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EFFECT OF DIFFERENT JAB TECHNIQUES ON PEAK ACTIVATION OF UPPER-BODY MUSCLES IN YOUTH BOXERS

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Abstract

The study purpose was to analyse the peak EMG at five upper-body muscles during four different jab techniques in youth boxers.

Materials and methods. Male youth national-level boxers (n=7) were assessed for peak electromyography (EMG) of anterior deltoid (AD), biceps brachii (BB), triceps brachii (TB), flexor carpi radialis (FCR), and upper trapezius (UT) while performing four jab techniques: long-range targeting head (LRH), long-range targeting body (LRB), medium-range targeting head (MRH), and medium-range targeting body (MRB).

Results. The LRH induced the highest EMG for AD (2092.9±411.9) and BB (1392.0±687.3). The MRB induced the highest EMG for the FCR (1337.16±538.28), TB (1589.3±600.3), and UT (1221.2±507.5). However, between jab techniques, only the AD showed a significant ($p<0.001$) different EMG. Specifically, the LRH induced greater AD EMG compared to LRB (157.5 [$p<0.001$]), MRH (411.0 [$p=0.003$]), and MRB (398.3 [$p=0.010$]). Further, the LRB induced greater AD EMG compared to MRH (253.5 [$p=0.024$]) and MRB (240.8 [$p=0.049$]). The MRH and MRB (-12.7 [$p=0.911$]) induced similar AD EMG.

Conclusions. Peak EMG at five upper-body muscles varies between jab techniques. However, the differences seem relatively small, except for the AD muscle, with a descending pattern of peak EMG for the LRH > LRB > MRH and MRB jab techniques.

Keywords: Boxing, Youth sports, Muscles, Electromyography, Musculoskeletal and neural physiological phenomena, Human physical conditioning.

Introduction

Boxing (also known as pugilism) is one of the oldest combat sports in the history of mankind (Chaabène et al., 2015). Interconnected factors like motor and psychological ability, sound technique, and tactics may impact the outcome of a boxing match (Buśko et al., 2014), as well as the selection and accurate execution of a punch above the belt, to the head or chest (Dinu & Louis, (2020). Among punching techniques, the jab is the longest-range punch used in boxing (Wigle et al., 2014). A jab is performed with several aims, such as establishing dominance or initiating further punching combinations (Gilbert, 2018; Wigle et al., 2014). Attacking an opponent with a jab is effective and energy-saving (Werner & Lachica, 2000). The jab can be executed using different techniques, such as the long-range (i.e., with step) and the medium-range (i.e., without step) jab (Wigle et al., 2014), aimed at different target areas: long-range jab targeting head, long-range jab targeting body, medium-range jab targeting head and medium-range jab targeting body. However, it is not clear which jab technique recruits which muscle in terms of peak muscle activation (Chen et al., 2021; Stanley, 2020; Walilko et al., 2005).

Electromyography activity (EMG) is useful to identify muscle recruitment and sequence of involvement during

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specific movements (Carrier et al., 2015; Reaz et al., 2006; Roberts & Gabaldón, 2008). Such information may help to design better training drills and physical fitness test batteries (Oliva-Lozano & Muyor, 2020; Türker & Sözen, 2013). Putra et al. (2021), used surface EMG on dominant upper limb muscles of healthy male adult (31.9 ± 3.1 years) during punch performance (in a virtual reality environment) in standing and sitting positions, revealing no difference in the percentage of maximum EMG of upper trapezius, anterior deltoid, biceps and triceps muscles of dominant side. Shigeki et al. (2018) examined the three-dimensional trunk kinematics and surface EMG of lower back muscle activity among experienced and inexperienced male boxers (20.9 ± 1.6 years) during a straight punch with the dominant and non-dominant arms and noted greater EMG in the inexperienced group. In another study by Lockwood & Tant (1997), the authors examined the EMG of the gastrocnemius, biceps femoris, rectus femoris, external oblique, serratus anterior, pectoralis major-s ternal, anterior deltoid, and triceps brachii muscles in synchronisation with two-dimensional kinematics, while professional and amateur male boxers (24.2 ± 1.0 years) performed jabs, and noted higher wrist and elbow velocity in the professional group, although similar EMG was noted between the groups for all the assessed muscles.

