

Effect of Compression Bandages on Muscle's Behavior

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Abstract: This study aims to explore the relationship between compression bandage (CB) and muscles' performance. Hand wrist, mid-calf, and ankle muscles are subjected to electrical voltage test with and without wearing CB. Electromyography (EMG) analysis is a substantial component often used for the assessment of muscles activity. Flexor Carpi (FC), Medial Gastrocnemius (MG), and Soleus (SO) muscles are selected to represent wrist, mid-calf, and ankle muscles respectively. The standardized activities protocol used to test FC muscles are (flexion-extension and squeezing a soft roll), while the activities for MG and SO muscles are (flexion-extension and while walking). The obtained data are analyzed using Mega-win and Mat-lab software. Wearing CB was associated with significantly lower muscle activation and higher median frequency for MG and SO muscles during different actions. These results suggest that using CB can improve muscles function, which might enhance walking performance and reduce muscles fatigue.

Key words—Compression bandages, Electromyography, Mega-win software, Muscle performance.

1. INTRODUCTION

1.1. Compression bandages

Compression bandages (CBs) consist of elastic textile that exert pressure onto muscles. Bandages can provide the required optimal environment by controlling moisture and compression levels for wound healing. These medical elastic textile structures can improve athletic performance and reduce sports injury, which exerts compression and pressure onto muscles to relieve muscle stiffness and fatigue during sports [1-6]. In clinical practice, CBs are applied in the form of overlapping layers which results in multiple layers of fabric that overlay a particular point of the surface of the limb [7]. CB which applied with spiral 50% overlap technique will overlay the leg with two layers of bandage, CB applied with 33% overlap will result in three layers of bandage and CB applied with the Fig.-of-eight technique with 50% overlap will result in four layers bandaging [7, 8]. Wei-Chun Hsu et al selected eight healthy male recreational runners to perform 40 min. treadmill running trials, one with compression garment (CG), and the other with control garment made of normal cloth. The rating of perceived exertion (RPE) and the surface EMG test of 5 lower extremity muscles including gluteus maximus (GM), rectus femoris (RF), semitendinosus (ST), tibialis anterior (TA), and gastrocnemius (GAS) were measured during the running trial. Participants wearing CG had lower muscle activation in GAS, ST, and RF muscles, despite no additional benefit to lactate clearance or RPE [9].

1.2. Detection and analysis of muscles activation

Electromyography is the subject which deals with the detection, analysis and utilization of electrical signals emanating from skeletal muscles. The electric signal produced during muscle activation, known as the myoelectric signal, is produced from small electrical currents generated by the exchange of ions across the muscle membranes and detected with the help of electrodes [10]. Many researchers have evaluated the effect of sports compression apparel using EMG, applied testing methods and mathematical modeling. However, there is a limited scientific work which has explored that wearing compression garments has a positive influence on muscle activation during running [11]. So that it was necessary in current study to discuss the enhancement of Medial Gastrocnemius (MG) and Soleus (S) muscles activation while wearing CB using eMotion wireless EMG system moreover describe muscle's performance of Flexor Carpi (FC) at different hand wrist actions.

2. EXPERIMENTAL WORK

A. Experimental Samples

Viscose/Polyamide bandages (VI-PA) and two types of Cotton CBs (as shown in “Fig. 1”) were used for hand and leg muscles testing respectively. The three bandages structures are plain weave. Yarn counts and densities are different depends on the construction and technology of the final product.



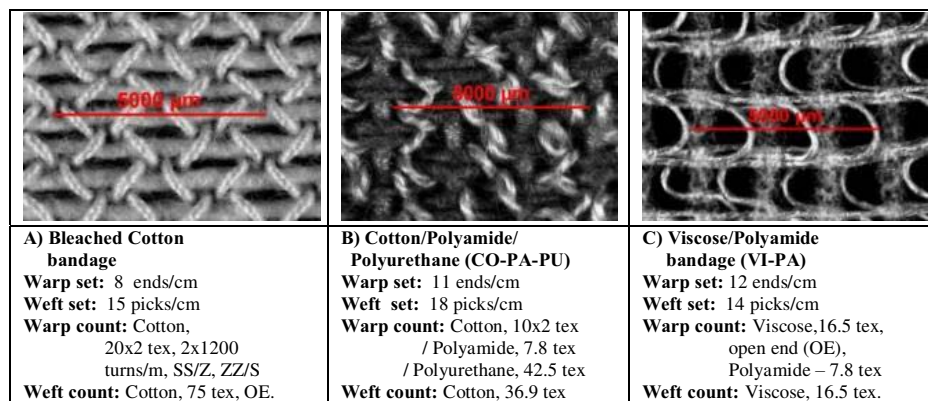


Fig. 1. Experimental Compression Bandages description.

