Near-infrared spectroscopy and hydrogen clearance: is there any difference between these two methods of muscle blood volume estimation?

Editor,

Muscle blood volume (MBV) is commonly estimated using two methods: near-infrared spectroscopy (NIRS) and the hydrogen clearance method (HCM). The HCM, which is invasive, was initially introduced by Auckland,1–3 NIRS, in contrast, is non-invasive, and has been used to measure the local skeletal muscle deoxygenation and also to estimate regional MBV.4

When studying potential effects of acupuncture, it is desirable to minimise the potential artefacts caused by invasive testing procedures. For this reason, as well as out of consideration for the subject’s comfort, the non-invasive NIRS method would be more desirable when evaluating muscle blood flow changes. Therefore, in this study we estimated MBV changes before and after electroacupuncture (EA) stimuli using NIRS and HCM, in order to determine applicability of the NIRS method in acupuncture experiments.

COMPARING TWO METHODS

Before the study began, the participants were told about the purpose and procedures of the study, and all participants signed consent forms. This study adhered strictly to the principles of the declaration of Helsinki and was approved by the institutional review board of Tsukuba University of Technology.

The experiments were conducted in a room with the temperature set at 25.0±0.5°C and 50.0±5.0% humidity throughout the experimental sessions.

Twenty healthy male students (mean age 21.5±0.9 years) were divided into two groups (HCM, NIRS) using the envelope allocation method.

Two disposable acupuncture needles (40 mm in length, 0.20 mm in diameter, Seirin Co, Ltd, Shizuoka, Japan) were inserted at a depth of 10–15 mm into BL22 (Sanjiaoshu, the same level as the inferior border of the spinous process of L1, 1.5 B-cun lateral to the posterior median line) and BL25 (Dachangshu, the same level as the inferior border of the spinous process of L4, 1.5 B-cun lateral to the posterior median line).5

EA stimulation (1 Hz, waveform/square) was then administered for 5 min, using an Ohm Pulser LFP-4000A (Zen Iryoki, Fukuoka, Japan). The intensity of stimulation was adjusted so that muscle-twitching contractions were elicited in the targeted muscles without causing pain or discomfort to the subjects.

The MBV was estimated by using one method in each group. For the MBV estimation via NIRS (Tissue SO2/Hb Monitor, PSA-IIIN; Biomedical Science, Tokyo, Japan), surface electrodes (20×50 mm dimensions) were attached to the probe with special double-sided tape, which was placed at the midpoint between the two stimulating sites. For the MBV estimation via HCM (UPS-400, Unique Medical Co, Ltd, Tokyo, Japan), needle electrodes (Platinum Electrode; UHE-201, Unique Medical Co, Ltd, Tokyo, Japan) were inserted inferior to the NIRS probe. The locations of the electrodes and EA sites are shown in figure 1.

The subjects were asked to lie on the table in a prone position, and measurement electrodes were applied. Subjects then rested for 30 min on the table before the measurement. Then the baseline MBV was recorded for 1 min, just before the EA (Pre). The MBV was then estimated at 5 min after EA had stopped (Post).

The MBV changes before and after EA were analysed between groups via two-way analysis of variance (ANOVA). Standard response mean (SRM=mean change/SD of change) was also calculated for the NIRS and HCM groups.

SPSS Advanced Models V.15 was used as the statistical analysis software. The level of significance was set at p<0.05. The values presented are mean±SE.

FINDINGS

The MBV responses are summarised in figure 2. The increases in MBV following EA estimated by both methods were significant: NIRS (p=0.001) and HCM (p=0.006). No significant difference existed between the two measurements.

For SRM before and after EA, HCM showed higher SRM than NIRS (6.007 and 0.073, respectively).

Figure 1 The stimulation and measurement sites. EA, electroacupuncture; HCM, hydrogen clearance method; MBV, muscle blood volume; NIRS, near-infrared spectroscopy.
A significant MBV increase was observed in both of the estimation methods and no significant difference existed between the two MBV estimation methods. However, the HCM method showed higher SRM, indicating that it is a more sensitive method for muscle blood estimation. Although the NIRS method showed smaller SRM, it was able to detect significant changes before and after EA. It was confirmed that both methods, NIRS and HCM, were useful for MBV estimation. However, there is a concern that the invasive needle electrode used with HCM might have acted as stimuli and modified the MBV response. NIRS, on the other hand, estimates MBV non-invasively, thus avoiding this problem. In addition, NIRS is a more desirable method, when considering the subject’s comfort during the testing procedure.

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