PHYSIOTHERAPY FOR RECOVERY OF THE EXPLOSIVE POWER AFTER KNEE SURGERY

Mariya Gramatikova, Stamenka Mitova, Ivan Glushkov, Ekaterina Mitova

Faculty of Public Health, Healthcare and Sports, South-West University "Neofit Rilski", Blagoevgrad, Bulgaria

Abstract

After reconstruction of the ACL in the second postoperative month patients display difficulties in explosive power (EP) manifestation of the operated limb in jumps. 187 patients with soft tissue injuries were tested, among whom 63 people with reconstruction of the ACL were identified and included in control and experimental groups. To achieve the goal of the study, a testing of the EP of the patients was conducted aiming at assessing the status and the changes in performing a vertical jump before physiotherapy and after ten-day procedures. During the first day the control group jumped on average 3.73±0.79 cm. After traditional physiotherapy, the bounce reached 10.19±0.99 cm., an improvement of 173.6%. In the experimental group during the first day the jump was X = 3.79±0.87 cm. After applying the experimental program of physiotherapy it reached 17.98±1.21 cm - a growth of 14.19 cm within ten days (374.8%). P1 = 0.826 and P2 = 0.000. Results show that patients with a score above (4) from the manual muscle testing of ischiocrural and hip muscles, a limit, underlying a sufficient dynamic joint and muscle stability, can begin risk-free (carefully) recovery of the EP of the operated limb in the second postoperative month.

Key words: kinesitherapy, knee, anterior cruciate ligament, rehabilitation

Introduction

The injuries on the anterior cruciate ligament lead to serious and permanent disorder of the mechanics of the knee joint, which, according to (A. Georgiev, 2005) is a result of failure in its proprioceptive and mechanical function. According to the author, one out of every 3000 people in the US gets a rupture of anterior cruciate ligament and its reconstruction is the sixth most common surgery performed by the American orthopedic surgeons. The ruptures of anterior cruciate ligament of the knee are among the most common sports injuries. In 70% of hemarthrosis in the knee joint a rupture of the anterior cruciate ligament is found. Annually 1.5 to 2 million patients at the age between 15-45 years experience similar traumas, and in 70% of them a rupture of the anterior cruciate ligament is diagnosed (W. Noyes, Barber-Westins, 2001). Currently, there is conclusive evidence showing that women present a higher percent of injuries of the anterior cruciate ligament compared to men, the main reasons for which are most probably due to anatomical and biomechanical specifics and hormonal and neuro-muscular factors (Hewett,T., K. Ford, B. Hoogenboom, G. Myer, 2010).

After reconstruction of the anterior cruciate ligament in the second postoperative month patients display a highly reduced explosive power of the operated limb. The reason lies in the explosive nature of the needed input power and the engagement of large muscle groups of the operated limb in performing jumping motor actions, as well as the involvement of the hip and ankle joint along with the knee joint. These motor actions are not only naturally applied, but are also basic sports and technical movements in a number of sports such as gymnastics, soccer, volleyball, basketball, athletics, etc.

In their implementation, the muscle groups involved in the movement act are characterized by synergistic and simultaneous priority muscle labour, as well as by simultaneous and sequential activation of the muscle groups involved. However, there is no consensus among physiotherapists about when the beginning of the recovery of the explosive power of the operated limb should start. When designing a recovery program the supporters of the intensive physiotherapy model recommend the inclusion of means for recovery the patients’ motor abilities including the power capabilities of the lower limb as early as the fifth or sixth week after the operation. They do not consider the explosive power, though. It is known that with intensive and more aggressive physiotherapy faster and higher results of the rehabilitation are achieved including the patients’ conditional abilities.

On the other hand, with moderate, cautious physiotherapy results are achieved slowly and later and such recovery scheme is suitable for untrained, elderly patients, particularly with those suffering of concomitant obesity. What is important is that there are few studies of the possibilities to improve the explosive power in the second postoperative month. We have not found programs for improving the explosive power of patients in the second postoperative month after surgery in the available sources, which is the main reason for drawing our attention to this particular issue. Another reason for our interest in this particular area is that we consider the recovery of the isometric strength through static exercises and the recovery of the isotonic strength through slow and averagely intensive motor actions as important as the recovery of the explosive power of the operated limb, especially with young people and athletes.
It can be concluded that it is necessary to develop new rehabilitation programs, which is the particular subject of this study, in order to ensure their rapid return on the sports field and to their daily and job duties.

