PROTEIN SUPPLEMENTATION IMPROVES RESULTS OF REHABILITATION FOLLOWING KNEE ARTHROSCOPIC SURGERY IN COMPETITIVE SOCCER PLAYERS

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Abstract:

Efficient rehabilitation of the quadriceps femoris muscle in convalescence is the cornerstone of full recovery after immobilization and surgery of the knee. A wide variety of kinesitherapeutic protocols have been described and used in order to ensure the athlete's rapid return to sports. The aim of this study was to investigate whether protein supplementation in the diet after arthroscopic surgery of the knee and during the application of a complete kinesitherapeutic programme is beneficial to the patient. A total of 56 patients, all competitive soccer players, were recruited for the study. Of these, 47 had undergone arthroscopic surgery for meniscal repair and 7 for anterior cruciate ligament (ACL) reconstruction. They were randomized into two groups of 28 patients each - experimental (EG) and control (CG). Identical kinesitherapeutic protocols were applied to both groups. All the patients received a similar standard diet; in addition to this diet, the EG patients received 1 g/kg/day of high-quality milk and egg-protein supplement (90.5% protein content). Kinesiological evaluation of the knee joint condition was carried out by myotonometry (MTM) of the quadriceps muscle, thigh circumference (TC) measurement, range of motion in the knee joint, and manual muscle testing (MMT) on the injured and uninjured limb before and after the experiment. Statistical analysis was performed by employing the Student's *t*-test (data were presented as mean±SD). At the end of the experiment the injured leg TC was closer to the uninjured leg TC in the EG patients (47.16±2.12 vs. 47.57±2.63 cm, $p>0.05$) than to that in the controls (46.70±2.52 vs. 48.38±2.78 cm, $p<0.05$). Also, MTM during contraction of the quadriceps muscle of the injured limb showed closer values to those of the uninjured limb in the EG patients (113.14±5.56 vs. 114.64±4.08 units, $p>0.05$) than to those of the control group patients (88.78±7.66 vs. 115.86±4.39 units, $p<0.001$). The EG patients showed better MMT scores at the end of the experiment than those of the CG patients (4.99±0.05 vs. 4.33±0.26, $p<0.001$). The results of the study suggest that protein supplementation of the diet during kinesitherapy can beneficially contribute to the successful management of the quadriceps hypotrophy after knee arthroscopic surgery of soccer players.

Key words: knee arthroscopic surgery, quadriceps muscle, rehabilitation, myotonometry, manual muscle testing

EIWEIßZUSATZDIÄT VERBESSERT BEI LEISTUNGSFUßBALLSPIELERN DIE REHABILITATIONSERGEBNISSE NACH DER ARTHROSKOPISCHEN KNIEOPERATION

Zusammenfassung:

Erfolgreiche Rehabilitation des Muskels quadriceps femoris, nach der Immobilisation und Operation des Knies, stellt den Eckstein einer kompletten Erhohlung dar. Eine große Anzahl von bewegungstherapeutischen Maßnahmen wurde beschrieben und angewandt um festzustellen, ob die Eiweißzusatzdiät nach der arthroskopischen Knieoperation und während der Anwendung eines kompletten bewegungstherapeutischen Programms für den Patienten wirksam ist. 56 Patienten, alle Leistungsfußballspieler, nahmen an der Forschung teil. 47 Fußballspieler hatten eine arthroskopische Meniskusoperation, und bei den 7 Patienten wurde die Rekonstruktion des vorderen Kreuzbandes durchgeführt. Sie wurden willkürlich in zwei Gruppen eingeteilt,

