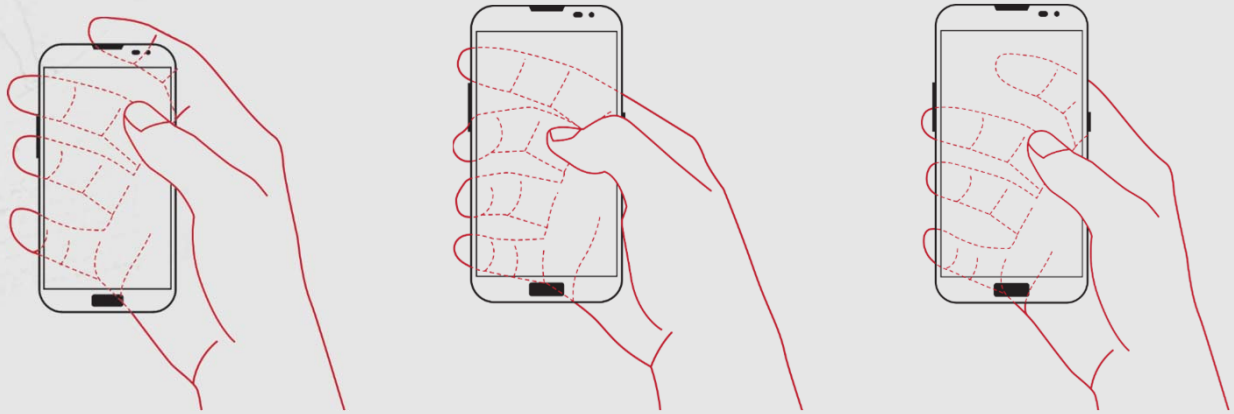
INDUSTRIAL AND MANAGEMENT ENGINEERING, POSTECH

Ergonomic Design Technology Lab

Analysis of Grip Posture for Ergonomic Smartphone Interface Design



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Global Contributor to Eco-Techno-Humanopia

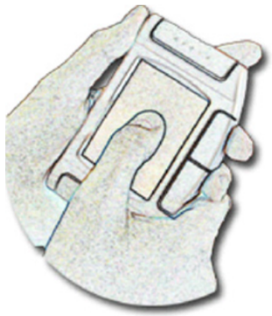
Contents

Importance of Ergonomic Smartphone Interface

- Understanding **user-preferred grip postures in one-handed operation of hard keys** on smartphones is needed.
  - **Operational efficiency of the hard keys can be improved** if they are properly located based on **user-preferred grip postures**
  - **Improperly designed locations of the hard keys** may lead to significant **discomfort in the fingers** (Finneran and O'Sullivan, 2013; Wobbrock et al., 2008)
  - **One-handed hard key operations** which require smartphone grasping and hard key operations simultaneously **can cause more discomfort** than two-handed hard key operations

Various Grip Postures for Different User Interfaces

- Wobbrock et al. (2008) analyzed **operation efficiency** of user interfaces on a PDA consisting of **touchscreens** at the front and back and **hard keys** on the side.

	Thumb-on-front	Thumb-on-back	Index-on-front	Index-on-back
Two-handed				
One-handed				

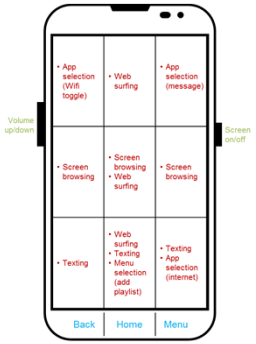
⇒ **No research has been reported regarding analysis of user-preferred grip postures to determine the proper locations of hard keys on smartphones.**

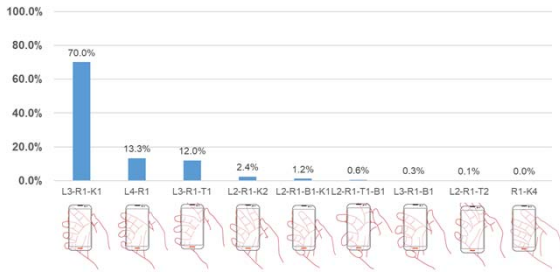
Research Objectives

Analysis of preferred grip posture for ergonomic smartphone interface design

1. Identification of **user-preferred grip postures in one-handed hard key operation**
2. Measurement and analysis of **grip postures and use frequencies**
3. Analysis of **effects by smartphone size and hand size** on grip posture

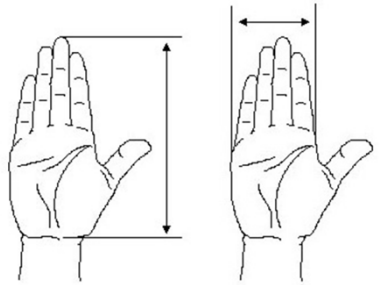
Task	Operating condition	Hand use	Screen orientation
• Screen on/off • Unlocking • Screen browsing • App selection • Web surfing • Homing • Menu popping • Undo • Texting • Volume up/down • Photo taking • Photo viewing • Calling • Music listening • Toggling	• Sitting • Standing • Walking	• Left hand • Right hand • Two hands	• Portrait • Landscape