**Methods**

**Study Hypothesis**

The recovery of the explosive power of the operated lower limb can begin early, namely in the second postoperative month after reconstruction of the anterior cruciate ligament of the knee joint.

**Aim of the study**

The study aims at exploring the possibilities for an early improvement of the explosive power by applying an experimental model of physiotherapy in patients after reconstruction of the anterior cruciate ligament of the knee joint, namely, during the second moderate-protective recovery period.

**Tasks of the study**

To achieve this aim, the following tasks are set:

* Study of the anatomic biomechanics of the motor actions and the participation of the knee joint and its soft tissues involved in the performance of vertical jumps.
* Determination of the possibilities to perform explosive power through vertical jump motor act by patients having undergone a knee surgery.
* Conducting a ten-day traditional physiotherapy model in a control group of patients.
* Conducting a ten day experimental physiotherapy model in an experimental group of patients.
* Evaluating the effectiveness of the experimental physiotherapy model for improving the explosive power indicator.

**Subjects**

187 patients were subjected to testing, 63 of who had undergone a reconstruction of the anterior cruciate ligament. They were divided into a control and an experimental group. All patients have signed a Statement of Informed consent for the research, which has been in accordance with the ethical standards, set out in the Declaration of the World Medical Association 1964 in Helsinki, amended by the World Medical Assembly in 1975 (Tokyo), in 1983 (in Venice) and in 1989 (in Hong Kong). The age structure of the patients with surgery of the anterior cruciate ligament is as follows: 28,6% of them were under the age of 21; 39,7% vary between 22 and 30 of age; 25,4% were between 31 and 40; and 6,3% were over 41.

The control group totaled 30 people all of whom are active sportmen. 7 are professional athletes, 23 do sport regularly and 1 does not do any sport. The predominant sport practiced by the patients in both the control and the experimental groups is soccer totaling 28 people, followed by skiing - 15 patients; martial arts - 5, basketball - 4, volleyball -3, sports dancing - 2; and 1 patient was involved in each of the following sports: tennis, mountaineering, sports gymnastics, ice skating. Finally, as already mentioned, there were 2 patients who did not do any sports.

**Venue of the study**

The experiment was carried out at the Military Medical Academy Hospital and the Multifarious Hospital for Active Treatment St. Sofia in Sofia, Bulgaria.

**Description of the experiment**

The recovery process of explosive power in 5-th and 6-th week after surgery is aimed at relieving the manifestation of the available, potential explosive power of the damaged limb. For this purpose, the experimental model of physiotherapy is directed to neutralizing the factors, which suppress the explosive power, as pain, lymphostasis, fear of instability and succumbing of the knee joint, etc., which process creates the conditions for the subsequent development of the said motor power of the operated limb at the end of the third post-operative month. In order to achieve the goal of the study and to fulfil the related tasks an experimental testing of the patients in order to determine their abilities to reveal explosive power was conducted. It consisted of performing vertical jumps before the beginning and after ten-day physiotherapeutical procedures. The test was conducted with patients with no less than (4) of the Manual Muscle Testing (MMT) of the m.biceps femoris, m.semitendinosus, m.semimembranosus and m.quadriceps femoris guaranteeing a sufficient dynamic joint and muscle stability to ensure a risk-free performance of the jump.

