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Randomized controlled trial of multidisciplinary rehabilitation therapy using mobile applications in cases of ankle fractures

Petya Kasnakova (1), Anna Mihaylova (1), Boris Djurdjev (2), Biyanka Tornyova (3)

(1) Medical College, Medical University of Plovdiv, Bulgaria; (2) Department of Physical and Rehabilitation Medicine, Faculty of Medicine, Medical University of Plovdiv, Bulgaria; (3) Department of Health Care Management, Faculty of Public Health, Medical University of Plovdiv, Bulgaria.

Abstract

A multidisciplinary approach to rehabilitation in patients with ankle fractures is needed to return to their daily activities. Mobile health applications can improve or optimize the rehabilitation process. The purpose of this study is to monitor the efficiency of a modified and validated rehabilitation scheme for the functional rehabilitation of the lower limbs. The subjects of the study are patients in the post-immobilization and post-operative period. The algorithm of procedures administered to the patients were performed by physiotherapists and monitored via mobile apps. The results show a reduction of the swelling and the pain, overcoming the muscular imbalance, enhanced stabilization, correct way of walking, and an improved quality of life of the patients with ankle fractures. Despite a certain trend towards residual deficit, the implementation of kinesitherapeutic means creates the necessary background on the basis of which specialized methods can be applied – joint-mobilizing techniques and passive stretching, for the purpose of the full recovery of the functions of the lower extremity. The application of mobile apps optimizes the recovery process and increases access to rehabilitation.

Key Words: Ankle fractures; multidisciplinary rehabilitation; physical therapy; telerehabilitation.

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The ankle is the most overloaded hinge joint with a joint surface of 6 sq.cm. and one of the joints suffering the most injuries. The Maisonneuve fracture is a spiral fracture of the proximal third of the fibula associated with a tear of the distal tibiofibular syndesmosis and the interosseous membrane.[1] According Goost H.[2] ankle fractures are initially evaluated by physical examination and then by x-ray. They can be classified according to either the AO Foundation (Association for the Study of Internal Fixation) or the Weber classification. Dislocated fractures need emergency treatment with immediate reduction; this is crucial for the prevention of hypoperfusion and nerve damage. Weber A fractures can usually be treated conservatively, while Weber B and C fractures are usually treated with surgery. An evaluation of the stability of the syndesmosis is important for anatomical reconstruction of the joint.[2] Ankle fractures often affect people in their active years and it reflects on their physical and social status. The ankle joint bears a great weight and is also the structural morphological unit that plays an active part in maintaining the static-dynamic balance of the body. Ankle fractures can be classified as single malleolar, bimalleolar, and trimalleolar if the posterior part of the tibial plafond is involved. Careful attention must be paid to all single malleolar fractures because ligament instability is frequently associated with the contralateral side. Ankle fractures are common, with an incidence of up to 174 cases per 100 000 adults per year. Their correct classification and treatment are of decisive importance for clinical outcome.[2] In a study of Kannus et al about prediction of the number and incidence of low-trauma ankle fractures in Finnish persons ≥60 years of age rose substantially: the total number of fractures increased from 369 in 1970 to 1545 in 2000, a 319% increase, and the crude incidence increased from 57 to 150, a 163% increase. The age-adjusted incidence of these fractures also rose in both women (from 66 in 1970 to 174 in 2000, a 164% increase) and men (from 38 in 1970 to 114 in 2000, a 200% increase). The regression model indicates that, if this trend continues,

there will be about three times more low-trauma ankle fractures in Finland in the year 2030 than there was in 2000.[3] In children ankle fractures occur in about 1 per 1000 per year.[4,5] Ankle fractures have a bimodal age distribution with peaks in younger males and older females.[6] There has been three-fold increase in the incidence amongst elderly females over the past three decades.[7] In addition, amongst multiply injured patients foot injuries are prognostically important: those who survive their injuries are far more impaired functionally if they have a foot injury in addition to multisystem trauma.[8,9] Ankle fractures result in significant morbidity in adults, with prognosis worsening with increasing age.[10] They usually result from indirect traumas. In recent years, surgical treatment has been increasingly applied in ankle fractures. The research of the Swiss group on osteosynthesis and the works of Weber have contributed to this. The Danis-Weber classification for ankle fractures is simple and is the most useful for primary care management. This classification scheme is based on the level of the fracture in relationship to the joint mortise of the distal fibula.[11,12] Calcaneal fractures are complex injuries that historically had a poor prognosis, resulting in substantial disability.[13]

