XBody Hungary Kft.

1125 Budapest, György Aladár u. 35-39.

APPLICATION OF WHOLE-BODY ELECTRICAL MUSCLE STIMULATION IN PROFESSIONAL SPORT

Rui Morbey

and

XBody Medical Expert Team

TABLE OF CONTENTS

1. Introduction

Electrical muscle stimulation (EMS) is the elicitation of muscle contraction using electric impulses. EMS has received an increasing amount of attention in the last few years for many reasons. EMS is capable of increasing muscle mass, strength and muscle power. Beyond that, it helps with the conditioning of healthy muscles. Further beneficial effects of EMS are also known, such as helping in weight control or being a solution for conditions such as cellulite. Also, it can be applied as a rehabilitation tool for balancing muscle imbalances caused by inappropriate muscle usage or restructure muscles damaged during aging or injuries.

The electric impulses are generated by EMS devices (XBody EMS devices) and delivered through cables to the electrodes on the skin surface of the muscles to be stimulated. Due to these impulses, the action potential is triggered in a similar way as in the case of impulses coming from the central nervous system. The resulting muscle contraction is similar to the natural movement and regular contractions of the muscles. Depending on the parameters of the electrical impulses (impulse frequency, impulse width, ramp-up, impulse duration, duration of rest), different types of muscle work can be imposed thus improving and facilitating muscle performance of the stimulated muscles.

2. EMS in professional sport

2.1. Training for optimal results

In the professional sports field, where strength, power, and speed is vital, this unique technology combined with sport-specific workout leads to a reduction of time needed for improving specific athletic skills and anaerobic power production. The EMS-evoked contractions have a beneficial effect on vertical jump ability (Squat Jump, Drop Jump, Counter Movement Jump), sprint performance (e.g. linear sprint running for 10 m, and sprint with direction changes) and sport-specific skills or tasks, such as kicking performance among soccer players or round-off salto backward tucked in case of gymnastics.

As deduced from the scientific results, it is recommended to integrate EMS training into the specific professional athlete’s training protocol. By this integration diversity and variability can be ensured, which enhances motivation and results in better performance in a shorter time. According to other scientific researches, besides adapting EMS to a professional training protocol to improve sport-specific skills, EMS also proved to be an alternate method for recovery after any kind of hard sports activity. It is primarily due to the fact, that the application of EMS resulted in significant reduction in blood lactate concentration, creatine kinase level, perceived muscle soreness and self-reported recovery compared with the implementation of other recovery strategies. The integration of EMS seems a good choice for professional athletes, e.g. soccer players, swimmers, and baseball players to improve recovery from intensive training, therefore reduce fatigue and the risk of overload injuries.

- **Deley et al.** examined the effect of a 6-weeks EMS training combined with gymnastics training program on isometric muscle strength and vertical jump ability of prepubertal women gymnasts. The measurement was evaluated by isokinetic tests, standard (Squat jump, Counter Movement Jump, Reactivity test) and 3 sport-specific jumping tests. In the group, which received EMS training in addition to the sport-specific gymnastic training, a significant improvement was observed in muscle strength of the knee extensors and vertical jumping performance. In the control group, which received only daily gymnastics training has no significant differences in the above-mentioned parameters. The main findings of the study indicated that a 6-weeks combined EMS and daily gymnastic training is able to improve the muscle strength and jumping performance of prepubertal women gymnasts significantly. These increased values can be sustained for 1 month after the end of the 6-weeks EMS training program. [1]
- The experiment of **Babault et al**. was conducted to investigate the improvement of strength and power of professional rugby players due to a 12-weeks EMS training program. The maximal voluntary torque of the knee extensor muscles, a squat test as a concentric strength test, vertical jumping tests (Squat Jump, Drop Jump, Counter Movement Jump) and a sprint test were evaluated during the examination. After a 12-weeks training program, significant improvement was observed in the maximal eccentric and concentric torque of the knee extensor muscles, in concentric muscle strength and vertical jumping ability (Squat Jump and Drop Jump) compared with the control group, where these significant improvements were not demonstrated. As deduced from the results, EMS training can be an effective tool for increasing muscle strength and power in elite rugby players. [2]
- **Benito-Martínez et al.** examined the effects of an 8-weeks combined EMS and plyometric training on the ability of vertical jumping and speed in mid-level sprinter athletes. As deduced from the results, in order to improve vertical jump ability, the application of EMS before plyometric training is needed, for sprinter athletes, the same application (EMS prior to plyometric training) or the combination of the two training types is the best way. Despite this, for improving both the vertical jump and speed performance the combined training

version is not recommended. An increased muscle strength can be achieved in a shorter time compared to the speed ability by the application of the combined training method. [5]

