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Influence of the eccentric mode of muscle contraction on pain intensity and mobility limitations in individuals with impaired knee joint function

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Abstract. With the increase in the number of patients presenting with pain and reduced mobility of the knee joint, the search for effective methods of functional restoration at the early stages of osteoarthritis became particularly important. The aim of the study was to identify a possible relationship between pain intensity, movement limitations in the joint and parameters of the eccentric mode of muscle contraction in individuals with impaired knee joint function. Within the study, an experiment was carried out in a medical centre to investigate the eccentric mode of muscle contraction in knee osteoarthritis. During the rehabilitation sessions, emphasis was placed on the eccentric phase of contraction of the quadriceps femoris muscle. Electromyograph readings, pain intensity on the visual analogue scale (VAS) and range of motion in the joint measured by goniometer were recorded before and after the experiment. The mean amplitude of eccentric contraction of the quadriceps femoris muscle more than doubled; for example, in the vastus lateralis muscle it increased from 98.7 μV to 298.4 μV. After the course of sessions, full knee extension was achieved in six of nine participants, and the level of pain decreased in all subjects, including complete disappearance of pain in two individuals. According to the results of the study, the eccentric mode of muscle contraction showed its effectiveness in reducing pain level, increasing range of motion and enhancing indices of electromyographic activity. The eccentric mode developed muscle strength and neuromuscular control during movement and reduced mechanical load on the articular cartilage. The results of this study demonstrated that exercises in an eccentric mode for the quadriceps femoris muscle at the initial stages of knee osteoarthritis may be effective, acting simultaneously on the cause (muscle weakness) and the consequences (pain, limitation of joint range of motion). The obtained findings may be used in the development of individual rehabilitation programmes for patients with early forms of knee osteoarthritis

Keywords: gonarthrosis; electromyography; negative phase; knee pain; range of motion

INTRODUCTION

Functional impairment and the number of complaints of pain and restricted mobility of the knee joint in the general population had been steadily increasing. Various factors could have contributed to this, such as a sedentary lifestyle and obesity, which increased the load on the joints. Pain was the main subjective symptom, which determined everyday activity, work capacity and quality of life. Limitation of joint mobility was an objective sign of joint dysfunction and directly affected the biomechanics of walking, stair ascent and descent, and other everyday activities. Particular attention was given to the eccentric mode of muscle contraction. Eccentric control was critically important for stabilising the knee joint during the stance phase of gait, especially during stair descent; this mode also absorbed impact loading

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and protected the articular cartilage from excessive compression [1, 2].

In the study by R. Çiftçi *et al.* [3] it was demonstrated that dysfunction of the quadriceps femoris muscle was not only a consequence, but also a significant factor in the progression of many joint diseases, including osteoarthritis. C.Y. Zeng *et al.* [4] reported that therapeutic exercise as an adjunct method of physiotherapy could prevent degeneration of cartilage tissue, suppress inflammation and prevent the loss of subchondral bone and metaphyseal trabecular bone. There had been increasing evidence that therapeutic exercise could reduce pain, stiffness, joint dysfunction and muscle weakness in patients with knee osteoarthritis. The authors noted that several types of therapeutic exercise for the management of knee osteoarthritis were available, including aerobic exercise, resistance training, neuromuscular exercises, balance training, proprioceptive training, aquatic exercise and traditional exercise programmes.

In the scientific article by S. Hody *et al.* [5], increases in strength and muscle mass as a result of the negative phase of muscle contraction were associated with DOMS (delayed-onset muscle soreness related to micro-damage of muscle fibres). The authors considered that eccentric work allowed meaningful functional improvements to be achieved with a relatively small training volume; therefore, with appropriate dosing and periodisation, DOMS was regarded as the main driver of unique adaptive responses. The same article also highlighted the use of eccentric exercise programmes in individuals with sarcopenia, where such training was found to effectively counteract fatty degeneration of the muscles. The systematic review by K. Čretnik *et al*. [6] showed that eccentric training in older adults led to more pronounced gains in strength and functional mobility compared with traditional methods. The authors emphasised the high mechanical efficiency of eccentric contractions under low metabolic load, which made this mode particularly promising for patients with limited exercise tolerance, including individuals with knee osteoarthritis. These data confirmed the importance of eccentric work in restoring muscle function and controlling movement.

