SEXUAL MEDICINE ORIGINAL RESEARCH

BASIC SCIENCE

Simultaneous Monitoring of Hemodynamic Response in the Pre-Frontal Cortex and Genital Organ During Sexual Arousal Using Near-Infrared Spectroscopy

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ABSTRACT

Background: The monitoring of brain activity along with genital organ response to sexual stimulation can play an important role in understanding the under-lying mechanisms of sexual arousal as well as diagnosing erectile dysfunction. Several studies have observed brain activity corresponding to sexual stimuli, but only a few studies have shown a simultaneous measurement of brain activation and penile response.

Aim: To introduce near-infrared spectroscopy (NIRS) as a portable, easily implemented, and low-cost technique to simultaneously record brain activity and hemodynamics in the genital organ during sexual arousal.

Methods: Hemodynamic measurements of 15 healthy men were obtained using a home-built NIRS system. In the initial experiment, hemodynamics in the pre-frontal cortex (N = 10) were measured during visual sexual stimulation (VSS) and neutral visual stimulation (NVS) to identify brain activity related to sexual arousal. In the subsequent experiment, cerebral and penile hemodynamics were simultaneously measured (N = 5) using NIRS during VSS and NVS.

Results: The pre-frontal cortex showed activity related to VSS but not to NVS. Simultaneous measurements showed a corresponding increase of penile oxygenated and deoxygenated hemoglobin concentration indicating an increase of blood volume associated with sexual arousal in healthy men. An average response delay of 4 seconds was observed in the hemodynamic changes between the brain and genital organ.

Conclusion: In this preliminary study, we presented a NIRS system capable not only of detecting cerebral hemodynamic changes related to sexual arousal but also the simultaneous measurement of penile hemodynamics. We believe the NIRS system can be a potential technique to supplement the field of sexual medicine and can be expanded further to diagnose erectile dysfunction. **Kim E, Kim S, Zephaniah P, et al. Simultaneous Monitoring of Hemodynamic Response in the Pre-Frontal Cortex and Genital Organ During Sexual Arousal Using Near-Infrared Spectroscopy. Sex Med 2018;XX:XXX–XXX.**

Key Words: Near-Infrared Spectroscopy; Hemodynamics; Pre-Frontal Cortex; Visual Sexual Stimulation; Erectile Dysfunction

INTRODUCTION

The inability to attain adequate erection sufficient to perform intercourse, known as erectile dysfunction (ED), leads to a significant negative impact on the quality of life. A number of psychological disorders may contribute to ED such as stress, depression, and performance anxiety. Likewise, it can also be one of the earliest manifestations of an under-lying serious physical disease including diabetes, multiple sclerosis, or cardiovascular disorders. Thus, distinguishing between the psychological and organic origin of ED is a critical task for the clinician.

The normal sexual arousal involves a number of physiological responses among which penile erection is the most definitive

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response in the male body. It has also been shown that there is a neural response during sexual arousal, which could indicate a psychological role in the arousal process. Since the psychological aspect can be revealed by brain activity measurements, numerous studies have tried to understand brain function during sexual arousal. Results from these studies associate sexual arousal with many deep brain and cortical structures in normal healthy men[1–3] suggesting that sexual arousal is indeed a complex neural process. Most studies have employed positron emission tomography (PET) or functional magnetic resonance imaging (fMRI) to observe brain response, along with plethysmography, pneumatic cuff, or the commercial device RigiScan (Timm Medical Technologies Inc, Eden Prairie, MN) to monitor penile tumescence and rigidity. However, even though PET and fMRI are established technologies to monitor brain activity during sexual arousal, they can be technically demanding and expensive. In addition, these modalities must be administered in a clinical environment, which could greatly influence psychological responses, especially for sexual arousal.

In this study, we propose to utilize a system that will enable the concurrent monitoring of cerebral and penile hemodynamics using near-infrared spectroscopy (NIRS). Being non-invasive, low-cost, and portable, NIRS is well-suited for hemodynamic response monitoring in a comfortable and natural setting. NIRS has become a widely used technique in the biomedical field, particularly for brain research.[4] In addition, NIRS can achieve higher temporal resolution, up to an order of milliseconds, compared to fMRI and PET.[5] Such high temporal feature could play an important role for comparison of the brain and genital organ hemodynamic response, and how it is affected by ED.

