressure distribution.

Moreover, biomechanical assessments can evaluate changes in joint kinematics and muscle activation patterns, which may influence joint loading.

As a result, biomechanical measurements can identify changes in joint function and load distribution that may not be apparent using other assessment tools.

Accelerometers are small, wearable sensors that can measure acceleration, velocity, and displacement.

They are non-invasive and provide continuous data during different activities, making them an ideal tool for measuring joint loading.

Accelerometers can be placed on various body segments, including the lower limbs, to evaluate joint loading during different activities such as walking, running, and stair climbing [17].

Additionally, accelerometers can be used to evaluate changes in gait parameters, such as cadence, step length, and stride time.

Gait analysis provides valuable information about joint function and load distribution during walking, which is a fundamental activity of daily living.

As a result, accelerometers are increasingly being used to evaluate the effects of various OA treatments, such as exercise interventions, knee braces, and footwear modifications [18].

In conclusion, biomechanical measurements provide valuable insights into joint function and load distribution, which are essential in the study of OA treatment effects.

The use of accelerometers has revolutionized the field of biomechanics, enabling non-invasive, continuous measurements during different activities.

Accelerometers can be used to evaluate changes in joint loading and gait parameters, making them a valuable tool in the evaluation of various OA treatments.

Due to the high prevalence and significant impact of osteoarthritis of the knee, there is a continuous effort to develop effective treatments that can improve knee biomechanics and relieve symptoms [19].

Dietary supplements, such as MUVON PLUS, have been proposed as a complementary therapy for osteoarthritis of the knee.

MUVON PLUS contains hydrolyzed collagen, sodium hyaluronate, and vitamin C, which have been proven to enhance joint health in patients with early osteoarthritis.

The use of dietary supplements like MUVON PLUS may improve knee biomechanics and provide symptom relief to patients with osteoarthritis, making them a promising option for the management of the condition.

Considering the potential benefits of MUVON PLUS on knee biomechanics, this study aimed to examine the effects of MUVON PLUS on the biomechanical function of the knee joint in patients with osteoarthritis using various experimental tests, with the goal of providing insights into the potential advantages of this supplement for the management of osteoarthritis of the knee.

Purpose

Although stair walking is one of the most common daily living activities, the kinetics of stair walking has only slightly been investigated.

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It is important to study gait measurements during stair walking.

The purpose of this study is to explore the effects of MUVON PLUS on knee biomechanics in patients with osteoarthritis using accelerometers and other experimental tests.

This study aims to provide insights into the potential advantages of this dietary supplement for improving joint function and load distribution, which are essential in the management of osteoarthritis.

Material and Method

Data acquisition systems

Biometrics Ltd offers the Ultimate Data Acquisition System, a versatile collection of technologically advanced instruments, sensors and software.

The system is available in laboratory and field versions and can collect both analogue and digital data from a wide range of sensors.

The first step in signature biometric data acquisition is to record the signature of a person either digitally or manually.

Electrogoniometers

Goniometers are instruments used to measure a specific angle, for example in measuring the special distribution of light or the range of motion in joints.

Biometrics™ has a wide range of goniometers and torsion meters, ideal for the quick, simple and precise measurement of the multiplanar movement.

Figure 1. Placement of the electrogoniometers on the knee joint.

Data LOG MWX8

The main system of the device is Datalog MWX8, (Figure 1), whose main role is to connect and synchronize the used sensors during experiments.

The DataLOG (MWX8) is a portable data acquisition and monitoring system developed by Biometrics Ltd [20]. It has metal connectors and can be synchronized with Xsens software.

It is used for data collection and monitoring in human performance, sports science, and medical research.

Figure 2. The test of stair descent with real-time collection of data.

Experimental protocol

The sample group

Fifteen individuals with second-degree osteoarthritis of the knee, consisting of seven males and eight females, were selected as a homogeneous group for this study.

Prior to participating in the experiment, all subjects were provided with information about the study and gave their written consent to participate voluntarily.

The tests were conducted in the Laboratory of Biomechanics Research, which is part of the research platform at INCESA, University of Craiova.

The Ethics Committee at the University of Craiova approved the testing.

MUVON PLUS dietary supplement

This supplement contains hydrolized collagen, chondroitin sulfate and vitamin C.

These MUVON Plus is a dietary supplement designed to support joint health and alleviate the symptoms of osteoarthritis.

It contains a combination of natural ingredients, including glucosamine, chondroitin, MSM, collagen, and hyaluronic acid.