- The study of **Maffiuletti et al.** provides a comparison between a 4-weeks EMS training program, plyometric training program, a combined EMS and plyometric training program on jumping ability, sprinting time, maximal voluntary isometric strength and muscle cross-sectional area among healthy adults. The results demonstrated that jumping ability and sprinting performance can be enhanced by a combined training (EMS and plyometric), furthermore EMS training or EMS combined with plyometric training is able to increase the maximal voluntary strength and achieve hypertrophy on the targeted muscle groups. [6]
- A study of **Wahl P. et al.** investigated the influence of neuromuscular electrical stimulation (NMES) on myokines and markers of muscle damage in healthy individuals. The measured parameters include Interleukin-6 (IL-6), brain-derived neurotrophic factor (BDNF), creatine kinase (CK) and myoglobin. The absence of a significant change was observed in CK, myoglobin levels, BDNF, and IL-6 in the group where cycling and electrical muscle stimulation were combined, therefore muscle soreness was the highest in this group compared to the other two group (electrical muscle stimulation group, cycling group). The conclusion of this study, the application of NMES during cycling may be able to enhance the endurance training effect without performing high external workloads. [7]
- The purpose of **Neric et al.** was to compare the changes in blood lactate removal during passive resting recovery, submaximal swimming recovery and recovery with the application of electrical muscle stimulation (EMS) among competitive swimmers. However submaximal swimming recovery proved the most effective type of recovery, the results demonstrated a significantly better-decreased blood lactate concentration (50%) evoked by EMS contrary to passive resting recovery, where this observed value was 35%. The study concludes that EMS can be utilized as an effective alternate recovery treatment for reducing blood lactate level. [8]
- The study of **Girold S. et al.** provides a comparison between a 4 weeks dry-land strength training and electrical muscle stimulation (EMS) program on 50m sprint swimming performance in case of competitive swimmers. At the end of the training program, a significant increase was found in swimming velocity, peak torque, and swimming performance during the 50m front crawl in both groups, whereas there was no significant difference in the control group. In the EMS group, significant improvement was observed in

isometric and eccentric torque compared to the dry-land strength training group. It was concluded that a combined training program (combination of a swimming training with a dry-land or EMS training) is more efficient, than the swimming program alone, thanks to the significant gain observed in sprint performance. [9]

- **Finberg M. et al.** assesses the benefits of different recovery methods, such as passive resting protocol, electrical muscle stimulation (EMS) and water therapy in moderately trained athletes. Significantly faster sprint times were recorded during the 24 hours post recovery in the EMS group compared the passive group, but there was no significant difference between EMS and water therapy group or between the passive and water-therapy group. In addition, the application of EMS resulted in significantly greater perceived recovery than the other groups. [10]
- The aim of **Warren CD et al. was** to evaluate the effects of different recovery methods, such as passive, active and electrical muscle stimulation (EMS) on range of motion (ROM), heart rate (HR), rating of perceived exertion (RPE) and blood lactate concentration in 21 baseball pitchers during a simulated game. From post-pitching to post-recovery significant decreases were determined in blood lactate concentration in the EMS group, while significant changes were not observed in the other groups. EMS and passive recovery protocols led to decreased RPE, while a decrease in HR occurred in both groups. There was no significant influence on ROM in both recovery protocols. Based on these measurements, the application of EMS proved the most effective way in the reduction of blood lactate concentration between innings. [11]
- **Beaven CM et al.** investigated the psychometric and physiological effect of compression garments intervention and electrical muscle stimulation (EMS) in professional rugby players during the recovery period. Thanks to the combined treatment, enthusiasm and other beneficial changes in self-assessed energy levels were found compared to cases when compression-garment was used. With the help of EMS, creatine kinase can return to baseline levels after 2 preseason rugby games, in contrast with the usage of the compression garment. In the case of professional rugby players, better self-reported and physiological recovery are expected due to the combination of lower body compression garment and EMS. [12]

