Kinetics and Kinematics of the Thumb during Smartphone Swiping Activities

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Summary

This study investigates the kinetics and kinematics of smartphone swiping using optical motion capture and bespoke force plates representing three sizes of phone. Swiping presented an increased range of motion (RoM) in all thumb joints compared to writing. A larger smartphone size was associated with a further increase in the trapeziometacarpal (TMC) joint RoM and greater external force exerted by the thumb.

Introduction

Smartphones have become an essential part of daily life, shifting the thumb's usage from a stationary support in tasks like writing and gripping to having a significant dynamic role in smartphone use, while other fingers stabilize the device [1]. This change in thumb usage implies changes in mechanical demands on the thumb and with them a potential change in risk of developing joint osteoarthritis. However, there are very few data on the kinetics and kinematics of smartphone use or on the impact of phone size on these factors.

Methods

This study recruited six participants to perform swiping gestures - up, down, left, and right - each repeated 10 times. A writing task was also captured for reference. Four clusters of optical reflective markers were attached to the distal phalanx, proximal phalanx, first metacarpal, and third metacarpal of the thumb, respectively. The primary degrees of freedom (DoFs) of the thumb are flexion-extension (F-E) at the interphalangeal (IP), metacarpophalangeal (MCP), and TMC joints, as well as adduction-abduction (A-A) at the TMC joint. These angles were calculated based on the coordinates of these markers recorded by a motion capture system (Qualisys AB, Sweden) and digitised bony landmarks.

Participants performed activities on force plates designed to capture normal and shear applied forces. Three force plates were used and designed to replicate size and weight corresponding to the 10th, 50th, and 90th percentiles of all smartphone sizes produced by Apple, Samsung, and Xiaomi. A simulated screen was installed to encourage realistic positioning of the hand whilst swiping. The motion capture system and the force plates were synchronized using LabVIEW (National Instruments, USA). Kinematics and kinetics between smartphone sizes and participants were conducted using two-way analysis of variance.

Results and Discussion

For all the participants, no difference was observed in IP F-E or MCP F-E across smartphone sizes. In contrast, a difference ($p<0.01$) was observed in both F-E and A-A at the TMC joint. Compared with writing, the RoM of all joints increased by more than 30° (Figure 1)

The maximum resultant force exerted by the thumb during swiping cycles increased with increasing phone size ($p < 0.01$; Figure 2).

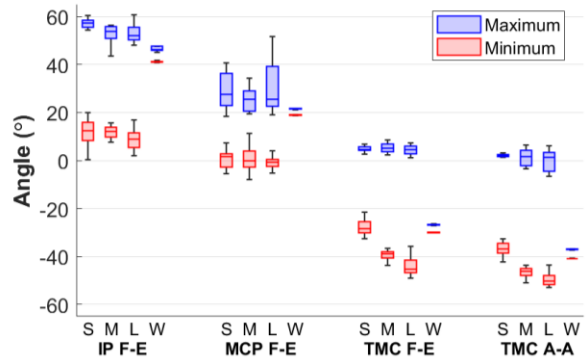

Figure 1: Maximum and minimum angles of four primary DoFs during swiping cycles with different sizes (S, M, and L) of simulated smartphone and during writing (W) for one representative participant. Flexion and adduction are positive.

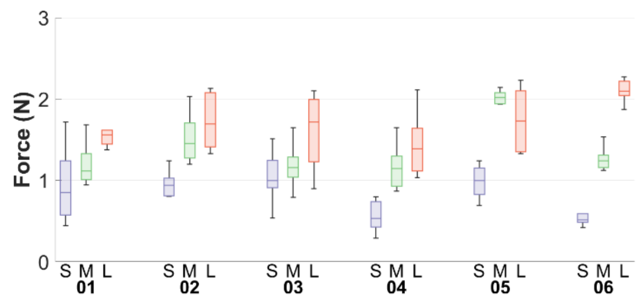

Figure 2: Magnitude of the resultant force exerted by the thumb of six participants with different sizes of simulated smartphone (S, M and L).

Conclusions

In general, larger phone sizes led to greater joint angles and applied thumb forces. Additional participants will be recruited to explore these observations further. The ability to collect kinetic and kinematic data during smartphone tasks can be used in finite element and musculoskeletal models that can examine TMC-joint mechanics and therefore infer likelihood of risk to develop osteoarthritis.

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References

[1] Kim et al. (2019). *J. Orthop. Res*, **37**:2437-2444