die experimentale Gruppe (EG) und die Kontrollgruppe (CG), mit je 28 Patienten. Identische bewegungstherapeutischen Heilmaßnahmen wurden bei beiden Gruppen angewandt. Alle Patienten erhielten ähnliche Standarddiät; die Patienten aus der EG Gruppe erhielten aber zusätzlich 1g/kg/Tag Milch hoher Qualität, sowie Eierproteinergänzung (90,5% Proteininhalt). Die kinesiologische Einschätzung des Kniegelenks wurde mittels der Myotonometrie (MTM) des Muskels quadriceps femoris, der Messung des Oberschenkelumfangs (TC) und des Bewegungsradius im Kniegelenk und des manuellen Testens des Muskels (MMT) auf der verletzen und auf der unverletzen Extremität durchgeführt, und zwar vor und nach dem Experiment. Die statistische Analyse wurde mit dem Student's *T*-Test vorgenommen (die Daten waren als Mittelwert±SA präsentiert). Am Ende des Experimentes waren die Werte für den Oberschenkelumfang (TC) des verletzten Beines näher dem Oberschenkelumfang des unverletzten Beines von EG Patienten (47,16±2,12 vs. 47,57±2,63 cm, p>0,05) als den Werten der Kontrollgruppepatienten (46,70±2,52 vs. 48,38±2,78 cm, p<0,05). Es wurde auch bemerkt, dass die MTM während der Kontraktion des Muskels quadriceps femoris der verletzten Extremität die Werte zeigte, die näher den Werten einer unverletzten Extremität der EG-Patienten (113,14±5,56 vs. 114,64±4,08 Einheiten, p>0,05) sind, als den Werten, die für die Extremitäten der Kontrollgruppe (88,78±7,66 vs. 115,86±4,39 Einheiten, p<0,001) erhalten wurden. Die EG-Patienten hatten bessere MMT Ergebnisse am Ende des Experiments als die CG-Patienten (4,99±0,05 vs. 4,33±0,26, p<0,001). Aufgrund der Ergebnisse dieser Studie lässt sich folgern, dass die Eiweißzusatzdiät während der Bewegungstherapie nach der arthroskopischen Knieoperation bei Fußballspielern einen positiven Beitrag zur Behandlung der Quadricepshypotrophie leisten kann.

Schlüsselwörter: *arthroskopische Knieoperation, Muskel quadriceps femoris, Rehabilitation, Myotonometrie, manuelles Testen des Muskels*

Introduction

Knee injuries are among the most common injuries sustained by athletes, while meniscal lesions and anterior cruciate ligament (ACL) tears are the most common injuries of soccer players (Tucker, 1997). Treating knee injuries by partial arthroscopic meniscectomy or by meniscal repair allows patients to be able to walk without support within 1 to 3 days after surgery, resume athletic training within two to three weeks and return to competition in three- to four-week time (St-Pierre, 1995). After arthroscopic repair of an ACL rupture the rehabilitation procedures aim at the rapid return of the athlete to sport participation within 10 to 12 months (Shelbourne & Nitz, 1990). As these two types of injuries usually affect professional soccer players, it is of vital importance to apply intensive kinesitherapeutic procedures to shorten the convalescence period by managing effectively the hypotrophy and the reduced capacity of the quadriceps muscle of thigh, the two conditions most often accompanying these injuries (Barber, 1994; Shelbourne & Wilkens, 1990; Spassov, 1998). Rehabilitation of the quadriceps femoris muscle is the cornerstone of full recovery after inactivity, immobilization or surgery of the knee (Antich & Brewster, 1986; Osteras et al., 1998). Muscle strengthening programmes include pain--free exercises which provide a faster progression of treatment and shorter rehabilitation period.

Various types of rehabilitation programmes have been described and used with the main purpose of recovering the structure and function of the quadriceps and the knee joint (Ellen, Young, & Sarni, 1999; Patkowski, Les, & Kalinowski, 1993; Paulos, Wnorowski, & Beck, 1991; Stanish & Lai, 1993; Tegner, 1990; Wheatley, Krome, & Martin, 1996). However, in spite of the wide variety of therapeutic procedures proposed by different authors, there have been no studies yet on the effect of high protein supplements included in the diet targeted at improving the results of the specific treatment by managing the quadriceps hypotrophy and strengthening the knee joint on the trauma-affected limb.

The present study was aimed at comparing the results of two rehabilitation programmes – with and without protein supplements in the patient's diet; we also assessed whether it is expedient to use protein supplementation in restoring the structure and function of the quadriceps after arthroscopic intervention in order to facilitate the adequate return of soccer players to active sport.