B. Testing Methods

Viscose/Polyamide bandages were used to test the FC muscle voltage during different wrist actions (flexion-extension, squeezing a soft roll) with and without wearing CB (as shown in “Fig. 2”). VI-PA compression is adjusted and standardized to medium compression ranges 22 ± 2 mmHg (through 70% bandage extension and 50% overlap). Bleached Cotton and CO-PA-PU bandages were used to test MG and SO muscles behavior during the standardized protocol actions (flexion-extension and while walking). The lower leg bandage pressure was adjusted to compression ranges 30 ± 2 mmHg (by 100% bandage extension and 50% overlap) [12]. All these tests were carried out on 3 healthy men (age ranges 29- 37 years) using eMotion wireless EMG system at different metronome beats (20, 30, and 40 beats/min). Surface electrodes were pasted on the mentioned muscles of the human skin as shown in “Fig. 2”, three trials for each activity [13]. In order to investigate the change of muscles activity, root mean square (RMS) is processed by exporting the filtered signals with band-pass filtering between 20–500 Hz using Matlab software.



Fig. 2. Emotion EMG system for Flexor Carpi, Medial Gastrocnemius and Soleus muscles [14], [15]

3. RESULTS AND DISCUSSION

“Fig. 3” illustrate the FC muscle voltage with and without wearing the VI-PA CB during the standardized action (flexion-extension), average muscle voltage was 85 and 93.33 μ V respectively (i.e. wearing CB decreases muscle activation by a percent 8.92 % (as listed in Table I).

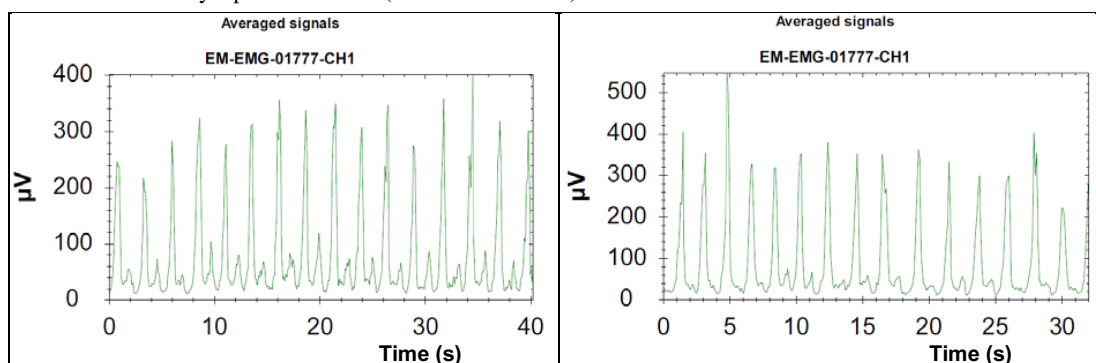


Fig. 3. Flexor Carpi muscle voltage with and without CB, (flexion-extension) action.

“Fig. 4” shows the FC muscle voltage with and without wearing the VI-PA CB during the action (squeezing a soft roll), the average EMG measured signal was 90.67 and 97.67 μ V respectively (i.e. wearing CB enables lower muscle activation by a percent 7.17 %) as illustrated in (Table I). The obtained results in “Figs. 3 & 4” confirm that wearing CB enhances the Flexor Carpi Radialis muscle performance while performing the

standardized activities. The frequency of flexion and extension are similar and therefore, the effect of CB focuses on a reduced muscle oscillation and improves muscle function and efficiency.