- The experiment of **Courtney D. et al.** was conducted to investigate the effects of passive, active (jogging) or electrical muscle stimulation (EMS) recovery method after an inning of pitching. The measurements included the blood lactate concentration, a physiological and a pitching speed test. EMS proved the most effective recovery protocol in reducing blood lactate concentration (significant decrease was observed), furthermore better self-reported, perceived recovery results and higher average pitching speed were achieved by and passive recovery, than active recovery. Based on the measurements, the application of EMS as a recovery method is a good choice for baseball players, thanks to the greater decrease in blood lactate concentration and better-perceived recovery. [13]
- The purpose of **Taylor T. et al.** was to investigate the electrical muscle stimulation (EMS) as a recovery strategy in 28 professional rugby and football players. EMS was applied after the sprint performance, while the control group received nothing during the 24 hours recovery period. Significant reduction in creatine kinase level and perceived muscle soreness were observed in the EMS group after 24 hours post sprint, these significant changes were not observed in the control group. According to the authors, EMS is an easily applicable recovery protocol that enhances recovery from intensive training in professional team sports players. [14]

2.2. Slow and fast twitching muscle fibers

For athletes, the dominance of the muscle fiber type might be essential during workouts. People have two general types of skeletal muscle fibers. Slow-twitch (type I) and fast-twitch (type II). Slow-twitch muscle fibers (type I) generate less power and strength than fast-twitch fibers (type II). Slow-twitch fibers could sustain activity for a longer period. In slow-twitch muscle fibers, there is a high-density of capillaries, which helps bring blood to the muscles. For example, during a marathon, slow-twitch muscle fibers are used primarily. Fast-twitch muscle fibers generate far more power and strength, but they fatigue much faster and require more time for recovery. In sprint or jumping, fast-twitch muscle fibers are used in the first instance.

Frequency can determinate which type of muscle fibers are activated during the training. Slow-twitch muscle fibers can be activated between 1-35 Hz (contraction intensity near to maximum at 10 Hz), and fast twitching muscle fibers above 30 Hz. Over 30 Hz firstly type 2a fast muscle fibers are activated and above 45 Hz type 2b can be activated.

2.3. Prevention and rehabilitation

EMS has several known beneficial effects in clinical applications. It can be used for preventive and rehabilitation purposes in neurology, orthopedics, rheumatology and many other medical fields.

- muscle strengthening, conditioning and increasing muscle mass,
- relaxation of muscle spasm,
- increasing local blood circulation,
- muscle re-education,
- prevention or retardation of disuse atrophy,
- prevention of venous thrombosis of the calf muscles immediately after surgery,
- maintaining or increasing the range of motion.

For athletes, the time needed for rehabilitation can be significantly shorter after with the help of EMS technology.

3. Soccer players

Filipovic et al. investigated the effects of a 14-weeks WB-EMS training program on the performance of elite soccer players. The anthropometric parameters, sprinting performance (linear and sprint with direction changes), vertical jumping performance, maximal muscular strength and blood parameters (CK, IGF-1) were measured by the scientists. Significant changes were demonstrated in maximal muscle strength (1RM), sprinting and vertical jump performance, kicking capacity, and CK serum levels after 24 hours the training. Based on the results, the authors proved that the integration of a 14-weeks in-season WB-EMS training into soccer player training program has a beneficial impact on soccer-specific abilities. [3]

Billot et al. designed the study to examine the effect of a 5-weeks EMS training program on sports performance in amateur soccer players. The supposed enhancement in strength production was measured by using an isokinetic dynamometer. The participants completed a ball speed measurement to evaluate the kicking performance, vertical jump tests, and 10m sprint test during the examination. A significantly increased eccentric, isometric, and concentric torques and ball speed were observed by the scientists whereas these improvements were not founded in the control group. It was concluded that the application of EMS on the quadriceps muscles over 5 weeks is an effective tool for improving force and specific soccer tasks. [4]

Based on the previously mentioned studies we hypothesized that an EMS-elicited contraction would be helpful for improving soccer player's sport-specific skills and performance.

