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ORIGINAL ARTICLE

TELEMETRY IN PHYSIOTHERAPEUTIC SUPERVISION OF PATIENTS WITH MUSCULOSKELETAL DISORDERS

TELEMETRIA W NADZORZE FIZJOTERAPEUTYCZNYM CHORYCH ZE SCHORZENIAMI NARZĄDU RUCHU

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ABSTRACT

Introduction

In recent years, there has been an intensive development of telerehabilitation as a special form of contact between the patient and the physiotherapist. As a result, publications on this issue appeared in the literature

Aim

Presenting up-to-date information on some clinical and economic aspects of telerehabilitation in relation to traditional rehabilitation of patients.

Methods

The research was conducted using PubMed datasets. The search period was limited to the years 2012–2022. Keywords telerehabilitation, physiotherapy, telemetry, costs, original papers, review papers, meta-analysis, dysfunctions, injuries, hip joint, knee joint were used. Less than 300 results were obtained, i.e. papers published in those years. Only original, review and meta-analyses were analysed, which resulted in limiting the number of researched publications to 15.

Results

Analysis of works shows that telerehabilitation is as effective as classical rehabilitation. This effectiveness mainly concerns the reduction of pain and physical performance. The use of the PEDro and AMSTAR scales made it possible to determine the quality and credibility of the papers included in the article.

Conclusions

The analysis of publications on telerehabilitation in the case of injuries and diseases of the hip and knee joints suggests that this form of therapy can be effective and bring benefits to patients. Telerehabilitation can also be less expensive compared to traditional rehabilitation. However, further research are needed to get a fuller picture of the effectiveness and benefits of telerehabilitation.

Keywords: telemetry, telerehabilitation, rehabilitation

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STRESZCZENIE

Wstęp

W ostatnich latach następuje intensywny rozwój telerehabilitacji jako szczególnej formy kontaktu pacjenta z fizjoterapeutą. Efektem tego były publikacje na ten temat w literaturze.

Cel

Przedstawienie aktualnych informacji na temat wybranych aspektów klinicznych i ekonomicznych telerehabilitacji w odniesieniu do tradycyjnej rehabilitacji pacjentów.

Metody

Badania przeprowadzono z wykorzystaniem zbiorów danych PubMed. Okres poszukiwań ograniczono do lat 2012–2022. Zastosowano słowa kluczowe telerehabilitacja, fizjoterapia, telemetria, koszty, prace oryginalne, prace poglądowe, metaanaliza, dysfunkcje, urazy, staw biodrowy, staw kolanowy. Uzyskano niecałe 300 wyników, czyli prac opublikowanych w tych latach. Analizie poddano wyłącznie prace oryginalne, przeglądowe i metaanalizy, co skutkowało ograniczeniem liczby badanych publikacji do 15.

Wyniki

Analiza prac wskazuje, że telerehabilitacja jest równie skuteczna jak rehabilitacja klasyczna. Skuteczność ta dotyczy przede wszystkim zmniejszenia bólu i wydolności fizycznej. Zastosowanie skal PEDro i AMSTAR umożliwiło określenie jakości i wiarygodności prac zawartych w artykule.

Wnioski

Analiza publikacji na temat telerehabilitacji w przypadku urazów i chorób stawów biodrowych i kolanowych sugeruje, że ta forma terapii może być skuteczna i przynosić korzyści pacjentom. Telerehabilitacja może być także tańsza w porównaniu z tradycyjną rehabilitacją. Konieczne są jednak dalsze badania, aby uzyskać pełniejszy obraz skuteczności i korzyści płynących z telerehabilitacji.