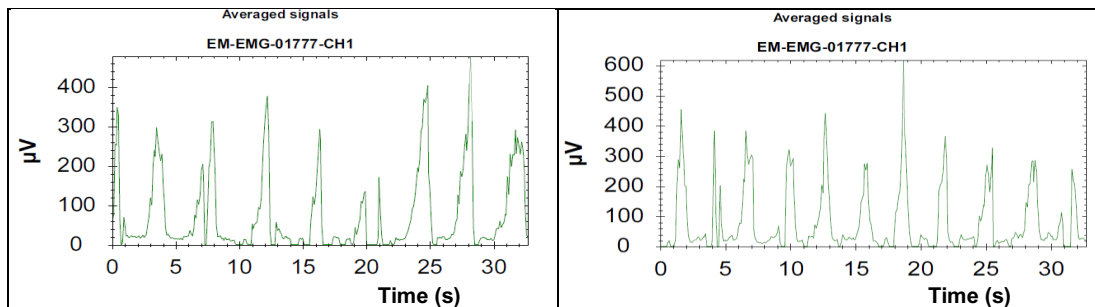


Fig. 4. Flexor Carpi muscle voltage with and without CB, (squeezing a soft roll) action.

3.1. EMG Test of Medial Gastrocnemius Muscle

Surface EMG signals were obtained from the MG and SO muscles by pre-amplified bipolar surface electrodes [16]. “Figs. 5 & 6” show MG muscle performance with and without wearing the CO-PA-PU CB during the standardized action (flexion-extension) and using the bleached Cotton bandage for walking action. Wearing CB enables a significant decrease in MG muscle activity during flexion-extension action by a percent 26.67% and 4.65% while walking (see Tables III and II respectively). This decrease may be due to the increase in the mean muscle fascicle length and the reduction in the mean muscle thickness and mean pennation angle [17]. Researchers have also claimed that muscle force being exerted for a limb's motion and stability may be wasted on muscle flexion-extension, while compression garment may prevent muscle vibrations during sports activities which can enhance athletic performance [11].

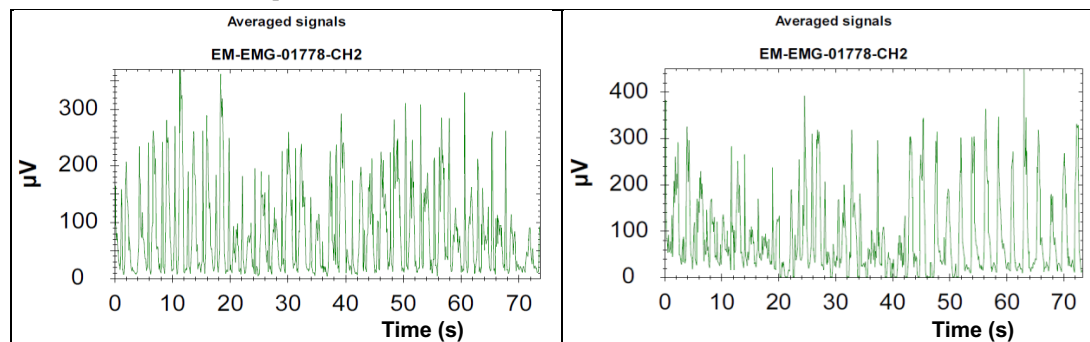


Fig. 5. MG muscle voltage with and without wearing CO-PA-PU bandage during (flexion-extension) action.

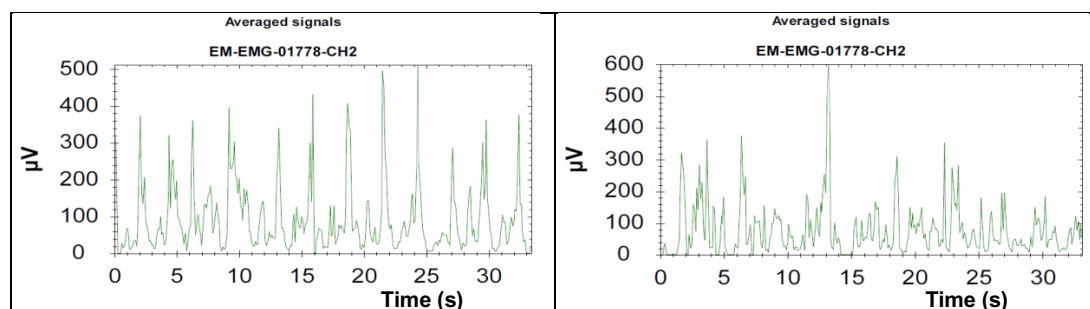


Fig. 6. MG muscle voltage with and without wearing bleached cotton bandage while walking action.

3.2. EMG Test of Soleus Muscle

“Figs. 7 & 8” show SO muscle behavior with and without wearing the CO-PA-PU and bleached Cotton CBs during the activities (flexion-extension and walking) respectively at same speed (using metronome beats 20, 30, and 40 beats/min). Wearing CB decreases SO muscle activity during flexion-extension action by a percent 21.88% and 34.13% while walking as summarized in (Tables III and II) respectively. These significant reductions in SO muscle activation clarify the enhancement of ankle muscle behavior wearing CB, because SO muscle is the main factor of controlling the walking performance while MG muscle is more effective for flexion-extension action.