4. XBody EMS Training for soccer players

4.1. Subjects

Two subjects participated in the study. Subject A was 28 years old and 170 cm tall. Subject B was 22 years old and 185 cm tall. The exclusion criteria included the contraindications that are described in the XBody Client's consent.

4.2. Procedure

Whole body-EMS (WB-EMS) device enables to stimulate the main muscle groups simultaneously. These muscle groups are the trapezius, back, lower back, pectoral, abs, glutes, quadriceps, hamstrings, arms, optional (e.g. shoulders, calves).

4.2.1. WB-EMS procedure for one competition per week

At the beginning of the season, both subjects performed one competition per week. EMS training was integrated into their training plan based on the following table:

Days	1	2	3	4	5	6	7
Training	Competition	WB-EMS for recovery and structural mobilization	Conventional training	WB-EMS for improving sport specific skills	Conventional training	WB-EMS for relaxation	Rest

Table 1 Training plan for one competition per week

Both subjects participated in the same team as they performed the same match on the 1st day.

After the competition, WB-EMS training was applied for recovery and for structural mobilization. For the structural mobilization low-frequency stimulation was chosen on 9 Hz in continuous mode. In continuous mode, the stimulus is generated continuously, without impulse break periods. The pulse width was 400 µs at the subject's maximum tolerance limit. In the continuous stimulation mode, the inhale-, exhale period were synchronized to the chosen exercises (e.g. variations of cardiovascular exercises with an elastic band).

After the structural mobilization Proprioceptive Neuromuscular Facilitation (PNF) method was applied. With the previously described WB-EMS training protocol, Proprioceptive Neuromuscular Facilitation

(PNF) method was combined with WB-EMS technology for stretching and improving flexibility. PNF technique uses autogenic and reciprocal inhibition and it helps the patient gaining an increased range of motion (ROM). From the starting position, a 10 seconds long impulse was applied for a sub-maximal isometric contraction of the target muscle. After it, in the resting period (2 seconds impulse break) active stretch was used to achieve an increased ROM. The subjects were carefully instructed and helped with manual resistance by research assistants to perform the following exercises. The performance of the exercises was synchronized with the 10 seconds impulse length and 2-seconds impulse break stimulation cycle at 9 Hz. The following exercises were performed in the final 4 minutes of the training:

- Glutes stretch in laying position
- Hamstring stretch in laying position
- Abductor stretch in laying position
- Pectoral stretch in sitting/ standing position
- Latissimus dorsi stretch in a sitting/ standing position.

PNF method and structural mobilization were performed for stretching, improving flexibility and eliminating muscle differences. The described WB-EMS procedure for recovery was hypnotized to relax the spastic muscles, increase local blood circulation facilities local oxygen supply, increase metabolic rate and lymphatic circulation and helps to flush out the harmful metabolites (e.g. lactic acid). Improved structural mobilization was also achieved by the improvement of the flexibility, thus it is the prevention of injuries due to the function performed by the athlete.

On the 3rd day, both subjects participated in conventional training with their team.

The conventional training was followed by WB-EMS training for improving sport specific skills. As the two subjects play a different position, as they performed different WB-EMS Training sessions with personalized exercises.

Firstly, subject A participated in “postural training” to gain muscle for 16 sessions, because his initial FMS measurements were weak and the core muscles needed to be improved. For strengthening 80 Hz were applied in burst mode. In this mode, active stimulation (impulse length) and break periods (impulse break) follow each other. In this case, both the impulse and the impulse break were set to 3 seconds, and the impulse width was 400 µs. The performance of the exercises was synchronized with the 3 seconds impulse length and 3 seconds impulse break stimulation cycle. The following exercises were performed, such as a lateral walk with elastic band, lunge with elastic band, wood chop, and glute bridge.

After 16 sessions the FMS measurements improved significantly, thus the sport specific training could be started. As the subject A's post is a midfielder, the WB-EMS training plan was focused on developing his endurance with low-frequency stimulation (15 Hz) and cardio exercises. The following exercises were performed, such as skipping, running, sport-specific exercises according to the midfield position e.g. running with the ball with direction-changing.

