
Electromyographic Analysis of Selected Upper Extremity Muscles during Jump Throwing in Handball

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Abstract: The purpose of this study was to determine upper extremity selected muscles activity of throwing performance in handball and work-loading to determine the percentage contribution of the muscles that more activation during throwing performance. Five male high level handball players participated in this study were (age: 20.5 ± 0.53 years; body mass: 81.00 ± 3.16 kg; height: 186.5 ± 3.69 cm). The EMG activity of the selected upper extremity muscles was measured using an 16-channel surface EMG system (ME6000 telemetric hardware system, Mega Electronics Ltd., FINLAND), Bipolar, Ag/AgCl surface electrodes (SKINACT, FS-521), Innsbruck, Austria) were placed over the motor point of each muscle, and the EMG signals were acquired at a sampling rate of 1000 Hz with the MEGAWIN version 3.1-b12 software. Results showed the activities and arrangement of selected muscles were Deltoid muscle - medial part 1268.20 ± 133.93 (38.70%), Flexor of the wrist 462.00 ± 89.04 (16.30%), Flexor carpi ulnaris 439.30 ± 33.87 (14.40%), Biceps brachii muscle 364.90 ± 31.34 (12.90%), Rectus abdominis muscle 314.80 ± 48.94 (9.70%), and Pectoralis major muscle 225.90 ± 36.70 (8.00%). The rationale for using sEMG to study muscle activation during a standardized jump throwing in handball is to provide a better understanding of muscle activation during this sport specific movement and muscle contributions during jump throwing in handball, and these data may be important for handball's coaches to jump throwing performance training.

Keywords: EMG, Handball, Muscle Activation, Upper Limb, Throwing

1. Introduction

Handball is an Olympic sport which requires a high level of physical fitness necessary for the relevant activities of the game, and a strenuous contact sport that emphasizes running, jumping, sprinting, throwing, hitting, blocking, and pushing [1, 2]. Among these, throwing capacity has been highlighted as the key to success [3].

Previous studies in team handball throwing [4, 5, 6, 7, 8, 9, 10, 11] analyzed standing throws, standing throws with run-up, as well as jump throws, and identified the ball release speed as the main performance factor determining the throwing movement. It has been estimated that velocity and precision play a fundamental role in scoring a goal [6, 12]. Despite the fact that performance improvement is attributed mainly to neural factors, few researchers evaluated simultaneously the changes in performance with the changes in muscle activation using surface electromyography (EMG) [13].

In throwing events, the shoulder and arm musculature is responsible for the propulsion of the object held in the hand as well as for the protection of the surrounding tissues [14]. Muscles participate critically in the execution of human motor tasks. When muscle strength, power, or coordination is impaired, task execution is compromised [15]. The muscle can perform many mechanical functions. A muscle can develop force and power, and over time produce work output, or it can dissipate mechanical energy if its active fibers are stretched. When its tendon, aponeurosis, and other in-series elastic elements are stretched, energy is stored. The force-length-velocity property of muscle can stabilize movement with its impedance-like function before reflexes become operative [16, 17, 18]. Muscles redistribute the net mechanical energy of the body segments because each muscle force causes reaction forces throughout the body with the net effect being to accelerate some segments and decelerate others [19].

Studies of the neuromuscular system often employ recordings of the electrical activity of skeletal muscle. These

electromyographic recordings may be of electrical signals detected within a muscle via needle or wire electrodes or from the surface of the skin via surface electrodes. Surface electromyography (EMG) is frequently used to estimate the amount of muscle activation required for specific tasks [20, 21] and to examine changes in muscle activation as a result of training and performance [22].

Despite the basic (body mass, body height, and body mass index) and specific (hand) anthropometric characteristics are important to technical and tactical skills [23], but elite performance also demands strength and power in both the upper and the lower limb muscles. So the purpose of this study was to determine upper extremity selected muscles activity of throwing performance in handball and work-loading to determine the percentage contribution of the muscles that more activation during throwing performance by using electromyography (EMG).