Multidisciplinary rehabilitation therapy is one of the main parts in the recover process in cases of fractures of the shank bones. Due to the accompanying muscular atrophy of the quadriceps of the thigh, the process of rehabilitation has to commence as early as possible. During the early postoperative period (3-7 days), mild exercises, segmental massage of the lower limb, and physiotherapeutic procedures can be performed. In the late postoperative period (24-30 days), is recommended balance and coordination exercises, muscle-strengthening exercises, cycle ergometer, and hydrotherapy. There is a wide range of kinesitherapeutic techniques that can be performed during this stage.

The physiotherapeutic interventions are the key elements of the multidisciplinary management of musculoskeletal conditions and diseases. The application of preformed physical factors is mandatory in disorders and diseases of the locomotor system. The means to choose from in this type of fracture include: electrical muscle stimulation with low-frequency current or medium frequency current. Transcutaneous electrical stimulation of low- and medium-frequency currents is commonly used in pain management. Interferential current (IFC) therapy, a medium frequency alternating current therapy that reportedly reduces skin impedance, can reach deeper tissues.[14]

The mechanism of impact of the various physical factors (electrical therapy, ultra sound, radiation, mineral water, mechanical influence, etc.) is complex and complicated. A significant clinical effect can be expected only when the effect of these factors is well known and used competently and expertly.

The rehabilitation therapy of ankle fractures is complex: physical therapy interventions, electrical therapy, cryotherapy, cryomassage, medicinal massage, drainage massage and selective massage, kinesitherapy and mechanical therapy, depending on the stage and the functional deficiencies The prompt and purposeful administration of the means and methods of kinesitherapy is of vital importance for the recuperation of patients who have suffered a trauma of the ankle joint.

The aim of this study is to follow up on the restoration of the locomotion in lower extremities among patients with ankle fractures.

Materials and Methods

In this survey, carried out in the period 2019-2020 in the Physical & Rehabilitation Medicine Departments of Multi-profile Hospital for Active Treatment and three other Medical Centers, included 57 people (n=57 subjects) with fractures of the ankle joint. The subjects referred to above gave their written consent to participate in the survey, and signed a Helsinki declaration of informed consent. They were offered a modified rehabilitation therapy program in university facilities, consisting of a rehabilitation therapy plan including kinesitherapy, massage, and physical therapy during the practical training of the students. The subjects were distributed as follows: 55.56% were treated as outpatients, and 44.44% - as inpatients, that is, in hospital conditions. The surveyed subjects were admitted in the departments of physical and rehabilitation medicine, with medical referrals from their GPs. The complex physical rehabilitation program was funded by the National Health Insurance Fund (NHIF). All subjects completed the proposed modified rehabilitation treatment program. The study was conducted in accordance with the principles of scientific ethics and all participants signed an informed consent to participate in research as an integral part of the documentation for admission of patients to a medical institution.

Design of the study

A randomized controlled trial of 57 people with ankle fracture was conducted. The subjects were randomly included in the target group, based on the order in which they were admitted to the departments of physical and rehabilitation medicine. The target group were administered an algorithm of kinesitherapy including relaxing massage, analytical exercises aimed at increasing the muscle strength of the weakened muscles, exercises aimed at practicing the right gait and walking; balance and coordination exercises; specialized kinesitherapeutic methods; joint-mobilizing techniques and passive stretching, within a period of ten days, in accordance with the concept of the classical physiotherapeutic interventions.

The subjects from the target group were monitored prior to and immediately after the completion of the 10-day course of physical rehabilitation therapy**.** The schedule

according to which the physical rehabilitation program was implemented was individual; in the event that a subject missed a physical rehabilitation intervention, they had it later, so the entire 10-day treatment course was accomplished.