In a randomised controlled trial by E. Hanci *et al.* [7], the effect of a 4-week eccentric training programme for the peroneal muscles in patients with chronic ankle instability was evaluated. The influence on range of motion was not directly assessed in that study, but increases in strength and control of dynamic range of motion were key outcomes. The results showed that training based on eccentric exercises could positively affect neurophysiological parameters in patients with joint instability, which suggested improved functional stability and control throughout the full range of motion. However, it remained unclear how long these neurophysiological adaptations persisted. For athletes, emphasis on eccentric exercises was reported by O. Younes-Egana *et al.* [8] to improve sports performance through increases in explosive strength and speed–strength qualities. Most studies on this topic had been short-term; long-term effects and the impact on injury prevention had not been sufficiently investigated. There was also an opinion that, for highly trained athletes, focusing on a particular contraction mode provided only a modest advantage. The effect on pain was examined in the study by S. Holden *et al.* [9]. Patients with knee pain were asked to perform a single session of exercises for the quadriceps femoris muscle in isometric and eccentric modes. Pain intensity was assessed using the visual analogue scale (VAS). The results showed that isometric exercises significantly reduced pain, whereas eccentric exercises did not lead to a meaningful change in pain severity.

Despite the importance of each component (pain, range of motion, muscle function), the relationship between subjective pain perception, objective restriction of mobility and neurophysiological parameters of eccentric contraction in individuals with impaired knee function had not been studied in a sufficiently comprehensive manner. The relevance of the present study was determined by the need for a deeper understanding of the complex interrelations between subjective and objective manifestations of dysfunction, the potential for developing new diagnostic criteria and the design of individualised rehabilitation approaches. The aim of the study was to determine the relationship between pain intensity, mobility limitations and parameters of eccentric contraction in individuals with impaired knee joint function. The objectives of the study were as follows: (1) to determine the subjective perception of pain in the participants and the objective limitations in range of motion; (2) to carry out spectral analysis of the data recorded by the electromyograph; and (3) to assess the relationship between objective and subjective indicators and the electromyogram of the quadriceps femoris muscle in an eccentric mode.

MATERIALS AND METHODS

To address the objectives of the study, the following methods were used: the visual analogue scale (VAS) for quantitative assessment of pain intensity; goniometry for objective measurement of range of motion; and surface electromyography for recording the electrical potential of the muscle under investigation. The VAS was applied to quantify pain intensity, where 0 corresponded to no pain and 10 to the maximum imaginable pain. The values were interpreted as follows: 1-3 points indicated mild pain, 4-6 points moderate pain, and 7-10 points marked pain syndrome. The scale made it possible to objectify the subjective sensations of the patient and to assess their changes over time.

An eight-channel electromyograph of Russian manufacture, KBK BP-08-4, was used in the study.

Interpretation of the recorded data was carried out using the EMGAnalyzer software. A root mean square (RMS) filter with a window length of 1000 was applied to the electromyographic signals. Before signal processing, a visual inspection of the raw electromyographic trace was performed to exclude artefacts related to poor electrode contact, electrical interference or excessive skin movement. Application of the RMS filter made it possible to obtain averaged amplitude values reflecting the level of neuromuscular activation during the eccentric phase of movement.

The study was conducted at the Ariadna Medical Centre (Moscow, Russian Federation). The sample consisted of 9 individuals aged 44-60 years, including 7 women and 2 men. The study was carried out in accordance with the ethical principles of the Declaration of Helsinki [10] and was approved by the local ethics committee of the Ariadna Medical Centre. The study protocol No. 2 dated "06" June 2025 was registered. All participants had been informed in advance about the aims, possible risks and conditions of participation and had signed voluntary informed consent. Personal data of the participants were processed confidentially and were used exclusively for scientific purposes. All participants presented with impaired knee joint function, and the diagnosis of gonarthrosis of grade 1-2 had been established by a physician. Inclusion criteria were stable clinical status, absence of arthritis exacerbation and absence of lower limb injuries within the previous 6 months. Exclusion criteria were severe pain syndrome above 7 points on the VAS, as well as the presence of neurological disorders or comorbidities that limited the ability to perform physical exercises.

The participants were instructed to perform knee extension in an eccentric mode for 12 repetitions, 4 sets, with a 2-minute rest interval. The effort was performed with maximal possible force but without pronounced pain (up to 4 points on the VAS). Baseline testing was carried out before the start of the course, prior to 12:00. The eccentric phase was provided by manual resistance from the instructor. As pain intensity decreased during the course of sessions, the manual resistance was gradually increased, while pain was continuously monitored (kept at or below 4 points on the VAS). The use of manual resistance allowed individual dosing of the load and prevented excessive increase in pain response. Before each training session, a 15-minute massage of the anterior thigh and stretching of the quadriceps femoris muscle using the method of post-isometric relaxation (1 set, 5 repetitions) were performed. This preliminary myofascial intervention reduced muscle tone, improved local perfusion and prepared the muscle for eccentric loading. After completion of the treatment course, which included 12 sessions performed every other day, repeated testing was carried out. It was also performed before 12:00 to minimise the influence of circadian variations in pain sensitivity and muscle tone.