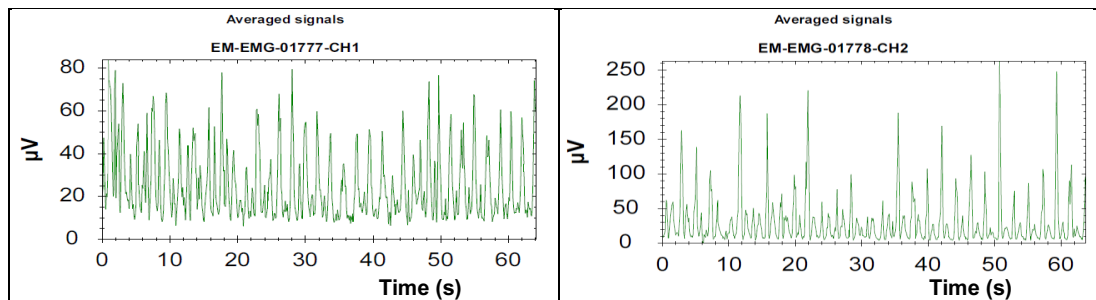


Fig. 7. Soleus muscle voltage with and without wearing CO-PA-PU bandage during (flexion-extension) action.

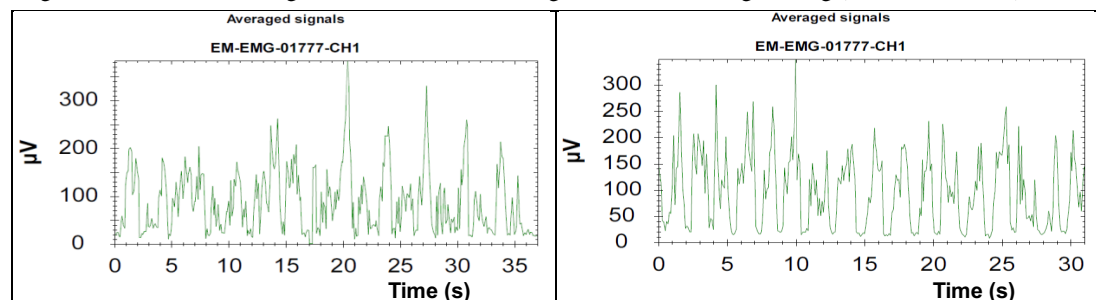


Fig. 8. Soleus muscle voltage with and without wearing bleached cotton bandage while walking action.

3.3. EMG Mean Voltage for FC, MG, and SO Muscles

Emotion EMG system and Mega-win analysis were used to investigate the relationship between three types of CBs and muscles activation. EMG mean voltage for Flexor Carpi muscle (FC) during standardized activities (squeezing a soft roll and flexion-extension) are illustrated as shown in (Table I). Average FC muscle voltages with and without wearing the VI-PA CB were 90.67 and 97.67 μV respectively (i.e. wearing CB decreases muscle activation by a percent 7.17 % during squeezing a soft roll action). Moreover using CB decreases muscle activation by a percent 8.92 % during flexion-extension action.

TABLE I

EMG MEAN VOLTAGE OF THE HAND SIGNALS FOR FLEXOR CARPI MUSCLE

Case	Metronome beats (BPM)	FC, squeezing soft roll action		FC, flexion-extension action	
		Mean voltage (μV)	Standard deviation	Mean voltage (μV)	Standard deviation
With bandage	20	75	101	78	85
	30	81	108	84	86
	40	116	124	93	103
	Mean	90.67	111	85	91.33
Without bandage	20	76	95	81	93
	30	98	121	85	101
	40	119	128	114	134
	Mean	97.67	114.67	93.33	109.33

EMG mean voltage for MG and SO muscles using the C-p-p and bleached cotton compression bandages during the standardized activities (flexion-extension and walking) at the same speed (using metronome beats 20, 30, and 40 beats/min) can be summarized and compared as listed below in (Tables II and III). Wearing bleached cotton CB while walking was associated with a decrease in average MG and SO muscles activation by a percent 2.91 and 18.18% respectively, whereas using C-p-p CB decreases MG and SO muscles activation by a percent 4.65 and 34.13% respectively. While wearing C-p-p CB during flexion-extension action decreases MG and SO muscles activation by a percent 26.67 and 21.88% respectively.