Organization of the survey

This survey was a multi-centre, randomized one. As to the technical implementation of the survey, the chief investigator played important role, as they personally controlled each stage of the procedures and tracked the all recovery of individual cases. The rehabilitation interventions administered to the patients were performed by physiotherapists. Due to the lack of validated and implemented specialized rehabilitation applications, we used the Superdock application to make the appointment for the rehabilitation session and the Viber application for tracking for the correct implementation of the exercises via video conection. In Bulgaria, telerehabilitation is still not working and therefore we used the available free opportunities for tele-access.

Methods of statistical processing, analysis and evaluation of the collected data

In view of the main aim and tasks of the survey, the following statistical methods were used: Parametric methods – variation and alternative analysis, t-criterion for testing hypotheses for the presence of statistically significant difference between the surveyed indicators/parameters, p-value of the degree of statistical significance $p \leq 0.05$.
A graphic analysis was used for the visual presentation of the results. The data was processed statistically by means of the software product SPSS 19.0.

Results and Discussion

The distribution by gender of the patients included in the research was as follows: 70.17±10.48% were women, and 29.81±16.14% were men. The average age of the patients was 52.77 years of age, that is, they were still part of the working population. Within two treatment courses, each 10-15 days long, complex rehabilitation therapy was administered, and at the beginning and the end of the therapeutic periods, the necessary tests and measurements were conducted. Our kinesitherapeutic efforts in these cases were aimed at improving the overall condition of the patients and facilitating their functional recuperation using the means of kinesitherapy. Our main tasks were concerned with restoring the scope of movement of the ankle joints, and the main priority was the restoration of the muscle tone and strength of the lower extremities and the elimination of swellings. Team of specialists as medical psychologist and social worker, encouraged and motivated our patients to take an active part in the process of recuperation and to develop a new lifestyle by influencing their mental and emotional state.
For the purpose of overcoming muscle imbalance, first we relaxed the enhanced-tone muscles using relaxation techniques.
Kinesitherapy, with its wide variety and medicinal methods - analytical exercise, isometric and isotinic exercises, post-isometric relaxation in the method of Levit, therapy applied when the patient is at rest, stretching, muscle-inhibiting techniques, proprioceptive neuromuscular facilitation – diagonal and reciprocal inhibition, passive movement, massage of and around certain biologically active points was included in the rehabilitation process from the very beginning of the treatment to its end. Concomitant reductions in muscle and tendon stiffness after contract-relax stretching suggest a broader adaptive response that likely explains its superior efficacy in acutely increasing range of motion.[15]
The exercises were strictly analytical. The patients were taught how to walk.

Methodological directions

The physiotherapeutic and kinesitherapeutic interventions are structured depending on the localization and severity of the fracture. Physical exercise has a therapeutic effect by improving blood circulation and perfusion and stimulating trophics, activating and enhancing the mineral metabolism, and boosting the bioelectric potential of the patient. In the active muscles, including cardiac muscle, the resistance vessels relax in response to local chemical changes to provide an increase in blood flow adequate for their metabolic requirements.[16]

Tests and measurements

We performed the first tests and measurements at the beginning (x_1), and repeated the said tests and measurements at the end of the treatmento (x_2) of the twenty-seven patients – n=57.
The results from the initial and final angulometric tests were processed by means of variation and alternative analysis and are shown in Table 1.
The analysis of the obtained results shows that at the end of the course of medical treatment the range and volume of movement increased but was still not within the normal physiological range of values. Dorsiflexion, that is extension failed to be achieved, and flexion contraction was observed.
This shows that the therapeutic complex served as a good initial basis for the functional recovery but the time was not enough.

Table 1. *Data on the active range and volume of movement in the ankle joint*

Tested movement	initial $X_1 \pm S$	Vi	final $X_2 \pm S$	v_2	Difference $d = X_2 - Xi \pm S$
Flexion	58°±7.33	2.88	77°±8.34	10.82	19°±6.45
Extension	-5°±3.08	1.55	-2°±2.51	125.7	3°±2.29

Table 2 shows the results from the manual muscle testing.

The analysis of the obtained results reveals that the muscles were weak and at the end of the treatment the patients did not achieve muscle strength. They have to continue their rehabilitation therapy until good results and regaining of the locomotive functions is restored. Continuous rehabilitation is necessary so that the extremity could be properly used. Data shows that when tested initially, 90% of the patients experienced severe pain during movement. At the end of the procedures, the pain subsided (was alleviated) to moderate and mild. The pain syndrome was examined using subjective pain assessment scales. In Table 3 we present the results from the centimetry of the ankle, and ankle through the heel.