Although previous studies (Lockwood & Tant, 1997; Shigeki et al., 2018) assessed EMG of muscles involved in boxing-related punching techniques, none investigated the upper body muscle EMG while performing different jab techniques. However, a study was conducted by Putra et al. (2021) investigated the EMG of upper body muscles while performing jab in standing and sitting variations indicated no significant differences. Since the study was confined to execution of jab in sitting variations and only on adults, it limits the implication of their results to young boxers. Therefore, the current study aimed at analysing the peak EMG at five upper-body muscles during four different jabs techniques in youth boxers.

Materials and methods

Study participants

To estimate the sample size of the participants, we used the G*Power software (Erdfelder et al., 1996). We had pre-set the effect size as 0.8 according to the benchmark suggested by Cohen (1988) for large effect size, α error probability as 0.05, power as 0.95, number of groups as 1, number of measurements as 4 (since a single group of boxers was repeatedly tested for four different techniques of jab), correlation among repeated measures as 0.5 and the non-sphericity correction € as 1 for repeated measures ANOVA (Lakens, 2013), the total sample size was n = 5. However, a sample of n = 8 was considered appropriate due to potential participants attrition. In addition, a greater number of participants may help to compensate for potential data death due to difficulties related to EMG recordings. For example, EMG recording is vulnerable to contamination from a variety of causes, including interference from the electrical supply, mechanical objects, stimulus objects, activity of other muscles, and fast movement (e.g., surface EMG electrodes can come off from the attached surface, or induce malfunction) (Türker, 1993). Indeed, after the completion of data collection, the equipment could not capture data for one subject. Therefore, we proceeded with a total of seven participants (n = 7, age = 17.3 ± 1.3 years, boxing experience = 5.9 ± 1.2 years) as the sample for the study. All the participants were members of a training centre and were practising to participate in an upcoming competition. The participants' height (175.3 ± 5.9 cm) and weight (72.1 ± 11.3 kg) varied since participants were competing in different weight categories. The study included those who had represented their state in junior national or higher-level competition and were free from any physical condition which might have hampered their normal physical performance.

Ethics and consent

Participants were informed about the study, methodology, possible outcomes, risks, and benefits. Then, the legal guardians of the participants signed an informed consent form that clearly mentioned the participants' right to withdraw at any time from the study. The youth participants provided verbal consent. The study was conducted in the sports biomechanics laboratory of Lakshmibai national institute of Physical Education, Gwalior, India, in accordance with the Declaration of Helsinki (World Medical Association, 2013). The study was part of a doctoral study that was approved by the departmental research committee (DRC) at the Department of Sports Biomechanics, Lakshmibai National Institute of Physical Education, Gwalior, India, with the registration number (No. Academic/Ph.D./409/1284).

Study design

The EMG of the anterior deltoid (AD), biceps brachii (BB), triceps brachii (TB), flexor carpi radialis (FCR), and upper trapezius (UT) muscles were recorded while boxers executed four jab techniques i.e., long-range targeting head (LRH), long-range targeting body (LRB), medium-range targeting head (MRH) and medium-range targeting body (MRB). All the EMG recording were obtained from the same upper-body limb preferred by the boxers to perform the punches. The whole data collection procedure was completed within one day.

Equipment and measurements

To investigate the EMG of the muscles, the BTS FREEEMG device was used (Bioengineering, 2011). The device was composed of EMG probs (up to 16 probs), a USB receiver, and the EMG-Analyzer software. Jang et al. (2018) conducted a study to establish the validity and reliability of the device and reported that the device exhibited moderate to high reliability and acceptable validity. Furthermore, Jang et al. (2018) concluded that the device is very adjustable and useful for any type and intensity of exercise because of its high accessibility and portability. For all the techniques of jab, the EMG of the five selected muscles were recorded at the frequency of 1000 Hz, using five probs and the signals were transferred and analysed using a USB receiver and the EMG-Analyzer software, respectively. The unit of measurement was microvolt (μV).