Electromyographic (EMG) recordings during athletic throwing movements allow for the determination of the timing and quantity of muscle activation, and they are helpful to trainers and therapists for providing athletes with appropriate technical instructions, strength training, injury prevention, and rehabilitation protocols [24].

The EMG signal variables related to the amplitude of the electrical activity (root mean square, i.e. RMS or integrated EMG, i.e. IEMG) is quantified as activity level [25] to more understanding of muscle activation during this sport specific movement and muscle contributions during jump throwing in handball.

2. Methods

2.1. Participants

Five male high level handball players participated in this study were (age: 20.5 ± 0.53 years; body mass: 81.00 ± 3.16 kg; height: 186.5 ± 3.69 cm). They were athletes in the state of Alexandria, Egypt, and participated in regional and national competitions; and they are members of a professional team that plays in the Egyptian handball Super League.

2.2. Procedures

A 15 min warm-up was allowed for each participant including general and shoulder-specific mobility exercises, as well as stretching exercises and familiarization trials. The speed-accuracy instruction was selected because it is similar to the competition requirements, where the player attempts to

throw as fast and accurately as possible in order to score a goal. The participants completed jump throws from the 7 m penalty line using a standard handball for men after 3 steps running. A total of 5 successful trials were recorded for each participant with one minute rest between trials as in the studies of Oliver, Plummer, & Keeley [26] and Rojas *et al.* [27], and the best two trials were selected to analysis for each participant.

The EMG activity of the selected upper extremity muscles (Deltoid muscle - medial part (D-m), Biceps brachii muscle (BB), Flexor of the wrist (FW), Flexor carpi ulnaris (FCU), Pectoralis major muscle (PM), and Rectus abdominis muscle (RA)) was measured using an 16-channel surface EMG system (ME6000 telemetric hardware system, Mega Electronics Ltd., FINLAND).

After skin preparation (shaving, gently scrubbing, and cleaning with alcohol), Bipolar, Ag/AgCl surface electrodes (SKINTACT, FS-521), Innsbruck, Austria) were placed over the motor point of each muscle. All EMG signals were visually monitored during the collection of data, and the EMG signals were acquired at a sampling rate of 1000 Hz with the MEGAWIN version 3.1-b12 software. EMG full-wave rectification by RMS Averaging. Averaged RMS value is calculated according to the following equation:

$$RMS\ value[I] = \sqrt{\frac{\sum_{i=n}^{n+N-1} |Data_{Raw}[i]|^2}{N}}$$

Where: I = index of RMS data

i = index of raw data

N = number of data points in RMS calculation

n = [1, N+1, 2N+1, ...]. [28]

2.3. Statistical Analysis

Data are expressed as means \pm standard deviations by IBM SPSS Statistics 21 was used to examine the descriptive statistics.

3. Results

The mean values and standard deviations of the muscles activity during jump throwing performance are presented in Table 1. The Deltoid muscle - medial part had greater activity during performance, then the Flexor of the wrist muscle is the second muscle by activity, Flexor carpi ulnaris muscle, Biceps brachii muscle, Rectus abdominis muscle, and in the last Pectoralis major muscle.

Table 1. Descriptive values (Minimum, Maximum, Mean, and Std. Deviation) of muscle activity during jump throwing in handball.

Muscles activity	Minimum	Maximum	Mean	Std. Deviation
Deltoid muscle - medial part (μ v)	1049.00	1447.00	1268.20	133.93
Biceps brachii muscle (μ v)	316.00	435.00	364.90	31.34
Flexor of the wrist (μ v)	345.00	591.00	462.00	89.04
Flexor carpi ulnaris (μ v)	405.00	518.00	439.30	33.87
Pectoralis major muscle (μ v)	170.00	283.00	225.90	36.70
Rectus abdominis muscle (μ v)	260.00	414.00	314.80	48.94

