CASE STUDY: COMPARISON OF UPPER LIMB MUSCLES BEHAVIOUR FOR SKILLED AND RECREATIONAL ARCHERS USING COMPOUND BOW

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The purpose of this study was to investigate muscles activity during archery by carrying out an electromyography (EMG) experiment towards 12 muscles and six joints involving two types of subject (skilled and recreational). EMG is used to detect muscle signals during any particular activity. There were two types of data recorded which were maximum voluntary contraction (MVC) and archery activity. The skilled archer was found to produce 280 N of biceps brachii, 213.9 N of the deltoid, 123.4 N of trapezius forces compare to that of the recreational archer with 371.1 N, 164.9 N and 163.8 N, respectively for the draw arm during drawing phase. It is concluded that the recreational archer tends to a muscle fatigue phenomenon thus may contribute to possible serious injuries.

KEY WORDS: archery, muscle activity, electromyography (EMG).

INTRODUCTION: Archery is one of the safest sport to be participated according to the findings of Palsbo (2012), as overall only 4.4 out of 10000 athletes reported injuries. Furthermore, archery requires skill to enhance performance besides frequent training. However, training will give good outcomes by considering muscles fatigue during training. Muscles fatigue will result in risk of injuries, which will take a long time to recover (Mann & Littke 1989). In order to avoid this phenomenon muscles fatigue must be addressed. There are several researchers involved in archery studies (Clarys et al., 1990; Ertan, Kentel, Tumer, & Korkusuz, 2003; Guttmann & Mehra, 1973; Hennessy & Parker, 1990; Lin et al., 2010; Mann & Littke, 1989; Martin, Siler, & Hoffman, 1990; Nishizono, Nakagawa, Suda, & Saito, 1984; Palsbo, 2012; Rayan, 1992; Soylu, Ertan, & Korkusuz, 2006). Most of them associated with an EMG in archery. Guttmann and Mehra (1973) is among the first researchers who studied on major group muscles that active during archery activity in three phases which are drawing, holding and release on disable athletes. Clarys et al. (1990) in his study found that bow stabilizer usage will reduce the tendency of muscle fatigue. The evaluation of flexion and extension muscles before and after drawing the bow is done by Martin et al. (1990). Ertan et al. (2003) studied on muscles strategy during contraction and relaxation of muscles towards different group of athletes which are elite, skill, recreational and novice. There is no previously published on muscles activity on compound bow of archery. Therefore, the purpose of this case study is to determine the force of muscles between skilled and recreational archers during six phases of archery performance using compound bow.

METHODS: An EMG raw data was obtained from EMG Works Analysis version 4.0.7. There were 12 muscles and six joints involved. Two subjects (skilled and recreational) participated in this study. The subjects gave their consent and both of them were free from any injuries besides that both of them are right-handed. Right hand was used as draw arm (DA) whilst left hand as bow arm (BA). There were six phases considered which were preparation, pre drew, drawing the bow, anchoring, holding and aiming, and release. There were two types of data recorded which were maximum voluntary contraction (MVC) and archery activity using compound bow. The maximum muscle activations were recorded during flexion movement of the arms. After several minutes break, subjects were requested to complete archery activity in five trials including resting between each trial. There were several stages of filtering raw data. The procedures started with a Butterworth band pass filter followed by absolute value data then the low pass filter applied for eliminating the noise of the signals. Finally, data normalization was performed. After all procedures were done the average of all trials was calculated where an EMG (X) and MVC data (Y) are divided as follows:
\[ Z_i = \frac{X_i, X_2, X_3, \ldots, X_n}{Y_j}; \quad i = 1, 2, \ldots, 12; \quad j = 1, 2, \ldots, 12 \]

where,

\( Z_i = \text{Normalized of EMG/Normalized of MVC} \)
\( X = \text{EMG data at each time frame} \)
\( Y_j = j^{th} \) of MVC for each muscle.