The participants were using their standard practice gloves. The size and weight of the gloves were as per the guideline of the International Boxing Association (IBA) (AIBA, 2010). As the target for different techniques of jab, medium size boxing punching bag (36" × 18") was used and hung from the practice area ceiling.

Procedure of data collection

The participants were informed and given sufficient time to familiarise themselves with the test procedure. The participants were instructed to remove their upper body wear for smooth placement of the EMG probs. The selected muscles were identified by the manual palpation method mentioned by Kothari et al. (2014). The placement of the EMG probs were undertaken as per the recommendation of the SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles) project (Hermens et al., 1999). The locations for the placement of the EMG probs were shaved and cleaned with alcohol swabs (Non Woven Alcohol Swab, Recombigen Clear & Sure, India) to reduce skin impedance. The surface EMG electrodes (H124SG, Adafruit, USA) were stuck to the muscle fibres line and connected to the securely attached wireless EMG probs. The wireless EMG probs were secured with adhesive medical tape (Mendwell Adhesive Tape USP, Prominence Healthcare Pvt. Ltd., India) so that it could not come off during the execution of the techniques of jab. The EMG probs were connected wirelessly to the USB receiver, which was later linked to a laptop to extract the data using the EMG-Analyzer software. The whole BTS FREEEMG system was calibrated as per the user manual (BTS FREEEMG 300 User Manual, 2013).

After adhering the EMG electrodes and the probs on the selected muscles, the participants were given 2 minutes for mild warm-up and shadow boxing with a focus on jab techniques. After the warm-up the participants were again verified for the stickiness of the EMG electrodes and probs. Afterward, the participants were asked to execute the techniques individually. The participants were allowed to complete three valid jab attempts for each of the four assessed techniques, with 1 minute of rest between techniques.

The targets were marked on the hung punching bag using a temporary marker pen according to the participant's height. For the target head, a rectangle was drawn of the size "head length × head width" at the level of the head of the athlete. Similarly, another rectangle was drawn of the size "torso length × shoulder width" for the target body at the participant's body level. For the long-range jab technique, the participants were instructed to take a step and then execute the punch. While for the medium-range jab technique the participants throw the punch from a standing position without significant step. The distance of the leading leg to the punching bag was according to the arm length of the participants. The participants were asked to perform the techniques with their maximum effort without external motivation.

Data analysis

After extracting the data from the USB receiver, the EMG-Analyzer software displayed the analysis reports on the laptop screen. The raw EMG signals were visualised along with the processed peak value, the root mean square, and the average rectified values. However, only the processed peak value (Figure 1) was considered for further analysis. The average values from the three trials were calculated manually using Microsoft Office Excel (Microsoft Office Professional Plus 2019).

Statistical analysis

Means and standard deviations were calculated. Data normality and sphericity assumptions were verified (Shapiro-Wilk test and Mauchly's test of sphericity). A one-way repeated measures analysis of variance (ANOVA) test was applied to compare muscles EMG (AD, BB, TB, FCR, UT) between jab techniques, using the Least Significant Difference (LSD) confidence interval adjustment method as post-hoc. All statistical analyses were performed using the IBM SPSS software for Windows (version 27.0, Armonk, NY: IBM Corp). For all the calculations level of significance was set at 0.05.