Słowa kluczowe: telemetria, telerehabilitacja, rehabilitacja

Introduction

The dynamic development of computer science at the beginning of the 21stcentury is referred to by many authors as the next technical revolution (Frueh *et al.* 2017). This fact is also observed in medicine and has been referred to as telemedicine (Teoli *et al.* 2022). It can be assumed that telemedicine is a form of remote communication between a patient and a specialist in a given field of medicine. The main advantages of this "remote communication" include the possibility of increasing the number of patients under the care of a given specialist and accelerating the exchange of information on the patient's health between several centers providing comprehensive medical care to the patient (Teoli *et al.* 2022). The above-mentioned features of telemedicine allow for a significant increase in access to specialist medical services for patients. This also applies to physiotherapeutic services, which, due to the number of functional problems under the supervision of physiotherapists and resulting from the number of services provided by them (Seron *et al.* 2021), seems to bode well in the near future in terms of the quality of physiotherapeutic care (Seron *et al.* 2021). In short, the development of communication technologies increases the

availability of physiotherapy. Taking into account the places where services are provided by physiotherapists, mainly larger cities (Tsvyakh *et al.* 2017), telemedicine in terms of physiotherapy has the potential to reduce the distance between the patient and the therapist.

In addition, due to the need to maintain the continuity of physiotherapy services in many clinical situations, it enables constant, supervised and smoothly controlled interaction between the patient and the physiotherapy specialist (Seron *et al.* 2021, Tsvyakh *et al.* 2017, Xie *et al.* 2021). Telemedicine in terms of physiotherapy is also the possibility of selective assessment of restored functions without exposing the patient to time-consuming and cost-intensive commuting to a physiotherapist. The previously mentioned "technical revolution" is not only image and verbal communication at a distance, but also the possibility of registering and measuring movement through the use of technically advanced and miniaturized cameras and motion sensors. Examples of such solutions already described in the literature are devices such as Kinect (it is a motion controller connected to a computer or console), cameras embedded in devices (televisions, computers, smartphones), sensors mounted on limbs, or phone applications (Azma *et al.* 2018, Wang *et al.* 2019, Kloek *et al.* 2018, PruvBettger *et al.* 2020, Tousignant *et al.* 2015, Huang *et al.* 2020). In the analysis of the benefits of telemedicine in the described area, it is also worth signaling the possibility of creating the desired environment in which the implementation of physiotherapeutic tasks takes on a completely different qualitative dimension (Berton *et al.* 2020, Piqueras *et al.* 2013). Thanks to appropriate software, gamification allows not only forcing specific movements in a patient with motor function deficits, but also, thanks to emotional stimulation, increases the patient's active participation in the rehabilitation process, (Berton *et al.* 2020, Pastora-Bernal *et al.* 2017). Virtual reality may be a good example here. It is used to stimulate the patient to re-educate their self-service activities (Berton *et al.* 2020, Piqueras *et al.* 2013). Augmented, virtual reality allows you to introduce fictitious elements into the existing environment that force the person using it to behave or perform certain activities.

It is also worth paying attention to the relatively low costs of therapy, mentioned in publications (Tsvyakh *et al.* 2017, Berton *et al.* 2020, Hinman *et al.* 2020, PruvBettger *et al.* 2020, Nelson *et al.* 2021), compared to the existing form of patient-specialist contact.

Aims

The aim of the study is to present the characteristics of selected papers fulfilling criteria described during the database analysis of the use of telerehabilitation with a focus on patients requiring rehabilitation treatment due to injuries or diseases of the joints of the lower limbs.

Methods

The research method was the analysis of publications available in the PubMed database. Publications from 2012 to 2022 were analyzed. Telerehabilitation, physiotherapy, telemetry, costs, original papers, review papers, meta-analysis, dysfunctions, injuries, hip joint, knee joint were used as keywords. Less than 300 works were found which, after applying the search criteria, allowed to select only 15 works related to the keywords used. Selected papers were subsequently analyzed in the PEDro and AMSTAR scales. (Pastora-Bernal *et al.* 2017).

Research articles, reviews and meta-analyses concerning both diseases and injuries of the knee and hip joints were analyzed, in which any contribution of telerehabilitation technology was assessed, the costs of classic rehabilitation and telerehabilitation were compared, and their effectiveness was compared. Telerehabilitation was defined as rehabilitation through any technology enabling the rehabilitation of a patient without direct control by a physiotherapist, using

telecommunication technologies, specialized devices mounted on the lower limbs, the Internet and virtual reality devices. The main categories to which special attention was paid were the effectiveness of a given method in restoring function and function in patients and the assessment of pain before, during and after therapy. Additional categories to which attention was paid were the comparison of the costs of classic rehabilitation and telerehabilitation, the patient's quality of life, the patient's participation in the study and his self-assessment. A total of 15 papers were analyzed, in which 9581 people were surveyed. Articles were checked using the PEDro (11 articles) and AMSTAR (4 articles) scales, and the results of these works were checked by placing them in Table 1, allowing for quick and transparent data checking.

