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Traditional archery: A pilot study of surface electromyography

Tiro con arco tradicional: un estudio piloto de electromiografía de superficie

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Abstract

Archery has always been a minority sport, therefore is a little investigated sport. The archery technique depends on the postural control, which is determinated by the muscular actividy, among others. Some authors have studied the importance of the musculature involved.

The aim was to determinate the importance of brachial biceps of the draw arm, lateral portion of the brachial triceps of the drow arm, anterior abdominal and lumbar portion of erector spinae during the technic action of archery in the divisions of longbow and instictive bow. Brachial biceps of the draw arm, lateral portion of the brachial triceps of the drow arm, anterior abdominal and lumbar portion of erector spinae of six archers were analised by surface electromyography.

The results of the study reflects a similar pattern of maxim activation is appreciated as on the absolute activation in four of the six archers with higher level of experience and performance and better adaptability to the personal training bow. Both the archers with different pattern of maxim and absolute activation, have similar patterns between them. Being the results of the study non suitables to the generalization, a higher implication of lateral portion of the brachial triceps of the drow arm is more necessary than the brachial biceps of the draw arm. In spite of the fact that it is not possible to compare the implication of the anterior abdominal with the activation of the lumbar portion of erector spinae, the maxim and absolute implication of the erector spinae may have influence in a inestable body posture during the archery technic. More investigation is needed to go deeper in these contents.

Keywords

Archery; Electromyography; EMGs; muscular activation

Resumen

El tiro con arco siempre ha sido un deporte minoritario, por lo que es un deporte poco investigado. La técnica de disparo depende del control postural, determinado entre otros factores por la implicación muscular. Algunos autores han estudiado la importancia de la musculatura implicada.

El objetivo de este estudio piloto ha sido determinar la importancia del bíceps braquial del brazo de cuerda, porción lateral del tríceps braquial del brazo de cuerda, recto abdominal y erector spinae en su porción lumbar durante la acción técnica de tiro con arco en las divisiones de arco longbow y arco instintivo. Se análizó mediante electromiografía de superficie la activación muscular del bíceps braquial del brazo de cuerda, porción lateral del tríceps braquial del brazo de cuerda, recto abdominal y erector spinae en su porción lumbar el disparo de dos flechas a seis participantes.

Los resultados apuntan a un mismo patrón de activación máxima y activación absoluta en cuatro de los y las seis participantes con mayor nivel de experiencia y rendimiento técnico y mejor adaptabilidad al propio material de entrenamiento. Los dos participantes con diferente patrón de activación máxima y activación absoluta, presentan dichos patrones similares entre ellos.

Siendo los resultados de este estudio no aptos para la generalización, parece ser necesaria una mayor implicación de la porción lateral del tríceps braquial del brazo de cuerda respecto al bíceps braquial del brazo de cuerda. Pese a no haber sido posible comparar la implicación del recto abdominal con la implicación del erector spinae, la implicación máxima y absoluta del erector spinae puede tener influencia en la adopción de una postura poco estable durante la acción técnica de disparo de una flecha. Se requiere más investigación para poder profundizar en estos contenidos.

Palabras clave

Tiro con arco; electromiografía; EMGs; activación muscular.

Introduction

Archery has always been a minor sport, with around 17.586 Spanish licenses in 2016 (Consejo Superior de Deportes, 2018). This might be one of the reasons why is a sport with little research, and in the last few years it has emerged greater scientific knowledge about its structure.

Precision sports´ technique is characterized by the postural control, which depends on, among other factors, the muscular implication and efficacy (Gianikellis et al., 1997; Marín Villada y col., 2013; Lee y col., 2009). This means that the differences in muscular activation might be related to the archery skill, being this an important aspect for a better understanding of the required skills in archery and for a better training (Shinohara 9and Urabe, 2018).