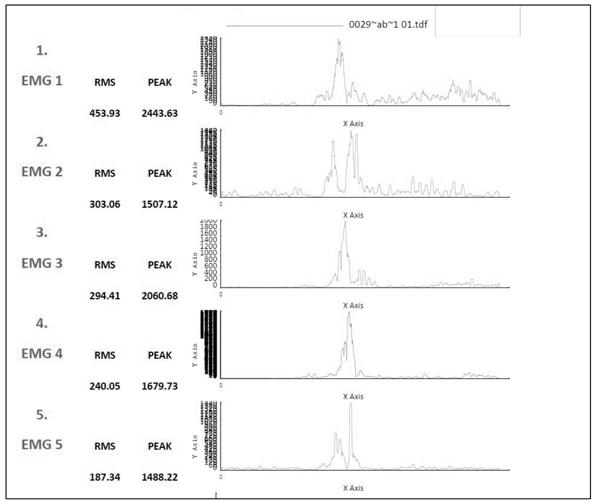

Fig. 1. Processed peak and root mean square values.
Note that during jab on head target area, the biceps brachii (EMG 2) experienced activation during preparatory phase of the punch followed by anterior deltoid (EMG 1) and triceps brachii (EMG 3) during elbow extension. The flexor carpi radialis (EMG 4) showed peak activity during impact on the punching bag, followed by peak muscle activity of the upper trapezius (EMG 5) and biceps brachii (EMG 2) during termination phase of the jab.

Results

The results from table 1 display the mean and standard deviation of EMG of the selected muscles for all four techniques of jab, along with the univariate test result of the within-subject factor. The descriptive statistics reveal that for the AD and BB muscles, the technique LRH exhibited the highest peak EMG (AD = 2092.9 ± 411.9, BB = 1392.0 ± 687.3), whereas for the muscles FCR, TB, and UT, the technique MRB exhibited the highest peak EMG (FCR = 1337.2 ± 538.3, TB = 1589.3 ± 600.3, and UT = 1221.2 ± 507.5). However, the F value for the within-subject factor 'Techniques of Jab' was significant only for AD muscle (AD: $F (3, 18) = 9.738$, $p < 0.001$, $\eta p2 = 0.619$, $1-\beta = 0.989$). It indicates that the main effect of the factor 'Techniques of Jab' is significant with a large effect size ($\eta p2 \geq 0.14$) and high power ($1-\beta = 0.989$) only for the muscle AD, which explains that there were significant differences in EMG between different techniques of jab only for AD muscle. Further, the pairwise comparison table 2 among the techniques of jab for the AD muscle reveals that except for the pair MRH versus MRB, all the other pairs exhibited significant differences among themselves. Table 2 reveals that for the AD muscle, the EMG of the technique of jab LRH is significantly higher compared to LRB ($\Delta = 157.5$, $p < 0.001$), MRH ($\Delta = 411.0$, $p = 0.003$), and MRB ($\Delta = 398.3$, $p = 0.010$); while the technique LRB is significantly higher than MRH ($\Delta = 253.5$, $p = 0.024$) and MRB ($\Delta = 240.8$, $p = 0.049$); however, for the pairs MRH

Table 1. Muscle peak EMG (μV) in selected upper-body muscles in youth boxers while performing four jab techniques

Muscle	LRH	LRB	MRH	MRB	Between jab techniques comparison
AD	2092.9 ± 411.9	1935.4 ± 381.6	1681.6 ± 414.6	1694.6 ± 291.4	F (3, 18) = 9.738, p < 0.001, ηp2 = 0.619, 1–β = 0.989
BB	1392.0 ± 687.3	1195.7 ± 404.5	1275.1 ± 433.7	1365.3 ± 590.3	F (3, 18) = 0.520, p = 0.674, ηp2 = 0.080, 1–β = 0.135
FCR	1029.8 ± 502.6	1206.3 ± 479.8	1135.0 ± 465.4	1337.2 ± 538.3	F (3, 18) = 1.505, p = 0.247, ηp2 = 0.201, 1–β = 0.329
TB	1393.3 ± 596.5	1342.9 ± 693.9	1482.9 ± 378.5	1589.3 ± 600.3	F (3, 18) = 0.636, p = 0.601, ηp2 = 0.096, 1–β = 0.157
UT	1019.2 ± 508.7	1192.6 ± 510.5	1030.1 ± 498.4	1221.2 ± 507.5	F (3, 18) = 1.724, p = 0.198, ηp2 = 0.223, 1–β = 0.374

