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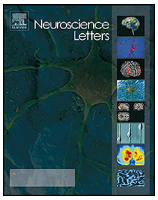

Research article

Supraposturaleffects of light digital touch on the modulation of postural sway can be modified by fingertip sensitivity

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HIGHLIGHTS

- We test if the suprapostural effect of light touch is affected by finger sensitivity.
- Fingertip sensitivity is manipulated by recruiting three types of athletes.
- Body sway is reduced in precision light touch relative to light touch condition.
- This effect is strongest in swimmers, followed by basketball players and rowers.
- These results show that finger sensitivity can modify suprapostural effects.

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ABSTRACT

We investigated whether the suprapostural effects of light digital touch on the modulation of postural sway can be modifiedby fingertip sensitivity. To achieve this, we recruitedthree types of athleteswith various fingertip sensitivity levels, including swimmers (high sensitivity), basketball players (intermediate sensitivity), and rowers (low sensitivity). We recorded the center of pressure (COP) excursions in 21 swimmers (20.57 ± 0.42 years), 22 basketball players (20.79 ± 0.75 years), and 22 rowers (20.32 ± 0.49 years) during light-touch (LT) and precision light-touch (PLT) conditions. In the LT conditions, participants touched a force plate while standing with their feet shoulder-width apart. In the PLT condition, participants were instructed to precisely touch a fixed point on the plate. Compared to the LT condition, the execution of the PLT condition significantly reduced the magnitude of COP excursion in the AP axis for all groups. This effect was most pronounced in swimmers, followed by basketball players, then rowers. These findings suggest that the suprapostural effects of precision light-touch on postural control can be modified as a function of fingertip sensitivity.

1. Introduction

Postural control while standing upright is critical for independently performing many physical activities, such as stepping over obstacles, climbing stairs, and maintaining static stances. The visual, vestibular, and somatosensory systems have essential roles in modulating postural sway [1]. In particular, an individual's touch on a stable surface with his or her fingertip, while maintaining the force of the touch below the degree required for mechanical support (<1 N), promotes postural stabilization (i.e., decreased amplitude of postural sway) [2]. The enhancement of postural stabilization with light digital touch is highly significant and reliable; the beneficial effects of light digital touch have been shown to occur independently of vision (i.e., eyes open or closed), age (i.e., children or elderly), and position of the feet (i.e., natural position, tandem position, or one-legged standing) (for a review, see [3]).

Of note, when precision demands were not emphasized in the instructions (that is, to just casually contact a suspended curtain), there were no differences in the amplitude of postural sway between the no touch and light touch (LT) conditions [4]. More interestingly, while precision control was the explicit goal of fingertip contact (that is, to keep the fingertip precisely in contact at a fixed point on the curtain and to minimize the movement of

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the curtain), postural sway reduced after transitioning from the no touch to precision light touch (PLT) condition [4]. According to Riley et al. [4], the mechanism behind how light digital touch affects postural control could be explained by the ability for postural control to subserve a suprapostural task goal, where the stabilizing effects resulting from light digital touch were probably due to the suprapostural effects of precision manual control. It is worth mentioning that, however, the suprapostural effects of precision digit contact on postural sway can be potentially confounded by the level of finger contact force received from a fingertip [5]. Nonetheless, in Riley et al.'s study, it was not clear whether the level of finger contact force was equal between the LT and PLT conditions, making it difficult to compare these two conditions. In an attempt to avoid this confounding effect, following Chen and Tsai's study [5], the level of finger contact force obtained from a fingertip during the execution of light digital touch in the present study is quantified via a force plate.

Importantly, Kaluga and Rostkowska [6,7] compared the threshold of light touch sensitivity on fingertips among athletes. Their studies reported that swimmers exhibit higher sensitivity than basketball players, who in turn have superior sensitivity to athletes engaged in paddling sports (e.g., kayaking, canoeing, and rowing). Individuals with various sensitivity levels may differentially detect and use tactile input (obtained from cutaneous receptors in the skin) to adapt their postural sway response [8,9]. Accordingly, it is highly likely that athletes with varying light touch sensitivity may demonstrate different characteristics when modulating postural sway while lightly and precisely contacting a stable reference using a fingertip. However, Riley et al. [4] did not measure light touch sensitivity, thus whether the sensitivity of light touch influenced the responses of postural sway was unknown. Therefore, the present study samples participants with different sensitivities of light digital touch, implemented by recruiting three groups of athletes, including swimmers, basketball players, and rowers.

