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Bioceramic fabrics improve quiet standing posture and handstand stability in expert gymnasts

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ABSTRACT

Bioceramic fabrics have been claimed to improve blood circulation, thermoregulation and muscle relaxation, thereby also improving muscular activity. Here we tested whether bioceramic fabrics have an effect on postural control and contribute to improve postural stability. In Experiment 1, we tested whether bioceramic fabrics contribute to reduce body-sway when maintaining standard standing posture. In Experiment 2, we measured the effect of bioceramic fabrics on body-sway when maintaining a more instable posture, namely a handstand hold. For both experiments, postural oscillations were measured using a force platform with four strain gauges that recorded the displacements of the center of pressure (CoP) in the horizontal plane. In half of the trials, the participants wore a full-body second skin suit containing a bioceramic layer. In the other half of the trials, they wore a 'placebo' second skin suit that had the same cut, appearance and elasticity as the bioceramic suit but did not contain the bioceramic layer. In both experiments, the surface of displacement of the CoP was significantly smaller when participants were wearing the bioceramic suit than when they were wearing the placebo suit. The results suggest that bioceramic fabrics do have an effect on postural control and improve postural stability.

1. Introduction

Bioceramic materials, materials that emit high-performance far-infrared (FIR) rays, have recently been the object of high interest mainly for therapeutic purposes including health-promoting practices [1]. Bioceramic garments may also be manufactured for performance enhancing apparel in both leisure activities and competitive sports area [2]. For Yoo et al. [3], ceramics increase thermal insulation by reflecting FIR rays from the body back to the body surface. The principle source of energy needed to power the FIR emission from the garments comes from the human body. Energy from the human body is transferred to these ceramic particles which are acting as "absorbers", maintain their temperature at sufficiently high levels and then emit FIR back to the body [2]. The body can experience energy of FIR as a radiant heat which can penetrate up to 4 cm beneath the skin. Elevation of skin temperature observed suggests that this might result of the acceleration of percutaneous blood circulation [3]. Enhancement of skin microcirculation has been shown using FIR in an animal model [4]. In line with this, an increase in forearm blood flow has been observed in resting subjects whose left arms were in fabric ribbon which was lined with ceramic disks [5]. Gloves have been made out of FIR emitting fabrics and there have been reports that these gloves can be used to treat Raynaud's syndrome [6], notably via improved vasodilatation and circulation. Significant improvements were also documented in both subjective measures of pain and discomfort and in objective measures of temperature and grip [6].

The usefulness of bioceramic materials added into fabrics has also been shown during physical exercise. For instance, ceramic coated clothing increased blood flow during a 30 min exercise on a bicycle ergometer at a work rate of 75 W in a cool environment

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[7]. Moreover, there were tendencies toward decreased tiredness and reduced skin temperature in subjects wearing a bioceramic shirt while running 30 min at a steady velocity of 6 km/h; [1]. Leung et al. [8] used electro-stimulation of amphibian skeletal muscle and found that FIR emitting ceramics delayed the onset of fatigue induced by muscle contraction. They also suggested that the presence of bioceramics could normalize acidification following muscle contractions. Even though the exact mechanisms of the hyperthermic effects and biological activities of FIR irradiation are still poorly understood, converging evidence suggests that bioceramic materials contribute to increase fatigue resistance, decrease energy expenditure even during steady state [1] and, improve dexterity [6].

Physical but also normal everyday activities depend to a large extent on the ability to control our balance. Postural equilibrium involves actively maintaining the chosen body configuration against gravity, and internal or external disturbances [9]. It therefore constitutes an important attribute of the musculoskeletal-proprioceptive apparatus with skeletal muscles continually making fine adjustments that hold the body in quasi-stationary positions. Any way to improve physical performance, dexterity and muscle fatigue, might therefore significantly affect postural performance. Therefore, bioceramic garments might well contribute to improve postural control, which to the best of our knowledge has never been investigated. In the present experiments, we tested whether bioceramic fabrics affect postural stability during unperturbed standing in non-athlete participants and for maintaining a handstand hold in expert gymnasts.

2. Materials and methods

2.1. Participants

Twelve participants participated in Experiment 1 (aged 20–35, mean = 28.5, 6 males). Fourteen confirmed gymnasts (nationally ranked in Switzerland, having more than 10 years of experience in gymnastics competition at the regional level or higher) participated in Experiment 2 (aged 15–28, mean = 21.5, 9 males). These participants were selected for their ability to maintain/sustain a handstand hold for at least 5 s. Participants had no history of balance or neuromuscular disorder. They were naïve to the aim of the study and gave informed-written consent prior to the study. The research was performed in accordance with the ethical standards specified by the 1964 Declaration of Helsinki and approved by the ethics review board of the University of Fribourg.

2.2. Apparatus

Both experiments took place in a well-lit room. A force platform equipped with four strain gauges linked to a computer was used to record the displacements of the center of feet (Experiment 1) or hand (Experiment 2) pressure (CoP) in the horizontal plane (i.e., along the *X*- and *Y*-axis). The force-platform was developed in the Biomedical Research Institute of French Armed Forces (IRBA). It is made of two steel plates (50 cm × 50 cm × 3 cm) and has a total height of 18 cm. The upper plate lies on four strain gauges (AG50C3SH10ef SCAIME) close to the vertices of the plate and distant from each other by 40 cm. The mean resolution for a 70 kg subject standing in the centre of the platform is inferior to 0.1 mm. The sampling frequency of the platform is 100 Hz, and high frequencies were attenuated using a second-order low-pass filter with a 10 Hz cut-off frequency. The antero-posterior (AP) and medio-lateral (ML) axes are referenced to the force platform.

Two types of suit were worn by the participants during the experiment: Bioceramic and Placebo suits. Both types of suit were made of polyester (85%) and spandex (15%) in addition to which bioceramic suits also integrated a bioceramic induction/layer (7 g of bioceramic/m^2 of cloth, i.e., 5% of total fabrics' weight). All suits consisted of second-skin, two-piece (top and bottom) black suits covering the whole body from neck to wrists and ankles. The suits came in four different sizes (S, M, L and XL) and the size worn by any given participant was always the same for the bioceramic and placebo suits. For any given size, bioceramic and placebo suits were identical in size, appearance and elasticity (220%). The only difference between bioceramic and placebo suits was a garment label indicating A or B.

2.3. Task

Experiment 1: Participants were instructed to stand quiet on the force platform with arms relaxed on the side of the body while fixing a plumb line located 90 cm in front of them for the 60 s duration of the trial. They stood barefoot on the platform with their feet abducted at 30° and heels separated by 2 cm.

Experiment 2: At the beginning of each trial, the gymnasts got up into a handstand on the force platform. An experimenter helped them establish and stabilize a proper handstand position. Once the gymnasts felt they were comfortable and stable in this position, the experimenter released their legs. Their task was to maintain the position and try to sway as little as possible for the 5 s duration of the trial. At the end of the trial, the experimenter took hold of their legs and helped bringing them back on the floor. For the handstand, each gymnast was free to use the hand width that was the most comfortable for him/her. But they were then required to use the same hand width and position throughout the experiment. Fig. 1 shows a participant performing the task (i.e., maintaining a handstand) with one of the experimental suits.

2.4. Design

Experiment 1: Participants performed four trials per suit type, for a total of 8 trials. Each trial lasted 60 s with a 1 min rest break

Fig. 1. A participant wearing the bioceramic suit while performing the standing (Experiment 1, left image) and the handstand (Experiment 2, right image) postural tasks. Different participants participated in the two experiments.