Stability in bow is reached by the activation and its intensity of the required muscles in specific gesture of archery (Gianikellis et al., 1997). These authors list the musculature implied in archery technique, and that by co-contraction it is possible to maintain the stable anchor position (Gianikellis et al., 1997; Enoka, 2015), and Jiménez (1988) previously classified in principal muscles: levator scapulae, extensor carpi radialis longus, extensor carpi radialis brevis, flexor digitorum superficialis, flexor digitorum profundus, rhomboideus major, romboideus minor, serratus anterior, extensor digitorum (antagonic, is fundamental for shooting), deltoideus (anterior, middle, and posterior), extensor indicis (antagonic, is fundamental for shooting), supraespinatus, pronator teres, subscapularis, pronator cuadratus, infraespinatus, brachioradialis, teres major (of bow arm), supinator, teres minor (of drawing arm), lumbo-abdominal girdle, erector spinae and triceps brachii; synergist muscles: sternocleidomastoideus, teres major (of drawing arm), latissimus dorsi (will be principal muscle downward draw or synergist muscle horizontal draw); slightly relevant: pectoralis major, bíceps brachii.

In recent studies, Tejo N. et al., (2017), observed that in an experimented archer, *multifidus* muscles further stabilize the lower back during the first 36 arrows, after which they stabilize it to a lesser extent. They also observed that there is a significant difference between the serratus anterior activation in the side which pulls the string and in the one that stabilizes the bow. Regarding the musculature of the drawing arm, the activation of the triceps brachii was considered constant.

Ertan H. et al., (2005) support that, when drawing the bow, the string is tried to be held and tightened with the muscles of the forearm, but as the drawing movement develops, the percentage of these decreases, and the muscles of the arm, the shoulder girdle and part of the back´s muscle are more involved. They also explain that to perform the shooting there must be an agonist-antagonist coordination at the time of shooting, so that the flexor muscles of the fingers relax while the extensor muscles of the fingers contract. Tejo N. et al., (2017) support this, confirming that elite archers have more activation in extensor muscles of the fingers and that this fact not only does not interfere with the movement, but also increases the chances of having a better performance.

Regarding the bow hand, Ertan H. (2009) maintains that not contracting the flexor and extensor muscles of the fingers, or only the extersors ones, is a fact of performing, since it minimizes the magnitude of the archer's paradox.

The aim of this study has been confirming the importance of triceps brachii caput laterale muscle of string arm (from now on TBCLSA), bíceps brachii of string arm (from now on BBSA), erector spinae in lower back (from now on ESLB) of dominant side and rectus abdominis (RA) of dominant side during perform of traditional archery.

Methodology

Participants

Six federated people, three men, aged between twenty-six and sixty years old and three women, aged between forty-two and fifty-two have participated. Of the six people, two men are left-handed and one right-handed, two of them compete with longbow and one with Instinctive. The three women are right-handed and compete with Longbow and two with Instinctive.

The participants have between four months and ten years of experience in traditional archery, and maintain a training frequency of one hour and a half to six hours a week. Regarding the bow power which they train and compete with, men vary from thirty-six to forty-five lbs and women from thirty to thirty-five lbs.

Material

To carry out the study, an analysis with EMGs has been carried out. The device used for electromyographic analysis has been a Biosignals Plux® device (Plux Wireless Biosignals, Lisbon, Portugal), with four generic channels, with an auxiliary port, a resolution of up to 16 bits / channel, a sampling rate of up to 400Hz / channel, Class II Bluetooth communication and a range of up to 10m. The sensors used have a Gain of 1000, a Range of + 1.5mV (with VCC = 3V), Bandwidth of 25-500Hz, Input Impedance:> 100GOhm and CMRR: 100dB (BiosignalsPlux, 2017). The system of this device has been used and validity in various studies published in scientific journals of different themes, such as the works of Krašna, S. et al. (2017), Muñoz, J., et al. (2017) and Romero-Moraleda, B., et al. (2017).

As for the sports equipment used for the study it has been used two wooden bows with the nock adapted to the height of the window, one for right-handed and another for left-handed, both with limbs of twenty-eight to thirty lbs and three initiation bows. The brace height was quantified from 8.35-8.5 inches. For the analysis of the data, it has been used the Microsoft Excel 2016 spreadsheet software (Microsoft Corporation, Redmond, WA, USA) with which, to obtain the conclusions of the study, several processes were performed.

Procedure

All participants, before carrying out the study, read and signed an information sheet of the study, an informed consent, and a brief questionnaire in which information was collected regarding age, laterality, experience and training frequency.

