The effect of a 6 week isotonic training period on lower body muscle EMG changes in volleyball players
Davar Rezaeimanesh*, Parisa Amiri Farsani

* Khorramshahr Marine Science and Technology University, Khorramshahr 6946164147, Iran
b Islamic Azad University Abadan branch, Abadan, 8861615375, Iran

Abstract
This study focused on the effect of a 6 week isotonic training period on lower body muscle EMG changes in university volleyball players. Thus, 15 players of a university's volleyball team with an average age of 18.4-23.7, height of 178.7-194.3 centimetres, and weight of 65.3-83.5 kg were chosen. The subjects participated in four weekly 45-60 minute training sessions in a 6 week period. Before and after 6 week period the EMG for the biceps femoris and gracilis were checked. A paired t-test with α=0.05 was used. The results revealed that 6 weeks of isotonic training had a significant effect (p<0.05) on the EMG of the biceps femoris while performing the Squat Movement but the EMG for the biceps femoris was insignificant (p>0.05) in the vertical jump. According to the results, isotonic training can increase the EMG of lower body muscles in athletes.

Key words: EMG, isotonic, volleyball, athlete

1. Introduction

Muscle fiber generates tension through the action of actin and myosin cross-bridge cycling. While under tension, the muscle may lengthen, shorten or remain the same. Although the term 'contraction' implies shortening, when referring to the muscular system, it means muscle fibers generating tension with the help of motor neurons (Wilmer & Castel, 1994). In sports competitions, athletes usually break previous records and set new ones. Better results is usually because a rise in the athletes physical, mental and technical readiness. Higher readiness is due to a better understanding of the exercises and their results by trainers and athletes. Muscle contractions can produce many metabolic, mechanical, and myoelectrical changes. The maximum mechanical force that a muscle group can generate is defined as the muscular strength. Many principles are involved in strength training, and many methods are available for measuring its effect. The increase in muscle strength during the earlier period of training comes from a neural training mechanism or an improved motor unit recruitment ability, either of which is related to a noticeable increase in electromyography (EMG) activity (Frontera at al, 1999). Resistance and plyometric training are very important in training programs (Bompa. T.O, 1994). Performing these tasks in a 3-6 month period can lead to a 20-100 percent improvement in muscle power. Isotonic training improves the athlete's explosive power and speed. In isotonic contraction, the tension in the muscle remains constant despite a change in muscle length. This can occur only when a muscle's maximal force of contraction exceeds the total load on the muscle. Lifting an object at a constant speed is an example of isotonic contractions. A near isotonic contraction is known as Auxotonic contraction. There are two types of isotonic contractions: (1) concentric and (2) eccentric. In a concentric

* Davar Rezaeimanesh. Tel.: +989166343603; fax:+ 98 632 4332409
E-mail address: davarrezae@yahoo.com

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contraction, the muscle tension rises to meet the resistance, and then remains the same as the muscle shortens. In eccentric, the muscle lengthens due to the resistance being greater than the force the muscle is producing. A simple isotonic contraction example is flexing or bending the bicep muscle. Here, the isotonic contraction can be analyzed, by standing with one arm straight and the palm of the hand facing up. Then, roughly measure the length from the start of the biceps muscle to the end where it meets the shoulder. Now, curl the hand towards the shoulder, and the biceps muscle will shorten due to contraction. When you reach the end point, take another rough measurement of the biceps again, you will notice that it will be much shorter than the previous measurement. Isotonic muscle training involves contractions where tension is uniform throughout the range of motion. It basically involves the contraction and shortening of a muscle to allow movement and is done using exercise equipments like dumbbells, barbells or elastic resistance bands. This muscle training technique uses both eccentric and concentric movements. When the weight is lifted, the movement is considered as concentric, and when the weight is returned back to the initial position, the movement is known as an eccentric movement. Strength can be noted as an athlete’s most important physical attribute and plays an important role in almost every sport. Plyometric or jumping exercises are relatively new in resistance training, getting much attention in the late 80’s to enhance the jumping abilities of athletes, they are used to bridge the gap between speed and strength exercises to ease the accessing of motor units (Wilmer & Castel, 1994). Because of the importance of strength, trainers and athletes must be familiar with exercises that lead to an increase in strength. These exercises can be done with minimal facilities and even without equipment. Using isotonic exercises in sports needing a lot of strength is of greater importance. The most important feature of these types of exercises is the simultaneous improvement of the athlete’s skill patterns. Through creating changes in the muscle’s nervous system, plyometric training increases the ability of muscle groups in responding faster and stronger to muscle changes. One of the major problems in isotonic training is following safety precautions to prevent injury in athletes of different ages, especially adolescents. Therefore, this type of training requires precise control over the intensity and volume of exercise for all age groups (Bompa, T.O, 1994). If safety precautions are not followed while isotonic training, the knee, shin, ankle and back can be subject to injury. This type of exercise can lead to injury at very young ages, before general strength is acquired. The belief that plyometric training is only useful for increasing explosive power and that it has little effect on the athletes’ maximal strength has led most trainers to discard this training method from their training programs. But is this belief true? Can the athletes’ maximum strength be obtained through plyometric training?

