journal homepage: http://kont.zsf.jcu.cz
DOI: 10.32725/kont.2023.036

KONTAKT / Journal of nursing and social sciences related to health and illness

Original research article

Effectiveness of telerehabilitation in patients following hip joint arthroplasty

Dita Hamouzová [1, 2] *, Leoš Navrátil [1]

[1] *Czech Technical University in Prague, Faculty of Biomedical Engineering, Kladno, Czech Republic*
[2] *Regional Hospital Kladno, a. s., Hospital of the Central Bohemia Region, Kladno, Czech Republic*

Abstract
The article focuses on comparing intensive rehabilitation with telerehabilitation carried out in the home environment using common computer communication technologies. To assess the effect of telerehabilitation, an instructional video was recorded, according to which patients after hip joint arthroplasty performed exercises independently in their social environment. A total of 92 patients who underwent hip joint arthroplasty surgery were divided into two groups. Group C (control) consisted of clients who were admitted to the inpatient department of a medical facility for intensive 14-day rehabilitation. Group T (telerehabilitation) performed rehabilitation in their home environment and exercised independently with the possible supervision of a physiotherapist via communication technologies.

The monitoring took place for 6 weeks, with the initial examination carried out in the first week after the surgery, a follow-up examination in the third week, and a final (exit) examination after 6 weeks of the total hip joint arthroplasty surgery. The range of motion (ROM) in the hip joint and the circumferential of the operated limb were compared for both groups. The functional examination was supplemented by walking and evaluated using the 10-Meter Walk Test (10MWT).

The results of the study indicate a comprehensive therapeutic effect of telerehabilitation in patients after hip joint arthroplasty.

Keywords: Hip joint arthroplasty; Telemedicine; Telerehabilitation

Abbreviations:
10MWT – 10-Meter Walk Test; THA – total hip arthroplasty; TKA – total knee arthroplasty; ROM – Range of motion

Introduction

In recent years, topics related to telemedicine and telerehabilitation have been increasingly prevalent in the professional literature. One of the driving forces behind this trend is the technological advancements in modern IT technologies. The development of communication technologies enables a revolution in all aspects of therapeutic rehabilitation. The use of robotics, virtual reality, nanotechnology, embedded sensors, neuroimaging, and other technologies enhances the impact on the health of citizens.

The dialogue among experts on telerehabilitation and its application in healthcare services has increased, particularly during the Covid-19 pandemic. In European and other countries, telerehabilitation (synchronous, in real-time) and distance rehabilitation (asynchronous) have started to be applied in the treatment of various diseases in both chronic and acute stages. Papers and articles in the professional literature focus on the benefits of remotely delivered physiotherapy sessions for different client conditions. The conclusions of the studies demonstrate the high effectiveness of telerehabilitation (Brigo et al., 2022; Cottrell et al., 2017).

One of the goals of telemedicine and mHealth implementation is to establish standards for telerehabilitation care. The Association of Speech-Language Pathologists of the Czech Republic (in Czech "AKL ČR") also contributes to their development. These standards are largely based on established guidelines from the United States or Australia (Pětioký et al., 2021; Washington State Department of Health, 2018). In general, everyone agrees on specific requirements for the provision of telerehabilitation care. One of the requirements is to establish rules for the education and competence of the therapist, the selection of suitable patients, tools and equipment, as well as regulatory and ethical criteria. For the needs of telerehabilitation, alternatives for assessment and digitally available therapeutic materials must be created. We include ICT security among the important requirements. These requirements are defined by the National Office for Cyber Security (in Czech "NÚKIB"), patient data protection rules (GDPR), and professional standards of organisations. The working group of the National Strategy of Electronic Health Care and the new work-

* **Corresponding author:** Dita Hamouzová, Czech Technical University in Prague, Faculty of Biomedical Engineering, Sítná Sq. 3105, 272 01 Kladno, Czech Republic; e-mail: DHamouzova@seznam.cz
http://doi.org/10.32725/kont.2023.036
Submitted: 2023-07-03 • Accepted: 2023-09-11 • Prepublished online: 2023-09-18
KONTAKT 25/3: 235–245 • EISSN 1804-7122 • ISSN 1212-4117

ing group for telemedicine at the Ministry of Health also take part in the development of the standards (Pětioký et al., 2021; 2022).

For the majority of the Czech population, terms like telerehabilitation, distance therapy, or telemedicine are not well understood. Before the Covid-19 pandemic, few could imagine the possibilities of distance learning in education, working from home (home-office), or the declaration of lockdown and crisis escalation to the point of a state of emergency. The pandemic caused by Covid-19 infection contributed to the popularisation and implementation of modern technologies into practice. However, there has also been confusion in labelling these services accurately. They are often mistaken for e-Health, e-pharmacies, and other e-services. While these applications provide a certain level of convenience for the client, they merely mediate certain services between the client and the provider (e-prescriptions, e-sick notes). Telemedicine, specifically telerehabilitation, and distance therapy are active forms of therapy, not just remote consultation services. However, it should be noted that care provided through open platforms such as Skype, YouTube, WhatsApp, and other media is considered non-binding communication (Čermáková, 2021).

In the context of these platforms, it is necessary to address data security concerns. The theft of healthcare information is continually increasing and becoming a business on its own. When engaging with clients, cyber security must be taken into account. The use of modern communication systems and therapeutic-diagnostic tools that can be used for therapy and client examination in a home environment further increases the risk (Čermáková, 2021).

The aim of the research published by Kopsa Těšinová and Dobiášová (2022) was to identify challenges associated with the introduction of telemedicine, develop a proposal for the application of telemedicine in the healthcare system, and identify future challenges of telemedicine in the Czech Republic. The surveyed experts agreed on the increased use of telephone calls, consultations, and video calls during the Covid-19 pandemic, but also drew attention to the risks and barriers to the use of telemedicine services in practice. One of the limitations is the lack of sufficient patient information, absence of tactile and visual perception, and unfamiliarity with the overall patient condition. Furthermore, they noted that telemedicine cannot be applied to all patients; it requires precise rules and predefined application conditions. The experts agreed that the Czech healthcare system is not adequately prepared for the implementation of telemedicine in practice. The desired output of a telemedical consultation is not clear to clients or insurance representatives. Information leakage risks are also cited in studies worldwide.

Currently, there is no legal legislation governing the practice of telemedicine. After 2020, the number of online services provided by general practitioners has been increasing. Certain healthcare professionals point out the lack of awareness among citizens regarding healthcare through telemedicine or telerehabilitation, the unavailability of internet access for all citizens, and the resistance of some doctors to new technologies. Nevertheless, scientific journals continue to publish studies on the benefits of telemedicine, telerehabilitation, and distance therapy for both clients and service providers.

The term "telemedicine" was not mentioned in the legislation of the Czech Republic until December 31, 2021. However, the inadequate legal framework did not prohibit the provision of this form of healthcare. As long as the therapy procedures were in accordance with professional standards and the proper level of providing healthcare services, the provider of this platform did not act unlawfully. The growing pressure during the Covid-19 pandemic to regulate telemedicine resulted in the inclusion of consultation services through remote means from January 1, 2022. The Act on Healthcare Services specifies within Article 11 Section 5 the term "consultation services". *Consultation services outside of healthcare facilities can be provided through remote access or in the patient's own social environment or another location where the patient is currently located.* [Article 11 Section 5 of Act No. 372/2011 Coll., on Healthcare Services and Conditions for Their Provision (Healthcare Services Act)] (Dubanská, 2022).

