CONTRIBUTION OF VARIOUS MUSCLES TO SHIVERING IN COLD-EXPOSED MAN

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INTRODUCTION

In many mathematical models of thermoregulation, the contribution of the various muscles to shivering is usually either based on the mass ratio of the muscles involved (1) or on a weighting that assigns shivering activity principally to the trunk muscles (2) (see Table). The purpose of this study was to quantify experimentally the contribution of various muscles to shivering during whole body exposure to cold air.

METHOD

1. ***Experimental.*** Data were obtained from ten male subjects resting in a supine position wearing shorts only and exposed to 10°C air (42% relative humidity and < 0.4 m/s air flow) for 2 h. Surface EMG recordings were taken continuously using Medi Trace pediatric surface electrodes placed 3 cm apart, center to center, on the pectoralis major (PE), rectus abdominus (AB), biceps femoris (BI), brachioradialis (BR), rectus femoris (FE), and gastronemius (GA) muscles. The first two and the latter four sites represent, respectively, the trunk and limb regions of the body.

2. ***Analysis.*** All EMG measurements were digitized at 1024 samples/s. Background (noise) and maximum voluntary contraction (mvc) signals were recorded for 1 s each prior to the 2 h exposure. The integrated or mean rectiiied EMG per 1 s interval was obtained as follows:

$$IEMG_j = \frac{\sum_{i=0}^{1024} |EMG_i|}{1024}, \quad j = 1 \rightarrow 7200$$

The IEMG component due only to shivering (sh) was obtained by subtracting the background value from the measured value, i.e. $IEMGsh_j = IEMG_j - IEMG_{noise}$.

The periods of voluntary movement during the exposure were removed from the data. This left a total of seventeen 4-min periods; average values were obtained as follows:

$$IEMGsh_k = \frac{\sum_{j=1}^{240} IEMGsh_j}{240}, \quad k = 1 \rightarrow 17$$

Mean values were then normalized by dividing each value by its corresponding *mvc* value and adjusted for the muscle mass it represented so that EMG values of different muscle sites could be compared on a relative basis. The contribution of a muscles's shivering activity to the overall activity was determined by dividing its normalized value by the sum of the normalized values of all muscles sites.

RESULTS

Figure of the percent of normalized integrated EMG activity of various muscles to overall shivering over time during exposure to 10°C air

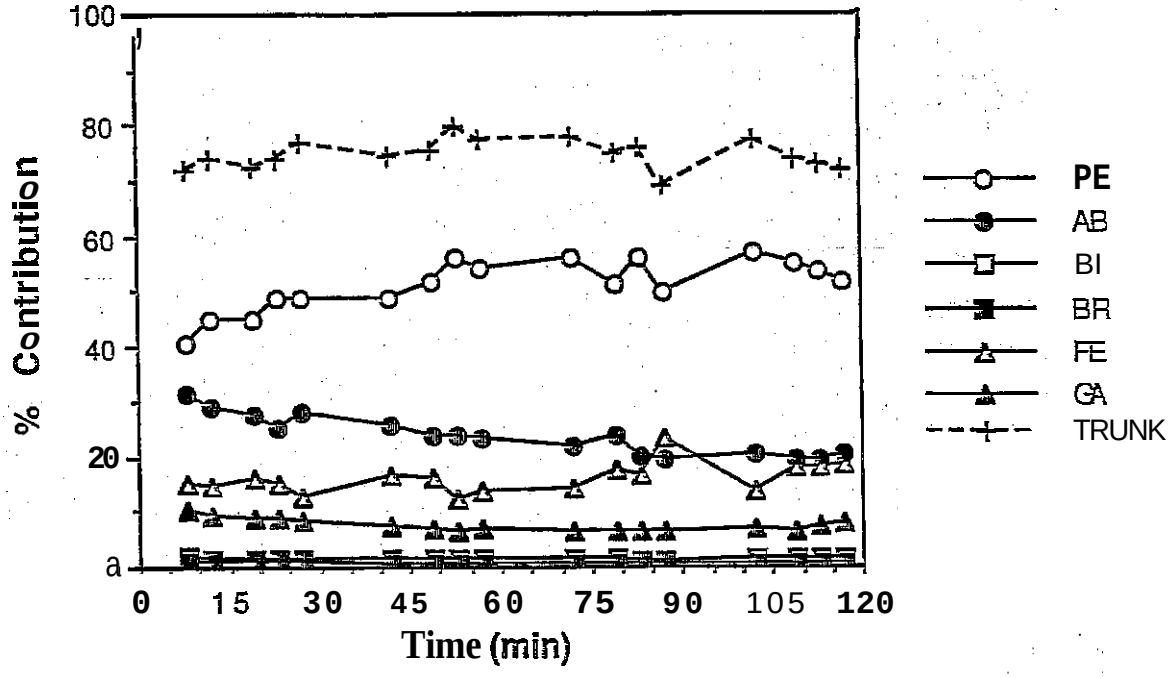

Table of percent contribution of various muscle sites to overall shivering. Experimental values are averaged over the 2 h exposure period.

Site	Mass-weighted (1)	Trunk-biased (2)	Experimental
Head	2	3	--
Trunk	55	85	75
Arms	11	5	2
Legs	32	7	23

CONCLUSION

The experimentally-determined values suggest that the trunk muscles are responsible for about 75% of the overall shivering activity of the body during nude cold air exposure. While this is greater than the trunk's proportionate muscle mass of about 55% (1), it is less than the value of 85% assigned in some models of thermoregulation (2).

REFERENCES

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