In the case of subject B, the sport specific goal was to increase speed, thus his position is a striker. For this, high-frequency stimulation on 95 Hz was applied in burst mode. In this mode, active stimulation (impulse length) and break periods (impulse break) follow each other. In this case, both the impulse and the impulse break were set to 3 seconds, and the impulse width was 400 µs. The performance of the exercises was synchronized with the 3 seconds impulse length and 3 seconds impulse break stimulation cycle. For strengthening core muscles, the following exercises were performed, such as wood chop, glute bridge, lunge and variations, and for improving speed ability, sport-specific exercises were performed according to the striker position e.g. running with the ball with direction-changing.

The different WB-EMS protocol was needed because different sport specific goals should be achieved during the training. With WB-EMS the training not only can be personalized by the proper exercises but also customized stimulation parameters can help to reach their goals.

On the 5th day, both subjects participated in conventional training with their team.

On the 6th day, both subjects had a passive EMS treatment. EMS can be applied passively in a lying position without performing any type of movement. The passive treatment was completed with the previously described PNF method.

During the passive treatment the local blood circulation was increased, thus it facilities local oxygen supply increases metabolic rate and lymphatic circulation and helps to flush out the harmful metabolites (e.g. lactic acid). Thanks to PNF method an improved structural mobilization was also achieved by the improvement of the flexibility, thus it is the prevention of injuries due to the function performed by the athlete.

The last day of the week was rest day when the subject did not participate in any kind of training.

4.2.1. WB-EMS procedure for two competition per week

In the second part of the season, both subjects performed two competition per week. Their training plan was extended, and they participated in two sessions in a day (morning and afternoon training) EMS training was integrated into their training plan based on the following table:

Days	1	2	3	4	5	6	7
Morning traning	Competition	Rest	Tactical training	Competition	Rest	Tactical training	WB-EMS for relaxation
Afternoon training	WB-EMS for recovery and structural mobilization	Tactical training /Conventional training/ Massage	Rest	WB-EMS for relaxation	Tactical training	Conventional training	Rest

Table 2 Training plan for two competition per week

As both subjects participated in the same team as they performed the same match on the 1st day morning.

In the afternoon WB-EMS session was applied for recovery and structural mobilization. For the structural mobilization and eliminating the muscle differences low-frequency stimulation, for stretching (PNF) method was applied as it is described previously.

The 2nd day morning was rest, but the afternoon they had the tactical or conventional training or if they had significant fatigue they only had a massage. It was decided by the coach of the team.

The 3rd day started with a tactical training and on the afternoon, there was no training session.

On the 4th day, they participated in the second competition during the week. After it, WB-EMS training was applied for relaxation. WB-EMS was used passively in a lying position without performing any type of movement. The passive treatment was completed with the previously described PNF method.

The 5th day started with rest in the morning and it was followed with tactical training.

On the 6th day they had tactical training in the morning and in the afternoon they had a conventional training.

The last day on the morning passive WB-EMS session was combined with PNF method and in the afternoon, there was no any kind of training session.

4.3. Measurements

4.3.1. Anthropometry measurements

Anthropometry measurements of height, weight, and body composition were applied. The body composition was determined by multifrequency, whole-body bioelectrical impedance technique (TANITA - OMRON BF511)

4.3.2. Functional Movement Tests (FMS)

Nowadays people are working to improve their flexibility, strength, endurance, and power in order to become stronger and healthier, despite being aware of the deficiency in their fundamental movements. If these fundamental weaknesses are not exposed, it can lead to muscular dysfunction, compensation, and even fatigue or pain, and due to these changes the training programs cannot improve the client's fitness and health in an effective way.

In the interest of individualizing each workout, it is important to determine who possesses, or lacks, the ability to perform certain essential movements.

The intended use of Functional Movement Screen (FMS) is to evaluate the quality of movement patterns for clients with identifying imbalances in mobility and stability during seven fundamental patterns.

By applying this innovative system the trainer can learn a simple and quantifiable method for defining basic movement abilities, identifying asymmetries, which result in functional movement deficiencies.