Progress in the legal regulation of telemedicine was expected with the issuance of Act No. 325/2021 Coll., on the Electronisation of Healthcare. This Act introduces a certain framework for the regulation of electronic healthcare through the use of telecommunications and information technologies and establishes conditions for secure data sharing within its scope. Some parts of the Act will not come into effect until 2026 or even 2030. Additionally, a supplementary decree regulating electronic healthcare documentation is being prepared for approval (Dubanská, 2022).

The legal framework for telemedicine service providers is still inadequate. The requirements for operators are the same as those for providing care in healthcare facilities. In therapy, it is necessary to always proceed *de lege artis*. There are no specific standards for telemedicine. When communicating with patients, it is essential to verify their identity, ensure security and protection of personal data, and obtain signed informed consent, which are certain limitations of telemedicine services. The responsibility lies with the healthcare provider, who is obliged to provide healthcare *de lege artis*, establish conditions and measures to safeguard patient rights, and who is also liable for any civil or criminal harm. The physician is also required to act *de lege artis* and has responsibilities towards both the employer and the patients (Dubanská, 2022).

The development of telemedicine is progressing at various levels worldwide. Research shows that the possibilities for growth in the telehealth aspect are enormous but slowed down by various barriers. Conditions and prospects for the technological development of telemedicine depend, among other things, on access to smart devices, 5G networks, and the internet. Coordinated efforts are needed to reduce barriers to compliance with privacy regulations and patient access to technologies.

In their systematic review of randomised controlled trials, Jansson et al. aimed to examine the effects and safety of telerehabilitation for clients with lower limb joint replacement. Medical databases were searched for articles published before February 2020. Some articles were further examined to identify additional relevant sources on the subject. The critical appraisal checklist from the Joanna Briggs Institute for randomised controlled trials was used to assess the quality of the published relevant studies. Native synthesis was utilised for the output. Nine studies involving 1,266 patients were included. Clients who underwent telerehabilitation showed similar improvement in functional mobility of the operated joint during daily activities compared to patients who underwent standard outpatient rehabilitation, without an increase in adverse effects. The impact of telerehabilitation on functional status was assessed as heterogeneous with moderate to low-quality proof of evidence. According to the findings, telerehabilitation is equally effective as conventional outpatient rehabilitation in improving both active and passive flexion and extension of the knee. Other validated tests, such as measuring limb circumference for swelling, stair climbing test, 6-minute walk test, and

10-meter walk test, as well as isometric quadriceps strength measurement, yielded comparable results for both groups of rehabilitation. The authors also addressed the variability of data across the reviewed studies, which could be attributed to the diversity of measurement outcomes. Significant influences include the diversity of healthcare systems and the socioeconomic status of patients. The systematic review identified several limitations, such as insufficient reporting of outcomes in the included studies, the absence of universal rehabilitation methods for patients with knee and hip joint endoprostheses, and therefore the inability to make strict recommendations for functional improvement methods (Jansson et al., 2022).

Material and methods

The study aims to demonstrate whether telerehabilitation is a suitable alternative to contact-based treatment in selected indications within a healthcare facility (face-to-face). According to several literary sources, telerehabilitation is considered a possible alternative to contact physiotherapy in cases where standard healthcare cannot be accessed or as a supplement to maintain the continuity of rehabilitation intervention. Most authors have focused on telerehabilitation using various computer applications, auxiliary sensors, and feedback systems. The main aim of the study was to compare the difference in the effectiveness of physiotherapeutic intervention applied through telerehabilitation and face-to-face rehabilitation using a simple, accessible, and repeatable programme. The secondary objective was to evaluate whether the results of entrance, control, and exit examinations demonstrate the effectiveness of rehabilitation care in both rehabilitation groups.

Participants

To utilise and evaluate the benefits of remote rehabilitation using the example of orthopaedic surgery, an instructional video titled "Physiotherapy after Hip Joint Arthroplasty" was created. We established a website (https://telerehabilitace.cz/) to provide clients with access to professional, easily understandable exercises and advice. The difficulty of the exercises in the instructional video ranged from simple exercises that can be performed in the first few days after surgery to more complex exercises with an overball or theraband. The exercise program was offered to individuals who underwent joint arthroplasty for use in their home environment. They performed the exercises independently based on the instructions provided in the specific video. They could pause or repeat exercise sequences at any time. If needed, communication with a physiotherapist for consultation and exercise correction was arranged through Internet communication applications.

Two groups were created to compare the effectiveness of telerehabilitation. Group T (telerehabilitation) received post-operative physiotherapy through telerehabilitation, while Group C (control) consisted of an equally sized group of subjects who underwent intensive rehabilitation in a hospital rehabilitation ward after total hip joint arthroplasty.

Data collection

The data was collected from November 2019 to June 2022. One of the criteria for selecting the participants was the original diagnosis that led patients to the need for total hip joint arthroplasty (THA). All participants in this study had been diagnosed with joint arthrosis without other traumatic changes in the lower limbs. Patients with other comorbidities were excluded from the sample. The age range of the participating patients was between 60 and 80 years in all observed groups. The clients were operated on at the Regional Hospital Kladno and provided informed consent for hospitalisation and medical care following the Universal Declaration of Human Rights, European Union Regulation No. 2016/679, Act No. 110/2019 Coll. on personal data processing, the Helsinki Declaration adopted by the 18th World Medical Assembly in 1964 as amended (Fortaleza, Brazil, 2013), and other generally binding legal regulations. To evaluate the data, measurements were taken from patients upon discharge from the hospital or during the initial kinesiological analysis in the rehabilitation department (6–9 days after the surgery). If necessary, examinations were conducted through telecommunication computer applications with the assistance of a family member. The control measurements were indicated halfway through the monitoring period (21 days after the surgery) when the group of clients was discharged from the hospital after 14 days of intensive rehabilitation. The final exit data were recorded during an examination by an orthopaedist 6 weeks after the surgery or measurements were conducted in a home environment in collaboration with a family member under remote supervision of a physiotherapist.

Telerehabilitation and telemonitoring of Group T

Group T consisted of participants who underwent hip joint arthroplasty and preferred rehabilitation care from their home environment through independent exercise with possible support from a physiotherapist via telephone or visual computer application. After accessing the website, they performed exercises based on the selected instructional video. It was recommended to exercise twice a day for 20 minutes. Out of the total number of approached patients (approximately 90), 46 subjects were selected who met the criteria for inclusion in the study on the effectiveness of telerehabilitation. The entrance, control, and exit measurements were taken at the specified intervals described above. Consultation with a physiotherapist through visual communication computer applications was not a requirement. The distribution of the participating patients is shown in Table 1.