TABLE II

EMG MEAN VOLTAGE FOR LEG MUSCLES WHILE WALKING (BLEACHED COTTON BANDAGE)

Case	Metronome beats (BPM)	Medial Gastrocnemius		Soleus Muscle	
		Mean voltage (μV)	Standard deviation	Mean voltage (μV)	Standard deviation
With bandage	20	76	69	74	59
	30	80	82	88	67
	40	110	114	117	102
	Mean	88.67	88.33	93	76
Without bandage	20	77	93	96	68
	30	94	106	111	98
	40	103	136	134	102
	Mean	91.33	111.67	113.67	89.33

TABLE III
EMG MEAN VOLTAGE FOR LEG MUSCLES WHILE WALKING (BLEACHED COTTON BANDAGE)

Activity	Case	Medial Gastrocnemius		Soleus Muscle	
		Mean voltage (μV)	Standard deviation	Mean voltage (μV)	Standard deviation
Flexion – extension	with bandage	22	27	25	16
	without	30	36	32	60
While walking	with bandage	82	79	83	87
	without	86	86	126	112

3.4. Data Analysis Using Matlab Software

The RMS value for each muscle's activation is calculated using Matlab software to clarify and compare the differences between different standardized actions for hand and leg muscles as shown in (Tables IV to VI). RMS values of the FC muscle using the VI-PA bandage are illustrated in Table IV. Wearing VI-PA bandage was associated with lower muscle activation by a percent of 8.13 % for FC muscle during the standardized activity (squeezing a soft roll) and 7.10% during (flexion-extension action).

TABLE IV
RMS VALUES FOR FLEXOR CARPI MUSCLE SIGNALS

Case	Metronome beats (BPM)	FC, squeezing a soft roll	FC, flexion-extension
		RMS value	RMS value
With bandage	20	136.98	132.36
	30	161.78	147.70
	40	180.43	164.72
	Mean	159.73	148.26
Without bandage	20	132.10	127.86
	30	189.11	155.44
	40	200.40	195.46
	Mean	173.87	159.59

Table V concludes the RMS values for the human leg muscles' signals using the bleached cotton bandage while walking. Wearing CB was associated with a reduction of muscle activation as assured by lower RMS values for MG and SO muscles as average value of the obtained results at metronome beats 20, 30, and 40 beats/min. Table VI summarizes the RMS values for the leg muscles signals using the CO-PA-PU bandage. Wearing C-p-p bandage decreases muscle activation as confirmed by lower RMS values by percentages of 21 and 13.42 % for MG and SO muscles respectively during flexion-extension action, and a percent reduction of RMS values as 6.03 and 22.31 % for MG and SO muscles while walking action. The enhancement of muscles' performance wearing CB may be due to a small increase in intramuscular pressure and in conjunction with the proposed reduction in muscle vibration [18].

TABLE V
RMS VALUES FOR MG AND SO MUSCLES' SIGNALS

Case	Metronome beats (BPM)	RMS value	
		Medial Gastrocnemius	Soleus muscle
With bandage	20	147.85	145.81
	30	165.65	151.47
	40	183.88	237.15
	Mean	165.79	178.14
Without bandage	20	138.4	167.53
	30	181.33	205.74
	40	191.13	190.94
	Mean	170.29	188.07

TABLE VI
RMS VALUES FOR MG AND SO MUSCLES' SIGNALS WEARING (C-P-P BANDAGE)

Activity	Case	RMS value	
		Medial Gastrocnemius	Soleus Muscle
Flexion – extension	with bandage	31.26	35.68
	without	39.57	41.21
While walking	with bandage	112.74	145.97
	without	119.97	187.88

CONCLUSION

Using VI-PA CB reduced the average FC muscle activation by a percent 7.17 and 8.92 % during the standardized actions (squeezing a soft roll and flexion-extension) respectively. Wearing bleached Cotton CB enabled lower muscle activation and higher median frequency for MG and SO muscles by a percent of 4.65 and 34.13 % during walking action. Using CO-PA-PU CB was associated with significantly reduction of MG and SO muscles activation by a percent 26.67 and 21.88 % during flexion-extension action. The obtained RMS values

using Matlab software confirmed that wearing CB improved the performance of FC, MG, and SO muscles and could enhance muscles' fatigue.

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