- The main FMS tests are Deep Squat, Hurdle Step, In-line Lunge, Active Straight-leg Raise, Trunk Stability Push-up, Rotary Stability, Shoulder Mobility, Clearing tests.
- The scores range from zero to three, see the four basic scores below:

Test Scoring	Evaluation	Category
3	perform the movement without compensation	Excellent
2	complete the movement with compensation	Fair
1	unable to complete the movement	Poor
0	pain appears	Bad

Table 3 FMS evaluation

Clearing Tests	
+ (positive)	pain → score will be “0” for the associated test
- (negative)	no pain

Table 4 Clearing Test evaluation

- **0:** A score of zero is given if the pain is associated with the test. In this case, a medical examination of this painful area is recommended.
- **1:** A score of one is given if the client is unable to complete the movement pattern or is unable to assume the position to perform the movement.
- **2:** A score of two is given if the client is able to complete the movement but the exercise is accomplished with any compensation.
- **3:** A score of three is given if the client performs the movement properly without any compensation.
- The majority of the FMS tests need to be done on both sides with scoring the left and right sides as well. The lower score of the two sides is recorded and is counted toward the total scores. In addition, it is useful to make notes about the imbalances between the right and left sides.

Further details about FMS are contained in the XBody Training Protocols document.

4.3.1. Alteration of Léger-Navette test

An alteration of Léger-Navette test (LN) was used to identify the improvement of the sport specific skills. The subjects run back and forth on a 20 m course with and without a ball. The number of the rounds were measured in 1 minute.

4.4. Results

4.4.1. Results of subject A

The FMS score of subject A was 11 before starting EMS training program with 48 sessions. After the first 16 training sessions, the score of FMS increased to 12. After 32 training sessions, the FMS increased furtherly (16). After the whole EMS training program (48 sessions) score of 20 was measured by the operator.

The Léger-Navette test (LN) was not applied before the EMS training program. During the WB-EMS training program, the score of the LN test with the ball was improved firstly from 9 rounds to 10,5 rounds, then to 12 rounds. The LN test was repeated without the ball as well. In these cases, there was an improvement also (11 rounds to 12,5 rounds and finally it was increased to 14 rounds).

The body weight of subject A decreased from 72.4 kg to 69.8 kg. The body composition measurements showed significant changes. The FAT % (body fat percentage) from 11.8 % decreased to 9.7 % and the MM% (muscle mass percentage) increased from 39.7 % to 42.0 %.

Athlete (MC)	Before WB-EMS sessions	16 WB-EMS sessions	32 WB-EMS session	48 WB-EMS sessions
FMS	11	12	16	20
LN with ball (rounds)	-	9	10,5	12
LN without ball (rounds)	-	11	12,5	14
Weight (kg)	72,4	72,1	71,2	69,8
%FAT (%)	11,8	11,3	10,4	9,7
%MM (%)	39,7	40,2	41,3	42,0

Table 5 Results of subject A

4.4.2. Results of Subject B

The FMS score of subject B was 13 before starting EMS training program with 48 sessions. After the first 16 training sessions, the score of FMS increased to 14. After 32 training sessions, the FMS increased furtherly (18). After the whole EMS training program (48 sessions) score of 20 was measured by the operator.

The Léger-Navette test (LN) was not applied before the EMS training program. During the WB-EMS training program, the score of the LN test with the ball was improved firstly from 10,5 rounds to 11,5 rounds, then to 12 rounds. The LN test was repeated without the ball as well. In these cases, there was an improvement also (12 rounds to 14 rounds and finally it was increased to 15 rounds).

The body weight of subject B decreased from 84.9 kg to 81.9 kg. The body composition measurements showed significant changes. The FAT % (body fat percentage) from 12.5 % decreased to 8.9 % and the MM% (muscle mass percentage) increased from 38.9 % to 43.4 %.

Athlete (LW)	Before Xbody sessions	16 sessions XBody	32 sessions XBody	48 sessions XBody
FMS	13	14	18	20
LN with ball	-	10,5	11,5	12
LN without ball	-	12	14	15
Weight (kg)	84,9	84,3	83,0	81,9
%FAT (%)	12,5	12,3	10,0	8,9
%MM (%)	38,9	40,0	42,3	43,4

Table 6 Results for subject B

4.5. Conclusion

The purpose of this study was to examine the effect of WB-EMS in case of professional soccer players. The hypothesis that an EMS-elicited contraction would be helpful for improving soccer player's sport-specific skills and performance.