Table 1. THA – group distribution of the participating patients

THA	Group C Classic rehabilitation	Group T Telerehabilitation
Number of participants (*n*)	46	46
Number of women (*n*)	26	29
Number of men (*n*)	20	17
Average age of the group	69.39 ± 6.48	71.31 ± 5.85
Average age of women	70.65 ± 6.99	71.93 ± 6.13
Average age of men	67.75 ± 5.69	70.29 ± 5.55

Rehabilitation in Group C

Patients hospitalised for inpatient rehabilitation undergo a standard two-phase exercise regimen. In the morning and afternoon, they engage in individual exercises with a physiotherapist. The exercises include stretching and strengthening elements. Exercises to increase the range of motion in the hip joint are supplemented with mechanotherapy using an electrically powered CPM device (passive flexion and joint extension exercises performed by the device), techniques aimed at reducing swelling in the operative area, and scar care. Rehabilitation

also includes training for walking on flat surfaces, stairs, and uneven terrain with an occupational therapist. After a 14-day hospitalisation (21 days after the surgery) and a follow-up examination, the clients were discharged home. They were recommended to continue exercising at home to maintain continuity. The exercises performed at home were not monitored. The final measurement was conducted during a follow-up examination by an orthopaedist 6 weeks after the surgery.

Monitored parameters

Simple and easily measurable data were selected from the kinesiological analysis. To evaluate the effect of telerehabilitation in a home environment, goniometry, anthropometry, and the 10-Meter Walk Test (10MWT) were utilised. These assessments are part of the standard examination in rehabilitation after total hip joint arthroplasty.

Goniometry – measurement of joint range of motion (ROM)

The range of motion in the hip joint was measured in degrees in a position simpler for the patient, lying on their back, with the ability to actively slide their foot along the surface. A standard goniometer or a folded paper placed within the hip joint's range of motion was used (the angle was then measured with a standard drafting protractor). The measurement was performed both actively and passively, with the physiotherapist or a family member performing the movement. For result comparison, the range of active motion into flexion was used (Gerhardt and Rondinelli, 2011; Kolář et al., 2009) – Figs 1 and 2.

Fig. 1. Measurement of Range of Motion (ROM) in the joint using a goniometer

Fig. 2. Measurement of Range of Motion (ROM) in the joint using folded paper

Anthropometry – measurement of leads and lengths of limbs and the entire human body

After the operation, swelling in the surgical area is commonly present due to soft tissue intervention. To monitor changes in swelling, measurements of lower limb circumferences were used. The circumference was measured on both lower limbs, and the recorded numerical value represents the difference between the obtained measurements. The measurements were typically taken 10 cm above the patella, at the patella, 10 cm below the patella, and at the ankle. To assess the effect of rehabilitation care in the hip joint arthroplasty group, the circumference measurement of the thigh below the surgical scar in the groin area was monitored (Fig. 3).

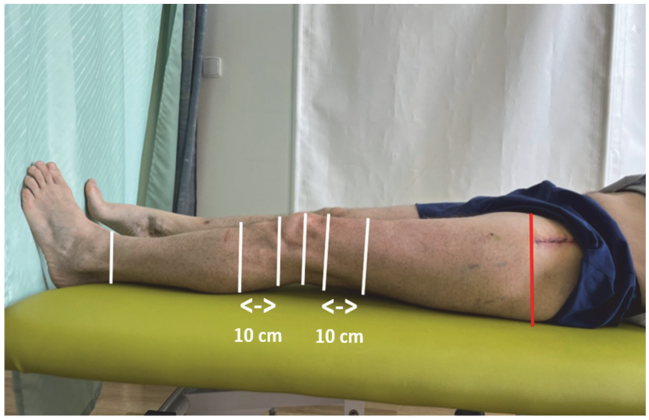

Fig. 3. Measurement of swelling during hip joint arthroplasty

10-Meter Walk Test (10MWT)

To assess the mobility of the participants after arthroplasty, a test of speed and commonly preferred walking speed over a distance of 10 meters was chosen. All participating patients used assistive devices – two forearm crutches – during the walk. The test was performed over a distance of 14 meters, with the precise timing recorded within the 10-meter segment. Two meters were allowed for possible acceleration at the beginning and two meters at the end of the segment for deceleration, excluding acceleration and deceleration movements (Fig. 4). The test was conducted 3 times, and the recorded time represents the average (Novotná et al., 2013).

Evaluation methods

The study aims to assess the benefits of telerehabilitation for clients undergoing hip joint arthroplasty through self-exercise based on instructional videos and to compare its effectiveness with intensive subsequent rehabilitation in the inpatient setting of a healthcare facility.

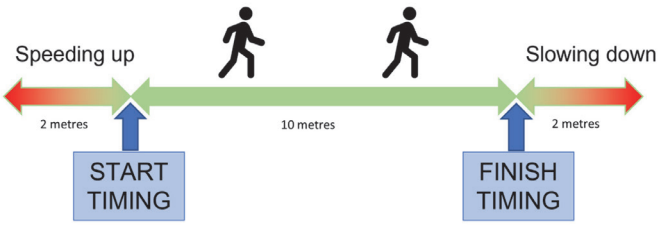

Fig. 4. Schematic representation of the 10MWT

Standard statistical tests were used for the result evaluation and comparison of measured values. The ANOVA test was employed for testing the equality of means. A two-sample *t*-test was chosen to compare the effects of rehabilitation between the entrance, control, and exit data in both groups (C and T). A two-sample *z*-test was applied to evaluate the therapy's effectiveness and assess the degree of improvement between groups C and T. In all tests, a significance level of 5% ($\alpha = 0.05$) was selected. The statistical tests and graphical comparisons of entrance, control, and exit data were performed using Microsoft Excel.

Results

Evaluation of goniometry – ROM into hip flexion

In both groups, a paired *t*-test showed a statistically significant increase in active hip flexion at a 5% significance level, with the recorded *p*-value significantly below the required threshold of 0.05.

The statistical difference between Group C and Group T in the exit parameters of active ROM for flexion was compared using a two-sample *z*-test. Since the p-value ($p = 0.0001$) was less than α ($\alpha = 0.05$), we can conclude that the measured data are significant at a 5% significance level (Chart 1). Telerehabilitation is a suitable alternative to in-person rehabilitation.

Chart 1 presents a comparison of the entrance values of hip flexion ROM (Range of Motion) between client groups. Clients in the rehabilitation department of Group C achieve a greater range of hip flexion at the initial examination (mean value for Group C: 57.5, for Group T: 54.3) compared to Group T. At the 3-week postoperative control examination, the measured values of active hip flexion ROM remain higher in Group C.