Methods

Patients

Our study sample included 56 competitive soccer players (aged 24±4.32 years, 78.98±5.34 kg) who had previously undergone arthroscopic knee surgery because of a trauma (47 patients with meniscal injury, 7 patients with anterior cruciate ligament rupture, and 2 with knee injury of another type). The time elapsed from the traumatic incident

to the actual performance of arthroscopy varied for different patients (from several days to several weeks) but all the patients had a pronounced hypotrophy and reduced capacity of the quadriceps as a result of the sparing regimen and the immobilisation of the knee joint. The patients were allocated to two groups – experimental (n=28) and control (n=28) (Table 1). Both groups were subjected to an identical post-operative rehabilitative programme. Unlike the controls, however, the experimental group received a daily high--protein dietary supplement in addition to the standard and controlled diet.

Diet and dietary supplementation

All patients received an identical controlled diet – 2800±300 kcal/24 h (11.7±1.3 MJ/24 h). The experimental group patients received in addition a high-protein milk-egg supplement (Table 2) by 1.0 g/kg body weight per day of their rehabilitation programme. The supplement contained a combination of milk whey and egg proteins with a high assimilability and biologic value (Protein Efficiency Ratio = 3.30) (Boyadjiev, Popov, & Hristov, 1992; World Health Organization Technical Report, 1985).

Table 2. Total chemical (g/100 g of product) and amino acid (g/100 g of protein) composition of the high--protein dietary supplement

	Protein		90.5
	Fats		1.0
	Carbohydrates		2.4
	Salts and vitamins		2.1
	Moisture		4.0
	Energy (kJ)		1 640.0
essential amino acids		*non-essential amino acids*	
Valine	5.5	Alanine	4.4
Isoleucine	5.1	Arginine	6.6
Leucine	8.1	Aspartic acid	10.3
Lysine	6.8	Glycine	3.4
Methionine	2.1	Glutamic acid	17.5
Cystine	1.5	Proline	5.2
Threonine	4.5	Serine	5.7
Tryptophan	1.3	Histidine	2.9
Tyrosine	3.9		
Phenylalanine	5.2		

Knee joint and quadriceps muscle assessment

To evaluate the mobility of the knee joint we used the standard anglemetry. The functional state of the quadriceps femoris muscle was evaluated by myotonometry (MTM) at rest and at maximal isometric contraction with myotonometer (Szirmai, Hungary) and by manual muscle testing (MMT) (Bohannon, 1986; Halpern, Beck, & Nesse, 1980; Silver et al., 1970). The hypotrophy severity and muscle recovery after it were determined by measuring the circumference of the thigh. All parameters were measured at the beginning and at the end of the experiment on the injured and uninjured legs by one and the same research team.

Table 1. Description of the experimental and control groups

Groups	Age (years)	Arthroscopic knee surgery because of			Time elapsed from the trauma to the arthroscopy (days)
		meniscal injury	ACL-rupture	other knee injury	
Experimental group (n=28)	23.1±5.26	24 cases	3 cases	1 case	8.93±3.86
Control group (n=28)	25.0±4.18	23 cases	4 cases	1 case	9.00±4.36

Legend:
ACL = anterior cruciate ligament
n = number of subject

The amino acid content of the supplement was balanced using the method of linear optimisation of the content of nutritional mixtures (Dragoev et al., 1992), the essential amino acids comprising 44% and the branched-chain amino acids 18.7% of all.

Rehabilitation programme

The rehabilitation programme was identical for both groups. It started on the first day and continued until day 40 after the operation. The programme was realised in three stages (Table 3): stage I – from the day following surgery to day 12, stage II – from day 13 to day 20, and stage III – from day 21 to day 40.

Statistics

Statistical indices were computed for each group and for all variables (StatView 4.51 Statistical Software, Abacus Concepts Inc, Berkely, California, USA). Student's *t*-test was

Table 3. Rehabilitation programme for the patients of the experimental and control groups