From the two described cases it can be concluded that WB-EMS can be a great help as the measurement showed a reduction in weight with positive body composition changes, namely the FAT % decreased and the MM % increased in the case of both subjects. The increase in the FMS values indicates that the subjects gained strength and muscle mass and the functionality improved in both cases. The study concentrated also on sport-specific skills. The LN test (with or without the ball) showed a significant increase also.

5. Bibliography

[1] Deley, G, Cometti, C, Fatnassi, A, Paizis, C, and Babault, N. Effects of combined electromyostimulation and gymnastics training in prepubertal girls. J Strength Cond Res 25(2): 520– 526, 2011.

[2] Babault, N., G. Cometti, M. Bernardin, M. Pousson, and J.-C. Chatard. Effects of electromyostimulation training on muscle strength and power of elite rugby players. J. Strength Cond. Res. 21(2):431–437, 2007.

[3] Filipovic, A., Grau, M., Kleinöder, H., Zimmer, P., & Hollmann, W. Effects of a Whole-Body Electrostimulation Program on Strength, Sprinting, Jumping, and Kicking Capacity in Elite Soccer Players. Journal of Sports Science and Medicine 15, 639-648, 2016.

[4] Billot, M, Martin, A, Paizis, C, Cometti, C, and Babault, N. Effects of an electrostimulation training program on strength, jumping, and kicking capacities in soccer players. J Strength CondRes24(5) :1407–1413, 2010.

[5] Benito-Martínez E, Lara-Sánchez AJ, Berdejo-del-Fresno D, Martínez-López EJ. Effects of combined electrostimulation and plyometric training on vertical jump and speed tests. J. Hum. Sport Exerc. Vol. 6, No. 4, pp. 603-615, 2011.

[6] Izquierdo, M., & Maffiuletti, N. A. Electromyostimulation and Plyometric Training Effects on Jumping and Sprint Time. Int J Sports Med, Aug 2005.

[7] Wahl P, Hein M, Achtzehn S, Bloch W, Mester J. Acute effects of superimposed electromyostimulation during cycling on myokines and markers of muscle damage. J Musculoskelet Neuronal Interact 15(1):53-9. Mar 2015.

[8] Neric FB, Beam WC, Brown LE, Wiersma LD. Comparison of swim recovery and muscle stimulation on lactate removal after sprint swimming. Journal of Strength and Conditioning Research, Volume 23, No. 9, pp. 2560-2567, Dec 2009.

[9] Girold S, Jalab C, Bernard O, Carette P, Kemoun G, Dugué B. Dry-land strength training vs. electrical stimulation in sprint swimming performance. J Strength Cond Res 26(2):497-505, Feb 2012.

[10] Finberg M, Braham R, Goodman C, Gregory P, Peeling P. Effects of electrostimulation therapy on recovery from acute team-sport activity. Int J Sports Physiol Perform. 8(3):293-9. May 2013.

[11] Warren CD, Szymanski DJ, Landers MR. Effects of Three Recovery Protocols on Range of Motion, Heart Rate, Rating of Perceived Exertion, and Blood Lactate in Baseball Pitchers During a Simulate Game. J Strength Cond Res. 29(11):3016-25. Nov 2015.

[12] Beaven CM, Cook C, Gray D, Downes P, Murphy I, Drawer S, Ingram JR, Kilduff LP, Gill N. Electrostimulation's enhancement of recovery during a rugby preseason.Int J Sports Physiol Perform. 8(1):92-8. Jan 2013.

[13] Courtney D. Warren, Lee E. Brown, Merrill R. Landers, Kurt A. Stahura. Effect Of Three Different Between-Inning Recovery Methods On Baseball Pitching Performance. Journal of Strength and Conditioning Research, Volume 25, No. 3, pp. 683-688. March 2011.

[14] Taylor T, West DJ, Howatson G, Jones C, Bracken RM, Love TD, Cook CJ, Swift E, Baker, JS, Kilduff LP. The impact of neuromuscular electrical stimulation on recovery after intensive, muscle damaging, maximal speed training in professional team sports players. J Sci Med Sport. 18(3):328-32. May 2015.