Both groups of clients reach the permitted range of motion of 90° for hip flexion at the exit examination. Group C has 22 participating clients, while Group T has 37 (out of a total of 46 subjects in each group). Total hip joint replacement has certain limits of movement, and it is not recommended to perform movements with flexion exceeding 90°, especially in the first few months after surgery. Clients reach 90° of hip joint flexion (maximum possible movement) and further increases are not observed. This is illustrated in Chart 2, where Group T shows a

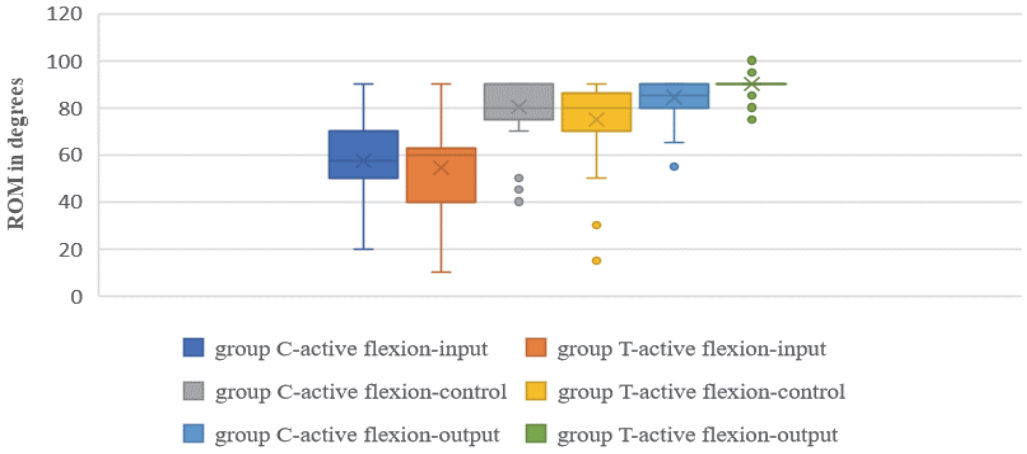

Chart 1. Goniometric assessment for input, control, and output – hip flexion

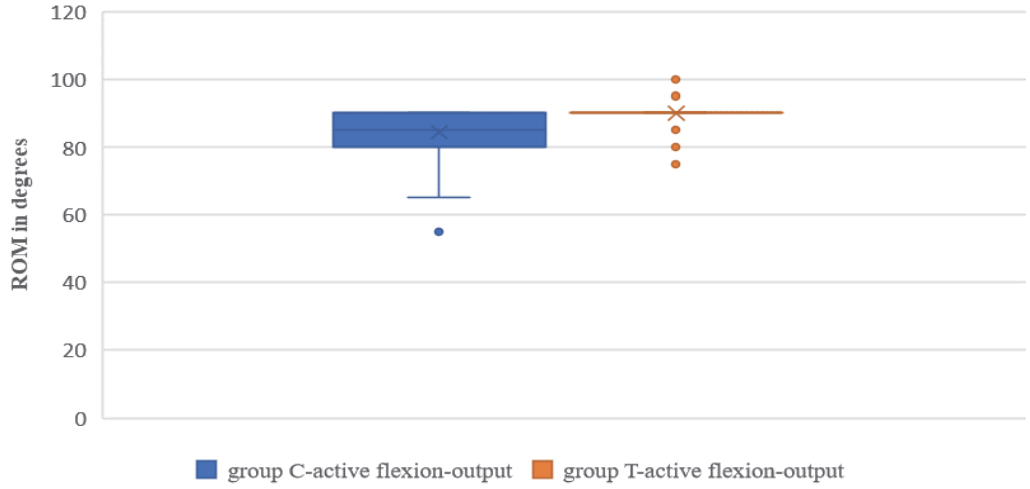

Chart 2. Goniometric assessment for output – hip flexion

small range of measured values. Chart 2 also demonstrates the improvement of Group T in the exit measurement, indicating a smooth rehabilitation process with better results. Clients benefit from regular and active independent exercise.

Goniometry evaluation – ROM for hip abduction

Paired *t*-tests at a 5% significance level indicate that there was a statistically significant increase in the range of active hip abduction in both groups between the entrance, control, and exit measurements, with $p = 0.001$. From these tests, we can conclude that during rehabilitation, there is a statistically significant increase in active hip abduction in both groups.

When comparing Group C and Group T, we used a two-sample *z*-test to compare the exit parameters of active ROM. Since the *p*-value ($p = 0.00048$) is less than α ($\alpha = 0.05$), we can conclude that the measured data are significant at a 5% significance level. Telerehabilitation is a suitable alternative to in-person rehabilitation. This result is supported by Charts 3 and 4.

The entrance values of the active hip abduction range in Group C have higher measured values compared to Group T. At the control examination (3 weeks post-surgery), the measured values of active hip abduction ROM remain higher in Group C. Clients benefit from a two-phase rehabilitation.

Chart 4 represents the exit parameters of hip abduction ROM for both groups. Regular, more active, and gradual rehabilitation of the clients in Group T results in better values of abduction range when compared to the clients in Group C.

Assessment of swelling

In hip joint anthropometry, we used the thigh circumference measurement in the groin area to assess swelling. The circumference was measured on both lower limbs, and the recorded numerical value represents the difference between the obtained measurements.

During statistical evaluation using a two-sample *t*-test within the groups, the values reached $p = 0.001$. At a 5% significance level, we conclude that there is a statistically significant