Physical therapy has a beneficial effect in the treatment of ankle fractures.

We applied a combination of cryotherapy, analytical exercises and slight drainage and selective massage, proprioceptive neuromuscular facilitation techniques for relaxation and strengthening, with interferential current and low impulse magnetic field. Electrophoresis and phonophoresis also yielded significant clinical effect.

The therapeutic results in fractures depend on the applied methods, their correct and appropriate combination in an efficient complex: for example, cryotherapy with kinesitherapy; underwater exercise with postisometric relaxation, propriceptive neuromuscular facilitation techniques (PNMFT) and electrical stimulation with active muscle contractions. Combined effects of low-frequency transcutaneous electrical nerve stimulation (TENS) with proprioceptive neuromuscular facilitation (PNF) produced significant improvements in balance, proprioception, strength, and range of motion, while also yielding reducing pain for post ankle sprain subjects. This treatment procedure will likely be helpful in rehabilitating post ankle sprain patients by improving overall function and helping build confidence in capacity for physical activity.[17]

We observed significant reducing in pain and relaxing through post-isometric relaxation. Post-isometric relaxation is aimed at achieving muscular facilitation and inhibition on the basis of the proprioceptive reflex influence. Since the analgesic and anesthetic effect of cryotherapy is achieved in an exteroreceptive way, and that of proprioceptive neuromuscular facilitation – in a proprioceptive way, when combined, a mutual potentiation of the anesthetic effect is achieved. The combination of post-isometric relaxation with cryotherapy yielded a very good pain-relieving effect and ensured the conditions needed for administering active rehabilitation.[18]

Taking into consideration the specific pathological finding in each case, we also necessarily included massage: preparatory massage, detailed massage, reflexogenic massage, special massage – periosteal massage, connective tissue massage, segmentary massage and acupressure.

The following contraindications were complied with 1. Kinesitherapy causing pain; 2. Redressing exercises; 3. Massage on the joint itself; 4. Simultaneous endogenous and exogenous warming influence; 5. Early overtaxing with walking, running and jumping.

For the functional recovery and rehabilitation of the ankle joint are appropriate an exercise aimed at strengthening the foot arch; swimming, cycling, walking and hiking.

Exercises in the closed kinetic chain stimulate the recovery and rehabilitation of the muscles which participate in the final support stage of walking. They facilitate the patient's teaching how to walk, climb up and down steps correctly.

Table 2. *Changes in manual muscle testing (MMT) of the ankle joint*

Movement	**Number – n**	**X_1**	**X_2**	**$d=X_2-X_1$**
Flexion	57	2.00	3.00	1.00
Extension	57	2.00	4.25	2.25

Table 3. *Changes in the measurements of the circumference of the ankle joint*

Movement	Number – n	X_1	X_2	$d=X_2-X_1$
Flexion	57	2.00	3.00	1.00
Extension	57	2.00	4.25	2.25

Proprioceptive neuromuscular facilitation techniques, combined with manual techniques aimed at improving the movement of the fascia, are an effective means of alleviating pain while walking, and regaining the locomotor skills.

The results from the changes of the anthropometric indicators and parameters of our patients with fractures, were in the direction towards improvement of the range of movements; beneficial effect on the atrophy of the thigh muscles; overcoming the results from the immobilization and improving the blood and lymph circulation in the lower extremities. The stabilization of these indicators and parameters, as well as the improvement of the gait, serve as conclusive evidence of the efficiency of the methods, and have a positive effect on the overall functional state of the patients.

As a result of the complex rehabilitation therapy and the efficiency of the treatment programme administered by the students, the treated patients recovered their active movements and locomotor skills, though not to an extent and range adequate for proper walking. The treatment should continue with subsequent courses of therapy or at home, provided the patients are given accurate methodological instructions.