The PEDro scale is based on the Delphi list and is used to help quickly identify which randomized clinical trials or studies likely to be randomized clinical trials (i.e., RCTs or CCTs) and likely to contain information likely to be valid may also contain statistical information sufficient to the results of these works could be interpreted using this scale. This scale consists of 11 criteria evaluating the components of the works.

The AMSTAR scale determines the quality of reviews and has four possible responses: Yes, No, Not Applicable and Unanswerable. Scores greater than 9 "Yes" indicate a high-quality review, scores greater than 5 indicate moderate quality, and scores below 5 indicate low-quality responses.

Results

Qualified papers were analyzed and all relevant data for this study are presented in tables 1–3. They contain the following information: characteristics of the works, their results, qualitative assessments using the PEDro (Table 2) and AMSTAR (Table 3) scales. The results of the work are discussed in the discussion and conclusions section. The analysis of selected works shows that telerehabilitation is as effective as classical rehabilitation, both in the short and long termevaluation. This effectiveness mainly concerns the possibilities of reducing the intensity of pain and improving physical fitness. Detailed data are presented in Table 1.

The use of the PEDro scale in relation to selected original works (N = 11) shows that these studies because of using blinding of participants were of medium to good methodological quality. Detailed data are presented in table 2. Possible answers are y(yes), n(not). Scores > 6 are of good quality, and scores < 6 are of medium methodological quality.

The analysis of selected review papers (N = 4) using the AMSTAR scale allows us to conclude that they are reliable and the conclusions drawn from them have an acceptable research value. Details are provided in Table 3.

Discussion

The development of computer science at the beginning of the 21st century contributed to the emergence of telemedicine, which enables remote communication between a patient and a medical specialist. The aim of this study was to present (based on the literature analysis) the current level of knowledge about telerehabilitation in relation to traditional rehabilitation in people after hip and knee arthroplasty, and in osteoarthritis of these joints (Xie *et al.* 2021, Berton *et al.* 2020, PruvBettger *et al.* 2020, Oritz-Piña *et al.* 2021). All papers cited in this review are of medium to good quality as assessed by the PEDro and AMSTAR scales, which proves their acceptable credibility (see Tables 2 and 3). The analysis indicated that the authors in their research focused primarily on such aspects of the use of remote methods of diagnosis and therapy, such as: VR, AR, gamification, telephone applications, telephone calls, videoconferences, computer simulations and sensor devices (see Table. 1). Comparing the results obtained by the authors, it is worth noting that the tools and methods used by them turned out to be as effective in combating pain, improving physical fitness and

Table 1. Characteristics of the studiesincluded of the research.