Abbreviations: AD – anterior deltoid; BB – biceps brachii; FCR – flexor carpi radialis; TB – triceps brachii; UT – upper trapezius; LRH – long-range targeting head; LRB – long-range targeting body; MRH – medium-range targeting head; MRB – medium-range targeting body. ηp^2: partial eta squared; 1–β: observed power.

Table 2. Pairwise comparison of anterior deltoid peak EMG (μV) between four different jab techniques

Pairs (jab techniques)	Mean difference
LRH versus LRB	157.5 (p < 0.001) *
LRH versus MRH	411.0 (p = 0.003) *
LRH versus MRB	398.3 (p = 0.010) *
LRB versus MRH	253.5 (p = 0.024) *
LRB versus MRB	240.8 (p = 0.049) *
MRH versus MRB	-12.7 (p = 0.911) *

*: *p* value for difference between jab techniques. *Abbreviations*: LRH – long-range targeting head; LRB – long-range targeting body; MRH – medium-range targeting head; MRB – medium-range targeting body.

and MRB (Δ = -12.7, p = 0.911) no significant difference was observed. An overview of the descriptive statistics of table 1 also reveals that among all the selected muscles, the AD muscle exhibited the highest peak EMG for all the techniques of jab (LRH = 2092.9 ± 411.9, LRB = 1935.4 ± 381.6, MRH = 1681.9 ± 414.6 and MRB = 1694.6 ± 291.4).

Discussion

During the execution of a jab in boxing, the analysis of EMG of muscles such as the biceps brachii, triceps brachii, anterior deltoid, upper trapezius and flexor carpi radialis are crucial due to their key role in the muscular recruitment sequence during punch movement (Dyson et al., 2007; Lockwood & Tant, 1997). A study by Valentino et al. (1990) already reported that there are techniques in the degree of muscle activation over different muscles and found a noticeable difference in the recruitment of muscles during a jab punch versus an uppercut, particularly on the deltoid muscle. However, in the current study the difference in peak muscle activation was observed only for AD muscle.

The current results revealed that the technique LRH exhibited the highest peak muscle activation for the AD and BB muscle, whereas the technique MRB exhibited the highest peak muscle activation for the FCR, TB, and UT muscles. The participants of the study had expressed that during the execution of the LRH technique, they were required to extend their punching arm the most. Previous studies have already explained that in doing so, the AD muscle is primarily responsible for moving the arm forward (Elzanie & Varacallo, 2022). It also explains the finding of pair wise comparison of the techniques of jabs which reveals that muscle activation of the technique LRH is significantly higher compared to LRB, MRH, and MRB, while the technique LRB is significantly higher than MRH and MRB. On the other hand, from an extended forward position of the punching arm, the BB muscle was required to work harder in the LRH technique compared to the other techniques to flex the arm to the original position. That is why the results show that the LRH technique exhibited highest peak muscle activation for the AD and BB muscles.

While performing the techniques targeting the body, the forearm tended to pronate more which caused the FCR and TB to activate more during the execution of those techniques. At the same time, the UT functioned to stabilize the downward movement of the arm while targeting the body. That is why for the muscles FCR, TB, and UT, the MRB technique of jab exhibited the highest peak muscle activation.