The values obtained \( (Z) \) were multiplied with maximum values of force, \( f_{\text{max}} \), in order to get force \( (F_k) \) for each muscle.

\[ F_k = Z \times f_{\text{max}} \]

where \( f_{\text{max}} \) is a product between constant maximum stress 25Ncm\(^{-2}\) (Bronzino, 2008) and physiological cross sectional area \( (pCSA_i) \) of each muscle. Table 1 showed the values of \( pCSA \) for each muscle. Both subjects have average and standard deviation of weight and height of 82(±1.41) kg and 166(±1.41) cm respectively.

<table>
<thead>
<tr>
<th>Muscles (( F_k ))</th>
<th>( pCSA_i ) (cm(^2))</th>
<th>Side of arm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexor Carpi Radialis (FCR)</td>
<td>11.16</td>
<td>DA and BA</td>
</tr>
<tr>
<td>Extensor Digitorum Communis (EDC)</td>
<td>0.76</td>
<td>DA and BA</td>
</tr>
<tr>
<td>Brachioradialis (BRD)</td>
<td>3.08</td>
<td>DA and BA</td>
</tr>
<tr>
<td>Biceps Brachii (BIC)</td>
<td>11.91</td>
<td>DA</td>
</tr>
<tr>
<td>Medial Deltoid (DELT)</td>
<td>9.08</td>
<td>DA and BA</td>
</tr>
<tr>
<td>Medial Trapezius (TRA)</td>
<td>6.24</td>
<td>DA and BA</td>
</tr>
<tr>
<td>Triceps Brachii (TRI)</td>
<td>19.07</td>
<td>BA</td>
</tr>
</tbody>
</table>

Source: (Ackland, Merritt, & Pandy, 2011; Garner & Pandy, 2001; Lemay & Crago, 1996)

**RESULTS:** Skilled and recreational subjects were compared. According to Figure 1, skilled subject showed bow arm produced higher maximum value of MVC in triceps brachii compared to that of draw arm. In contrast, recreational subject showed draw arm produced higher maximum value of MVC in deltoid compared to that of bow arm MVC in triceps brachii which were 93 % and 84 %, respectively. Based on Figure 2, both subjects applied the least amount of force of EDC muscle compared to other muscles in all phases. This muscle might be less required during archery activity besides its \( pCSA \) value was the smallest among the other muscles. Skilled subject has a maximum muscle force on biceps brachii and triceps brachii which contributed 280 N and 337 N, respectively. Similarly, recreational subject produced the maximum value of force in biceps brachii and triceps brachii of 371 N and 323 N, respectively.

**DISCUSSION:** Comparatively, recreational subject required a huge amount of force to draw the bow string while skilled subject tended to use greater amount of force to hold the bow. Similar muscle forces were produced for bow arm of both subjects. Draw arm might require more force to pull the string but bow arm needed a huge force to resist the bow during anchoring phase. As more forces were applied, the chances of the muscles to be fatigue will be higher. Since the skilled archer used two maximized muscles on draw arm during drawing the string compared to recreational archer who used only one muscle, it clearly showed that muscles of recreational archer might tend to muscles fatigue. This case study should be done with additional subject for more precise results.
Figure 1: The MVC data for skilled and recreational archers for both draw and bow arms.

Figure 2: The muscle force of skilled and recreational archers for both draw and bow arms during archery activity.
CONCLUSION: The skilled archer was found to produce 280 N of biceps brachii, 213.9 N of the deltoid, and 123.4 N of trapezius forces compare to that of the recreational archer with 371.1 N, 164.9 N and 163.8 N, respectively for the draw arm during drawing phase. Referring to draw arm muscles data for both subjects, skilled archer used two maximum muscles to pull the string compared to recreational subject who only used one maximum muscle on that particular phases. It is concluded that the recreational archer tends to a muscle fatigue phenomenon thus may contribute to possible serious injuries.

REFERENCES:

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