Country, author and year	No. of patient	Study design	Remote virtual rehabilitation technology	Tracking (how long)	Study result
1. Su-Hang Xie *et al.* 2021 China [5]	791	Meta-analysis	Internet (videos, graphic demonstrations of knowledge, video conversations with doctors or physiotherapists)	A review of articles from 20 years	Telerehabilitation effectively relieved pain in knee osteoarthritis as assessed on the basis of the WOMAC pain subscale (SMD −0.21, 95% CI −0.4 to −0.01, p = 0.04) but did not increase the patients' physical fitness compared to the control group as assessed under the WOMAC function rock (SMD −0.08, 95% CI −0.27 to 0.12, p = 0.43).
2. Nelson M. *et al.* 06. 2019 Australia [6]	70	Randomized controlled clinical trial	Application (eHABandWellpepper)	6 weeks after the surgery	Telerehabilitation was comparable to classic rehabilitation, all HOOS, SF −12 and EQ-5D subscales showed no differences between the groups. The same was true for the TUG test, step test, and muscle strength.
3. Berton A. *et al.* 2020 Italy [7]	2284 (in 25 papers)	Review/Meta-analysis	Remote virtual rehabilitation (VR, AR, gamification, telerehabilitation)	Review of papers from 2015–2020	The effects of telerehabilitation were comparable, patients had higher self-esteem and, despite initial difficulties with the use of new technologies, reported an increase in the level of physical fitness. Costs fell mainly due to lower travel costs.
4. Pastora-Bernal JM *et al.* 2017 Spain [8]	1316	Review/Meta-analysis	Video conferencing, telephone counselling, video games, asynchronous exercise videos and interactive virtual systems	Review of papers from 2000–2016	The article confirms the effectiveness of telerehabilitation of the lower limb after total arthroplasty.
5. Azma K. *et al.* 2017 Iran [9]	54	Randomized controlled clinical trial	Information booklet and telephone control	6 months after the completed treatment	Effectiveness of telerehabilitation was comparable to classical rehabilitation when WOMAC, KOOS scales were used. They were statistically significant, but the difference between them was not significant and amounted to p = 0.860 and 0.619, respectively. The decrease in VAS scores was statistically significant, but there was no significant difference between the two groups (p = 0.859).
6. Wang X. *et al.* 2019 Australia and Brazil [10]	2971 (in 21 papers)	Meta-analysis	All medical services provided using telecommunication technologies, the Internet, VR technology and software	Overview of all papers up to Nov 7, 2018	Efficacy in pain relief was demonstrated (VAS scores for the control group [MD: −0.25; 95% CI: −0.48; −0.02] and for the telerehabilitation group [MD: −0.19; 95% CI: −0.36; −0.03]) and increasing physical fitness as measured by the 6-minute walk test (no significant difference between the groups was observed [MD: 29.36; 95% CI: −6.99, 65.71]) and the get up and go test (Significant improvement for the telerehabilitation group [MD: −7.03; 95% CI: −11.18, −2.88]).
7. Kloek CJJ, *et al.* 2018 The Netherlands [11]	208	Randomized controlled clinical trial	Application (e-Exercise)	12 months	The effects of telerehabilitation and the control group were comparable and no statistical differences were observed between the two groups after 3 and after 12 months.
8. Hinman RS, *et al.* 2020 Australia [12]	175 (but 158 completed)	Randomized controlled clinical trial	Telephone advice, training videos, information booklet	12 months	After 12 months, there was no significant difference between telerehabilitation and classic rehabilitation. The only differences in this study were increased physical activity (17.9%, 95% CI 4.3% to 31.4%), pain during activities of daily living (1.2 units (95% CI 0, 2 to 2.1), walking pain (1.0, 0.1 to 1.8), pain management (−1.2, −1.8 to –0.6). Total cost $514 none evidence of cost savings.
9. Prvu Bettger J. *et al.* 2020 USA [13]	306 (but 287 completed)	Randomized controlled clinical trial	Digital simulation, 3D biometrics at home and telerehabilitation with a remote clinician under the supervision of a physiotherapist	12 weeks	Virtual rehabilitation was comparable to traditional rehabilitation in terms of KOOS at 6 weeks (difference, 0.77; 90% confidence interval [CI], −1.68 to 3.23) and 12 weeks (difference, −2.33; 90% CI, −4.98 to 0.31), pain severity, knee range of motion, gait speed, and rehospitalizations, while costs decreased significantly (median, $1.050 for virtual rehab versus $2.805 for traditional rehab) falls were recorded in 19.4% of virtual rehabilitation patients and 14.6% of traditional rehabilitation patients.
10. Tsvyakh AI. *et al.* 12.2017 Ukraine [4]	74	Randomized controlled clinical trial	Application on the phone attached to the limb	3 months	The effects of telerehabilitation were comparable, patients' satisfaction with telerehabilitation was high. The costs as well as the time needed to consult a patient with a specialist have decreased.
11. Tousignant M. *et al.* 2015 Canada [14]	197	Randomized controlled clinical trial	Video conference	8 weeks	In urban and rural areas, telerehabilitation therapies were less expensive than home therapies when the round-trip distance was 50 km or more (Can$97 <$144, P < 0.001). In metropolitan areas, telerehabilitation therapies were less expensive than in-home therapies when the round-trip distance was 30 km or more (Montreal, Can $80 < $152, P < 0.001; Quebec City, $82 < $108, P = 0.001).
12. Piqueras M *et al.* 2013 Spain [15]	142	Randomized controlled clinical trial	Interactive virtual rehabilitation system	3 months	Virtual rehabilitation was comparable to the control group with traditional rehabilitation. The range of flexion and extension were comparable in both groups, quadriceps muscle strength was greater after 3 months in the group with virtual rehabilitation (p = 0.018), in the get up and go test the control group gained greater growth (p = 0.008), hamstring muscle strength and the VAS and WOMAC scales were comparable in both groups.
13 Ortiz-Piña M. *et al.* 2021 Spain, The Netherlands, Canada [16]	133 (in 2 papers)	Non-Randomized controlled clinical trial	Instructional videos and written instructions	12 weeks	Telerehabilitation achieved better results than traditional rehabilitation in such tests as FIM (measure of functional independence) where the result of this test increased more in the telerehabilitation group (1.06 Cohen's d; p < 0.001), and physical functions TUG (get up and go test) where the group telerehabilitation group had a greater decrease in performance time compared to the control group (0.95 Cohen's d; p = 0.001); 0.067).
14. Huang YP. *et al.* 2020 Taiwan [17]	35	Randomized controlled clinical trial	Sensor devices, Cybex, phone app	from June 2015 to May 2016	The device is effective in monitoring ranges and was compared with the Cybex device and its mean absolute error ranges were 1.65˚, 2.74˚ and 3.27˚ at three different angular velocities of patient movement, which significantly affects the effects of therapy and its costs.
15. Nelson M. *et al.* 09.2019 Australia [18]	70	Randomized controlled clinical trial	Application (eHAB)	6 weeks	Telerehabilitation gives comparable effects as traditional rehabilitation, but its costs are lower on average by USD 28.90 (USD 516.12 in the control group and USD 487.22 in the telerehabilitation group) and saves the time of the therapist and the patient by an average of 4.21 hours.

