

# STUDY ON THE CHARACTERISTICS OF LOWER LIMB MUSCLE MOTOR ORGANIZATION AMONG ATHLETES WITH TRAUMATIC KNEE INJURIES



ORIGINAL ARTICLE  
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ESTUDO SOBRE AS CARACTERÍSTICAS DE ORGANIZAÇÃO MOTORA MUSCULAR DO MEMBRO INFERIOR ENTRE ATLETAS COM LESÕES TRAUMÁTICAS NO JOELHO

ESTUDIO SOBRE LAS CARACTERÍSTICAS DE LA ORGANIZACIÓN MOTRIZ DE LOS MÚSCULOS DE LAS EXTREMIDADES INFERIORES EN ATLETAS CON LESIONES TRAUMÁTICAS DE RODILLA

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## ABSTRACT

**Introduction:** Traumatic injury to the knee joints and their adjacent muscles is common among athletes, and their organizational characteristics require thorough analysis. **Objective:** Investigate the motor organization of muscles in the lower limbs of athletes with traumatic knee injuries. **Methods:** A systematic survey of the peculiarities of motor organization in the muscles of physically healthy athletes was preceded by an analytical survey of the peculiarities of this organization among athletes with traumatic knee injuries interested in medical treatment to restore the functional condition of the knee joints and perform active sports activities. **Results:** The characteristics of muscle motor organization in traumatic injuries and their recovery methods were determined, as well as the formation of a sequential understanding of the recovery process of knee joint injuries for athletes representing various sports. **Conclusion:** The results of this scientific study and the conclusions formulated based on them are of great importance for athletes concerned with restoring functional status after knee joint injuries sustained during the competition and in the training process. **Evidence level II; Therapeutic studies - outcomes research.**

**Keywords:** Lower Extremity; Knee Injuries; Physical and Rehabilitation Medicine; Recovery of Function.

## RESUMO

**Introdução:** A lesão traumática nas articulações do joelho e seus músculos adjacentes é comum entre atletas e suas características organizacionais exigem uma análise minuciosa. **Objetivo:** Investigar a organização motora dos músculos nos membros inferiores de atletas com lesões traumáticas no joelho. **Métodos:** Uma pesquisa sistemática sobre as peculiaridades da organização motora na musculatura de atletas fisicamente saudáveis foi precedida a uma pesquisa analítica das peculiaridades desta organização entre atletas com lesões traumáticas no joelho, interessados no tratamento médico a fim de restaurar a condição funcional das articulações do joelho e realizar atividades esportivas ativas. **Resultados:** Foram determinadas as características de organização motora muscular nas lesões traumáticas e seus métodos de recuperação, bem como a formação de uma compreensão sequencial no processo de recuperação das lesões das articulações do joelho para os atletas que representam diversos esportes. **Conclusão:** Os resultados deste estudo científico e as conclusões formuladas com base neles são de grande importância para atletas preocupados com o restauro do estado funcional após as lesões nas articulações do joelho sofridas durante o período de competição e no processo de treinamento. **Evidência nível II; Estudos terapêuticos – pesquisa de resultados.**

**Descritores:** Extremidade Inferior; Traumatismos do Joelho; Medicina Física e Reabilitação; Recuperação de Função Fisiológica.

## RESUMEN

**Introducción:** Las lesiones traumáticas de las articulaciones de la rodilla y sus músculos adyacentes son frecuentes entre los deportistas y sus características organizativas requieren un análisis exhaustivo. **Objetivo:** Investigar la organización motora de los músculos de las extremidades inferiores de atletas con lesiones traumáticas de rodilla. **Métodos:** Una investigación sistemática sobre las peculiaridades de la organización motora en los músculos de los atletas físicamente sanos fue precedida por una investigación analítica de las peculiaridades de esta organización entre los atletas con lesiones traumáticas de la rodilla, interesados en el tratamiento médico para restaurar la condición funcional de las articulaciones de la rodilla y realizar actividades deportivas activas. **Resultados:** Se determinaron las características de la organización motora del músculo en las lesiones traumáticas y sus métodos de recuperación, así como la formación de una comprensión secuencial en el proceso de recuperación de las lesiones de la articulación de la rodilla para los atletas que representan varios deportes. **Conclusión:** Los resultados de este estudio científico y las conclusiones formuladas a partir de ellos son de gran importancia para los deportistas preocupados por