RESULTS AND DISCUSSION

The study yielded data reflecting the dynamics of pain intensity, range of motion and muscle activation level after the course of eccentric training. The graphical materials presented below demonstrated changes in the investigated parameters compared with baseline values. Analysis of the results made it possible to identify stable positive trends in most participants (Fig. 1).

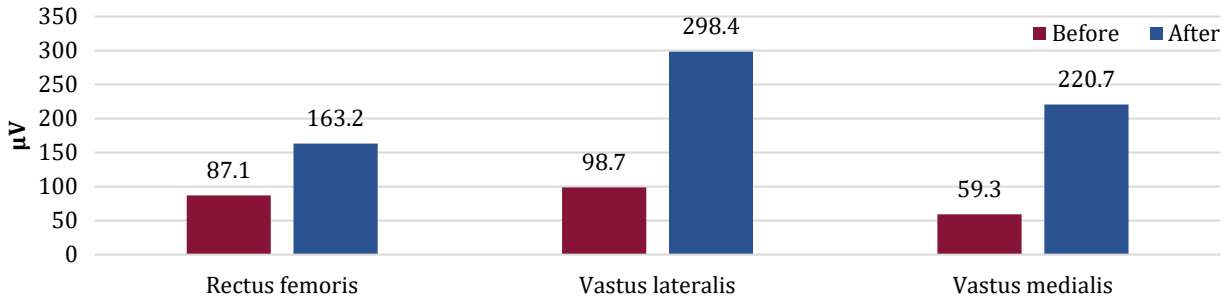

Figure 1. Mean amplitude of eccentric contraction of the quadriceps femoris muscle
Source: compiled by the authors

Figure 1 shows the mean electromyographic amplitude of eccentric contraction of the quadriceps femoris muscle: the rectus femoris increased from 87.1 μV to 163.2 μV, the vastus lateralis from 98.7 μV at baseline to 298.4 μV at the end of the intervention, and the vastus medialis from 59.3 μV before to 220.7 μV after the experiment. Analysis of the electromyography (EMG) results for the quadriceps femoris muscle indicated that the increase in mean EMG amplitude for each head had important functional significance. The increase in rectus femoris amplitude reflected its active contribution to knee extension, which was essential for movements requiring strength and power, such as jumping and sprinting. The rise in activity of the vastus lateralis indicated its role in stabilising the knee joint during dynamic loading, which was critical for injury prevention and for maintaining appropriate movement mechanics. Similarly, the increased EMG amplitude of the vastus medialis pointed to its contribution to knee stabilisation, particularly during eccentric movements such as

downhill walking or landing after a jump. Increased activation of the deeper portions of the quadriceps could have been related to their role in supporting overall knee joint stability and distributing load between the other heads.

The pronounced increase in activity of the vastus medialis and vastus lateralis could be explained by the need to enhance knee joint stabilisation during eccentric exercises. These muscles helped to control knee motion and prevented lateral displacement, which was crucial for reducing the risk of injury. During eccentric exercise, load redistribution between the four heads of the quadriceps might have occurred, leading to increased activity of the vastus medialis and vastus lateralis. This was important for appropriate force distribution and prevention of overloading of other muscles. Moreover, the rise in activity of these muscles could be regarded as an adaptive response to eccentric loading, allowing the musculature to cope better with mechanical demands and to increase its strength. To assess peak values of muscle activation, the maximal amplitude of eccentric contraction of the quadriceps femoris muscle was additionally analysed, and these results are presented in Figure 2.

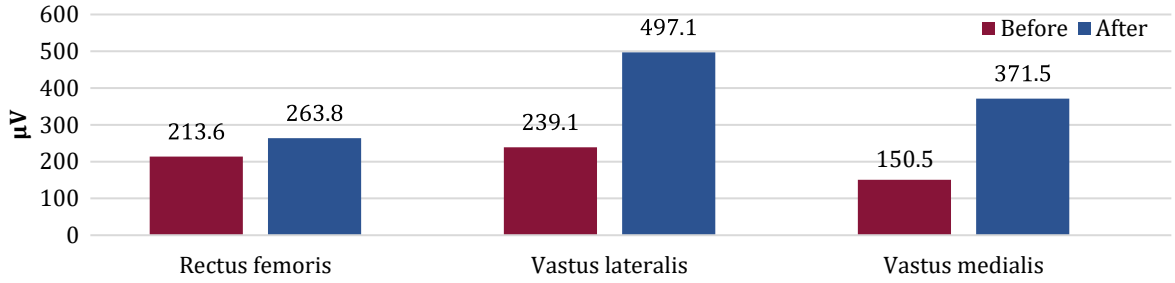

Figure 2. Maximal amplitude of eccentric contraction of the quadriceps femoris muscle
Source: compiled by the authors