In another study, Dyson et al. (2007) reported higher punching force and speed when the target area was head over the body. The study also validated that when a lead arm straight punch is thrown on the head, there is a quarter turn of the torso and pelvis, which adds additional torque to the upper body movement and due to which peak muscular activity might be observed for the deltoid and biceps muscle group. It is observed that FCR begins at the medial epicondyle of the humerus and connects to the second metacarpal at the base, and it is crucial for flexing and abducting the hand at the wrist (Kanevsky et al., 2015), whereas the flexion of the wrist is an involuntary movement during impact on the target area in boxing, so highest peak activation for FCR muscle might be due to more flexion at the wrist joint during the execution of jab in MRB technique. The TB muscle is responsible for the extension of the elbow at shoulder elevation and contributes more to elbow extension (Kholinne et al., 2018), while UT is also responsible for elevation and depression of the shoulder (Shih & Kao, 2011). Hence, the highest peak muscle activation for the TB & UT muscles in the technique MRB might be observed due to more elbow extension and higher shoulder elevation while executing the jab at the body target area in the medium range.

Some potential limitations should be acknowledged. The investigators felt that there was a limitation of sample size in the study. Further studies with greater sample size should attempt to replicate current findings.

Conclusions

Peak muscle activation at five upper-body muscles may vary depending on the jab technique preferred by the youth boxers. However, differences between jab techniques seems relatively small, except for the AD muscle, with a descending pattern of peak EMG for the LRH > LRB > MRH and MRB jab techniques.

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Conflict of Interest

The authors declare no conflict of interest.

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ВПЛИВ РІЗНИХ ТЕХНІК ДЖЕБА НА МАКСИМАЛЬНУ АКТИВАЦІЮ М'ЯЗІВ ВЕРХНЬОЇ ЧАСТИНИ ТІЛА В БОКСЕРІВ-ЮНАКІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – statаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 2 табл., 1 рис., 34 джерела.

Мета дослідження полягала в тому, щоб проаналізувати максимальну амплітуду ЕМГ п'яти м'язів верхньої частини тіла під час виконання чотирьох різних технік джеба в боксерів-юнаків.

Матеріали та методи. У боксерів-юнаків національного рівня (n=7, чоловічої статі) оцінювали максимальну амплітуду електроміографії (ЕМГ) переднього дельтоподібного м'яза (ПДМ), двоголового м'яза плеча (ДМП), триголового м'яза плеча (ТМП), променевого м'яза-згинача зап'ястка (ПМЗЗ) та верхнього трапецієподібного м'яза (ВТМ) під час виконання ними чотирьох технік джеба: з дальньої дистанції в голову (ДДГ), з дальньої дистанції в корпус (ДДК), із середньої дистанції в голову (СДГ) та із середньої дистанції в корпус (СДК).

Результати. Джеб ДДГ викликав максимальну амплітуду ЕМГ м'язів ПДМ (2092,9±411,9) та ДМП (1392,0±687,3). Джеб СДК викликав максимальну амплітуду ЕМГ м'язів ПМЗЗ (1337,16±538,28), ТМП (1589,3±600,3) та ВТМ (1221,2±507,5). Проте залежно від техніки виконання джеба лише м'яз ПДМ показував достовірну (p<0,001) відмінну амплітуду ЕМГ. Конкретно, джеб ДДГ викликав більшу амплітуду ЕМГ м'яза ПДМ порівняно з джебами ДДК (157,5 [p<0,001]), СДГ (411,0 [p=0,003]) та СДК (398,3 [p=0,010]). Крім того, джеб ДДК викликав більшу амплітуду ЕМГ м'яза ПДМ порівняно з джебами СДГ (253,5 [p=0,024]) та СДК (240,8 [p=0,049]). Джеби СДГ та СДК (-12,7 [p=0,911]) викликали подібну амплітуду ЕМГ м'яза ПДМ.

Висновки: Максимальна амплітуда ЕМГ п'яти м'язів верхньої частини тіла різниться залежно від техніки виконання джеба. Проте ці відмінності здаються відносно невеликими, за винятком м'яза ПДМ, який демонструє спадний характер максимальної амплітуди ЕМГ для технік джеба ДДГ > ДДК > СДГ та СДК.

Ключові слова: бокс, юнацький спорт, м'язи, електроміографія, м'язово-скелетні та нейрофізіологічні явища, фізична підготовка людини.

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