Glucosamine and chondroitin are two of the most commonly used supplements for joint health, and studies suggest that they can help reduce joint pain and stiffness in people with osteoarthritis.

MSM is a sulfur-containing compound that is believed to have anti-inflammatory properties and may help reduce pain and swelling in the joints.

Collagen is a protein that makes up a significant portion of the connective tissue in the body, including the joints, and is essential for maintaining the structural integrity of the joint.

Hyaluronic acid is a substance found naturally in the body that helps to lubricate and cushion the joints.

MUVON Plus is marketed as a safe and effective dietary supplement for joint health, and the ingredients have been studied individually for their potential benefits in osteoarthritis.

However, more research is needed to fully understand the effectiveness of the supplement as a whole.

As with any dietary supplement, it is important to consult with a healthcare provider before taking MUVON Plus, particularly if you are pregnant or have a medical condition.

Experimental tests

Experimental tests were performed by a group of 15 participants in three stages, namely, before administration, three and six months after administration.

The subjects had to perform 2 tests (Figure 2), representing daily activities and which, most of the time, raise problems for people with joint disorders. The 2 tests were:

Test 1-Stairs climbing-12 steps;

Test 2-Stairs descending-12 steps.

Experimental data processing

For the processing of experimental data and the creation of diagrams of the average cycles, -stdDev, and +stdDev for each subject and for the whole group, the research team utilized Biometrics and SimiMotion software.

These software programs were used in a series of stages to ensure accurate and reliable results.

The first stage of data processing involved the collection of raw data from the experimental tests performed by the subjects.

This data was then transferred to the Biometrics software, where it was processed and analyzed to generate graphs and other visual representations of the data.

In the second stage, the SimiMotion software was used to further analyze the data and generate additional visual representations of the experimental results.

SimiMotion is a software program that is specifically designed for motion analysis and can provide detailed information about joint kinematics and kinetics.

The third stage of data processing involved the creation of diagrams of the average cycles, -stdDev, and +stdDev for each subject and for the whole group.

These diagrams were created using the Biometrics and SimiMotion software and were used to analyze the experimental results and to identify any trends or patterns in the data.

Overall, the use of Biometrics and SimiMotion software allowed the research team to process and analyze the experimental data in a rigorous and systematic manner.

The resulting diagrams of the average cycles, -stdDev, and +stdDev provided valuable insights into the effects of the experimental treatment on the subjects and allowed the research team to draw meaningful conclusions about the efficacy of the treatment.

The dietary supplement was administered, and the experimental tests to measure the biomechanical behavior of the knee joint were performed before and after supplement administration.

The following details the specific methods used in this study.

The protocol utilized in this study facilitated the collection of a vast amount of biomechanical data.

This data was then employed to evaluate the impact of MUVON PLUS on the knee joint of individuals suffering from osteoarthritis.

The findings obtained from the biomechanical testing were carefully scrutinized and analyzed to

10.12865/CHSJ.49.01.08

determine the efficacy of the dietary supplement in enhancing the biomechanical performance of the knee joint.

The collected data included various biomechanical parameters such as joint range of motion, joint torque, and joint stiffness.

These parameters were assessed in both the knee joint affected by osteoarthritis, as well as the healthy knee joint, to provide a comparison between the two.

Furthermore, the data was obtained through various tests and exercises designed to evaluate the overall functionality and performance of the knee joint.

Overall, the protocol utilized in this study allowed for a comprehensive evaluation of the effects of MUVON PLUS on the knee joint in patients suffering from osteoarthritis.

The collection and analysis of a vast amount of biomechanical data enabled the researchers to determine the effectiveness of the supplement in enhancing the biomechanical behavior of the knee joint, providing valuable insights for future research and treatment.

Statistical Analysis

The statistical analysis was conducted to determine the effect of the MUVON PLUS dietary supplement on the biomechanical behavior of the knee joint in patients with osteoarthritis.

The data collected from the experimental tests was processed and analyzed using Biometrics and SimiMotion software, and statistical analyses were conducted using SPSS (Statistical Package for Social Sciences) software.

The significance level was set at $p < 0.05$ for all analyses.

Descriptive statistics were used to summarize the data obtained from the experimental tests.

Mean values and standard deviations were calculated for each of the biomechanical parameters measured in the tests, including joint range of motion, joint torque, and joint stiffness.

A paired samples t-test was conducted to determine the significant differences in the biomechanical parameters measured before and after supplement administration.

The t-test was used to compare the mean values of each biomechanical parameter at baseline and at three and six months after supplement administration.