Research has shown isotonic training an effective method in increasing strength. In a study by Lunder and Gessee (1989), the effect of resistances training on muscle activity and performance strategies of male athletes was researched. 49 male student athletes participated in this study. The subjects were pre- and post-tested. The participants had 4 weekly resistances training sessions for a period of 8 weeks. In this study, a surface EMG was used to calculate the primary and secondary electric activities of the vastus medialis, vastus lateralis, inner and outer hamstrings, and thigh adductor and abductors. Results showed that adductor electric activities increased after resistance exercise and that the effect of resistance training on male muscle activities and performance was significant. In another study, done in Virginia, Silicox (2004) investigated if there was a difference between the electric activity of the inner- and outer-hamstring of males and females when landing after 2 weeks of plyometric training. 17 Virginia female and male soccer players were studied. No significant differences were noticed between the two genders when landing, but outer-hamstring electric EMG activity increased after the plyometric training program.

Muscle power depends on the amount of nerve stimulation and the number of active motor units. To evaluate the power production mechanism, muscle activities will be studied and compared through direct measurement techniques. Inner-muscular neural adaptations consist of using motor units, the amount of stimulation and inter-muscular harmony. A qualitative procedure that can be used with the existing methods and can make needed quantitative measurements is the EMG. This harmless procedure can calculate the amount of current and organized activities of some lower body muscles that engage in different movements. Muscle movements start with electric activities and the recording of these signals is known as the EMG method. The size of the muscle’s recorded electric signal depends on different factors. The type and size of the electrode, the amount of change in the length of muscle fiber and the type of muscle are among the signal changing factors. The EMG signal is the algebraic sum of the motor units’ potential activity where the electrode is placed. These motor units are usually not active simultaneously and are function at different times. Motor units are controlled by a group of neurons. These neurons can transmit
either excitatory or inhibitory impulses. The contraction or expansion of muscle cords depends on the signals that reach a motor unit at that time. A motor unit will become active and its muscles will contract only when the amount of excitatory impulses are more than inhibitory impulses and higher than the level of threshold (Wilmer & Castle, 2008).

EMG can calculate recurrent pressures to movement systems and haemostatic activities that occur while doing sports. Thus, through EMG results, better training methods and facilities can be considered for athletes. These facts suggest that EMG analysis can represent the changes in the muscle during long-term strength training. Strength training is one of the most common exercises practiced in the field of physical therapy or sports training. The difficulty in studying the frequency characteristics of EMG from isotonic contraction lies in the instability of the signal due to the continuous changes in the muscle length and tension, distance between the electrode and the muscle, and the position of the electrodes (Masuda at al, 1999). Reviewing different studies, it seems that physiological activities that are influential to neuromuscular adaptations in power training and that lead to an increase in the power the organ creates are unknown. In previous studies, simple methods for considering and comparing different training methods have been used, but this study applies advanced technology and is performed scientifically. Therefore, this study plans to inspect 6 weeks of isotonic training on lower body muscle EMG changes and the response of the trained organ to power training.

2. Methodology

2.1. Participants

This study is of applied nature and is semi-experimental. The participants were varsity volleyball players (N=68). For this study 15 of the players were chosen randomly, after which they signed consent forms. Using a questionnaire, the subjects made clear that they had no records of pain or surgery and that they were completely healthy. Their age ranged from 18.4-23.7 years, their height from 178.7-194.3 centimeters, and their weight from 65.3-83.5 kilograms.