After this, the measurements, which were performed on the string arm, were carried out, as well as the placement of the sensors by an expert in electromyography.

The measurements were subsequently started; they were made on the string arm, and, as the placement of the sensors, they were placed by an expert in electromyography. The placement of the electrodes was as it follows: or TBCLSA, immediately after the insertion of the deltoid tuber or deltoid into the muscular belly, with a separation between the two sensors from one to two cm; for BBSA, in the bulkiest area of the muscular belly, in the middle of the arm with a separation between the two sensors from one to two cm; for ESLB, an imaginary line is drawn between the top of the iliac crests. This line intersects the spine at the intervertebral level L3-L4. the sensor is placed to one or two fingers of width of the thorny process of the identified level, with a separation between the two sensors of one to two cm; for RA, the sensor is placed at a lateral distance of two fingers to the line alba in the umbilical portion, with a separation between the two sensors of one to two cm.

After the placement of the sensors, a functional check was made, performing an elbow flexion with a 2.5kg lift and subsequently an extension of the elbow. Once it was verified that the placement of the sensors was functional, the data was recorded during the firing of two arrows.

The activation of TBCLSA, BBSA, ESLB, and RA during the two-arrow technical shooting action was measured with the following protocol: Relaxation (start of registration) two seconds; Complete execution, technique and individual rhythm; Relaxation two seconds after (registration ends).

The data obtained from each muscle, on each arrow and from each person were converted to mV using a formula provided by the EMG device brand (BiosignalsPlux, 2017). Once the data was converted, the process of standardization of the collected data was made, which had to be done manually taking as reference the beginning of the activation of the

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TBCLSA and the end of the activation of the BBSA, since they were the most clear in each shot and in each person.

Once the data was standardized, the quadratic mean, Root Mean Square (RMS) was applied, with which the square root of the average of the squares of the bounded sample was obtained (Cabrera Ávila and Montes Fernández, 2012), which did not need a previous rectification of the signal (Villarroya Aparicio, 2005), to measure the absolute electrical potential of the electromyographic signal of each muscle on the data of all the technical action of archery. After this, the standardized signals of each muscle were rectified to obtain their maximum activation value, which allowed comparing the maximum positive electrical potential of each muscle during the entire archery technical action.

During the filtering and standardization of the data it was decided to suppress from the study the data obtained from RA of each arrow and each archer, because heart rate artefacts mixed with the electrical signals of the muscle were recorded, as can be verified in Figure 1, which contaminated the data of that muscle.

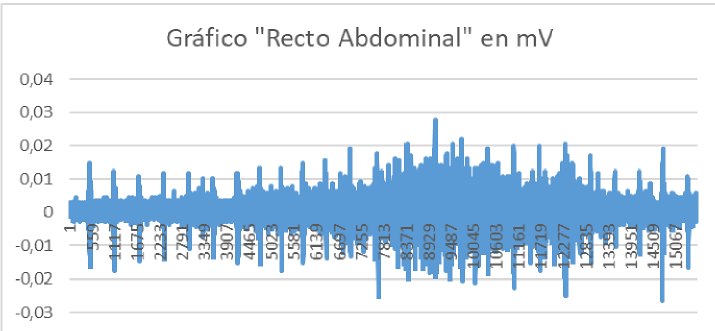

Figure 1. Graphic of the registry, in mV, of the RA activation with FC artefact.

Due to the sample size, the analysis of the study was made by comparing the maximum activation pattern and the absolute potential of the electrical signal of TBCLSA BBSA and ESLB for each archer and archer on each arrow, and the comparison in implication media during the shooting action of the two arrows of each archer and archer.

Once the results were obtained, in order to favor their interpretation, a second questionnaire composed of three items related to the real time of practice in each training

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session, the suitability of the bow which they train with and the archer's technical capacity was made by via telematics.