The null hypothesis was that there would be no significant difference in the biomechanical parameters measured before and after supplement administration.

Correlation analyses were conducted to identify any relationships between the different biomechanical parameters measured in the experimental tests.

The Pearson correlation coefficient was used to determine the degree and direction of any linear relationships between the variables.

The significance level was set at $p<0.05$ for all correlation analyses.

In addition, a repeated measures analysis of variance (ANOVA) was conducted to determine the effect of the MUVON PLUS supplement on the biomechanical parameters measured in the experimental tests.

The ANOVA was used to compare the mean values of each parameter at baseline and at three and six months after supplement administration.

The significance level was set at $p<0.05$ for all ANOVA analyses.

The statistical analysis was conducted to identify any significant changes in the biomechanical behavior of the knee joint in response to the MUVON PLUS dietary supplement.

The results of the analysis were used to determine the effectiveness of the supplement in improving the biomechanical behavior of the knee joint in patients with osteoarthritis.

Results

The results of the experimental tests showed significant improvements in the biomechanical parameters of the knee joint in all patients during the treatment with MUVON PLUS.

The improvements were observed in all types of tests, including horizontal walking, stairs climbing, stairs descending, sitting/standing up from a chair, and knee squats, which indicates a clear clinical benefit, also reflected in the improvement in the quality of life reported by patients.

The variation intervals of the maximum cycles and the maximum of the average cycle of the flexion-extension angle when climbing stairs are presented in Table 1 and for descending stairs in Table 2, respectively.

Table 1. Variation intervals of the maximum of averaged cycles and of the maximum of averaged cycle of the flexion-extension angle of knee joint in the test of climbing the stairs.

Subject	Baseline		3 months of treatment		6 months of treatment	
	Maximum interval of cycle values	Maximum value for averaged cycle	Maximum interval of cycle values	Maximum value for averaged cycle	Maximum interval of cycle values	Maximum value for averaged cycle
#1	68.55-74.55	71.55	71.81-76.81	74.81	80.70-85.7	83.70
#2	77.91-82.91	80.91	90.47-93.47	91.47	91.08-94.08	92.08
#3	86.47-89.47	87.47	87.24-93.24	90.24	94.85-96.85	95.85
#4	81.93-84.93	82.93	80.28-85.28	83.28	93.35-97.35	94.35
#5	85.06-87.06	86.06	87.0-89	88.0	90.85-93.85	91.85
#6	44.52-46.52	45.52	47.19-50.19	48.19	49.11-54.11	51.11
#7	85.95-87.95	86.95	82.49-88.49	85.49	85.85-90.85	88.85
#8	87.01-89.01	88.01	88.96-90.96	89.96	94.73-97.73	96.73
#9	82.24-88.24	85.24	87.92-90.92	88.92	91.38-95.38	92.38
#10	60.22-66.22	63.22	63.20-67.2	66.20	69.92-72.92	71.92
#11	70.67-72.67	71.67	85.09-88.09	87.09	91.95-93.95	92.95
#12	62.35-65.35	63.35	64.72-68.72	65.72	78.66-82.66	79.66
#13	92.73-95.73	93.73	94.39-98.39	95.39	100.9-106.9	103.9
#14	65.49-70.49	68.49	78.4-82.4	81.4	80.74-83.74	82.74
#15	68.57-72.57	71.57	83.97-88.97	86.97	72.01-74.01	73.01

Table 2. Variation intervals of the maximum of averaged cycles and of the maximum of averaged cycle of the flexion-extension angle of knee joint in the test of descending the stairs.

Subject	Baseline		3 months of treatment		6 months of treatment	
	Maximum interval of cycle values	Maximum value for averaged cycle	Maximum interval of cycle values	Maximum value for averaged cycle	Maximum interval of cycle values	Maximum value for averaged cycle
#1	69.65-73.65	70.65	69.04-74.04	72.04	76.84-78.84	77.84
#2	77.77-79.77	78.77	86.57-90.57	89.57	85.19-91.19	88.19
#3	85.38-89.38	88.38	96.30-98.3	97.30	100.9-106.9	103.9
#4	81.15-84.15	82.15	78.73-82.73	81.73	83.75-88.75	85.75
#5	70.36-72.36	71.36	74.56-77.56	76.56	82.25-87.25	84.25
#6	37.48-41.48	38.48	37.42-40.42	38.42	47.45-50.45	48.45
#7	41.08-45.08	43.08	43.49-48.49	45.49	46.99-51.99	49.99
#8	42.97-47.97	45.97	49.03-53.03	50.03	51.59-56.59	54.59
#9	87.81-91.81	88.81	86.39-89.39	87.39	93.12-97.12	95.12
#10	64.15-66.15	65.15	72.01-75.01	73.01	72.73-74.73	73.73
#11	67.12-72.12	70.12	91.87-95.87	92.87	95.73-99.73	96.73
#12	52.38-57.38	54.38	53.51-57.51	56.51	59.04-61.04	60.04
#13	81.20-85.2	84.20	86.01-90.01	88.01	90.48-94.48	91.48
#14	42.93-46.93	44.93	40.20-45.2	43.20	73.18-76.18	75.18
#15	33.71-37.71	34.71	39.08-43.08	42.08	52.46-57.46	55.46