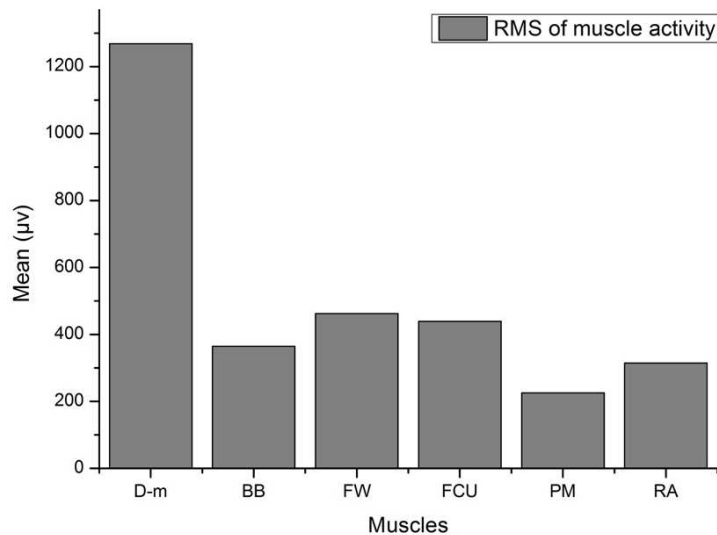


Figure 1. Muscle activity: Deltoid muscle - medial part (D-m), Biceps brachii muscle (BB), Flexor of the wrist (FW), Flexor carpi ulnaris (FCU), Pectoralis major muscle (PM), and Rectus abdominis muscle (RA) during jump throwing in handball.

And the mean values and standard deviations of the work-loading during jump throwing performance are presented in Table 2. That demonstrate muscles contributions during performance are following, The Deltoid muscle - medial part

had greater contribution during performance, the Flexor of the wrist muscle, Flexor carpi ulnaris muscle, Biceps brachii muscle, Rectus abdominis muscle, and in the last Pectoralis major muscle.

Table 2. Descriptive values (Minimum, Maximum, Mean, and Std. Deviation) of work-loading during jump throwing in handball.

Muscles Work-loading	Minimum	Maximum	Mean	Std. Deviation
Deltoid muscle - medial part (%)	35.00	44.00	38.70	3.16
Biceps brachii muscle (%)	10.00	15.00	12.90	1.45
Flexor of the wrist (%)	13.00	21.00	16.30	2.67
Flexor carpi ulnaris (%)	13.00	17.00	14.40	1.26
Pectoralis major muscle (%)	6.00	9.00	8.00	1.05
Rectus abdominis muscle (%)	7.00	14.00	9.70	1.89

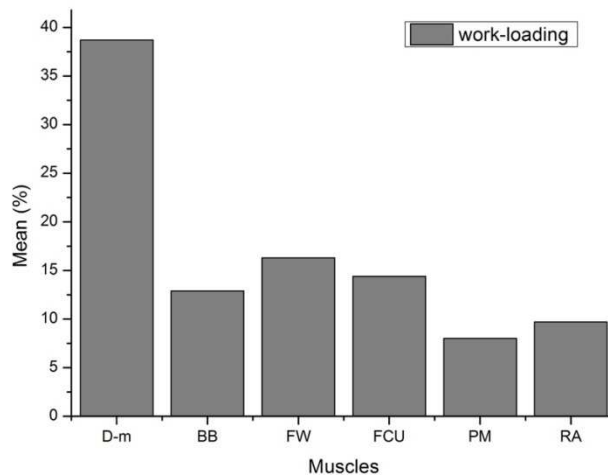


Figure 2. Work-loading of muscles: Deltoid muscle - medial part (D-m), Biceps brachii muscle (BB), Flexor of the wrist (FW), Flexor carpi ulnaris (FCU), Pectoralis major muscle (PM), and Rectus abdominis muscle (RA) during jump throwing in handball.