Results

The results show that 4 of the participants maintain the same pattern of maximum and absolute activation, the involvement of TBCLSA being greater, followed by BBSA for the 2 arrows (Figure 2).[1]

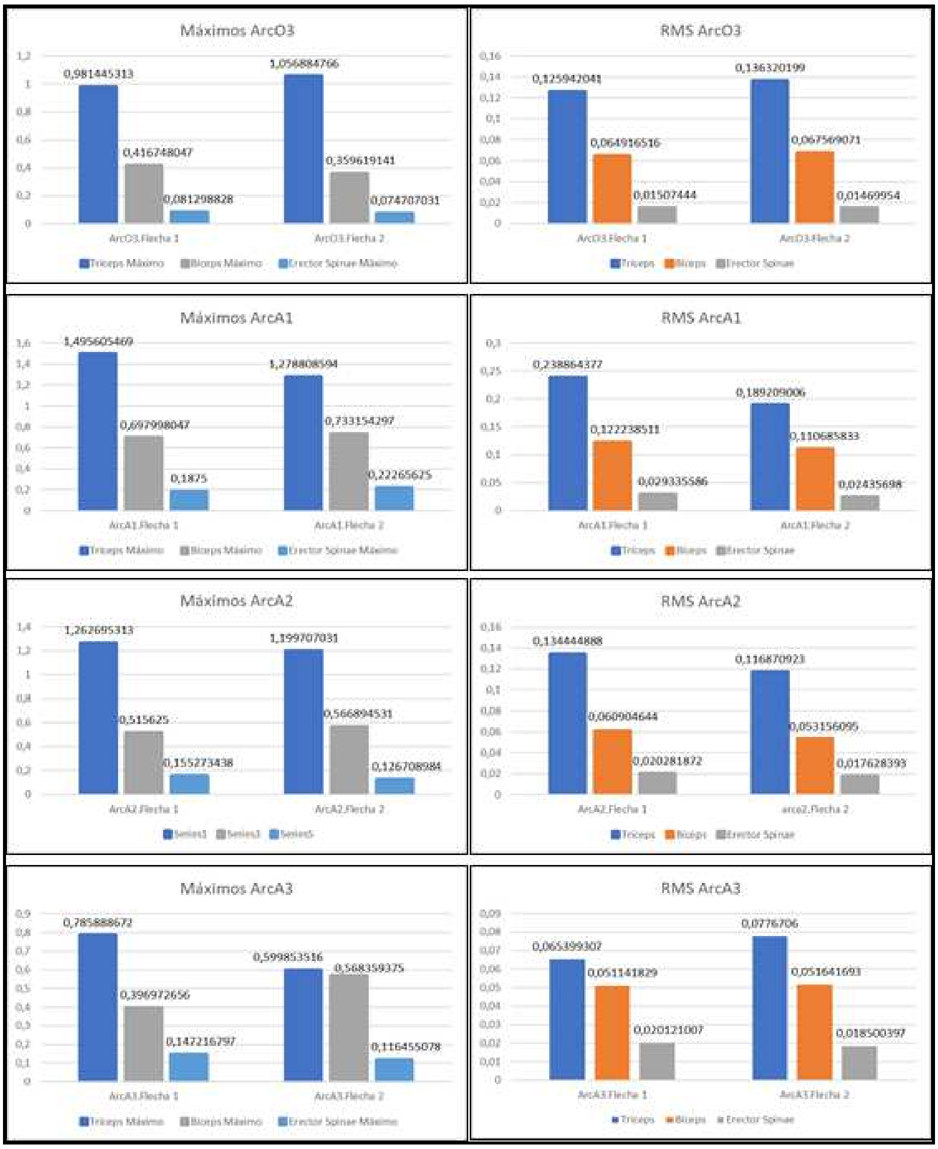

Figure 2. Graphics of Maximum and Absolut Muscular Involvement with the same pattern.

[1] ArcA refers to female participants; ArcO refers to male participants

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Only 2 archers presented a maximum and absolute opposite activation pattern (Figure 3). ESLB maintains a lower activation on all archers and archers.