Figure 3 shows a comparison between the average flexion-extension cycles for the knee joint during the steps in the 3 stages of the study.

It can be seen the increase of the flexion-extension angle amplitude along with the increase of the administration period.

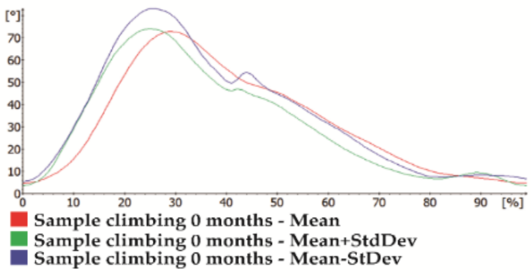

Figure 3. Comparative diagrams-Averaged cycle in the 3 timepoints of the study-Subject 1-test 1.

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The average flexion-extension cycle for climbing the stairs was also calculated at group level.

Thus, the corresponding graph for the stage before administration is presented in Figure 4 a, while the average flexion-extension cycle 3 and 6 months after administration is presented in Figures 4 b and c, respectively.

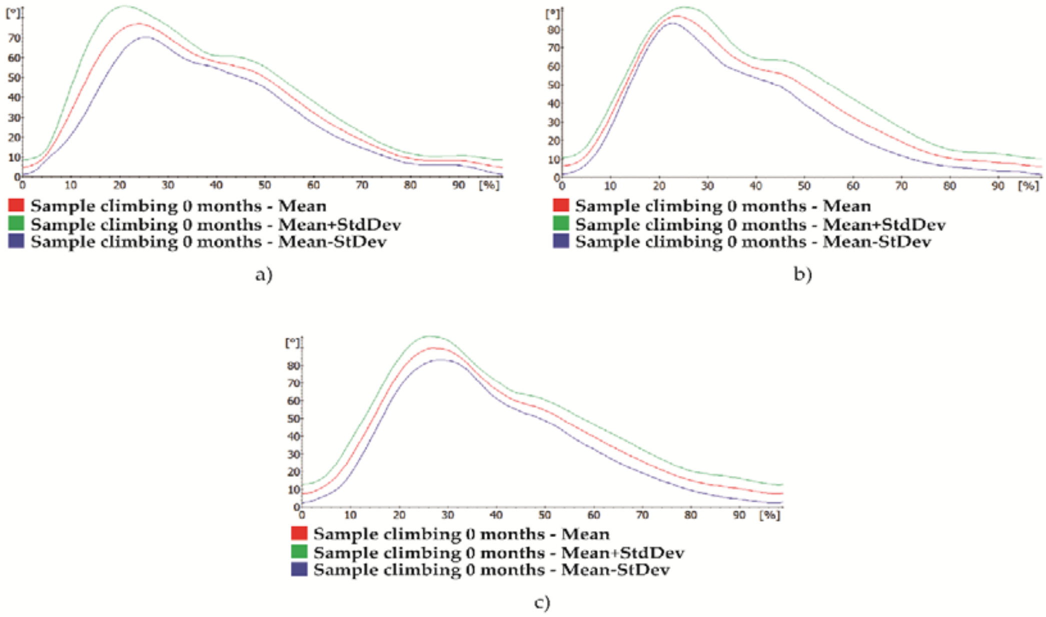

Figure 4. Averaged cycle, averaged cycle plus and minus standard deviation for the knee joint: comparison between baseline a), after 3 months b) and after 6 months c) -Sample-test 1.

The average flexion-extension cycle was also calculated during stairs descending, so the corresponding graph for the stage before administration is presented in Figure 5 a, while the average flexion-extension cycle after 3 and 6 months of administration is presented in Figures 5 b and c, respectively.