Table 2. PEDro scale assessment.

Quality feature	2. Nelson M. *et al.* [6]	5. Azma K. *et al.* [9]	7. Kloek CJJ. *et al.* [11]	8. Hinman RS. *et al.* [12]	9. Prvu Bettger J. *et al.* [13]	10. Tsvyakh AI. *et al.* [4]	11. Tousignant M. *et al.* [14]	12. Piqueras M. *et al.* [15]	13. Ortiz-Piña M. *et al.* [16]	14. Huang YP. *et al.* [17]	15. Nelson M. *et al.* [18]
Qualification criteria	y	y	y	y	y	y	y	y	y	y	y
Randomization	y	y	y	y	y	n	y	y	n	n	y
Blinded randomization	n	n	n	n	n	n	y	n	n	n	n
Comparable groups	y	y	y	y	y	n	y	y	y	y	y
Subject blinding	n	n	n	y	n	n	n	n	n	n	n
Therapist blinding	n	n	n	n	n	n	n	n	n	n	n
Blinding of evaluator	y	n	n	y	n	n	y	y	y	n	y
Appropriate tracking	y	n	n	n	y	y	y	n	y	y	y
Analysis whether patients were treated as intended	y	y	y	y	y	y	y	n	y	y	y
Statistical comparisons	y	y	y	y	y	y	y	y	y	y	y
Scoring and variability evaluation	y	y	y	y	y	y	y	y	y	y	y
Total score	7	5	5	7	6	4	8	5	6	5	7
Quality assessment	Good	Average	Average	Good	Average	Average	Good	Average	Average	Average	Good

Legend to the Table 2.
Y – Criterion met
N – Criterion not me

Table 3. AMSTAR scale assessment.