Analysis of the EMG results for the maximal amplitude of the quadriceps femoris muscle demonstrated differences in the change of mean EMG amplitude for each head. The rectus femoris showed the smallest increase, from 213.6 μV to 263.8 μV, which indicated stable but relatively modest activity under eccentric conditions. In contrast, the vastus lateralis exhibited a pronounced rise in amplitude, increasing from 239.1 μV to 497.1 μV. This pointed to its important role in ensuring knee joint stability and adapting to eccentric loading, which could be critical for injury prevention and optimisation of movement mechanics. The vastus medialis also demonstrated a marked increase, with values rising from 150.5 μV to 371.5 μV. This confirmed its active involvement in controlling and stabilising the knee joint during eccentric exercise.

The difference in activity between the muscle heads could be explained by their specific functions in maintaining knee stability. The vastus lateralis and vastus medialis, as key stabilisers, were activated in response to eccentric loading, enabling more efficient force distribution and reducing the risk of injury. The rectus femoris, although active, did not show the same level of adaptation, which might have indicated a more limited role in this context. Overall, the increased activity of the vastus medialis and vastus lateralis reflected their capacity to adapt to eccentric modes of work, contributing to improved functional characteristics and enhanced overall strength. Figure 3 presents the results for pain intensity according to the VAS, where a reduction in pain syndrome by the end of the experiment was observed in all participants.

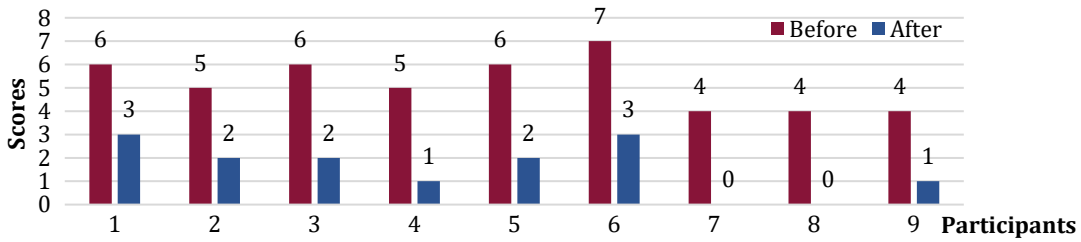

Figure 3. Results of pain assessment on the visual analogue scale
Source: compiled by the authors

The reduction in pain intensity after the eccentric exercises was associated with improved movement control, a decrease in the inflammatory component and adaptation of the muscle-tendon structures. The experimental results showed heterogeneity in pain reduction among the participants, which might have

been due to differences in baseline pain levels. The obtained data were consistent with the known rehabilitative effects of eccentric loading in gonarthrosis. Previous studies indicated that eccentric exercises could lead to a considerable decrease in pain and an improvement in the functional status of the joints. In particular, they helped to strengthen the muscles supporting the joint and contributed to enhanced joint stability. To evaluate the overall muscular response to the course of eccentric training, the total amplitude of electrical activity of the quadriceps femoris muscle was additionally analysed, which made it possible to assess the integrated contribution of all heads to knee joint extension (Fig. 4).

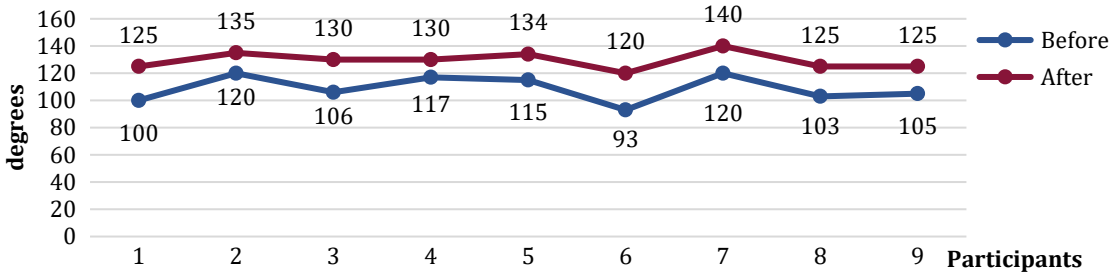

Figure 4. Knee flexion range of motion

Source: compiled by the authors

For a more comprehensive evaluation of the findings from Figure 4, they were compared with normal values of knee flexion range of motion for the corresponding age group. Normal values may vary, but on average, in healthy individuals aged 50-70 years, knee flexion is approximately 130-140 degrees. At the beginning of the course, many participants demonstrated a marked deficit in flexion range of motion, for example 93 degrees in one participant, which indicated pronounced limitation of mobility. After the course of sessions, most participants reached values close to normal, which testified to substantial progress. Improvement in knee flexion could have had a considerable impact on gait. Due to the increase in flexion range, gait dynamics became smoother and more natural, which could lead to reduced fatigue during prolonged walking. Enhanced mobility also facilitated the performance of such tasks as squatting, stair climbing and other everyday activities, thereby improving quality of life. From a biomechanical perspective, an increased range of motion promoted more free execution of movements in daily life, which was important for preserving functional capacity. Joint and soft-tissue loading was reduced, which decreased the risk of injury. Figure 5 presents the results for knee extension range of motion before and after the experiment.