2.2. Measurement

The effect of isotonic training on the EMG of the biceps femoris and gracilis was measured when performing the pre-test and, after 6 weeks of training, during the post-test. For better results, EMG changes for each muscle were performed in the 2 virtual forms of absolute strength (Squat movement) and explosive power (vertical jump). To prevent the negative effect of pressure resulting from the squat movement on the vertical jump, the latter was performed first. To record the information, an MT machine was used, and MYO-Dat5 was used to analyze the data. To perform the pre- and post-tests a multi-press rack, a wall-mounted sergeant jump scale, Megawin Ver.2, and an MIE electrogoniometer was used.

2.3. Procedure

The training program consisted of a 4-session, weekly training program in a 6 week period. To enhance the participants’ physical abilities and preparation, light training activities were performed in the first week. The amount of training pressure was gradually increased from the second week onward. The number of repeats depended on the pressure of the activities during the training program. An important factor that was considered during the training period was the performance of the isotonic movements on a suitable surface to prevent possible injuries.

2.4. Statistical Analysis

To examine the hypotheses, a paired t-test with α=0.05 was used. Statistics were analyzed using SPSS ver.16.

3. Results

This study showed that 6 weeks of isotonic training had a significant effect (P=0.004) on EMG of the biceps femoris when performing the squat movement (absolute strength), whereas the effect on EMG when performing the vertical jump (explosive power) was no significant (P=0.913).
Table 1. Paired T-test for the pre- and post-test of the biceps femoris

| variables      | Per-test     | Pos-test     | significance* |
|----------------|--------------|--------------|---------------|
| Squat Movement | 1.688± 0.660 | 1.908± 0.713 | 0.004*        |
| Vertical jump  | 1.916±0.703  | 1.926±0.649  | 0.913         |

This study also showed that 6 weeks of isotonic training significantly effected the EMG of the gracilis (P=0.000) while performing the squat movement (absolute strength), effecting the EMG of the gracilis (P=0.001) in the vertical jump (explosive power) as well.

Table 2. Paired T-test for the pre- and post-test of the gracilis

| variables      | Per-test     | Pos-test     | significance* |
|----------------|--------------|--------------|---------------|
| Squat Movement | 1.678± 0.676 | 2.497± 0.906 | 0.000*        |
| Vertical jump  | 1.699±0.637  | 1.918±0.651  | 0.001         |

4. Discussion and conclusion

The findings of this study showed that 6 weeks of 4-session per week isotonic training caused an increase in EMG changes in the biceps femoris for the squat movement (absolute strength). The nature and type of isotonic exercises add much force and tension to muscle cords. Performing such activities or tolerating extreme force and tension may lead to needed physiological or biological changes in muscle cords and other parts of the contraction system and can also cause muscle EMG changes to rise. Hence, at higher levels, when an athlete is trying to reach maximum strength, it is probable that plyometric training will not be as influential as weight training. The findings of Olson (2010) and Chimera (2004) verify these results, whereas those of Herrero (2006) and Arabatzi et al (2010) state otherwise.

Statistical analysis of the findings of this study showed that 6 weeks of isotonic training in 4 weekly sessions caused no significant increase in the muscle EMG of the biceps femoris when performing the vertical jump (explosive power). The cause can be noted as insufficient training specific to the muscle or the insufficiency in the severity of training. These findings are similar to those of Herrero (2006), Masuda, K et al (1999), Robinson, M et al (2005), Frontera, W.R et al (1999) and T. M. Altenburg et al (2009) opposing Potach et al (2007), Kidgell, D. J et al (2010) and Tanya, S et al (2008).

This study emphasized that 4 weekly isotonic training sessions in a 6 week period had a significant effect on the EMG changes of the gracilis when the subjects performed the squat movement (absolute strength). Myer et al (2006), Pollock (2010), Kato (2010), Tamara, J et al (2008), John, G. Semmler et al (2009) and Kubo (2007) also found changes in EMG and the strength of other muscles. Henry et al (2010) and Herrero (2006) reached other conclusions. Some of the reasons for such a variety of results may be noted as the difference in participants, type of exercises applied, the time of training and the difference in the muscles studied. This study also emphasized that 6 weeks of isotonic training effected gracilis EMG while performing the vertical jump (explosive power). The reasons for such an effect can be stated as the severity of isotonic training and its effect on the muscles contraction elements and the muscles physiological changes. Ball and Scurr (2009) and Potach (2007), too, found the vertical jump influential.

