2023-2024 School of Exercise and Nutritional Sciences Student Research Grant Report

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Title: Relationships between unintentional force drifts and surface texture

Purpose: The ability to pick up and hold objects is an integral part of many activities of daily living. While maintaining sufficient grip force production is necessary to keep an object stable in hand, unintentional decreases in finger force production have been well-documented. Humans typically have difficulty maintaining constant force production when pressing against a surface: finger force production consistently in isometric conditions consistently decreases once it exceeds a relatively low force level. Force drifts drifts are an adaptive process used by the nervous system to minimize energy expenditure as fingertip friction increases due to increases in fingertip hydration. The purpose of this study was to investigate whether increasing friction between the fingertip and surface due to skin hydration is related to force drift.

Methods: Twenty young healthy adults (ages 18-35; 11 women) participated in the study. Finger force production was recorded with a multi-axis force and torque sensor. A 3D-printed platform containing two glass plates was fixed to the sensor. One of the glass plates was covered in a layer of a silicone elastomer, polydimethylsiloxane, to give it a consistent high surface friction. The second glass plate was left untreated and smooth for it to maintain a low surface friction. Participants received visual feedback on a computer screen about the amount of downward (normal) force they applied to the glass plate. During experimental trials, participants were instructed to press on the plate to reach the goal force level. After a randomly assigned time between 4 and 7 seconds, the visual feedback "froze" at the target level such that changes in participants' force production did not affect visual feedback, although participants were not informed of this change. 2-20 seconds after the feedback froze, the trial ended.

Results: For the PDMS-coated surface, there was no correlation between time and coefficient of friction ($r = 0.002$; $P = 0.952$). In contrast, for the smooth glass surface, there was a positive correlation between trial duration and the coefficient of friction ($r = 0.213$; $P = 7.007e^{-7}$) indicating a consistent increase in coefficient of friction as the contact time increased. Force drifts typically begin very soon after the loss of visual feedback. All trials lasted at least 2 seconds after visual feedback was frozen, so we used these data from all trials to investigate the initial decrease in force production. For each participant, we compared the time constants for fitted decays between the two surfaces using a paired t-test. We did not find a significant difference between the fitted time constants ($T_{19} = 1.298$; $P = 0.210$) for the PDMS (2.47 ± 1.77 s) and smooth glass (3.97 ± 5.46 s).

Conclusion: While we confirmed that coefficient of friction only increased on the glass plate, we did not find a difference in force drifts between these two surfaces, although we found some evidence that force drift could be associated with coefficient of friction. Our findings point to factors other than peripheral changes in contact area as the primary driver for force drifts.