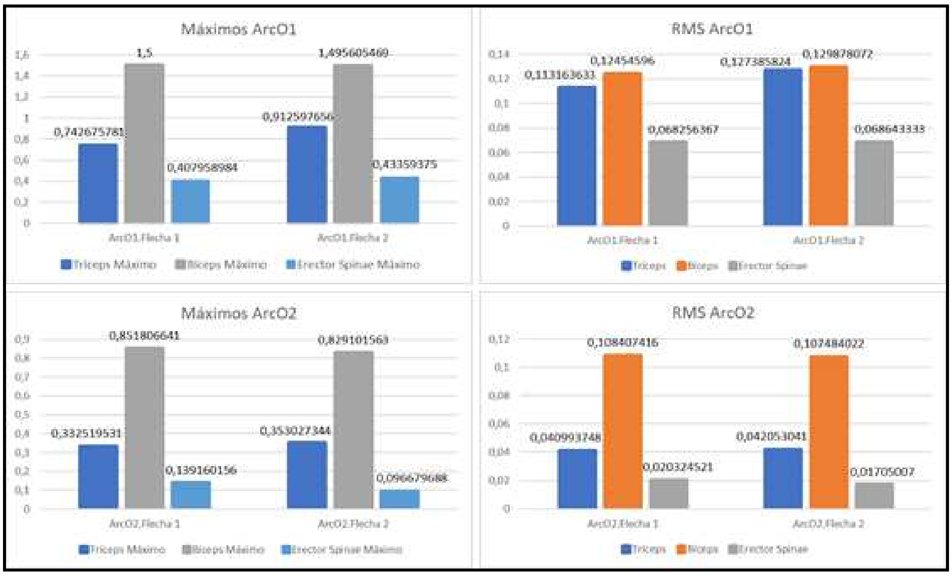

Figure 3. Graphics of Maximum and Absolut Muscular Involvement with opposite pattern

At an average level, as can be seen in Table 1[2] and 2 and in Figures 4[3] and 5, the same relationship is maintained in the pattern of maximum activation of the musculature, with the first 2 archers who maintain a pattern contrary to the rest. By linking these three muscles, the maximum involvement of ESLB becomes more important. Both situations remain in the middle absolute activation.

Table 1

Comparation of maximum involvement between muscles of each archer, male and female

Arquero/Arquera	% implicación TBPLBC	% implicación BBBC	% implicación ESPL
ArcO1	30% (±0.003)	55% (±0.12)	15% (±0.018)
ArcO2	26% (±0.016)	65% (±0.014)	9% (±0.03)
ArcO3	69% (±0.05)	26% (±0.04)	5% (±0.004)
ArcA1	60% (±0.15)	31% (±0.024)	9% (±0.02)
ArcA2	64% (±0.04)	28% (±0.03)	8% (±0.02)
ArcA3	53% (±0.13)	37% (±0.12)	10% (±0.02)

[2] TBPLBC means TBCLSA, BBBC means BBSA, and ESPL means ESLB.

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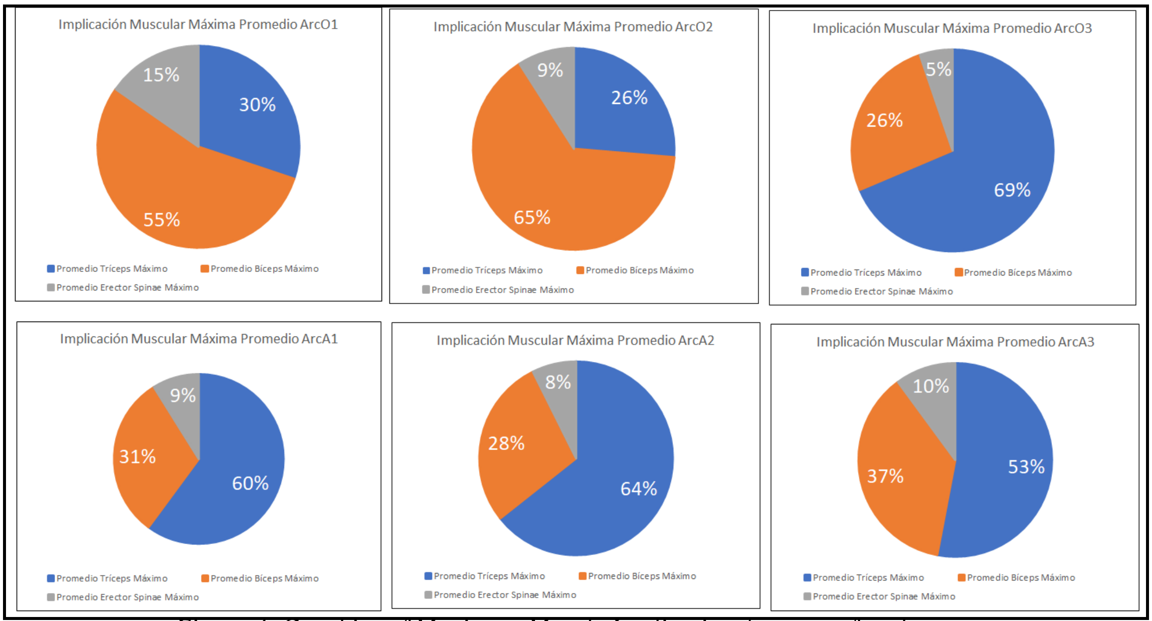