Unsupervised rehabilitation – in the absence of a specialist in physical and rehabilitation medicine (PRM) – always serves as an undesired precondition for the development of complications, regardless of how trivial the condition of the patient may seem at first sight. Telerehabilitation approaches can be provided in a variety of different ways, including two-way real-time visits with audio, video or both, asynchronous e-visits, virtual check-ins, remote evaluations of recorded videos or images on the telephone.[19]

In our survey we used mobile app Superdoc to make appointments easier with the patients and also platform Viber for videos, pictures from exercises and distance control of rehabilitation process. Through telemedicine, thelatter offer affordable care for their patients, whichnot only saves time, but also leads to better treatmentresults and fewer missed or annulled consultations. People have a positive attitude towards the use of e-services and the issuance of e-prescriptions andhealth documents, and they want to share information and communications technology (ICT) healthinformation during visits, as well as in real time, via an Internet connection with a doctor.[20] Many health care systems throughout the world performed effective reforms such as the transition to telerehabilitation as a new approach to common rehabilitation practice.[21]

Conclusions

To sum up, the following conclusions can be made:

1. The application of physical therapy and kinesitherapy is a mandatory component for the development of a physiologically and pedagogically justified physical rehabilitation therapy, for modeling and correction of the restorative process in patients following an ankle fracture. 2. In patients with exacerbated motor deficit, the routine implementation of kinesitherapeutic means does not ensure the thorough achievement of short-term results. 3. Despite a certain trend towards residual deficit, the implementation of kinesitherapeutic means creates the necessary background on the basis of which specialized methods can be applied – joint-mobilizing techniques and passive stretching, for the purpose of the full recovery of the functions of the lower extremity. 4. The application of mobile apps optimizes the recovery process, increases access to rehabilitation, improves communication between medical professionals and the patient, and hence the implementation of the rehabilitation program and its results.

Although most people return to normal daily activities, except for sports, within 3 to 4 months, studies have shown that people can still be recovering up to 2 years after their ankle fractures. It may take several months for you to stop limping while you walk, and before you can return to sports at your previous competitive level. Most people return to driving within 9 to 12 weeks from the time they were injured.

List of acronyms

AO Foundation - Association for the Study of Internal Fixation
ICT - information and communications technology
IFC - Interferential current
GPs – General practitiones
NHIF - National Health Insurance Fund
MMT - manual muscle testing
PNF - proprioceptive neuromuscular facilitation
PNMFT - propriceptive neuromuscular facilitation techniques
TENS - transcutaneous electrical nerve stimulation

Contributions of Authors

PK, AM, BD, BT were involved in the conception, drafting and critical revision of the manuscript. All authors approved the final edited typescript.

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Conflict of Interest

The authors declare no conflicts of interest.

Ethical Publication Statements

We confirm that we have read the journal's position on ethical issues involved in publication and affirm that this report is consistent with those guidelines.

Corresponding Author

Anna Mihaylova, Medical College, Medical University of Plovdiv, Bulgaria 120 Br. Bukstone str., 4004 Plovdiv, Bulgaria. Phone +359 888 315382
ORCID iD: 0000-0002-7674-6074
E-mail: anna.mihaylova@mu-plovdiv.bg

E-mails and ORCID iD of co-authors

Petya Kasnakova: petya.kasnakova@mu-plovdiv.bg
ORCID iD:0000-0003-0415-2004
Boris Djurdjev: boris.dzhurdzhev@mu-plovdiv.bg
ORCID iD: 0000-0003-0387-3002
Biyanka Tornyova:
btornyova@meduniversity-plovdiv.bg
ORCID iD: 0000-0003-4332-3216