**Descriptor:** Extremidad Inferior; Traumatismos de la Rodilla; Medicina Física y Rehabilitación; Recuperación de la Función.

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## INTRODUCTION

The characteristics of the leg muscle motor organisation of athletes with traumatic knee injuries necessitate a thorough analysis of the injury causes of athletes in the context of the specific characteristics of the sport during which such an injury occurred.<sup>1</sup> Traumatic injury to knee joints and the muscles directly adjacent to them is one of the most common musculoskeletal injuries among people involved in sport. According to numerous studies, up to a quarter of all athletes suffer these types of injuries each year, which means that, given the intensive physical exertion and a long period of sporting activity, the rate can be as high as 100% and represent a significant health risk for athletes.<sup>2</sup>

In general, it is more common for athletes to suffer injuries to muscles that are in the contraction phase, while injuries to muscles of different groups when they are in a relaxed state are almost non-existent. Such injuries are most often closed, as in this case there is no damage to the integrity of the skin. In the case of open type damage, there is usually no difficulty in diagnosing these situations. They are easy to detect and can be treated by suturing the damaged areas during the initial examination of the injury site.<sup>3</sup> It should also be noted that such muscle ruptures can be complete or incomplete, and the term "muscle strain", which was used extensively in the past, is now almost completely out of use, due to the fact that in all cases one should speak of partial ruptures of muscular tissue. Frequently, abrupt, unintentional and unexpected movements lead to closed muscle ruptures; this is also characteristic of sudden reflex muscle contractions arising from defensive reactions.<sup>4</sup> This is most often caused by lack of preparation of muscle groups and knee joints for physical exertion, poor warm-up or absence of it, lack of proper muscle warm-up before a performance, and excessive training caused by prolonged exposure to excessive physical exertion of an athlete. The specific site of injuries is most often determined by the specific type of sport, in this context it should be noted that sprinting, jumping, football, basketball, volleyball and skiing are the most dangerous sports in terms of the prospects of knee injuries and muscle ruptures. Football players often injure their hip muscles, with knee injuries being extremely common among them.<sup>5</sup>

## MATERIALS AND METHODS

The first stage of this study involved a theoretical analysis of available publications on the issues related to the study of characteristics of leg muscle motor organisation among athletes with traumatic knee injuries. Also, at this stage of the study, a systematic research was carried out on the motor organisation features of leg muscles among physically healthy athletes with no knee joint injuries, which contributes to the formation of holistic views regarding the possibilities of remedying such injuries sustained by athletes in various sports.

The next stage of this study involved analytical research into the characteristics of this kind of organisation among athletes with traumatic knee injuries, who are asking for medical management of such injuries in order to restore the functional status of knee joints and to be able to perform full, active sporting activities. Furthermore, an analytical comparison of the preliminary results obtained in the course of the study with the results and conclusions of other researchers who have studied

various aspects of leg muscle motor organisation among athletes with traumatic knee injuries from various sports activities was carried out.

The final stage of this research study, based on the results obtained, led to the formulation of the final conclusions, which are a logical reflection of these results and summarise the entire body of research work. In general, the results of this study and the conclusions formulated on their basis provide a complete picture of the scientific study of the leg muscle motor organisation features among athletes with traumatic knee joint injuries sustained in various sports in the preparatory and competitive periods.