Stage I (Day 1 to day 12 postoperatively)	**Stage II** (Day 13 to day 20 postoperatively)	**Stage III** (Day 21 to day 40 postoperatively)
A. Days 1 and 2: - Active flexion of knee joint to 50°. - Isometric contractions of quadriceps femoris muscle. - Mobilization of the patella. - Isotonic contractions including the antagonists and muscles in the hip joint and the tibia. - Contralateral contractions. - Passive movement therapy: elevation of the leg combined with cryotherapy and isometric muscle contractions. - Instruction how to walk unaided. *B. Day 3 to day 12:* - Active flexion of knee joint to 90°. - Continuation of kinesitherapy started in A - Suspension therapy – resorptive and trophic technique. - Cryotherapy with a metal tube and a percutaneous application drug. - Electric stimulation of quadriceps femoris muscle, superimposed technique with no resistance.	- Active full flexion of knee joint - Pulley therapy for quadriceps femoris muscle - Superimposed electric stimulation against a resistance of 2% of body weight at the beginning and 4% of body weight at the end of stage II - Cycle ergometry - Manual and subaquatic massage	*A. Day 21 to day 25* - Continuation of kinesitherapy started in stage II. - Superimposed electric stimulation of quadriceps femoris muscle against a resistance of 5% of body weight, amplitude 0° - 30° - Pulley therapy for quadriceps femoris muscle - Cycle ergometry - Swimming *B. Day 26 to day 30* - Superimposed electric stimulation of quadriceps femoris muscle against a resistance of 7% of body weight, amplitude 0° - 30°, 3 cycles. - Pulley therapy for quadriceps femoris muscle – submaximal technique. - Cycle ergometry - Individual running programme - Swimming - Fitness exercises *C. Day 31 to day 40* - Superimposed electric stimulation of quadriceps femoris muscle against a resistance of 7% of body weight, amplitude 0° - 90°, 3 cycles. - Pulley therapy for quadriceps femoris muscle – hypertrophic technique. - Cycle ergometry - Swimming - Fitness exercises - Long-distance running

performed. All data are presented as mean (±SD). Values at the 0.05 level were accepted as being statistically significant.

Results

Thigh circumference of the injured and uninjured limb *(Table 4)*

The severity of the quadriceps hypotrophy and its successful management during rehabilitation were assessed by measuring the thigh circumference of the injured limb and comparing it with that of the uninjured limb. The circumference of the injured limb's thigh in the experimental group at the baseline was significantly smaller than that of the uninjured limb (44.05±2.02 vs. 47.54±2.27 cm, $p < 0.001$) with a mean difference of 3.57±0.78 cm between the two limbs. There was also a significant difference between the baseline values of the injured and uninjured limbs of the controls (44.93±2.38 and 48.61±2.94 cm, respectively, $p<0.001$) with a difference of 3.82±0.80 cm between them.

At the end of the experiment, however, the thigh circumferences of the injured and uninjured limbs of the experimental group patients had become equal (47.16±2.12 vs. 47.57±2.63 cm, respectively, $p>0.05$), with a non-significant difference of 0.41±0.41 cm between them. The thigh circumference of the injured limb of the controls at the end of the experiment remained smaller than that of the uninjured limb (46.70±2.51 vs. 48.38±2.78 cm, $p<0.05$), retaining the significant difference of 1.75±0.75 cm between them.

Table 4. Thigh circumference (cm) of the injured and uninjured limbs of the patients of the experimental and conrol groups at the beginning and end of the experiment

	Experimental group		Control group		Differences between the groups			
Variable	Beginning	End	Beginning	End	p1-p2	p3-p4	p1-p3	p2-p4
	1	2	3	4				
1. Circumference of the thigh of the injured leg	44.05±2.02	47.16±2.12	44.93±2.38	46.70±2.51	0.001	0.01	NS	NS
2. Circumference of the thigh of the uninjured leg	47.54±2.27	47.57±2.63	48.61±2.94	48.38±2.78	NS	NS	NS	NS
3. Differences of the circumferences between the injured and uninjured legs	3.57±0.78	0.41±0.41	3.82±0.80	1.75±0.75	0.001	0.001	0.001	0.001

Table 5. MTM (units) of m. quadriceps femoris of the injured and uninjured limbs of the patients of the experimental and conrol groups at the beginning and end of the experiment

	Experimental group		Control group		Differences between the groups			
Variable	Beginning	End	Beginning	End	p1-p2	p3-p4	p1-p3	p2-p4
	1	2	3	4				
1. MTM at contraction of the injured leg	73.78±11.56	113.14±5.56	68.93±6.72	88.78±7.66	0.001	0.001	NS	0.001
2. MTM at contraction of the uninjured leg	113.21±5.53	114.64±4.08	115.78±4.50	115.86±4.39	NS	NS	NS	NS
3. Difference in MTM scores at contraction between the injured and uninjured leg	39.43±13.96	2.36±3.18	47.21±6.89	26.71±9.88	0.001	0.001	0.05	0.001
4. MTM at rest of the injured leg	60.28±7.30	61.57±5.64	55.64±3.73	55.64±2.72	NS	NS	0.01	0.001
5. MTM at rest of the uninjured leg	62.43±5.45	62.78±5.89	55.78±3.66	55.93±3.50	NS	NS	0.001	0.001
6. Difference in the MTM scores at rest between the injured and uninjured legs	2.14±4.58	1.21±1.99	0.14±4.80	0.28±2.59	NS	NS	NS	NS