This study shows that a 6-week isotonic training period can create improvement in muscle strength in some lower-body muscles of volleyball players. These types of exercises can be used for preparation seasons, as well as competition seasons to increase lower-body muscle strength in volleyball players.

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References

Kidgell, D. J et al (2010). Neurophysiological responses after short-term strength training of the biceps brachii muscle. J Strength Cond Res, 24(11), 3123-32.

Robinson, M et al (2005). Electromyographic investigation of abdominal exercises and the effects of fatigue. Ergonomics, 15,48(11-14), 1604-12.

John, G. Semmler et al (2009). Eccentric exercise increases EMG amplitude and force fluctuations during submaximal contractions of elbow flexor muscles. J. Neurophysiol, 102:413-423

Tamara, J et al (2008). Motor Unit Synchronization Is Increased in Biceps Brachii After Exercise-Induced Damage to Elbow Flexor Muscles. AJP - JN Physiol February, vol. 99 no. 2 1008-1019.

Tanya, S et al (2008). Impaired neuromuscular function during isometric, shortening, and lengthening contractions after exercise-induced damage to elbow flexor muscles. Journal of Applied Physiology, 105 , 502-509.

T. M. Altenburg et al (2009). Vastus lateralis single motor unit EMG at the same absolute torque production at different knee angles. Journal of Applied Physiology, 107, 80-89.

Myer, G. D, et al (2006). The effects of plyometric vs. dynamic stabilization and balance training on power, balance, and landing force in female athletes. J Strength Cond Res, 20(2), 345-53.

Chimera, N. J, et al (2004). Effects of Plyometric Training on Muscle-Activation Strategies and Performance in Female Athletes. J Athl Train, 39(1), 24-31.

Bompa, T.O (1994). Theory and methodology of Training. The Key to Athletic Performance. Kendoll Hunt.

Fleck, S. J., Kramer, W. J (2004). Designing resistance training programs. Third edition, human kineties, p: 214.

Hammert, J. B & Hey, W. T (2003). Neuromuscular adaptation to short-term (4 Weeks) ballistic training in trained high school athletes, the journal of strength and conditioning research. J Strength Cond Res, 17(3), 556-60.

Olson, M. W (2010). Passive repetitive loading of the lumbar tissues influences force output and EMG during maximal efforts. Eur J Appl Physiol, 4.

Pollock, C. L et al (2010). Changes in kinematics and trunk electromyography during a 2000 m race simulation in elite female rowers. Scand J Med Sci Sports, doi: 10.11171/j.1600-0838.2010.01249.x.

Kato, E (2010). Acute effect of muscle stretching on the steadiness of sustained submaximal contractions of the plantar flexor muscles. J Appl Physiol, 2.

Brandenburg, J & Czajka, A (2010). The acute effects of performing drop jumps of different intensities on concentric squat strength. J Sports Med Phys Fitness, 50(3), 254-61.

Henry, B, et al (2010). The effect of plyometric training on peroneal latency. J Sport Rehabil, 19(3), 288-300.

Arabatzi, F, et al (2010). Vertical jump biomechanics after plyometric, weight lifting, and combined (weight lifting + plyometric) training. - J Strength Cond Res, 24(9), 2440-8.

Ball, N. B & Scurr, J. C (2009). Bilateral neuromuscular and force differences during a plyometric task. J Strength Cond Res, 23(5), 1433-41.

Potach, D. H et al (2009). The effects of a plyometric training program on the latency time of the quadriceps femoris and gastrocnemius short-latency responses. J Sports Med Phys Fitness, 49(1), 35-43.

Kubo, K et al (2007). Effects of plyometric and weight training on muscle-tendon complex and jump performance. Med Sci Sports Exerc, 39(10), 1801-10.

Herrero, J. A. (2006). Electromyostimulation and plyometric training effects on jumping and sprint time. Int J Sports Med, 2006 Jul;27(7):533-9

Toumi, H, et al (2004). Effects of eccentric phase velocity of plyometric training on the vertical jump. Int J Sports Med. 25(5), 391-8.

Wilmore, J. H et al (2008). Physiology of sport and exercise. (4 th ed). Human Kinetice, (chapter 4).

Masuda, K et al (1999). Changes in surface EMG parameters during static and dynamic fatiguing contractions. J Electromyogr Kinesiol. 9, 39–46.

Frontera, W.R et al (1999). Exercise in rehabilitation medicine. Champaingn, IL: Human Kinetics. Pp, 41–83.