## RESULTS AND DISCUSSION

Modern sporting activities are characterised by a steady increase in physical exertion as well as in the intensity of the training process. This is due to the high demands placed on the athlete's body and significantly increases the risk of various musculoskeletal injuries and damage. Knee joint injuries are particularly prominent among these, as this part of body is subjected to considerable strain in almost all types of sport. Injuries and damages to the knee may involve the musculoskeletal apparatus itself, but also cartilage tissue of the joint, ligaments inside and outside the joint, as well as extending well beyond it.<sup>6</sup> Moreover, knee joint injuries can provoke abnormal functioning in other parts of the musculoskeletal system, since such injuries are the actual expression of abnormal movement patterns of the athlete, usually far from their optimum state.<sup>7</sup>

Tables 1 and 2 present the research findings on the characteristics of designing training sessions aimed at restoring the impaired motor skills of leg muscles among athletes with traumatic injuries of knee joints. The data are presented on the basis of studies conducted with athletes competing in football and track and field as representatives of both playing and non-playing sports.

As the data in Tables 1 and 2 show, it takes longer for athletes in playing sports to regain the motor skills of the leg than it does for athletes in non-playing sports. This is due to the characteristics of specific sports, as football in particular is characterised by high levels of contact and injury risk in general, which necessitates a longer recovery period for injuries sustained by athletes.

Leg muscle motor organisation of athletes with knee injuries involves the gradual recovery of muscle mobility in the area of the injured knee

**Table 1.** Peculiarities of designing training sessions aimed at restoring impaired motor skills of leg muscles among football players with traumatic injuries of knee joints.

Training focus	Duration of exercise by day	Training days	Training sessions
Physiological recovery	25	21	28
Restoring mobility to the injured joint	10	8	15
Restoring coordination of movement in the joints	12	10	13
Restoring general coordination of movement	7	5	8
Restoring motor activity and skills	14	11	15

**Table 2.** Peculiarities of designing training sessions aimed at restoring impaired motor skills of leg muscles among track athletes with traumatic injuries of knee joints.

Training focus	Duration of exercise by day	Training days	Training sessions
Physiological recovery	20	18	25
Restoring mobility to the injured joint	8	6	12
Restoring coordination of movement in the joints	10	7	11
Restoring general coordination of movement	6	4	6
Restoring motor activity and skills	11	8	12

joints, involving the motor nerve fibres that are directly responsible for the muscle strength expressed in the manifestation of specific movements. The recovery of motor organisation from knee joint disorders among athletes takes a long time, which is determined by the severity of the injury and the nature of the recovery measures aimed at remedying these injuries. The sequence of operations aimed at fully resolving the problems of motor organisation involves three main stages.<sup>8</sup>

### The preparatory period

The basic rehabilitation period to restore the impaired joint functions, taking into account the individual characteristics of the athlete.

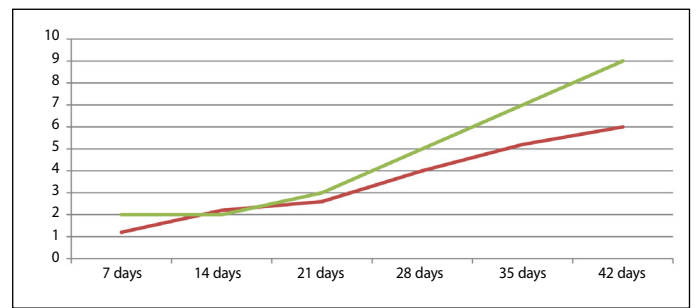
Gradual improvement to an optimum functional state, taking into account the specifics of the particular sport.

High-quality training sessions for the recovery of leg muscles in knee injuries involve the gradual mobilisation of soft tissues for a full flow of the subsequent process. The peculiarities of the motor organisation of the athlete's leg muscles in traumatic knee joint injuries imply gradualness in the build-up of exertion during the recovery period and directly at the stage of bringing them to an optimal functional state; therefore, gradualness in soft tissue mobilisation is an essential element in the restoration of impaired motor skills in injured knee joints among athletes in various sports.