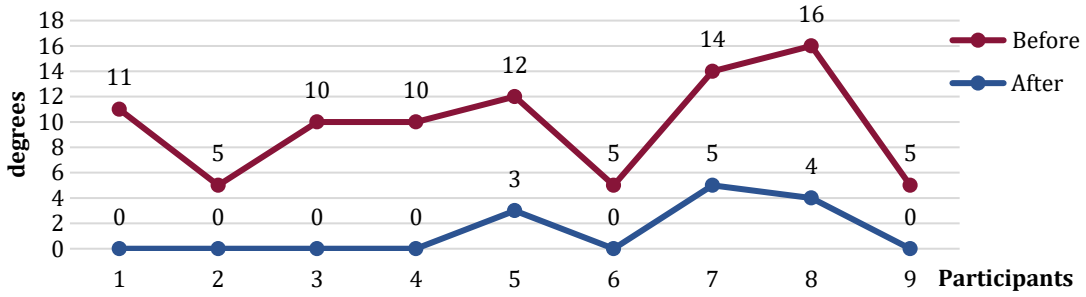

Figure 5. Knee extension range of motion

Source: compiled by the authors

A deficit of knee extension could have led to deterioration of gait biomechanics. Incomplete extension disrupted the normal rhythm and range of motion, resulting in inefficient distribution of load across the joints and muscles. The load on the anterior compartment of the knee joint also increased, which could have caused excessive cartilage wear and accelerated progression of gonarthrosis, as well as an increased risk of osteoarthritis or other degenerative changes in the patellofemoral joint. Reduced extension was likely to be associated with pain, which limited physical activity and decreased patients' quality of life. As shown in Figure 5, the observed improvement in knee extension directly influenced pain scores on the VAS.

The present study was an initial stage aimed at evaluating the effectiveness of a short-term course of eccentric exercises for the quadriceps femoris muscle in patients with gonarthrosis of grades 1-2 (n = 9). Standard tools commonly used in rehabilitation research were applied: subjective pain assessment using the VAS,

objective goniometry and surface electromyography to analyse muscle activation. The obtained results demonstrated positive dynamics for all three parameters: a substantial reduction in pain syndrome, an increase in range of motion (both knee flexion and extension) and an increase in EMG amplitude, particularly in the vastus medialis and vastus lateralis muscles. On the basis of this study, the method could be considered effective, with its effects explained through neuromuscular, morphofunctional and biomechanical components.

The studies by E. Hanci *et al.* [7] on the ankle joint were methodologically similar to the present research. They also employed methods consistent with the contemporary evidence-based rehabilitation approach, which required a combined assessment of subjective (pain, function) and objective (biomechanical, neurophysiological) parameters, including the same triad of VAS, goniometry and EMG. Comparable findings in the interpretation of EMG data were reported by P. Correia *et al.* [11], who examined the potential consequences of insufficient eccentric strength of the hamstring muscles. The results of the present study regarding the greatest increase in activation of the vastus medialis and vastus lateralis, which are key dynamic stabilisers of the knee joint, were in line with the findings of P. Correia *et al.,* who identified an activation deficit of specific heads of the hamstring muscles after injury. This confirmed that the beneficial effect of eccentric work was mediated not only by an increase in strength but also by normalisation of the recruitment pattern of motor units and improvement of joint control.

The present data were consistent with the results of the systematic review by H.Y. Lim & S.H. Wong [12], which showed that eccentric exercises exerted a pronounced analgesic effect and improved functional outcomes in athletes with patellar tendinopathy. Despite differences between populations, the proposed adaptation mechanisms – increased neuromuscular activation, improved movement coordination and redistribution of muscular effort – could have been universal and manifested in various musculoskeletal disorders. According to H.Y. Lim & S.H. Wong, eccentric contractions created conditions for more effective management of load on the affected structures, potentially reducing pain and improving movement control. These conclusions were in agreement with the observed changes in EMG amplitude and pain reduction in response to eccentric training, which supported its promise for both sports and clinical rehabilitation. P.R. Camargo *et al.* [13], in a study on shoulder impingement, used methods that differed from those of the present research. Their work employed ultrasound imaging and multiple orthopaedic tests and was characterised by a larger sample and longer duration (6 weeks with sessions every other day). Ultrasound imaging was able to visualise tendon integrity, degenerative changes, muscle thickness, micro-damage and other structural alterations, which could be highly valuable in such studies.