**Programs of Physiotherapy**

The program of physiotherapy in the control group was based on the already set standards while for the experimental group an experimental model was developed (M. Gramatikova, 2015) which includes:

* cryotherapy;
* recovery of the motor walking stereotype, normalization of the workload of the damaged limb, normalization of the locomotor abilities of the patients and neutralization of the adaptive pathological walking changes;
* manual soft-tissue mobilization following J.C.Terrier aiming at the recovery of the mio-articular mobility, a pain-relieving effect and reducing the edema of the knee joint (J.C. Terrier, 1996) (J.C. Terrier,1997);
* kinesio-taping for pain relief and drainage effect aimning at improving the muscle and joint mobility;
* analytical training for checking the strength of the operated limb including new complexes for enhancing the explosive power, for static and dynamic strength resilience combined complexes for other motor abilities;
* proprioceptive training using new complexes of exercises with and without appliances for balance, equilibrium, for proprioceptive
sensibility and neuro-muscular control and for increasing the dynamic joint and muscle stability); dynamic aquatherapy for enhancing the muscle strength and endurance, for increasing the volume of motion, reducing the muscle spasticity, as well as the edema and pain, and for increasing the mio-articular dynamic stability (M., Gramatikova, 2015).

It is important to note that in the accessible sources for three of the physiotherapeutic techniques listed above, namely the soft tissue manual mobilization after Terrier, the use of kinesiotape, and dynamic aquatherapy we have not found a developed program that has been applied after an operation on the anterior cruciate ligament of the knee joint. In summary, the applied physiotherapeutical means in the experimental group included kinesio-taping; cryotherapy; manual soft tissue mobilization after J.C.Terrier; Therra-band system; football; elastic bands; board stones; balance board; mechanotherapy including leg press, multifunctional gladiator, treadmill, exercise bike; analytical gymnastics and aquatherapy. Most of these means used in the course of the recovery treatment of patients after an operation on the anterior cruciate ligament of the knee joint due to injury are either new or updated. The verification of the scientific generalizations is ensured by the attached evidential materials; the methods of mathematical statistics (variance and alternative), the optimal number of the subjects tested and the high reliability of the applied test.

**Notes:**
The term kinesitherapy in Bulgaria is equivalent to physiotherapy used in other countries. Physiotherapy (kinesitherapy) is a state regulated profession in Bulgaria. It is performed by specialists with a Bachelor’s or Master’s degree, whose education is provided in the specialty Physiotherapy (Kinesitherapy) which is regulated according to the State Educational Standards.

**Results**

**Localization of the injuries**
The data concerning the localizations of the knee injuries show that in the control group 22 are on the left knee, and 9 - on the right knee, whereas in the experimental group 18 traumas are on the left knee and 14 on the right knee. The totals of studied patients with a trauma on the left knee are 40 and those on the right knee are 23.

**Frequency of injuries**
In the process of the study other patients with different soft tissue injuries were also diagnosed, which allowed the establishment of the frequency of injuries of the anterior cruciate ligament in particular. The results show that the relative share of the damage of the anterior cruciate ligament is 33.7%, followed by injury of the medial collateral ligament – 19.8%, tria – 18.7%, followed by partial meniscectomy menisci medialis – 11.8%, sutura menisci – 7%, partial meniscectomy menisci lateralis – 6.4%, microfracture chondroplasty – 2.7%. This data has substantiated our orientation to the study the most common soft tissue damage, namely this of the anterior cruciate ligament, whose high frequency places it among the most significant problems among the soft tissue injuries of the knee.