Participants

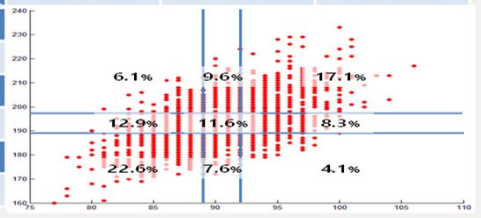
- **45 smartphone users** (male: 28; female: 17) with **right hand grip for one-handed operation**
- 9 groups with 3 hand length and 3 hand width categories for each gender



Korean Hand Size

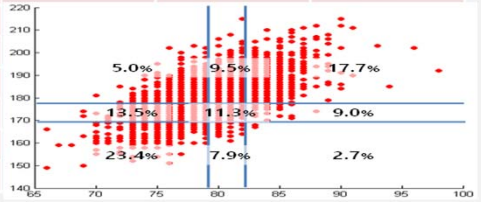
Male

Hand length \ Hand width	≤ 33rd	34th ~ 66th	> 66th
	≤ 83 mm	83 ~ 87 mm	≥ 87 mm
≤ 33rd			
≤ 181 mm			
34th ~ 66th			
181 ~ 188 mm			
> 66th			
≥ 188 mm			



Female

Hand length \ Hand width	≤ 33rd	34th ~ 66th	> 66th
	≤ 74 mm	74 ~ 78 mm	≥ 78 mm
≤ 33rd			
≤ 166 mm			
34th ~ 66th			
166 ~ 173 mm			
> 66th			
≥ 173 mm			



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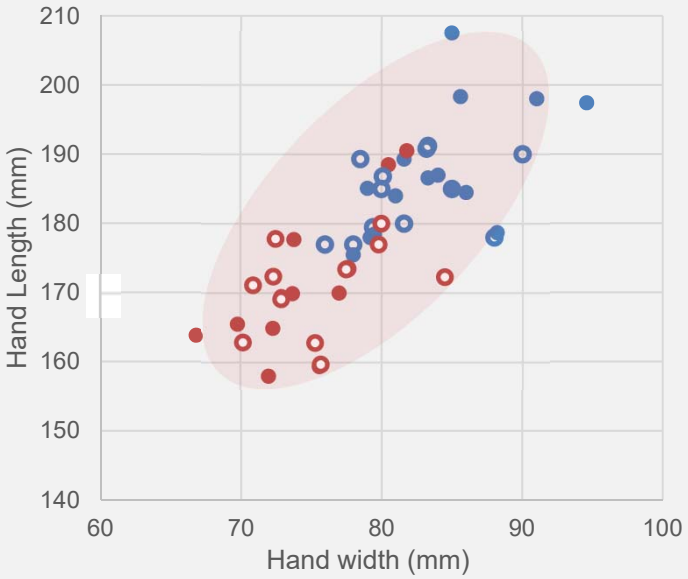
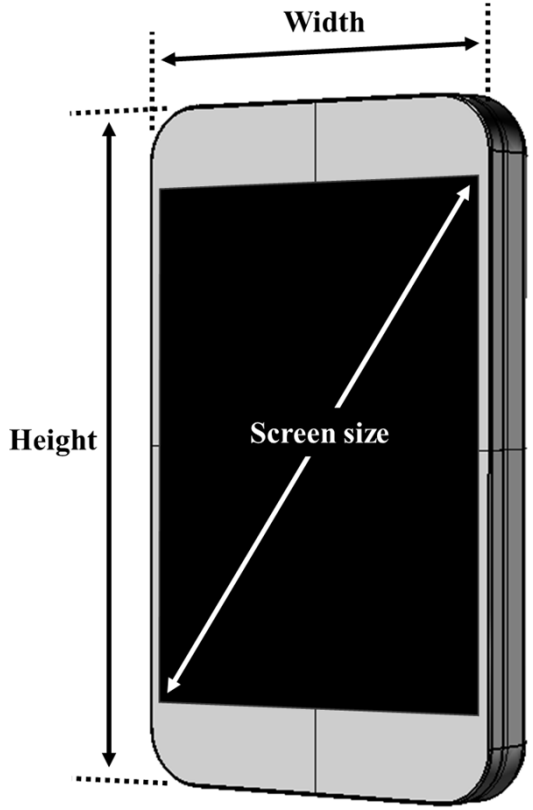
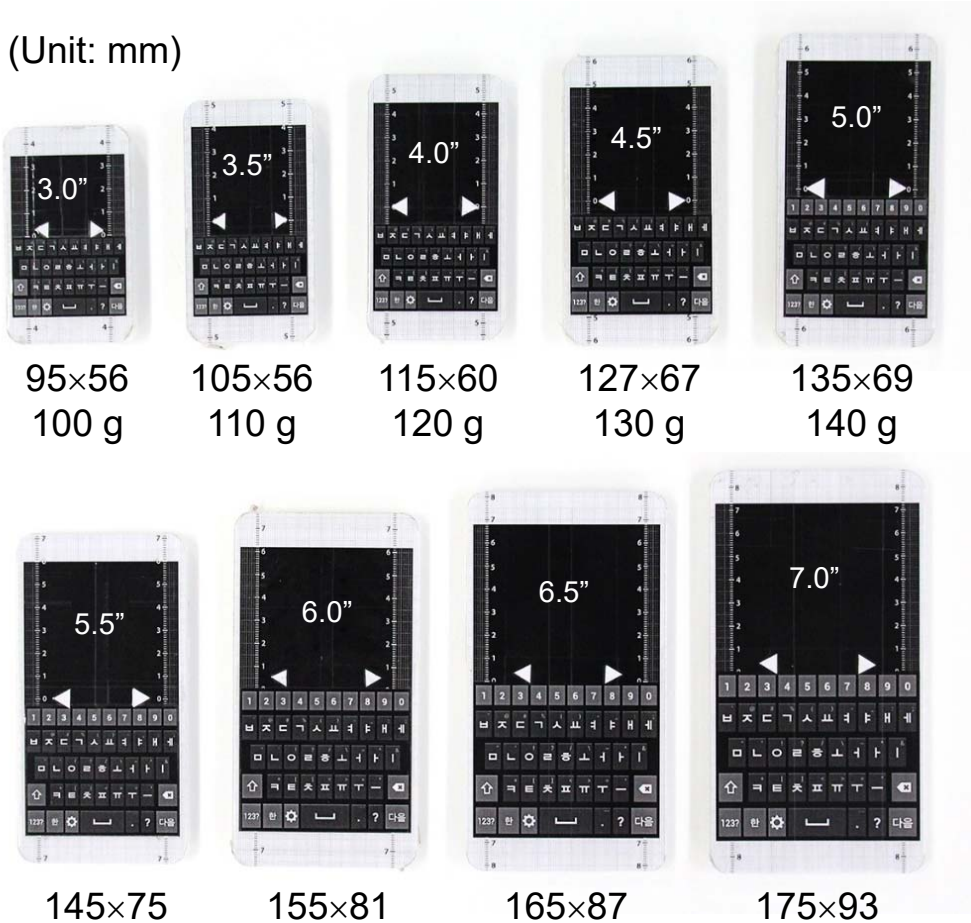