References

1. Wilson, FC. Fractures of the ankle: pathogenesis and treatment. J South Orthop Assoc. 2000;9(2):105-115
2. Goost H, Wimmer MD, Barg A, Kabir K, Valderrabano V, Burger C. Fractures of the ankle joint: investigation and treatment options. Dtsch Arztebl Int. 2014 May 23;111(21):377-88. doi: 10.3238/arztebl.2014.0377.
3. Kannus P, Palvanen M, Niemi S, Parkkari J, Jarvinen M. Increasing number and incidence of low-trauma ankle fractures in elderly people: Finnish statistics during 1970-2000 and projections for the future. Bone. 2002;31:430–433.
4. Yeung DE, Jia X, Miller CA, Barker SL. Interventions for treating ankle fractures in children. Cochrane Database Syst Rev. 2016 Apr 1;4(4):CD010836. doi: 10.1002/14651858.CD010836.pub2.
5. Eiff MP, Hatch R. Ankle fractures. In: Eiff MP, Hatch R, eds. Fracture Management for Primary Care. 3rd ed. Philadelphia, PA: Elsevier Saunders; 2012:chap 13.
6. Court-Brown C, McBirnie J, Wilson G. Adult ankle fractures: an increasing problem? Acta Orthop Scand. 1998;69:43-7.
7. Kannus P, Palvanen M, Niemi S, Parkkari J, Järvinen M. Increasing number and incidence of low-trauma ankle fractures in elderly people: Finnish statistics during 1970- 2000 and projections for the future. Bone. 2002;31:430-3.
8. Wilson LS Jr, Mizel MS, Michelson JD. Foot and ankle injuries in motor vehicle accidents. Foot Ankle Int. 2001;22:649-52.
9. Michelson JD. Fractures about the ankle. J Bone Joint Surg Am. 1995 Jan. 77(1):142-52
10. Keene DJ, Costa ML, Tutton E, Hopewell S, Barber VS, Dutton SJ, Redmond AC, Willett K, Lamb SE. Progressive functional exercise versus best practice advice for adults aged 50 years or over after ankle fracture: protocol for a pilot randomised controlled trial in the UK - the Ankle Fracture Treatment: Enhancing Rehabilitation (AFTER) study. BMJ Open. 2019 Nov 2;9(11):e030877. doi: 10.1136/bmjopen-2019-030877.
11. Miller TL, Skalak T. Evaluation and treatment recommendations for acute injuries to the ankle syndesmosis without associated fracture. Sports Med. 2014 Feb. 44 (2):179-88.
12. Ferri FF. Ankle Fracture. In: Ferri FF, ed. Ferri's Clinical Advisor 2016. Philadelphia, PA:Elsevier; 2016:117-118.
13. Çolak İ, Çolak T, Polat MG, Timurtaş E, Bulut G, Gülabi D. The Results of Physical, Radiologic, Pedabarographic, and Quality-of-Life Assessments in Patients with Surgically Treated Intraarticular Calcaneus Fractures. J Foot Ankle Surg. 2018 Nov-Dec; 57(6):1172-1180. doi: 10.1053/j.jfas.2018.06.009.
14. Rampazo ÉP, Liebano RE. Analgesic Effects of Interferential Current Therapy: A Narrative Review. Medicina. 2022, 58, 141. doi: 10.3390/medicina58010141.
15. Kay AD, Husbands-Beasley J, Blazevich AJ. Effects of Contract-Relax, Static Stretching, and Isometric Contractions on Muscle-Tendon Mechanics. Med Sci Sports Exerc. 2015 ;47(10):2181-90. doi: 10.1249/MSS.0000000000000632.
16. Shepherd JT. Circulatory response to exercise in health. Circulation. 1987 Dec;76(6 Pt 2):VI3-10.
17. Alahmari KA, Silvian P, Ahmad I, Reddy RS, Tedla JS, Kakaraparthi VN, Rengaramanujam K. Effectiveness of Low-Frequency Stimulation in Proprioceptive Neuromuscular Facilitation Techniques for Post Ankle Sprain Balance and Proprioception in Adults: A Randomized Controlled Trial. Biomed Res Int. 2020 Sep 23;2020:9012930. doi: 10.1155/2020/9012930.
18. Féron JM, Mauprivez R. Fracture repair: general aspects and influence of osteoporosis and anti-osteoporosis treatment. Injury. 2016 Jan;47 Suppl 1:S10-4. doi: 10.1016/S0020-1383(16)30003-1.

19. Prvu Bettger J, Resnik LJ. Telerehabilitation in the Age of COVID-19: An Opportunity for Learning Health System Research. Phys Ther. 2020 Oct 30;100(11):1913-1916.
20. Kilova K. The application of telemedicine in Bulgaria in the conditions of COVID-19. Fresenius Environmental Bulletin 30(7A):9180-9187.
21. Papathanasiou J, Kashilska Y, Bozov H, Petrov I, Masiero S. Telerehabilitation in Bulgarian health care system. Eur J Transl Myol 32 (1): 10350, 2022 doi: 10.4081/ejtm.2022.10350.

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