The focus on joint pathology (gonarthrosis) and the use of eccentric training to improve joint function were directly related to the studies by D. Stasinopoulos *et al.* [14], who investigated tendinopathies. A common feature with the present research was the attempt to demonstrate that controlled eccentric loading, despite a potential risk of pain exacerbation, ultimately resulted in pain reduction and improvement in objective measures. In a study on the effects of isokinetic eccentric exercise on strength, muscle volume and postural stability, A.D. Kay *et al.* [15] reached similar conclusions that eccentric exercises promoted improvement of thigh muscle function and reported increases in strength and muscle volume of the knee extensors. The main difference from the present study was the evaluation of postural stability, which, according to the authors, was not influenced by exercises performed in the selected mode. It should also be noted that ultrasound imaging was used in that work. In a randomised controlled trial, B.A. Baxter *et al.* [16] indicated that one weekly session of submaximal eccentric resistance training over 12 weeks led to improvements in neuromuscular function comparable to those achieved with the currently recommended twice-weekly training. Given the considerable improvement in neuromuscular function and previously documented low adherence to twice-weekly training recommendations, eccentric training could have played a key role in developing minimal-load strategies to prevent neuromuscular decline. That study differed substantially from the present one, as it included a larger sample (n = 36), employed a control group and had a 12-week intervention period. The main similarities with the current research lay in the focus on the effects of eccentric loading and the assessment of thigh muscles.

In the studies by E. Hanci *et al.* [7] and D. Stasinopoulos *et al*. [14], and in the present research, the methodology, results and data interpretations were broadly comparable. Their main difference lay in the fact that the above-mentioned works were large studies designed as randomised controlled trials that included a control group performing alternative exercises or receiving standard therapy, and they involved a larger sample. The present study, as noted earlier, represented an initial stage and conclusions regarding the effectiveness of the proposed protocol were therefore preliminary. A similar object of research was found in the work of J.P. Gordon *et al.* [17] on eccentric muscle contraction and its influence on functional outcomes. Both articles regarded eccentric exercises as a powerful training stimulus. Convergence was observed in the assessment of their key role in joint stabilisation and improvement of movement biomechanics, which in the present study was directly linked to pain reduction. The differences between the studies were fundamental: the

article by J.P. Gordon *et al.* investigated adaptations in healthy trained individuals with an emphasis on gains in strength, power and athletic performance, whereas the present research had a rehabilitative focus, involving a sample with gonarthrosis, and the key dependent variables were pain, range of motion and EMG activity as a marker of neuromuscular control rather than maximal strength. In the study by J.P. Gordon et al. the effectiveness of the protocol for performance enhancement was assessed, whereas in the current work its therapeutic effect (reduction in pain and increase in range of motion) was evaluated.

Additional mechanistic aspects of eccentric contractions could be explained in terms of the dependence of muscle force on the preceding history of stretch and shortening. As demonstrated by W. Herzog & T.R. Leonard [18], the force generated by skeletal muscle depended substantially on whether the contraction was preceded by stretch or shortening, which was reflected in the phenomena of residual force enhancement and residual force depression. These effects were particularly pronounced during eccentric contractions, when prior muscle stretch facilitated a subsequent increase in force. In view of these mechanisms, the increase in electromyographic amplitude observed after the course of eccentric exercises might have been related not only to enhanced neuromuscular activation but also to changes in the mechanical properties of the muscle in accordance with these regularities. This supported the view that eccentric loading was capable of eliciting specific adaptive responses that improved the efficiency of muscle work and enhanced movement control in the presence of functional knee joint disorders.

The findings were consistent with current concepts of the role of knee joint morphotype in the development of degenerative changes. In particular, the study by L. Kylymniuk [19] showed that structural abnormalities in the proximal tibia could influence load distribution within the knee joint and promote the progression of degenerative processes. Taking these data into account, the increase in neuromuscular activation and stabilising function of the quadriceps femoris observed after eccentric training could be considered a compensatory mechanism that potentially reduced loading of altered joint structures. This underlined the clinical relevance of eccentric exercises in patients with early manifestations of gonarthrosis. The data obtained from the analysis of electromyographic activity were in line with the results of F. Hanno *et al.* [20], who reported that amplitude and frequency characteristics of the EMG signal are important indicators of the functional state of muscles and allow an objective assessment of the degree of their activation. The authors emphasised that changes in EMG amplitude may reflect both neuromuscular and mechanical adaptive processes induced by the training stimulus. These conclusions were consistent with the observed increase in EMG amplitude of the quadriceps femoris after eccentric exercises, indicating the development of adaptations aimed at improving movement control and strengthening the stabilising function of the knee joint.