AMSTAR control list	1. Su-Hang Xie *et al.*[5]	3. Berton A. *et al.*[7]	4. Pastora-Bernal JM *et al.*[8]	6. Wang X. *et al.*[10]
1. Was an „a priori" design ensured?	yes	yes	yes	yes
2. Were the study selection and data extraction repeated?	no answer	yes	yes	no answer
3. Was a comprehensive literature search conducted?	yes	yes	yes	yes
4. Was publication status (i.e., gray literature) used as an inclusion criterion?	yes	yes	yes	yes
5. Is a list of studies (included and excluded) provided?	Included – yes Excluded – no	Included –yes Excluded-no	yes	Included – yes Excluded – no
6. Are the characteristics of the included studies provided?	yes	yes	yes	yes
7. Has the scientific quality of included studies been assessed and documented?	yes	yes	yes	yes
8. Was the scientific quality of the included studies appropriately used in drawing conclusions?	yes	yes	yes	yes
9. Were methods used to combine the study results appropriate?	yes	yes	yes	yes
10. Has the likelihood of publication bias been assessed?	no	no	no	yes
11. Has the conflict of interest been considered?	yes	yes	yes	yes

Source:own data, based on https://amstar.ca/

increasing the range of motion in the joints as the methods commonly used so far (Xie *et al.* 2021, Nelson *et al.* 2020, Berton *et al.* 2020, Azma *et al.* 2018, Wang *et al.* 2019, Kloek *et al.* 2018, Oritz-Piña *et al.* 2021). Therefore, in the enumerated areas of assessment, it cannot be said that telemedicine methods offer more than classical methods.

However, if we pay attention to the costs of standard diagnosis and therapy, i.e., those taking place in direct cognition, it turns out that telemedicine offers lower costs, a higher level of self-esteem in patients and a very significant increase in the sense of agency in relation to the therapy conducted. (Berton *et al.* 2020, Hinman *et al.* 2020, PruvBettger *et al.* 2020, Nelson *et al.* 2021).

It is worth paying special attention to the fact observed in publications on telemedicine that the costs of telerehabilitation are lower the greater the distance between the patient and the therapist. The factor differentiating urban and rural areas in this aspect is the distance of 30 km in urban areas and 50 km in rural areas (Tsvyakh *et al.* 2017).

Focusing on the costs of telemedicine, it should be emphasized after Janet PrvuBettger and Michel Tousignant that they are mainly generated by the need to purchase appropriate equipment to participate in remote therapy and the need to master the skills of using this equipment or applications.(Tsvyakh *et al.* 2017, PruvBettger *et al.* 2020).

On the other hand, pain and the possibility of its abolition or mitigation with the use of telemedicine methods was also described in works in this diagnostic and therapeutic field. It turns out that pain therapy controlled with WOMAC and VAS scales is as effective in this case as in classic rehabilitation, which translates into comparable coping with everyday activities.(Xie *et al.* 2021, Azma *et al.* 2018, Wang *et al.* 2019, Piqueras *et al.* 2013). Thus, the efficiency of the subjects can be seen that they achieve a comparable or greater level in the telerehabilitation group.

(Xie *et al.* 2021, Nelson *et al.* 2020, Berton *et al.* 2020, Hinman *et al.* 2020, Piqueras *et al.* 2013, Oritz-Piña *et al.* 2021).

To sum up – telerehabilitation has recently been given a lot of attention, providing valuable knowledge about the principles of its use and the effects it brings. When analyzing publications in this field, it is worth noting that they included large groups of patients, which increases the credibility of the results obtained. As with any new form of therapy, the authors' interests were diverse and covered many aspects requiring further analysis. Future research should continue to test the effectiveness, usefulness and cost of telerehabilitation in the treatment of various medical cases.

Conclusions

Telerehabilitation is in many cases as effective as traditional rehabilitation in patients after total knee and hip arthroplasty and in the treatment of knee and hip osteoarthritis. Some sources clearly define it as a good alternative to classic rehabilitation for patients. Supporting the assumptions of the work with the results of range of motion tests, physical fitness tests, the get up and go test, self-esteem surveys, and pain perception by patients, which in many cases was comparable or less felt in the group of patients after telerehabilitation.

Telerehabilitation can complement or – if necessary – replace classic rehabilitation on many levels, which is undoubtedly supported by the constant development of technology. Remote rehabilitation is also cheaper and more efficient than classic physiotherapy, which can shorten the time that patients have to wait for therapy.

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