**Influence of the vertical jump on the units of the lower limb**
The results of the conducted anatomical analysis of the biomechanics of the vertical jump of the patients-athletes with an injury of the knee joint open opportunities for physiotherapists to find out how the indicated motor action engages various units of the lower limb. In the process of research it has been found out that, in the performance of a vertical jump, especially in the phase of the push up from the prop m.gastrocnemius is engaged first, followed by m.tibialis posterior and m.flexor hallucis longus. During the second phase of the prop period, the extensor of the knee joint m.quadriceps femoris is emergently activated. M.biceps femoris and m.gastrocnemius are simultaneously activated, which contributes to the bilateral and additional unfolding of the support limb. The forces in the knee and ankle joints of the patients are directed to increase the push off by folding the ankle joint and unfolding the knee joint. This causes an increase of the thrust force, as a result of the activation of the muscles in the chain from the proximal to the distal joints. Dimitrov, 2003 establishes the highest electroactivity in m.gluteus maximus and m.biceps femoris both of which cease their action at the same time, namely at the moment of the unfolding of the thigh during the pushing up from the prop. M.rectus femoris and m.vastus medialis work synergistically. However, according to the author the latter ceases its work after ¼ of their active period and the work is taken over by m.rectus femoris (D., Dimitrov, 2003). During the landing, at the moment of touching the prop the extensors of the foot are activated, providing the depreciation. During the depreciation, the angle in the hip joint increases at the expense of the angles in the knee and ankle joint that decrease, respectively. This is a result of the operational forces produced by the prop reaction and the body weight. At the next moment these forces do not allow the body to bend, reducing the angles in the three joints. In this way the deploying forces engaged in the push up, the bounce and the landing achieve their maximum capacities. During the unfolding of the lower limb the participation of m.gluteus maximus is most active. Along with it m.biceps femoris is activated, its activity being caused by the necessity of the lower leg to extend thus providing a better interaction with the prop. The unfolding of the knee joint during landing is related to the participation of m.semitendinosus, m.semimembranosus and m.tibialis posterior. In the transition from the vertical moment to the landing, the unfolding is a result of the forces acting during the contraction of m.rectus femoris and m.vastus medialis.
Changes in the explosive power of patients after physiotherapy treatment

In addition to the anatomical and biomechanical analysis of the vertical jump in order to clarify its effects on the muscle groups of the lower limb, the study sets the task to identify the patients' capabilities to demonstrate an explosive power using the performance of a vertical jump after knee surgery. The data from the experiment have been statistically processed and show that the skewness coefficient \( A \) and the kurtosis coefficient \( E \) present normal or close to normal distributions. The values of \( A \) in the control group change from 0.906 during the first testing to 0.971 during the second (final) testing, while in the experimental group \( A \) at the first testing is 1.050 decreasing to 0.920 at the final testing. The coefficient of kurtosis \( E \) in both groups does not change varying from 0,029 to 1,118.

In the control group

The results of the conducted variance and alternative analysis show that the patients in the control group are strongly hampered in revealing explosive power before the beginning of physiotherapy procedures. They were able to bounce off from the prop 3,726 cm. on average, measured at a high standard deviation (quadratic) \( S = 4,425 \) and representative error \( m_x = 0,795 \) determining the relatively wide confidence interval of the average value \( 3,7 \pm 0,795 \). The variability of the results of the first testing in the control group is high as \( V\% = 118,766\% \). As a result of a ten-day traditional physiotherapy in the control group, the vertical jump height reaches 10,194 cm. showing a growth of 6,468 cm. In relative values the increase is estimated to 173,592 cm. There is also a significant reduction of \( V\% \), which during the physiotherapy decreases from 118,8% to 54,3%.

In the experimental group

In the experimental group the average values of the vertical jump of the patients on the first day of the experiment and before the start of physiotherapy treatment, are similar to those in the control group \( X = 3,788 \pm 0,868 \text{ cm} \).

Again, the results show strong difficulty for the patients to reveal explosive power during the jump. The values of the standard deviation \( S = 4,908 \) and \( V\% = 129,571 \) are high too.

As a result of the applied experimental model of physiotherapy, however, the possibilities for manifestation of explosive power by the patients increase to a level allowing them to achieve an average bounce of 17,984\( \pm 1,208 \) cm. performed on the tenth day after the final physiotherapy procedure. The growth of the result in absolute of the explosive power of the patients in the experimental group and high efficiency of the applied experimental model of physiotherapy.

Statistical significance of the differences

In order to establish the degree of statistical significance of the differences in the improvement of the average value of the explosive power indicator measured by the vertical jump test, the non-parametric criteria of Mann Whitney for independent samples, with a probability of error \( \alpha = 0,05 \) has been applied. This was necessary due to the specifics of the type of data where their discrete values and numeric characteristics \( A \) and \( E \) lay outside the interval \((-1,1)\). \( P \)-values show that during the first test (before the beginning of physiotherapy treatment), there is no statistically significant differences in the results of the patients in the control and the experimental group \(( P = 0,826)\). The final testing, however, attests that the differences are statistically significant and shows that the experimental model of physiotherapy is more effective for recovery of the explosive power of the studied patients \(( P = 0,000)\).