Modern approaches to the management of gonarthrosis have implied a comprehensive intervention aimed at reducing pain, improving joint function and enhancing patients' quality of life. In the review by M.A. Kolesnikov [21] it was emphasised that non-pharmacological strategies, including therapeutic exercise and graded resistance training, were key components of treatment because they strengthened the musculo-ligamentous apparatus and optimised knee joint biomechanics. In this context, the increase in neuromuscular activation and the improvement in range-of-motion characteristics observed after the application of eccentric exercises in the present study could be viewed as consistent with contemporary principles of rehabilitation for gonarthrosis. These results supported the notion that eccentric training could serve as an effective functional intervention aimed at reducing load on damaged joint structures and stabilising joint performance.

Thus, the obtained data demonstrated a marked reduction in pain, an increase in range of motion and a substantial rise in neuromuscular activation of the quadriceps femoris muscle after the course of eccentric exercises. The positive dynamics were observed in all participants, indicating the universality of the identified adaptive changes. Improvements in mean and peak EMG values reflected an enhanced functional capacity of the muscle to control movement and stabilise the knee joint. Taken together, these changes indicated the formation of stable adaptations directed towards optimisation of motor function in the presence of degenerative knee joint alterations.

CONCLUSIONS

The results of the present study showed that a course of eccentric exercises exerted a pronounced positive effect on the functional state of the quadriceps femoris muscle and on pain intensity in patients with gonarthrosis of grades 1-2. After only 12 training sessions performed every other day, a clear positive trend was observed across all key parameters. According to the visual analogue scale (VAS), a reduction in pain was recorded in all participants. The maximal baseline pain level was 7 points, whereas by the end of the course the values had decreased to the range of mild or moderate pain, which confirmed the clinical effectiveness of eccentric loading in relation to pain symptoms. Electromyographic analysis also demonstrated significant improvements. The mean amplitude of electrical activity of the rectus femoris increased from 87.1 μV to 163.2 μV, reflecting an enhanced contribution to knee extension. The vastus lateralis showed an even more pronounced change, from 98.7 μV to 298.4 μV, indicating a strengthening of its stabilising role. The amplitude of the vastus medialis rose

from 59.3 μV to 220.7 μV, which testified to improved movement control and redistribution of load within the knee joint. The increase in EMG activity of all investigated heads confirmed the development of adaptive neuromuscular responses to the eccentric work regime.

In addition, an increase in knee joint range of motion was observed, reflecting improved biomechanics and enhanced functional mobility of the limb. This was of practical importance for patients with osteoarthritis, in whom restricted mobility is a major factor contributing to reduced quality of life. Thus, eccentric exercises demonstrated effectiveness in reducing pain, increasing muscle activation and improving range of motion. The obtained findings supported the feasibility of incorporating eccentric training into rehabilitation programmes for patients with early stages of knee gonarthrosis. Further research is required to examine the long-term effects of eccentric exercises in order to determine whether improvements in pain, strength and range of motion are maintained after completion of the course and whether maintenance therapy is necessary. An important avenue for future work is the comparison of eccentric exercises with other rehabilitation modalities to assess their relative effectiveness and to define optimal conditions for their use. The development of individualised eccentric training programmes with tailored intensity, frequency and volume for different patient groups also remains a promising direction. Subsequent studies in these areas may help to increase the effectiveness of rehabilitation and improve the quality of life of patients with knee osteoarthritis.

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CONFLICT OF INTEREST

None.

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Эксцентрикалык режимде булчуң жыйрылуусунун тизе муунунун функциясы бузулган адамдарда оорунун интенсивдүүлүгүнө жана кыймылдын чектелишине тийгизген таасири