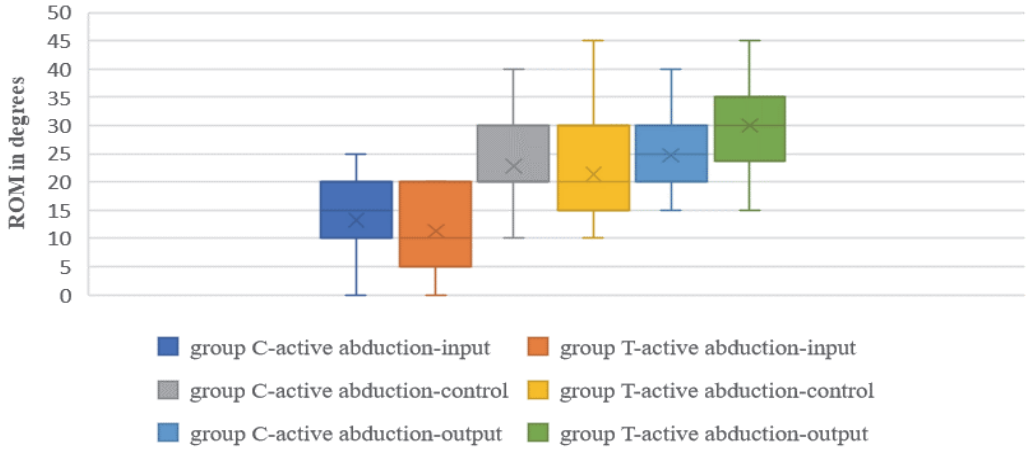

Chart 3. Goniometric assessment for input, control, and output – hip abduction

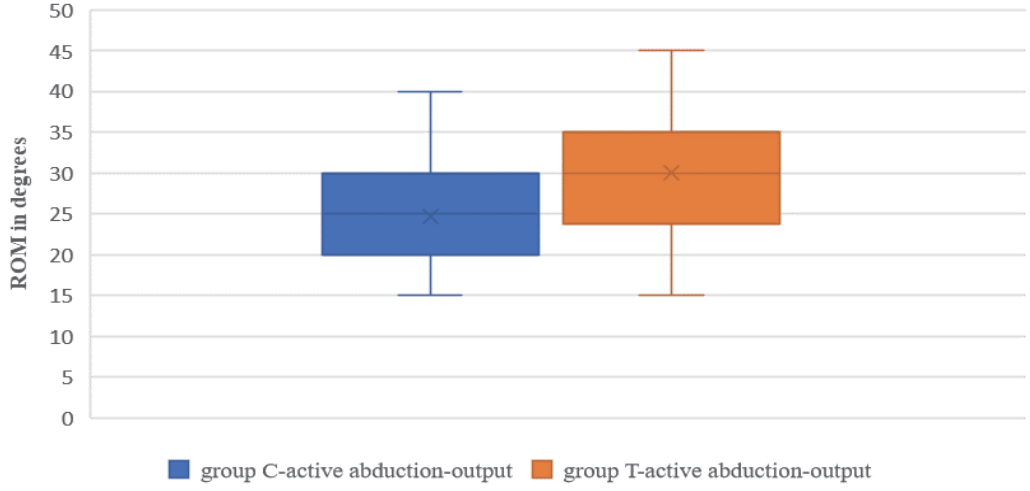

Chart 4. Goniometric assessment for output – hip abduction

reduction in swelling in the operated joint area during rehabilitation in both groups.

When using a two-sample *z*-test to compare the exit parameters between the groups, the value is $p > \alpha$ ($p = 0.1721$). The measured data for both groups are the same. At a 5% significance level, it has been demonstrated that telerehabilitation has the same effect as standard in-person rehabilitation. This is supported by the graphical representation (Chart 5) of the measured differences in average thigh circumference values in the groin area between the limbs.

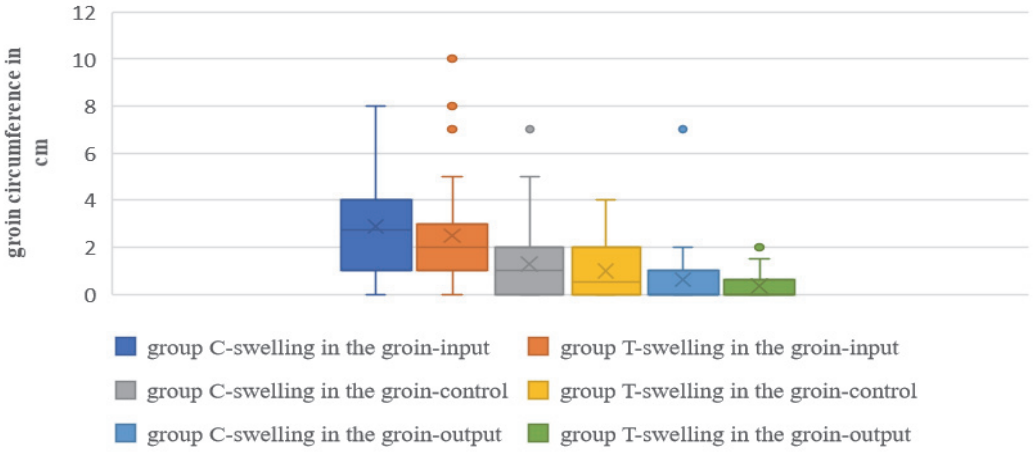

Chart 5. Assessment of anthropometry for input, control, and output – degree of swelling

During rehabilitation, the swelling decreases in both groups. When assessing the average values, as shown in Chart 5, the measured values for Group T are smaller in the entrance, control, and exit measurements. The trend in reducing swelling is continuous in both monitored groups. There is no difference in the effect of telerehabilitation and contact physiotherapy on swelling after total knee arthroplasty.

Assessment of 10MWT

Walking with two forearm crutches is recommended until checked by the operating surgeon. For the uniformity of the performed test, the testing is carried out using an aid. Paired *t*-tests at the 5% level of significance, when the value of $p = 0.001$, statistically demonstrate an increase in the walking speed in both groups during therapy, regardless of the chosen form of rehabilitation.

Chart 6 shows the 10MWT rating. We chose the two-sample *z*-test for statistical evaluation. The calculated *p*-value (0.8511) exceeds the chosen α (0.05). We do not reject the claim, *i.e.*, at the 5% level of significance, the effect on walking acceleration is the same for both rehabilitation approaches.

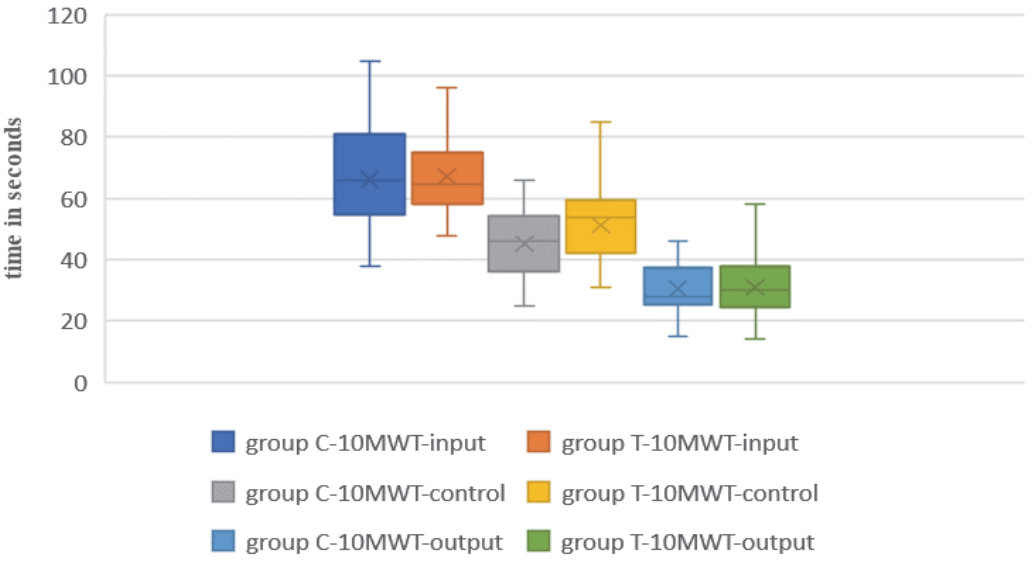

Chart 6. Assessment of 10MWT for input, control, output

Without practised agility, uncertain walking with two forearm crutches affects the speed. Clients gain more stability and smoother walking through intensive training during bed rehabilitation. Physiotherapy performed twice a day during bed rehabilitation results in a more effective improvement in walking speed in Group C at the control examination.

During the final monitored period (3–6 weeks after the operation), the telerehabilitation group of clients improved in walking in the field, gained confidence, and in the final 10MWT examination, both groups scored identically (Chart 7). The effect of telerehabilitation and face-to-face rehabilitation on walking speed is identical.