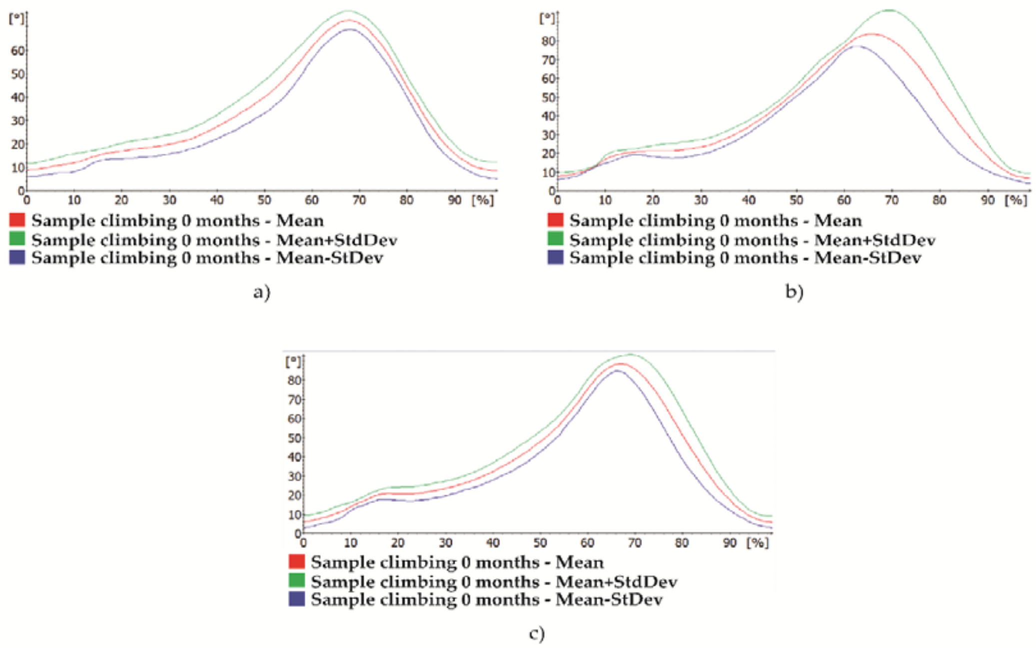

Figure 5. Averaged cycle, averaged cycle plus and minus standard deviation for the knee joint: comparison between baseline a), after 3 months b) and after 6 months c)-Sample-test 2.

In the case of the stairs climbing test, the results showed that the values of the maximum flexion-extension angle are about 7% higher after 3 months of administration, which translates into an increase of approximately 8° of the extension-flexion angle and approximately 12% higher after 6 months of administration, which means an increase of approximately 16° in the flexion-extension angle (Figure 6).

Figure 6. Variation of the flexion-extension angle of the knee joint-climbing stairs-at the baseline, after 3 months and after 6 months of treatment-Sample-test 1.

All these values are reported at group level, but looking at the subject level, there were participants in the study whose value of the extension-flexion angle exceeded the group average as presented in Figure 7, but also participants whose value of the extension-flexion angle was below the group average, still in both cases a maximum value of approximately 90° at the end of the study is observed, as it is also found in the specialized literature [21,22].

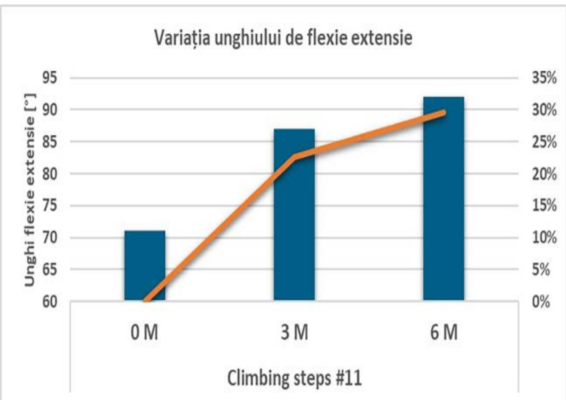

Figure 7. Variation of the flexion-extension angle of the knee joint- climbing stairs-at the baseline, after 3 months and after 6 months of treatment-Subject #11-test 1.

Also in the case of the experimental stairs descending test, the results showed that the values of the maximum flexion-extension angle are higher after 3 months by approximately 8% (about 5°) and about 19% after 6 months of administration (about 19°) (Figure 8), as also found in the specialized literature [21,22].