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Аннотация. Тизе муунунда оору жана кыймылдын чектелиши менен кайрылган бейтаптардын санынын өсүшү остеоартроздун баштапкы стадияларында функцияны калыбына келтирүүнүн эффективдүү ыкмаларын издөөдөн өзгөчө мааниге ээ кылды. Изилдөөнүн максаты – тизе муунунун функциясы бузулган адамдарда оорунун интенсивдүүлүгү, муундагы кыймылдын чектелиши жана булчуң жыйрылуусунун эксцентрикалык режими боюнча параметрлердин ортосундагы мүмкүн болгон байланышты аныктоо болгон. Изилдөөнүн алкагында медициналык борбордо тизе остеоартрозунда булчуң жыйрылуусунун эксцентрикалык режими изилденип, эксперимент жүргүзүлгөн. Реабилитациялык сессиялар учурунда сан сөөгүнүн төрт баштуу булчуңунун жыйрылуусунун эксцентрикалык фазасына өзгөчө көңүл бурулган. Экспериментке чейин жана андан кийин электромиографтын көрсөткүчтөрү, оорунун интенсивдүүлүгү визуалдык аналогдук шкала (ВАШ) боюнча, ошондой эле муундагы кыймыл амплитудасы гониометрдин жардамы менен катталган. Сан сөөгүнүн төрт баштуу булчуңунун эксцентрикалык жыйрылуусунун орточо амплитудасы эки эседен ашык өскөн; мисалы, латералдык кең булчуңда көрсөткүчтөр 98,7 мкВдан 298,4 мкВга чейин жогорулаган. Сабактар курсунан кийин тогуз катышуучунун алтысында тизе муунун толук жазуу калыбына келтирилип, бардык изилденгендерде оорунун деңгээли азайган, алардын экөөндө оору толугу менен жоголгон. Изилдөөнүн жыйынтыктары боюнча булчуң жыйрылуусунун эксцентрикалык режими оорунун деңгээлин төмөндөтүүдө, кыймыл амплитудасын жогорулатууда жана электромиографиялык активдүүлүктүн көрсөткүчтөрүн күчөтүүдө эффективдүү экени көрсөтүлгөн. Эксцентрикалык режим булчуң күчүн жана кыймыл учурундагы нейромускулалык көзөмөлдү өнүктүрүп, муун кемирчегине түшкөн механикалык жүктү азайтты. Бул изилдөөдө алынган натыйжалар сан сөөгүнүн төрт баштуу булчуңу үчүн эксцентрикалык режимде аткарылган көнүгүүлөр тизе остеоартрозунун баштапкы стадияларында булчуң алсыздыгы сыяктуу себептерге жана оору, муундагы кыймыл амплитудасынын чектелиши сыяктуу кесепеттерге бир убакта таасир этүү аркылуу эффективдүү болушу мүмкүн экенин көрсөттү. Алынган маалыматтар тизе остеоартрозунун эрте формалары бар бейтаптар үчүн индивидуалдык реабилитациялык программаларды иштеп чыгууда колдонулушу мүмкүн

Негизги сөздөр: гонартроз; электромиография; негативдүү фаза; тизе оорусу; кыймыл амплитудасы

Влияние эксцентрического режима мышечного сокращения на интенсивность боли и ограничения подвижности у лиц с нарушением функций коленного сустава

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Аннотация. С ростом числа пациентов с болевым синдромом и ограничением подвижности коленного сустава особое значение приобретает поиск эффективных методов восстановления функции при начальных стадиях остеоартроза. Целью исследования было выявить возможную взаимосвязь интенсивности боли, ограничений движений в суставе и параметров эксцентрического сокращения у лиц с нарушением функций коленного сустава. В рамках проведенного исследования на базе медицинского центра проведен эксперимент по изучению эксцентрического режима мышечного сокращения при остеоартрозе коленного сустава. Во время реабилитационных сессий делался упор на эксцентрическую фазу сокращения четырехглавой мышцы бедра. Оценивались показания миографа, уровень боли по визуально-аналоговой шкале и амплитуда движения в суставе при помощи гониометра до и после эксперимента. Средняя амплитуда эксцентрического сокращения четырёхглавой мышцы увеличилась более чем в два раза: например, у латеральной широкой мышцы – с 98,7 мкВ до 298,4 мкВ. После курса занятий у шести из девяти участников было достигнуто полное разгибание в коленном суставе, а уровень болевого синдрома снизился у всех испытуемых, включая полное исчезновение боли у двух человек. По результатам исследования эксцентрический режим мышечного сокращения показал свою эффективность в снижении уровня боли, повышении амплитуды движений, а также увеличения показателей электромиографической активности. Эксцентрический режим развил силу мышц, нейромышечный контроль при движениях, снижает механическую нагрузку на суставной хрящ. Результаты данного исследования продемонстрировали, что упражнения в эксцентрическом режиме для четырехглавой мышцы бедра, при начальных стадиях остеоартроза коленного сустава, могут быть эффективны, воздействуя одновременно на причину (мышечная слабость) и следствие (боль, ограничение амплитуды движений в суставе). Полученные результаты могут быть использованы при разработке индивидуальных реабилитационных программ для пациентов с начальными формами остеоартроза коленного сустава

Ключевые слова: гонартроз; электромиография; негативная фаза; боль в коленном суставе; амплитуда движения