Journal of Health, Sports, and Kinesiology, 2021, 2(1), 7-8

Research Critique **Open Access**

The Effect of Hand-Held Technology on Thumb Biomechanics

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Abstract

The rise of portable units calls attention to the impact of device design and it challenges to biomechanical capabilities of the thumb and increased musculoskeletal discomfort. The purpose of this critiqued article, therefore, is to understand the significance of thumb biomechanics on hand-held technology and upper extremity pain.

Keywords: user interface design, thumb swipe gestures, thumb posture

Article History
Received 26 September 2020
Accepted 10 October 2020
Published 31 January 2021
Available online 19 February 2021
https://doi.org/10.47544/johsk.2021.2.1.7

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Methods

Healthy sixteen right-handed participants (21-40 years) performed a multitude of swiping gestures with the thumb of their right hand on 8'' and 10'' tablets (Samsung Galaxy III). The swiping gestures differed in swipe direction (outward v. inward), swipe orientation (horizontal v. vertical), swipe location (4 swipe zones), and swipe length (short v. long). Data was acquired using a custom Android application, thumb/wrist posture and forearm muscle activity was quantified using three-dimensional motion analysis and surface electromyograph, respectively. Data was analyzed using repeated measures of ANOVA. Self-reported perceived wrist and hand discomfort was measured using a visual analogue scale after each trial.

Results

Swiping actions closest to the palm rendered less pain, decreased forearm muscle activity, neutral thumb biomechanics and wrist posture. The left zones had greatest metacarpal (16°) and carpometacarpal abduction (10°) and topmost wrist movement, ulnar deviation (18°) and extension (14°) (Table 1), compared to the right zones. Regarding tablet orientation, portrait mode of both devices amassed more muscle activity related to landscape mode.

Discussion

The limits of upper extremities and thumb biomechanics can be seen in specific swipe locations of hand-held technology. The p-values for wrist extension ($p < 0.01$) and ulnar deviation ($p < 0.03$) on tablet size and orientation

quantitatively illustrate the poor wrist posture commonly adopted by users under these conditions. Swipe zone results proved users had best performance and lower discomfort rates when gestures were performed near the palm. Carpometacarpal abduction data found high joint angles during trials on the left side of the tablet and no movement (0°) on the right side. This constant biomechanical exertion to swipe in out-of-reach areas may lead to musculoskeletal disorders or pain. The results suggest tablet hardware and user interface design to allow for neutral thumb and wrist posture while accounting for decreased muscle demands.

Table 1. Joint Angles (°) Measured Relative to Thumb and Wrist Posture of the Two-Handed Grip for 8" and 10" Tablets.

	Tablet Size			Tablet Orientation			Swipe Zone[a]				
	P-Value*	8"	10"	*P*-Value	Portrait	Landscape	*P*-Value	TL	TR	BL	BR
Wrist											
Extension (°)	**.01**	12	14	.55	12	12	**< .001**	14	11	13	11
Ulnar Deviation (°)	.09	15	16	**.03**	14	16	**< .001**	18	16	15	13
Carpometacarpal											
Abduction (°)	.32	3	4	.22	3	4	**< .001**	7	0	10	0
Metacarpal											
Abduction (°)	.65	14	14	.58	15	14	**< .001**	16	11	17	10

[a] *TL= top left, TR=top right, BL=bottom left, BR=bottom right*

* *Bold values indicate a significant effect (p < 0.05). Repeated Measures ANOVA with participant as random variable, Tablet Size (2 levels), Tablet Orientation (2 levels), Swipe Zone (4 levels) as fixed effect.*

Critique

The purpose of the study was to identify the effect of hand-held technology on thumb biomechanics, thumb/wrist posture, and forearm muscle activity. The findings demonstrated increased user performance and lower musculoskeletal pain while performing gestures closer to the palm. The authors' ability to pinpoint the specific location where users experienced greatest extension, abduction, pain, and forearm muscle activation (top left zone) was one of the articles supreme strengths. Nonetheless, the study should be considered within context of its limitations. A limitation within the experiment was the criteria to be a participant. The study did not inquire about the amount of time users usually spent on their device in a normal week, this may give evidence to the biomechanical loads their thumb and upper extremities are accustomed to. A suggestion for research design is to improve participant criterion. Users thumb strength can be quantified with the pinch test or examined through manual muscle tests to indicate a correlation between thumb strength and participant perception of fatigue post-trial(s).

Reference

Coppola, S. M., Lin, M. Y. C., Schilkowsky, J., Arezes, P. M., & Dennerlein, J. T. (2018). Tablet form factors and swipe gesture designs affect thumb biomechanics and performance during two-handed use. *Applied Ergonomics,* 69, 40-46. doi:https://doi.org/10.1016/j.apergo.2017.12.015