Figure 4. Graphics of Maximum Muscle Implication Average of archers

Table 2

Comparation of Absolut Involvement between muscles of each archer, male and female.

Arquero/Arquera	% implicación TBPLBC	% implicación BBBC	% implicación ESPL
ArcO1	38% (±0.01)	40% (±0.003)	22% (±0.0002)
ArcO2	24.69% (±0.0007)	64.19% (±0.0006)	11.11% (±0.002)
ArcO3	62% (±0.007)	31% (±0.0006)	7% (±0.002)
ArcA1	60% (±0.035)	33% (±0.008)	7% (±0.003)
ArcA2	62% (±0.012)	28% (±0.005)	10% (±0.001)
ArcA3	50% (±0.008)	36% (±0.0003)	14% (±0.001)

[3] Blue refers to average maximum triceps; Orange refers to maximum biceps; Grey refers to maximum erector spinae.

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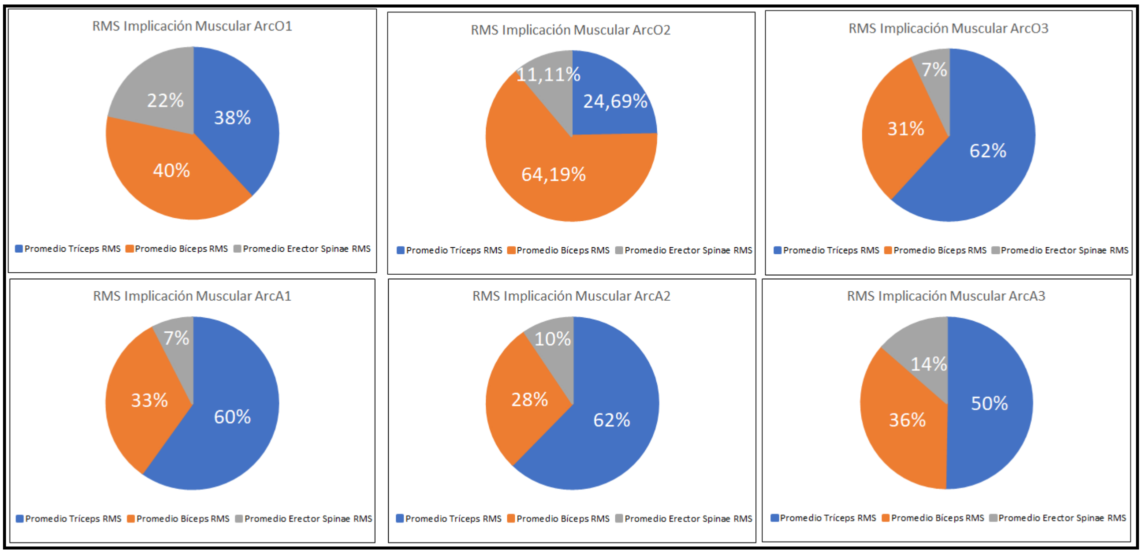

Figure 5. Graphics of Absolut Muscular Involvement Average of Archers.