No published work has yet addressed the issue of how the suprapostural effects of light digital touch on postural control can be modified via the sensitivity of light digital touch. This research topic is of particular value and interest because it clarifies the interplay between the execution of light digital touch and adjustments in body sway. Further, it can test the potential use of sport training to modify the suprapostural effects of light digital touch on the control of postural sway. Thus, this study intentionally compares the amplitude of postural sway between LT and PLT conditions and investigates the differences in the suprapostural effects of light digital touch among swimmers, basketball players, and rowers.

2. Methods

The experiment protocol was approved by the Antai Memorial Hospital Institute Review Board and complied with the Declaration of Helsinki for human research ethics. All participants gave informed, written consent prior to the experiment.

Participants

As light touch sensitivity can be influenced by age [10] and gender [11], only 20–21-year-old males were recruited. A convenience sampling was used in this study. Participants included 21 swimmers (age = 20.57 ± 0.42 years; weight = 71.34 ± 8.12 kg; height = 172.34 ± 7.75 cm), 22 basketball players (age = 20.69 ± 0.35 years; weight = 76.63 ± 9.63 kg; height = 175.34 ± 5.33 cm), and 22 rowers (age = 20.32 ± 0.49 years; weight = 73.86 ± 7.88 kg; height = 169.46 ± 8.93 cm) from school teams of two local colleges. Each collegiate athlete had belonged to his team for more than two years and all were accustomed to participating in strenuous exercise (of a type appropriate to their sport) at least three times per week, for 3–4 h each time, during the training and competition seasons. No participants reported neurological or orthopedic disorders and none had acquired injuries known to impact postural control in the last six months. All were right-handed with normal or corrected-to-normal vision.

Light touch sensitivity test

Participants' sensitivity to light touch was tested on the palmar side of the index finger of the dominant hand using the complete 20-piece Semmes Weinstein Monofilaments Kit (North Coast Medical, Inc., California, USA). During the test, participants were seated with eyes closed. The 20 filaments of the esthesiometer were employed in a successive stepwise procedure. The maximum force was applied initially and gradually decreased until the participants could no longer detect the stimulation. Thicker filaments were then applied until the participant could perceive the stimulation again. Light touch sensitivity was determined as the average of the minimal force detected by the participants from three ascending and descending assessments.

Apparatus

Force platform

A force platform (model 9260AA6; Kistler Instrumente GmbH, Ostfildern, Germany) was employed to acquire kinetic data about ground reaction forces in three dimensions. The kinetic data were converted to trajectories of center of pressure (COP). The sampling rate was set to 100 Hz and raw data were filtered with a 10 Hz low-pass Butterworth filter [5]. The force platform was calibrated before each trial. Participants were asked to stand barefoot on the platform with feet planted shoulder-width apart for all trials, including static balance test, practice, and formal trials (for details, see the Protocol section below). The position of each participant's feet was marked on the platform to ensure consistency across trials.

Light touch plate

A uniaxial load cell (LSB 200, Futek Advanced Sensor Technology, Inc., Irvine, CA) was attached to a 5 × 5 cm plate mounted on a tripod. The height and position of the tripod was adjusted such that the configuration of the upper extremities (i.e., the angle of elbow joint) remained similar across participants. The data on the kinetics of light fingertip touch in the vertical direction were obtained with a frequency of 100 Hz [5]. The touch force data were collected by Labview 2012 (National Instruments Inc., Austin, Texas) running on a laptop and stored to the disc for later analysis.

Protocol

Research was conducted in the laboratory at National Pingtung University of Science and Technology. The experimental procedures were first explained to participants. The sensitivity of light fingertip touch was then examined. Participants then stood on the platform with eyes closed for all trials. The duration of each trial was 60 s. In order to test the possible confounding effects originating from individuals' static balance ability, all participants were instructed to stand as still as possible (with eyes closed) for three trials. Participants were then exposed to a total of six trials within the two experimental conditions, three with LT and three with PLT. Trials were performed in a random order. For the LT condition, participants were instructed to hang the non-dominant arm to the side and to keep the inner side of the dominant upper arm close to the side of the body, flex the elbow joint at an approximately 90° angle, keep the wrist joint in a neutral position, and use the tip of the dominant index fingertip to lightly contact the touch plate