This time, too, the lines of the graphs for the 3 stages (Figure 9) are similar, but with an increase in maximum value, which highlights an improvement in the mobility of the study participants.

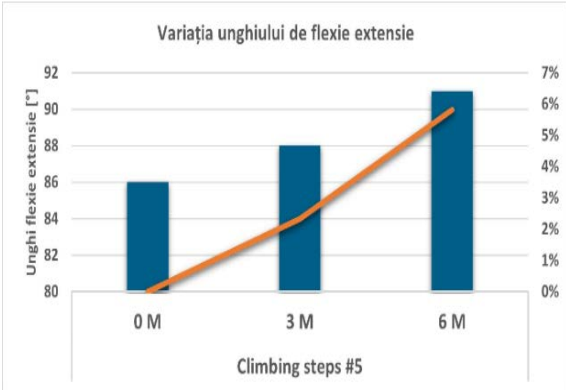

Figure 8. Variation of the flexion-extension angle of the knee joint at baseline, after 3 months and after 6 months of treatment-Sample-test 5.

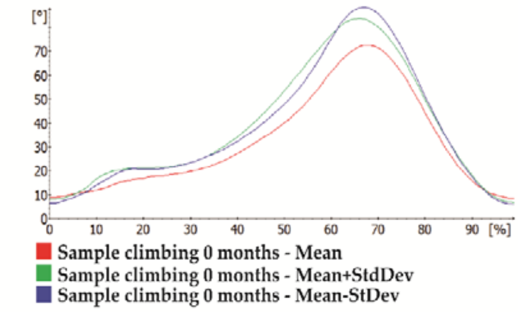

Figure 9. Variation of the flexion-extension angle of the knee joint at baseline, after 3 months and after 6 months of treatment-Subject #11-test 1.

Discussion

Climbing and descending stairs is a common activity for both healthy individuals and for those with musculoskeletal disorders.

Climbing and descending stairs is a much more demanding exercise than walking [21-23], especially for people with deficient or limited motor skills.

Muscular moments in the joints of the ankle, knee and hip are longer during climbing and

 10.12865/CHSJ.49.01.08

descending stairs than during normal walking [23].

The findings of this study suggest that the administration of MUVON PLUS, a dietary supplement containing hydrolized collagen, chondroitin sulfate, and vitamin C, can improve the biomechanical behavior of the knee joint in patients with osteoarthritis.

The improvement in knee biomechanics is reflected in an increase in the maximum flexion-extension angle during stair climbing and stair descending tests, indicating an improvement in mobility.

Previous studies have suggested that hydrolized collagen and chondroitin sulfate can have a beneficial effect on joint health in patients with osteoarthritis [12,14,23,24].

The results of this study are consistent with these findings, as the treatment with MUVON PLUS, which contains both hydrolized collagen and chondroitin sulfate, was associated with improvements in knee biomechanics.

Vitamin C is also known to have a role in collagen synthesis and could contribute to the beneficial effects of MUVON PLUS [15,16].

The improvement in knee biomechanics observed in this study has important clinical implications. Stair climbing and stair descending are demanding activities that can be challenging for individuals with osteoarthritis of the knee [9-11].

The increase in the maximum flexion-extension angle observed in the study participants during these activities suggests that the administration of MUVON PLUS can lead to an improvement in mobility and a reduction in knee pain, which can have a positive impact on the quality of life of patients.

It should be noted that this study has some limitations.

The sample size was relatively small, and the study did not have a control group

Future studies with larger sample sizes and control groups are needed to confirm the findings of this study and to further investigate the effects of MUVON PLUS on knee biomechanics and joint health.

Conclusions

Significant improvements of the biomechanical parameters of the knee joint were found in all patients during the treatment with the MUVON PLUS.

These improvements were found in all types of tests (stairs climbing/descending, sitting/standing up from a chair and knee squats), which indicates the clear clinical benefit, also revealed by improving the quality of life reported by patients.

The experimental biomechanical analysis of motor functions involved in stairs climbing and descending with the help of electrogoniometer sensor type equipment helps improve knowledge about human locomotion and assessing activity over time.

In conclusion, the results of this study suggest that the administration of MUVON PLUS can improve the biomechanical behavior of the knee joint in patients with osteoarthritis.

The improvements in knee biomechanics were reflected in an increase in the maximum flexion-extension angle during stair climbing and stair descending tests, indicating an improvement in mobility.

Further research is needed to confirm these findings and to investigate the effects of MUVON PLUS on joint health in larger and more diverse populations.

Conflict of interests

None to declare.

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