Legend:
NS = no score

Myotonometry of the quadriceps of the injured and uninjured limb (Table 5)

a. MTM at contraction: At the beginning, the *m. quadriceps femoris* tonus of the injured limb in the experimental group during contraction was significantly lower than that of the uninjured (73.78±11.56 vs. 113.21±5.53 units, respectively, $p<0.001$) with a difference between them of 39.43±13.96 units. These baseline characteristics in the control group patients was 47.21±6.89 units (68.93±6.72 vs. 115.78±4.50 units, respectively, $p<0.001$).

At the end of the experiment the controls retained the same significant difference in this parameter of 26.71±9.88 units (88.78±7.66 vs. 115.86±4.39 units, respectively, $p<0.001$); this difference in the experimental group receiving the protein supplement was negligible: 2.36±3.18 units (113.14±5.56 vs. 114.64±4.08 units, $p>0.05$).

b. MTM at rest: There was no difference between the quadriceps tonus at the beginning and end of the experiment both in the experimental and control groups.

Manual muscle test (MMT) of the m. quadriceps femoris (Figure 1)

The muscle strength of the quadriceps muscle was assessed by employing the manual muscle test. The test was performed by three measurers. The patients from the experimental group exhibited an increase of knee extension strength on manual muscle testing from grade 3.66±0.12 to grade 4.99±0.55 at the end of the experiment ($p<0.001$). Also significant ($p<0.001$) but to a smaller degree, was the increase of the muscle strength in the patients of the control group - from grade 3.57±0.12 to grade 4.33±0.26 at the end of the experiment.

Discussion and conclusions

The characteristics of the patients of both groups, that we established immediately after the operation, are quite typical of the cases of pronounced quadriceps hypotrophy observed in knee injuries of long duration (Antich & Brewster, 1986; Osteras, Augestad, & Tondel, 1998; Paulos, Wnorowski, & Beck, 1991; St-Pierre, 1995; Stanish & Lai, 1993; Vervest et al., 1999). At the beginning of the experiment there was no difference between the two groups in the severity of the hypotrophy assessed by the circumference of the thigh of the injured leg: 44.05±2.02 cm for the controls versus 44.93±2.38 cm for the experimental group ($p>0.05$). At the end of the experiment the hypotrophy was successfully managed in both groups by the kinesitherapeutic programme, the thigh circumference of the group receiving protein supplement being greater by 7.1% (only by 3.9% in the controls) and equal to that of the uninjured leg.

It is well known that supplementing the diet with protein, especially one with high value (Protein Efficiency Ratio > 3.0) realised along with systemic physical exercise of the muscles, can effect an increase in the protein anabolism and bring about a considerable muscle hypertrophy (Widdowson, 1993). An increase of growth performance (incl. muscles) could be achieved through improved protein quality. This is usually obtained by supplementing the diet with the controlled amounts of amino acids. More generally, adjusting the supplies of essential amino acids to an 'ideal' protein pattern should be a way of expressing completely the growth potential of muscles. In our case the experimental group received a supplement to the diet of 1.0 g/kg/day (~100% RDA) of protein (US Food and Nutrition Board, 1989). The possible relationships between changes in protein turnover after protein supplementation and hormone concentrations (e.g. insulin, IGF-1 and glucocorticoids) have been discussed but have not yet been established (Grizard et al., 1995).