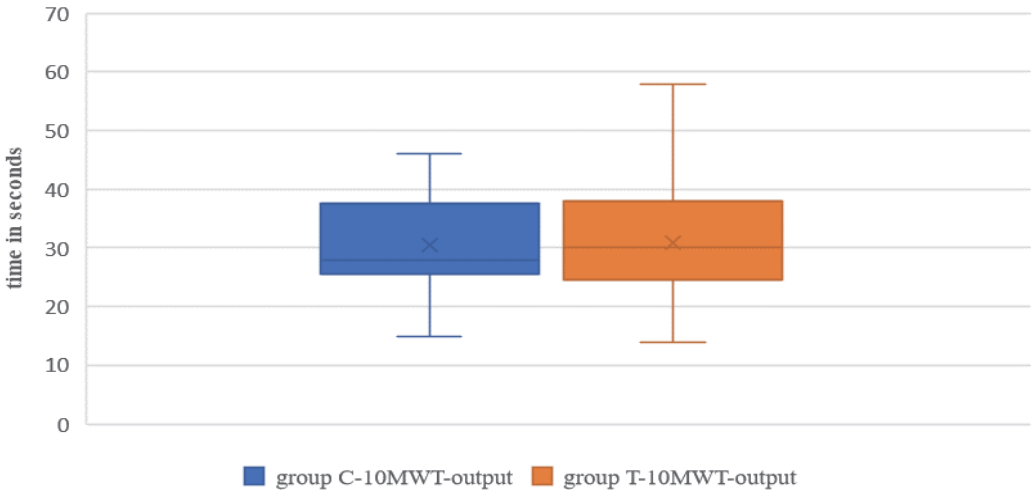

Chart 7. Assessment of 10MWT for output

Discussion

Digital technologies emerged as a useful education tool during the COVID-19 pandemic in 2019. Digital approaches were utilised in both pre-operative and post-operative periods, significantly expanding care possibilities. These platforms assist not only in education but also in remote patient monitoring. The implementation of digital technologies has the potential to reduce healthcare costs. Recent studies suggest that enabling individuals to access education and participate in self-care can help prevent unnecessary emergency visits, reduce expenses, and improve patient interactions with healthcare professionals (Knapp et al., 2021).

For example, Knapp et al. (2021) conducted a study to assess patients' engagement in educational programs based on digital applications and evaluate which content was most beneficial for patients during the postoperative period of total hip and knee joint replacement. The application provided comprehensive education to individuals through a series of modules delivered at set intervals before and after surgery. The study results indicate that digital technology platforms offer a scalable and meaningful approach to engaging patients throughout the entire continuum of care and can serve as a cost-effective complement to traditional methods.

In the Czech Republic, emphasis is placed on the accessibility of healthcare. Overcrowded rehabilitation departments struggle to provide timely care to all clients. The waiting time for appointments with rehabilitation physicians and subsequent individual exercise sessions with physiotherapists ranges, on average, from 3 weeks to 2 months. Telerehabilitation and distance-based rehabilitation options can be recommended as suitable care alternatives. One of the responsibilities of a physiotherapist is to provide instruction for independent exercises, empower patients to take control of their recovery and increase motivation for self-care. Telerehabilitation aligns with these goals and is supported by the results of our work.

One of the study's goals was to demonstrate whether telerehabilitation is a suitable alternative to face-to-face treatment in selected indications within healthcare facilities. To compare and evaluate the effect of telerehabilitation, a control group of subjects undergoing rehabilitation in an inpatient setting was created. Acute hospital rehabilitation mostly admits patients after orthopaedic surgeries due to traumatic fractures and planned procedures on the musculoskeletal system. Another group consists of patients after a stroke or with neurological conditions affecting the musculoskeletal system. Joint replacement and total endoprosthesis replacement are common surgeries with standard procedures and predetermined rehabilitation programs. To compare the effects of different rehabilitation approaches while maintaining an identical procedure for the physiotherapist, we chose to focus on the care of clients after hip arthroplasty surgery. For patients with neurological conditions, physiotherapy is more frequently individually tailored based on their specific impairment, which would pose a challenge in maintaining identical groups.

In preparing the study, we assumed that the measurement results within the individual groups of subjects would differ between entrance, control, and exit examinations. We performed comparisons of values using a two-sample t-test, where for all tests, the p-values scored < 0.001. The results of the measured values are significant and demonstrate the effect of rehabilitation on increasing the range of motion in the joint, reducing swelling in the area, and increasing the walking speed in patients after total knee or hip joint arthroplasty. Improvements in the observed parameters were recorded in

both groups. Both contact rehabilitation as well as telerehabilitation have an impact on the recovery of patients after joint arthroplasty.

The main objective of the project was to compare the effects between groups with different forms of rehabilitation. We utilised a two-sample *z*-test and compared the exit values of the observed parameters between the groups. From the results, it is evident that there is a faster onset of rehabilitative effects in all parameters during the control examination in the control group. The more intensive therapy in inpatient rehabilitation initiates the recovery in patients more effectively. However, at the end of the observation period, the resulting examination values after 6 weeks from surgery were higher in the telerehabilitation group (except for the 10MWT, where the results are the same). Subjects in the telerehabilitation group perform exercises independently at home according to instructions. Although the rehabilitation is not as intensive (lacking mechanotherapy) as in a hospital setting, it is continuous, consistent, and effective. The learned, independent activity during exercises with the option of correction by a physiotherapist through an internet application contributes to the overall effect. Clients adhere to the established exercise program and perform exercises regularly. Upon discharge from hospitalisation in an inpatient rehabilitation ward, patients become more passive at home, rest more, and do not continue with exercises. Their achieved results through exercise diminish, leading to a slowing down of the recovery process. Regular exercising proves to be more significant than higher intensity within the same therapy.

The achieved results of the study are evaluated based on the monitored parameters of goniometry, anthropometry, and assessment of functional movement. These are standard components of the kinesiological analysis following musculoskeletal surgeries. A goniometer was used to measure the range of motion in the joint by the therapist. For clients in a home setting, a non-standard procedure was employed for measurements (Chart 1 and 2). We consider the measurements to be sufficient. For instance, Mehta et al. (2021) from Marshall University, West Virginia, USA, conducted research focused on the reliability of virtual assessment of musculoskeletal conditions during rehabilitation. Their study concentrated on the reliability of virtual measurements of knee and wrist joint range of motion (ROM). The movement of the patient's joint was recorded by the camera at a remote location, and the angle of joint movement was measured through the image using a standard goniometer for flexion and extension. The measured values were compared with those obtained by a physiotherapist directly assessing the patient. The research authors also compared the measurement accuracy between experienced physiotherapists and medical students. The study's results demonstrate that virtual measurement of joint range of motion can be considered equivalent to direct contact with the patient, and measurement accuracy depends on the experience of the physiotherapist. Their conclusions support the possibility of using virtual assessment of joint range of motion (ROM) as a reliable technique when performed by experienced physiotherapists.

During hip joint arthroplasty surgery, the approaches and operative techniques differ from procedures in other hospitals. Physicians have different options for primary hip joint replacement compared to joint reimplantation. This study focuses on patients with hip osteoarthritis indicated for the initial implantation of a hip joint. The hospital primarily performs hip arthroplasties using the anterior mini-invasive approach (MIS-AL). [The benefits of minimally invasive techniques are associated with shorter soft tissue repair time, resulting in accelerated recovery and faster return of the operated hip to full function (Kubeš et al., 2009)]. In Group C, 9 out of 46 participating clients underwent lateral approach surgeries, while in Group T it was only 2. Kubeš et al. (2009) agree there is no proof supporting the clear and time-unlimited advantage of the mini-invasive THA implantation over the standard surgery. Therefore, the difference in the approach to THA surgery is not relevant in the groups.