Figure 1 shows the graphical dependence of the degree of muscle motor impairment recovery among athletes in playing and non-playing sports on the time spent on rehabilitation and recovery measures. The x-axis represents the time intervals of the recovery period, the y-axis represents the recovery parameters in conventional units. The graphical dependence of muscle motor recovery for athletes in non-playing sports is shown in green, the same indicator for athletes in playing sports is shown in red.

The main peculiarities of the leg muscle motor organisation of an athlete with a knee joint injury include differences in the dynamics of leg motor recovery among athletes of different ages, years of sporting experience and the degree of exercise perception included in the recovery complex for typical injuries. Such differences in complex determine the athletes' final level of fitness for physical exertion and the length of their sporting careers in general. Moreover, racial criteria should be taken into account, as numerous studies demonstrate significant differences in leg muscle motor organisation between European, African American and Asian athletes, indicating the need for further research into the specifics of organising recovery procedures for athletes of different fitness levels and racial backgrounds.

Traumatic muscle injuries can be conventionally divided into microscopic ruptures (where the injury site does not exceed 3-5 mm) and ruptures where the injury site exceeds 5 mm. The injuries sustained by athletes can be longitudinal, running along the muscle fibres, as well as transverse. Muscle tissue elasticity has a high tensile strength and tear resistance, whereas connective tissue, rich in collagen fibres,



**Figure 1.** Dependence of the degree of muscle motor impairment recovery among athletes in playing and non-playing sports.

has a high tensile strength and is easily stretched. When a tense muscle is stretched, prevention of damage is ensured by the restraining reaction of the connective tissue. In this case, if a force is applied that exceeds the strength of the connective tissue, the damage also affects the connective tissue itself in the first place.<sup>9</sup>

Given the significant improvements in the understanding of the nature of fully functioning spinal systems controlling various aspects of motor activity inherent in internal organisation, the multiple spinal segmental mechanisms of motor skill development in adulthood remain largely unexplored. At the same time, there is no doubt that there are significant changes in the neural circuits of the spinal cord and the corresponding neuromuscular circuits during sustained sports activity, and their direction is largely determined by the duration, power, kinematic characteristics and structure of regular physical exertion.<sup>10</sup>

Knee joint injuries are a frequent cause of premature end of sporting careers for many athletes competing in various sports. However, in playing sports (football, basketball, handball, etc.) these injuries are often the result of external influences such as collisions, hits, intentional and unintentional injuries, etc. There are frequent situations in athletes' sporting careers in which traumatic injuries to knee joints occur during training and are caused as a result of overexertion, exceeding the limits of acceptable physical activity and overtraining caused by this circumstance.<sup>11</sup> For this reason, studies on the causes of impaired knee joint functioning in the context of understanding the characteristics of leg muscle motor organisation among athletes with traumatic knee injuries occupy a special place in sports science as they contribute to understanding the causes of such injuries among athletes as well as options for recovery from the injuries and return to full training and competition activities.

In modern conditions of the training process organisation and conducting competitive activities of athletes performing in various sports, the search and practical application of actual possibilities of rehabilitation measures with athletes after their injuries is an urgent problem that needs to be solved as soon as possible. The quality solution of such problems requires the practical use of the resources of such scientific disciplines as sports medicine, physiology, psychology, biomechanics, as well as a whole range of other disciplines related to the field of sport. The possibilities for rehabilitation of athletes through the application of a whole rehabilitation complex, including therapeutic gymnastics and massage, to facilitate the recovery of athletes in playing sports after injuries are not yet fully studied, which necessitates further scientific research in this area, which will contribute to a full immersion in the subject and create the fullest possible picture of the research possibilities for rehabilitation of athletes after muscle and joint injuries sustained during training and the competition period.<sup>12,13</sup>