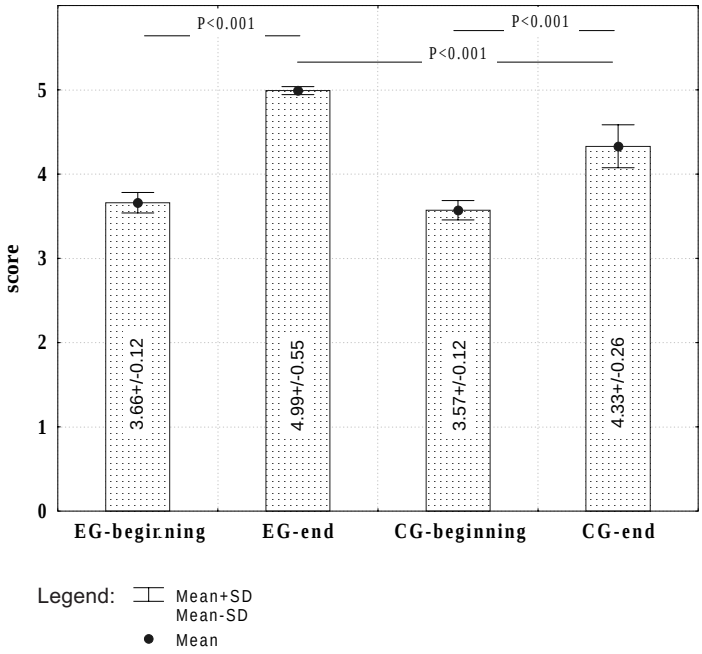

Figure 1. MMT score of quadriceps muscle of the experimental (EG) and control (CG) groups at the beginning and at the end of the experiment.

The positive effect of the protein supplementation, applied together with kinesitherapy for 40 days, was also shown unequivocally by the functional study of the quadriceps using myotonometry and the manual muscle test of the knee joint. While the tonus at contraction of the injured leg quadriceps in the control group increased by 28.8% without reaching that of the uninjured leg, the tonus of this muscle in the experimental group increased by 53.3% and became equal with the quadriceps tonus at contraction of the uninjured leg.

The higher grade that the MMT found in the knee joint of the operated limb in the protein-receiving group compared with that found in the controls at the end of the experiment after conducting of a 40-day rehabilitation programme also confirmed the advantages of including a high-protein supplement in the diet in such cases.

The results clearly suggest the efficaciousness of the applied kinesitherapeutic programme in competitive soccer players after arthroscopic knee surgery because of a knee injury; it adequately deals with the muscle hypotrophy. The results are considerably better when this rehabilitation programme is carried out alongside a supplementation of the diet with high biological value protein in a dose of 1.0 g/kg/day for a period of 40 days.

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PROTEINSKA DOPUNA PREHRANI POBOLJŠAVA REZULTATE REHABILITACIJE NOGOMETAŠA NAKON ARTROSKOPSKE OPERACIJE KOLJENA

Sažetak

Uvod

Učinkovita rehabilitacija mišića kvadricepsa femorisa osnovno je pitanje potpunog oporavka nakon imobilizacije i operacije koljenskog zgloba. Koristi se široki raspon kineziterapijskih postupaka kojima se sportašu osigurava što brži povratak u trening i natjecanje.. Cilj ovog rada bio je istražiti jesu li za pacijenta proteinski dodaci prehrani nakon artroskopske operacije koljena, uz provedbu opsežnog kineziterapijskog programa, dodatno korisni.

Metode

Uzorak ispitanika. U istraživanje je uključeno 56 pacijenata, aktivnih sportaša nogometaša u nogometu. Od tih pacijenata 47 imalo je artroskopsku operaciju zbog ozljede meniska, a 7 zbog rekonstrukcije prednjeg križnog ligamenta (ACL). Ispitanici su slučajnim odabirom raspoređeni u dvije grupe, po 28 u svakoj, u kontrolnu (CG) i eksperimentalnu (EG). Pacijenti u objema grupama prolazili su jednak kineziterapijski tretman. Svi su se pacijenti standardno hranili, s time da su pacijenti iz eksperimentalne grupe dobivali i proteinsku suplementaciju, i to dnevno 1 g/kg visokokvalitetnog mlijeka i proteinskog dodatka na bazi jaja (sadrži 90,5% proteina).

Uzorak varijabli. Kineziološka evaluacija koljenog zgloba i mišićnog sustava provedena je pomoću miotonometrije (MTM) mišića kvadricepsa femorisa, mjerenja opsega natkoljenice (TC), amplitude pokreta u koljenom zglobu te manualnog mišićnog testiranja (MMT), i to na ozlijeđenoj i neozlijeđenoj nozi prije i nakon intervencije.