The 10-Meter Walk Test (10MWT) was chosen for evaluating hip joint functional movement. The testing is simple, and it is not a problem to conduct the test with the assistance of family members in a home environment while maintaining uniform conditions. All subjects performed the walking test over a distance of 10 meters with two forearm crutches, and the measured data represents the average of three attempts. The average norm for the test is a walking speed of 1.36 m/s without aids, which cannot be established as the norm in our study. However, the same conditions for walking were maintained for all subjects.

In a worldwide context, our study is not unique. The integration of robotically controlled exercise programmes into rehabilitation, the effort to monitor patients, and the use of devices with feedback on exercise effectiveness are part of the modern technologies available today. However, are these approaches and devices accessible to a larger group of patients? Is loaning such devices for home use beyond their financial means? The results of this study highlight a cost-effective, accessible, and feasible rehabilitation solution for patients after hip arthroplasty. Our findings are supported by corroborating studies.

In January 2022, an article by a team led by Samreen was published in the "*Journal of the Pakistan Medical Association*". It was a systematic review of clinical studies on the effectiveness of telerehabilitation compared to face-to-face rehabilitation for patients after total hip replacement. The study's conclusions were uniform. Telerehabilitation demonstrated similar improvements in activities of daily living compared to individuals undergoing standard face-to-face rehabilitation. Telerehabilitation emerges as an alternative to traditional face-to-face rehabilitation in home care settings (Samreen et al., 2022).

The study *"Telemedicine Technologies Selection for the Post-hospital Patient Care Process after Total Hip Arthroplasty"* by Kamecka et al. (2022) aimed to identify telemedicine technologies that could be used in future implementation projects for post-hospital care processes for patients who underwent total hip arthroplasty. The study found that post-hospital care for patients after hip arthroplasty could be conducted through telecommunication networks, internet services, phone calls, and visual messaging. Scientific reports and market surveys of technologies indicate that the telemedicine technology sector is dynamically growing and attracting high interest from state institutions, healthcare organisations, scientific researchers, technology manufacturers, and innovators. According to the authors, the technology market analysis revealed solutions in three telemedicine areas: teleconsultation, telerehabilitation, and telemonitoring. Certain technological barriers were identified, the absence of ethical and legal regulations, unknown insurance coverage methods, and also cultural challenges.

Among widely performed joint arthroplasty surgeries also ranks the knee joint replacement. Studies in the professional literature also explore the effectiveness of postoperative telerehabilitation in these patients. An article by Gazendam et al. (2022) published in the peer-reviewed scientific journal *"Knee Surg Sports Traumatol Arthrosc"* focuses on a systematic review

and meta-analysis of randomised controlled trials (RCTs) involving virtual reality-based rehabilitation after total knee arthroplasty (TKA). The objective of the systematic review was to compare the functional improvement outcomes of patients and analyse the costs of RCTs using virtual reality-based rehabilitation (VR). The authors conclude that VR-based rehabilitation in patients undergoing TKA represents an evolving field that may offer some patients advantages over traditional treatments.

In a study led by Bell et al. (2020), a remote monitoring platform for rehabilitation (interACTION) was used for patients after total knee arthroplasty. The aim was to assess the impact of the interactive system on patients' self-exercise at home. The authors of the study have compared postoperative outpatient rehabilitation supplemented with interACTION with a standard postoperative outpatient rehabilitation programme. In the interACTION group, a small decrease in the number of individual physiotherapy visits was observed, and there was no significant difference in the financial costs between the two groups.

Telerehabilitation is not limited to orthopaedic surgeries. Studies also highlight the possibilities of introducing new technologies into rehabilitation and promoting a more proactive approach to self-care, even for neurological conditions. The objective of a study led by Martínez de la Cal et al. (2021) was to explore the opinions of physiotherapists regarding the effectiveness and drawbacks of implementing a web-based telerehabilitation programme for the treatment of chronic low back pain. The results suggest that telerehabilitation is effective when patients actively engage in their own treatment. Physiotherapists who worked with patients suffering from chronic non-specific low back pain believe that new technologies can provide highly effective means to reach a larger number of patients and achieve significant cost savings in healthcare.

Wang and colleagues from China are conducting a study to support the implementation of mobile telerehabilitation applications for patients after total hip or knee joint arthroplasty. This study aims to explore the effectiveness of a telerehabilitation programme provided through the mobile application WeChat for patients after total hip or knee joint arthroplasty. It includes the theory of the effectiveness of self-care and increasing the efficiency of rehabilitation through mobile applications for total hip arthroplasty (THA) and total knee arthroplasty (TKA). The mobile app rehabilitation programme consists of physical exercises and techniques to enhance participants' self-care during rehabilitation. The application also hosts a discussion forum that involves all experiment participants, researchers, physicians, nurses, and physiotherapists. The results of the study have not been published as of the current date (Wang et al., 2022).

Conclusion

The implementation of telerehabilitation brings significant benefits for both providers and clients. In the Czech Republic, there is a persistent lack of studies on the possibilities of applying telerehabilitation in physiotherapy without the use of technologically expensive aids. Our study is unique in this regard. More work is needed to evaluate not only the effectiveness but also the cost-effectiveness of telerehabilitation compared to in-person rehabilitation. Physiotherapy is widely used in society, and it is extremely costly for health insurance companies. Significant obstacles to the implementation of telerehabilitation include budgetary limitations and reimbursement of costs, protection of personal data, inadequate understanding, and limited education of healthcare professionals about communication technologies.

Modern technologies and applications are essential for delivering telerehabilitation services. To promote awareness of the potential for remote care provision, there is a need to support simple, affordable, and secure technologies that can be utilised by both the clients and providers. The absence of regulations for technologies enabling remote communication with clients, inadequate security measures when handling medical data, and the sharing of clients' information with insurers hinder the progress of telerehabilitation. It is crucial to establish a unified, transparent, and accessible digital environment. Without a digitally secure environment, the successful implementation of modern technologies in healthcare is not attainable.

Telerehabilitation appears to be a feasible and effective strategy for providing remote rehabilitation services and ensuring continuity of care. It reduces the travel costs, accommodation expenses, and other costs associated with patient transportation to rehabilitation centres. Telerehabilitation enables physicians to provide healthcare recommendations to patients in remote or hard-to-access areas. It is helpful in the rehabilitative care of caregivers in social facilities. Instructional videos can also be used in group exercises in senior homes or other facilities with nursing services, where trained rehabilitation personnel may be lacking.

Funding
The establishment of the website (https://telerehabilitace.cz/) and the filming of the instructional film were financed within the framework of the Czech Technical University project GS17/205/OHK 4/3T/17 and SGS20/089/OHK4/1T/17.

Ethical aspects and conflict of interest
The authors have no conflict of interest to declare.