NIRS has been previously shown to be a reliable tool to measure penile hemodynamics and at the same time provide a more convenient and comfortable setting for the patient.[6,7] In contrast with the prevailing commercial device RigiScan, which measures penile tumescence and rigidity through loops bound to the stem and tip of the genital organ,[8,9] NIRS can provide vasculogenic information with a simple source-detector configuration in order to minimize the discomfort for the subject. Other methods have been applied to assess vascular involvement during penile tumescence including selective pudendal angiography, duplex Doppler ultrasonography, and cavernosometry.[10,11] However, they are limited by the expensive cost and complexity in methodology. The aim of this study is to introduce NIRS as a practical option for the studies of male sexual arousal by measuring the vasculogenic state during penile erection and the concomitant brain response. The authors hope that the study will lead to NIRS being utilized to assist in the proper diagnosis of ED.

METHODS

This study has been reviewed and approved by the Institutional Review Board of the Gwangju Institute of Science and Technology (20140319-HR-10-01-02). 15 Right-handed healthy men (age 24 ± 3 years) participated in the study. The subjects were recruited through university advertisements. Written informed consent was obtained from each subject prior to the experiment.

A home-built NIRS system described in a previous study[6] was used to measure cerebral and penile hemodynamics during visual sexual stimulation (VSS). In the first part of the experiment, hemodynamics from the pre-frontal cortex in 10 subjects were measured to identify the existence of a measurable change in signal related to sexual arousal. In the second part, the simultaneous change in hemodynamics in both the pre-frontal cortex and genital organ from 5 subjects were measured.

The NIRS probes consisted of a light source and detector, where a monolithic photodiode with single-supply transimpedance amplifier was used as a light detector (OPT101; Texas Instruments Inc, Dallas, TX). The light source was a light-emitting diode emitting wavelengths of 735 nm and 850 nm (L735/850-40D32; Epitex Inc, Kyoto, Japan). The 2 wavelengths from the light-emitting diode source sequentially illuminated the tissue, and the transmitted light was detected by the photodetectors. The complete cycle of data acquisition takes 0.25 seconds, for a temporal resolution of 4 Hz.

The placement of the probes in the forehead and genital organ are shown in Figure 1A, B. The head probe had a source-detector separation distance of 3 cm, which provides a penetration depth sufficient to observe a signal from superficial hemodynamics and also cortical areas. Therefore, a shorter channel of 0.8 cm was used to detect hemodynamic change within superficial layers and later the short channel data were suppressed from the longer channel to isolate the critical activation. The head probes were attached by the experimenters using double-sided adhesive 20 × 8 disks (BioSemi Instrumentation, Amsterdam, The Netherlands), which allow adequate fixation of probes without

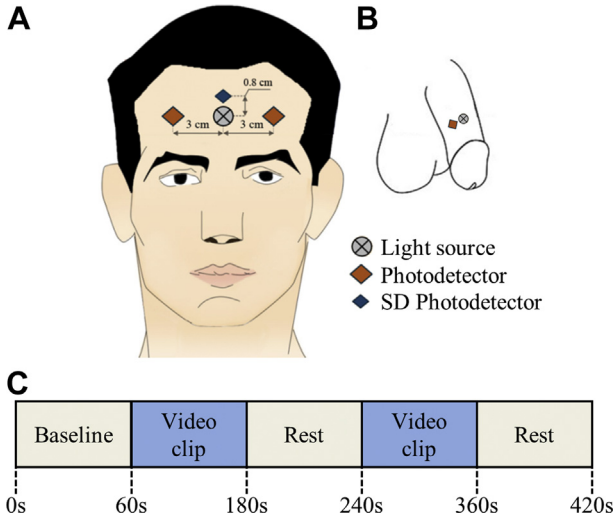

Figure 1. The location of near-infrared spectroscopy probes: on the forehead (A) and genital organ (B). C, Time of procedure for the experiments. SD = short distance.