Massage and therapeutic exercises have been shown to be the most effective measures for the rehabilitation of athletes who have sustained traumatic knee joint injuries.<sup>14</sup> The positive effect of these methods on

the recovery processes of the impaired functions of the damaged joints and limbs in general has been well determined by scientific studies. In particular, it has been established that such techniques are completely natural, as they underpin the use of movement of all types to restore impaired motor activity as a result of trauma sustained. The treatment of traumatic knee muscle injuries by increasing motor activity involves the patient performing a series of movements in a dynamic that is personally comfortable for him or her, in order to obtain the most comfortable sensation. Gradually performed physical exercise restores the balance between the basic processes of excitation and inhibition in the central nervous system, which leads to the establishment of a normal balance of visceral impulses in the athlete's body. The result is the formation of a new cortical stereotype arising from the performance of a particular exercise or series of exercises, which ensures the inhibition of pathological cortical stereotypes, and restores the full connections between the main systems of the entire body. Exercises in therapeutic exercise complexes have a good tonic effect, which is particularly reflected in the stimulation of reflexes, both visceral and motor.<sup>15-17</sup>

The characteristics of the leg muscle motor organisation among athletes with traumatic knee injuries suggest the need for special rehabilitation measures aimed at restoring the impaired mobility of the injured joint and at the gradual, complete recovery of all lost functions. In this case, soft tissue mobilisation should be carried out gradually prior to the main exercise to fully incorporate the injured athlete into the complex post-injury rehabilitation measures and then move on to the main stage of the process. Special attention should be paid to restoring the mobility of the injured knee joint, in particular by restoring its passive flexibility while gradually increasing the physical stress applied to it.<sup>18</sup> This stage of the physical rehabilitation process is particularly significant when recovering from knee joint injuries among football players, as the ability to perform rapid flexion and extension movements is of particular importance when performing such a technical move as a tackle. Furthermore, the problems of lack of flexion exercises at the initial stage of the rehabilitation process are often accompanied by the risk of occurrence and subsequent development of significant structural damage to the knee joint, since a good passive flexion requires stretching of the quadriceps muscle, combined with squats performed with a gradual increase in the amplitude of the exercise. Generally, results in this case are

not achieved before 4-5 months after the start of the rehabilitation process. In addition, it is advisable to perform various exercises involving rest and hanging, to perform lunges in a variety of planes and to gradually switch to the use of rubber expanders in the exercises. Special attention should also be paid to strength training exercises, as restoring the performance of the muscles surrounding the knee joint is also of great importance in the context of restoring its performance in general.<sup>19</sup>

## CONCLUSIONS

Traumatic knee joint injuries of athletes performing various sports require special approaches to the study of the motor organisation of their leg muscles, as well as to the issues of recovery and rehabilitation after traumatic knee joint injuries sustained. In this context, it is worth noting the difference in approaches to the organisation of this process for athletes in playing and non-playing sports, since in the former case more time and training sessions are required for the qualitative solution of all the tasks related to the organisation of the recovery process. This situation can be explained by the higher rate of injury cases specifically among athletes in playing sports, as well as by the higher degree of severity of their injuries, which leads to difficulties in the recovery of damaged joints and the quality motor organisation of leg muscles.

At the same time, a study of leg muscle motor organisation among athletes who have suffered knee injuries illustrates the fact that the recovery rate of muscle motor impairments is higher among athletes from non-playing sports in comparison to those from playing sports, as the latter injuries are usually more severe and more challenging to treat, and the recovery procedures in this case are more difficult. Football players and track athletes need different amounts of time to recover from their injuries, with football players' recovery of muscle motor skills likely to have significant complications caused by recurring injuries, which is also associated with a high risk of re-injury. Furthermore, with repeated traumatic knee joint injuries, the recovery process tends to be more difficult and may take more time, negatively affecting the athlete's physical condition and his or her level of competitive readiness.

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