Discussion

The results of this study seem to partially confirm the assumption made by Jiménez (1988) regarding the importance of the brachial triceps and the low involvement of the brachial biceps in the technical firing action, given that four of the six archers and archers who have participated, show a greater involvement of TBCLSA than of BBSA. The two archers who show an activation pattern contrary to the rest have confirmed that the power of the bows with which they usually train is excessive to their abilities, one of the two even states that it does not reach the anchor position, shooting early. Based on the results, there is a relationship in the co-activation of TBCLSA and BBSA, and although TBCLSA has a greater implication, BBSA also has relevance in the technical action of archery, although according to the results obtained in the work of Shinohara and Urabe (2018), it seems that the involvement of the brachial biceps and brachial triceps are significantly lower in elite categories compared to beginners.

On the other hand, it would be appropriate to analyze the involvement of the entire triceps in the technical action of archery to determine the overall involvement of this muscle in this sport, which would better guide the physical preparation of archers. Similarly, it would be important to deepen the importance of BBSA, that is, determine whether it is an agonist muscle or a synergistic muscle in the technical action of archery, which would be another point to consider in the physical preparation of the archers

The participants show a maximum and absolute involvement of ESLB from 5% to 22% of the muscle involvement compared, which can be interpreted as a risk factor of adopting a position in pelvic anteversion that increases lumbar lordosis. This can cause instability to the upper part of the trunk, which, at the time of locating the distances of the target, an action that must be performed by tilting the trunk starting at the waist (Jiménez, 1988), other body segments will be constantly modified. Regarding this, Tejo N. et al., (2017) affirm that the constancy of the accuracy of the shots depends on the position adopted by the archer, so, in addition to the mentioned musculature, muscle chains are also involved flexion and extension of the trunk and lower limbs and the opening and closing chains of the lower limb, giving a complementary flexion-extension-opening-closing, thus providing static balance (Busquet, 2002; Busquet, 2001) , except for the long muscles of the head and spiny of the head, which should be relaxed to prevent the neck from spreading (Jiménez, 1988). Therefore, the activation of ESLB should be accompanied by the activation of the entire CORE to prevent the aforementioned pelvic anteversion (Niestroj et al., 2018; Myers, 2014).

In the practice of archery, a static position must be maintained for a certain maximum time, supporting the resistance exerted by the bow during the anchoring phase, which can cause rocking and trembling due to fatigue of the muscles responsible for maintain that position (Jiménez, 1988). This means that archery demands a high level of proprioception and neuromuscular control, so that, thanks to these mechanoreceptor senses, postural changes are perceived, relevant anticipatory responses are made and the archer himself becomes aware of its position (Lluch, A. et al., 2015), enabling the voluntary correction of lumbar hyperlordosis mentioned in the previous paragraph. Thus, the loss of perpendicularity of the frontal plane of the archer with respect to the frontal plane of the target could be prevented or reduced consciously and autonomously (Jiménez, 1988).

During the performance of this work a series of difficulties and errors have been perceived to be correctable. The two main difficulties encountered were, in the first place, the scarcity of scientific literature concerning the subject of this work, even more so that specialized in traditional archery, and, secondly, the limited availability of the means necessary to carry out the study, both material and at the sample level. On the other hand, several difficulties were encountered in standardizing the data to be compared, which may have been due to the data recording protocol used.

Conclusions

The first conclusion that is obtained from the present study is that the results obtained, given the sample size and the procedure that has had to be followed to obtain them, cannot serve as a generalization regarding the muscular involvement in the shot with arch, nothing beyond that for a slight didactic orientation.

On the other hand, although the greatest involvement is from TBCLSA ,BBSA is also important in technical action, being able to be an important synergist in this sport and given the magnitude of the relative involvement of ESLB, well-designed and planned core work should take special importance in archery.

Regarding the procedure of this study, it would be appropriate to repeat it with a more rigid registration protocol, standardizing the preparation, completion and final firing times, which would require a previous intervention in which, without modifying the movements of the action individual technique, the participants are prepared at a certain firing cycle rate, which is intended to objectively standardize the data to be analyzed later. Similarly, a larger sample size that allows comparisons between sexes and categories would be advisable.

In future studies, it would be appropriate to analyze the global involvement of the brachial triceps in this sport and it would be interesting to analyze the timing of activation of the musculature involved in the technical action of archery so that more data are available for the correct teaching orientation in your physical-technical training

Thanks- you note

The author appreciates the collaboration of Mr. Javier Carballo López, thanks to which it was possible to process and compare the data recorded in this study.

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