Rezultati i rasprava

Za statističku analizu dobivenih podataka uporabljen je Studentov *t*-test. Podaci su prikazani kao aritmetička sredina ± standardna devijacija.

Ozbiljnost hipotrofije kvadricepsa femorisa, kao i uspješno zbrinjavanje te popratne pojave ozljede koljena, procijenjena je na osnovi usporedbi mjera opsega natkoljenice ozlijeđene i neozlijeđene noge. Mjera TC bedra ozlijeđene noge kod pacijenata iz eksperimentalne grupe u inicijalnoj točki mjerenja bila je statistički značajno niža nego vrijednost TC bedra neozlijeđene noge (44.05±2.02 naspram 47.54±2.27 cm, $p<0.001$), s prosječnom razlikom od 3.57±0.78 cm. Također je utvrđena statistički značajna razlika istih mjera u inicijalnoj točki mjerenja kod pacijenata iz kontrolne grupe (44.93±2.38 i 48.61±2.94, $p<0.001$), s prosječnom razlikom od 3.82±0.80 između mjera dobivenih na ozlijeđenoj i neozlijeđenoj nozi. Na kraju eksperimenta, međutim, došlo je do izjednačavanja mjera opsega natkoljenice ozlijeđene i neozlijeđene noge pacijenata eksperimentalne grupe, tj. nije utvrđena statistički značajna razlika. U eksperimentalnoj grupi dobivene su vrijednosti za ozlijeđenu i neozlijeđenu nogu 47.16±2.12 naspram 47.57±2.63 cm, $p>0.05$, s prosječnom razlikom 0.41±0.41. Vrijednosti mjera TC na ozlijeđenoj nozi ostale su niže u kontrolnoj grupi od onih dobivenih na neozlijeđenoj nozi (46.70±2.51 naspram 48.38±2.78 cm, $p<0.05$), tj. utvrđena je prosječna statistički značajna razlika od 1.75±0.75 cm.

Na samom početku eksperimenta, kod pacijenata eksperimentalne grupe tonus je za vrijeme kontrakcije mišića kvadricepsa femorisa ozlijeđene noge bio statistički značajno niži od tonusa istog mišića neozlijeđene noge (73.78±11.56 naspram 113.21±5.53 jedinica, $p<0.001$), s prosječnom razlikom od 39.43 ±13.96 jedinica. Te iste karakteristike kod pacijenata kontrolne grupe bile su 47.21±6.89 jedinica u prosjeku (68.93±6.72 naspram, 115.78±4.50, $p<0.001$). Na kraju eksperimenta je kod pacijenata kontrolne grupe utvrđena jednaka, statistički značajna razlika ovog parametra za vrijeme kontrakcije od, u prosjeku, 26.71±9.88 jedinica (88.78±7.66 naspram 115.86±4.39, $p<0.001$); dok je kod pacijenata eksperimentalne grupe koji su primali proteinsku suplementaciju razlika bila zanemariva: 2.36±3.18 jedinica (113.1±5.56 naspram 114.64±4.08 jedinica, $p>0.05$).

Ni u pacijenata eksperimentalne ni u pacijenata kontrolne grupe nije dobivena statistički značajna razlika inicijalnih mjera tonusa mišića kvadricepsa femorisa u mirovanju u odnosu na mjere nakon provedene intervencije.

Na temelju ocjena dobivenih ručnim testiranjem mišića utvrđeno je da je nakon provedenog eksperimenta kod pacijenata eksperimentalne grupe došlo do značajnog povećanja snage mišića pri ekstenziji u koljenom zglobu, i to s ocjene 3.66±0.12 na 4.99±0.55 ($p<0.001$). Također je utvrđen značajan, ali slabiji pozitivan pomak u povećanju mišićne snage u pacijenata iz kontrolne grupe, i to s ocjene 3.57±012 na 4.33±0.26 ($p<0.001$).

Zaključak

Rezultati jasno oslikavaju učinkovitost primijenjenog kineziterapijskog programa kod nogometaša, aktivnih natjecatelja, nakon artroskopske operacije koljena zbog ozljede, kojim se adekvatno može sanirati hipotrofija mišića. Rezultati su znatno bolji ako se program poprati suplementacijskom dijetom na bazi proteina s visokom biološkom vrijednošću u dnevnoj dozi od 1,0 g/kg tijekom četrdeset dana.

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