4. Discussion

Handball is one of games that require a high level of fitness beside the technical and mental preparation, and it's one of the most sports that required physical fitness elements such as strength and power and speed, especially in the upper

extremity to adopt a lot of skills on the efficiency and effectiveness of the muscular strength of the upper extremity.

And jump throwing in handball is the most important skill for their impact and effectiveness during the games where they constitute more than 80% of the throws number during the games [29].

And the most important muscles of upper extremity that

contribute to this skill that working on the joints of arm throwing (shoulder – elbow - wrist), and emphasize the importance of muscular work balance of these muscles not only for better performance level of skill, but also to prevent injuries, where previous studies indicated to the injury rate in high level players were 0.6-2.4 injury per 1,000 hours of training and 13.3-108 injury per 1,000 hours during the games [30, 31, 32, 33].

So the purpose of this study was determine muscular activity of selected muscles of the upper extremity while performing jump throwing in handball.

The results indicated that the Deltoid muscle - medial part is the most active during the performance, due to the deltoid muscle which is working to start moving the shoulder joint that work in a big range of motion during jump throwing in handball, and cause a subscription that muscle during the performance significantly and the results showed that from the high rate of activity of this muscle than other muscles which is confirmed by studies [24, 34, 35, 36] that deltoid muscle - medial part is one of more active muscles during performance throwing skills, and also to maintain the shoulder joint during movement or abduction position [37, 38].

The results show that the Flexor of the wrist, Flexor carpi ulnaris are the second and third, due to the fact that these two muscles work to catch movements by hands on the ball, as is evident from the beginning of the performance that the player catch the ball, resulting in the movement of muscle contraction from the beginning of the throwing until the moment the ball out of the player's hand, as they work for directing the ball through moving wrist joint at the ball release [39, 40].

And the results indicated that the muscular activity of Biceps brachii in fourth place due to the fact that the muscle is working to move the elbow joint of the maximum swing arm to stabilize it until the moment before throwing to the goal, and the muscle move the joint forward to increase the throwing arm velocity and through it help in the stability of the shoulder [24]. As well as the basic function of this muscle is flexion of the elbow joint and help of shoulder joint flexion [41].

The present EMG results indicated that the EMG activity of the Rectus abdominis muscle is in the fifth among the selected muscle and that muscle work in the case of contraction from the beginning of takeoff phase during the throwing, where they are working on hyperextension of lumbar spine, which helps the player to take off higher than the opponent and it's one of important muscles that contract through the cocking phase in throwing [42].

The results show that the Pectoralis major muscle ranked last, although it's a big and effective muscle in the upper extremity movements due to the quality of the phase measured from the moment of maximum arm swing to the moment of ball release, resulting in activity of muscle is greater in arm muscles than Pectoralis major muscle, as a result of catch the ball and carry it from the beginning of the performance to the end where they are moving the arm from

back to the top and front [34, 36, 43], and also because the jump throwing skill in handball be arm movement rather than forward to the inside, where the activity of the pectoralis major muscle increases when the arm do internal movement, where they work on the arm adduction movements, and so was its less according to the nature of the performance of the jump throwing skill [24].

5. Conclusions

The purpose of this study was determine muscular activity of selected muscles of the upper extremity while performing jump throwing in handball. Results showed the activities and arrangement of selected muscles were Deltoid muscle - medial part 1268.20 ± 133.93 (38.70%), Flexor of the wrist 462.00 ± 89.04 (16.30%), Flexor carpi ulnaris 439.30 ± 33.87 (14.40%), Biceps brachii muscle 364.90 ± 31.34 (12.90%), Rectus abdominis muscle 314.80 ± 48.94 (9.70%), and Pectoralis major muscle 225.90 ± 36.70 (8.00%). Finally, the rational for using sEMG to study muscle activation during a standardized jump throwing in handball is to provide a better understanding of muscle activation during this sport specific movement and muscle contributions during jump throwing in handball, and these data may be important for handball's coaches to jump throwing performance training.

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