Účinnost telerehabilitace u pacientů po artroplastice kyčelního kloubu

Souhrn
Článek se zabývá porovnáním intenzivní rehabilitace s telerehabilitací prováděnou v domácím prostředí pomocí běžných počítačových komunikačních technologií. Pro zhodnocení efektu telerehabilitace byl natočen instruktážní film, podle kterého pacienti po operaci artroplastiky kyčelního kloubu cvičili samostatně ve svém sociálním prostředí. Celkem 92 pacientů, kteří podstoupili operaci artroplastiky kyčelního kloubu, bylo rozděleno na dvě skupiny. Skupina 1 (kontrolní) byla složená z klientů, kteří nastoupili na lůžkové oddělení zdravotnického zařízení k intenzivní čtrnáctidenní rehabilitaci. Skupina 2 (telerehabilitační) využila rehabilitaci v domácím prostředí a cvičila samostatně s možným dohledem fyzioterapeuta přes komunikační technologie.

Sledování probíhalo 6 týdnů, kdy vstupní vyšetření bylo provedeno v prvním týdnu po operaci, kontrolní ve 3 týdnech a výstupní po 6 týdnech od operace totální endoprotézy kyčelního kloubu. U obou skupin byly porovnány hodnoty rozsahu pohybu (ROM) v kyčelním kloubu a obvodové míry operované končetiny. Funkční vyšetření bylo doplněno chůzí a zhodnoceno dle 10 Meter Walk Test (10 MWT).

Výsledky studie poukazují na plnohodnotný terapeutický vliv telerehabilitace u pacientů po artroplastice kyčelního kloubu.

Klíčová slova: artroplastika kyčelního kloubu; telemedicína; telerehabilitace

References

1. Bell KM, Onyeukwu C, Smith CN, Oh A, Devito Dabbs A, Piva SR, et al. (2020). A Portable System for Remote Rehabilitation Following a Total Knee Replacement: A Pilot Randomized Controlled Clinical Study. Sensors 20(21): 6118. DOI: 10.3390/s20216118.
2. Brigo E, Rintala A, Kossi O, Verwaelst F, Vanhoof O, Feys P, Bonnechère B (2022). Using Telehealth to Guarantee the Continuity of Rehabilitation during the COVID-19 Pandemic: A Systematic Review. Int J Environ Res Public Health 19(16): 10325. DOI: 10.3390/ijerph191610325.
3. Čermáková H (2021). Telerehabilitace Kladruby: Hrazené telerehabilitace míří k prvním pojištěncům OZP. [Telerehabilitation Kladruby: Paid telerehabilitation is aimed at the first insured persons OZP]. [online] [cit. 2023-03-20]. Available from: https://www.artak.cz/wp-content/uploads/2022/01/OZP_BONUS_0121.pdf
4. Cottrell MA, Galea OA, O'Leary SP, Hill AJ, Russell TG (2017). Real-time telerehabilitation for the treatment of musculoskeletal conditions is effective and comparable to standard practice: A systematic review and meta-analysis. Clin Rehabil 31(5): 625–638. DOI: 10.1177/0269215516645148.
5. Dubanská B (2022). Legal aspects of telemedicine and telerehabilitation - legal regulation in practice. Third Czech teleneurorehabilitation conference, Spa Belohrad, 3. 11. 2022.
6. Gazendam A, Zhu M, Chang Y, Phillips S, Bhandari M (2022). Virtual reality rehabilitation following total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. Knee Surg Sports Traumatol Arthrosc 30(8): 2548–2555. DOI:10.1007/s00167-022-06910-x.
7. Gerhardt JJ, Rondinelli RD (2001). Goniometric techniques for range of motion assessment. Phys Med Rehabil Clin N Am 12(3): 507–527. DOI: 10.1016/S1047-9651(18)30047-0.
8. Jansson MM, Rantala A, Miettuen J, Puhto A-P, Pikkarainen M (2022). The effects and safety of telerehabilitation in patients with lower-limb joint replacement: A systematic review and narrative synthesis. J Telemed Telecare 28(2): 96–114. DOI: 10.1177/1357633X20917868.
9. Kamecka K, Foti C, Gawiński Ł, Matejun M, Rybarczyk-Szwajkowska A, Kiljański M, et al. (2022). Telemedicine Technologies Selection for the Posthospital Patient Care Process after Total Hip Arthroplasty. Int J Environ Res Public Health 19(18): 11521. DOI:10.3390/ijerph191811521.
10. Knapp PW, Keller RA, Mabee KA, Pillai R, Frisch NB (2021). Quantifying Patient Engagement in Total Joint Arthroplasty Using Digital Application-Based Technology. J Arthroplasty 36(9): 3108–3117. DOI: 10.1016/j.arth.2021.04.022.
11. Kolář P, et al. (2009). Rehabilitace v klinické praxi [Rehabilitation in clinical practice]. Praha: Galén, 713 p.
12. Kopsa Těšinová J, Dobiášová K (2022). The challenges of telemedicine in the Czech Republic from the Cas Lek Cesk 161(6): 247–254.
13. Kubeš J, Landor I, Podskubka A, Majernícek M (2009). Total hip arthroplasty from the MIS-AL approach - comparison with the standard anterolateral approach. Acta Chir Orthop Traumatol Czech 76(4): 288–294.
14. Martínez De La Cal J, Fernández-Sánchez M, Matarán-Peñarrocha GA, Hurley DA, Castro-Sánchez AM, Lara-Palomo IC (2021). Physical Therapists' Opinion of E-Health Treatment of Chronic Low Back Pain. Int J Environ Res Public Health 18(4): 1889. DOI: 10.3390/ijerph18041889.
15. Mehta SP, Kendall KM, Reasor CM (2021). Virtual assessments of knee and wrist joint range motion have comparable reliability with face-to-face assessments. Musculoskelet Care 19(2): 207–215. DOI: 10.1002/msc.1525.
16. Novotná K, Lízrová Preiningerová J (2013). Poruchy chůze u pacientů s roztroušenou sklerózou [Gain impairtment in multiple sclerosis patient]. Neurol Praxi 14(4): 185–187.
17. Pětioký J, Hoidekrová K, Grünerová Lippertová M (2022). Digitisation and telehealth – Telemedicine in rehabilitation in the Czech environment. Vnitr Lek 68(3): 166–171. DOI: 10.36290/vnl.2022.033.
18. Pětioký J, Hoidekrová K, Trtilková M (2021). Telerehabilitation: current development in the Czech Republic. Letters of Clinical Speech Therapy 5(2): 44–49. DOI: 10.36833/lkl.2021.030.
19. Samreen S, Ahmad A, Ahmed A, Khan I, Asim HM, Aziz A (2022). Role of tele-rehabilitation in patients following total hip replacement: systematic review of clinical trials. J Pak Med Assoc 72(1): 101–107. DOI: 10.47391/JPMA.832.
20. Wang Q, Hunter S, Lee RL, Wang X, Chan SW (2022). Mobile rehabilitation support versus usual care in patients after total hip or knee arthroplasty: study protocol for a randomised controlled trial. Trials 23(1): 553. DOI: 10.1186/s13063-022-06269-x.
21. Washington State Department of Health (2018). Telepractice guidelines [online]. Tumwater, Washington: Washington State Department of Health. [online] [cit. 2021-09-28]. Available from: https://www.doh.wa.gov/Portals/1/Documents/2300/2018/TelepracticeGuidelines.pdf