Discussion

Despite the fact that in the fifth and sixth week after the operation the patients are hampered in the performance of motor actions, associated with explosive power, the results of the conducted study and the statistical data show regularities disclosing the possibility the recovery of the explosive power of patients after reconstruction of the anterior cruciate ligament of the knee joint to be started as early as the second postoperative month.

The results also show that the developed and applied experimental model of physiotherapy increases the explosive power of the studied patients (374, 8%) to a much higher degree, which proves its advanced efficiency in comparison with the traditional model of physiotherapy in the control group. The variation in the results of the performance of explosive power in the studied patients before application of physiotherapy in both groups is significant.

In the control group it reduces from 118,8% at the first test to 54,3% at the second test, while in the experimental group it decreases from 129,6% to 37,99%.

This comes to show that a strict differentiated approach and applying a careful, sparing and gradual
physiotherapeutical treatment for recovering the explosive power of lower limb after surgery is needed.

Conclusion

The results of the study show that patients with a score above (4) estimated after manual muscle testing (MMT) of the m.biceps femoris, m.semitendinosus, m.semimembranosus and m.quadriceps femoris, which is the threshold ensuring sufficient dynamic joint and muscle stability for performing a risk-free execution of the test during the second postoperative month, a recovery of the explosive power of the operated limb may start gradually and under favorable conditions. However, with patients with a lower than (4) of MMT, the process of recovery of the explosive force should be postponed until a stable state of the operated lower limb is reached. In conclusion we recommend the application of the newly designed model of physiotherapy that can speed up the recovery of the knee and improve the motor function of patients after knee surgery.

References


tа z mogu početi bez rizika гpažljivoд oporavak EP operiranog uda u drugom postoperativnom mjesecu.

Sažetak

Nakon rekonstrukcije ACL-a u drugom postoperativnom mjesecu pacijenti pokazuju teškoće u manifestaciji eksplozivne snage (EP) operiranog uda u skokovima. 187 pacijenata s ozljedama mekog tkiva je testirano, među kojima je 63 osoba s rekonstrukcijom ACL identificirana i uključena u kontrolu i eksperimentalne skupine. Da bi se postigao cilj studija, ispitivanje EP bolesnika provedeno je s ciljem procjene stanja i promjena u obavljanju vertikalnog skoka prije fizioterapije i poslije desetodnevnih postupaka. Tijekom prvog dana kontrolna skupina skočila je u prosjeku 3,73 + 0,79 cm. Nakon tradicionalne fizioterapije, odsok je dosegao 10,19 + 0,99 cm., poboljšanje od 173,6%. U eksperimentalnu skupinu tijekom prvog dana skok je bio X = 3,79 + 0,87 cm. Nakon primjene eksperimentalnog programa fizioterapije je dostigao 17,98 + 1,21 cm - rast od 14,19 cm u roku od deset dana (374,84%). P1 = 0826 i P2 = 0.000. Rezultati pokazuju da bolesnici s rezultatom iznad (4) ručnog mišićnog testiranja ishiocrural m. i mišića kuka, granice, na kojima se temelji dovoljno dinamično u zglobovima i mišićima stabilnost, mogu početi bez rizika (pažljivo) poravak EP operiranog uda u drugom postoperativnom mjesecu.

Ključne riječi: kineziterapija, koljena, prednji križni ligament, rehabilitacija

Received: February 07, 2016
Accepted: April 15, 2016
Correspondence to:
Mariya Gramatikova
Department of Kinesitherapy
Faculty of Public Health, Healthcare and Sports
South-West University, Blagoevgrad, Bulgaria
tel: ++359 897-920-446
e-mail: mari_gramatikova@abv.bg

Acknowledgements:
The authors express gratitude to authorities whose help was crucial: Prof. Dr. Troycho Troey, Head of the Department of Physiotherapy at the Military Academy in Sofia, and Dr. Christo Mazneykov, CEO of the Multifarious Hospital for Active Treatment St. Sofia