Smartphone Mock-ups

- **9 smartphone mock-ups** with different sizes (3.0” ~ 7.0” screen sizes) and weights (100 ~ 190 g)

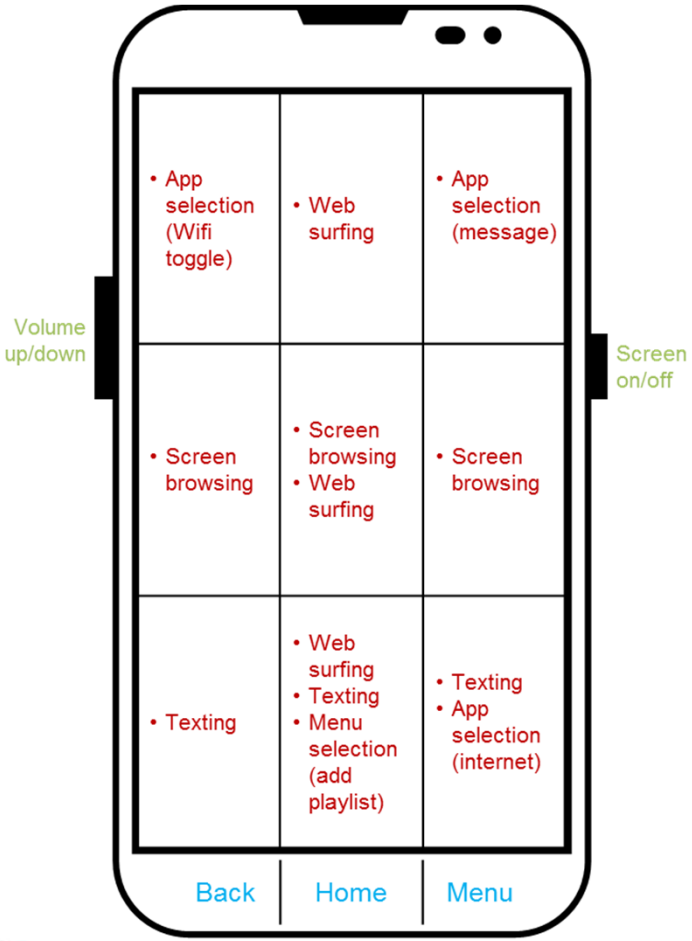


(Unit: mm)



Major Tasks & Specific Actions

- **Major tasks** such as answering a call, listening to music, texting, and browsing the web **were defined with specific actions**



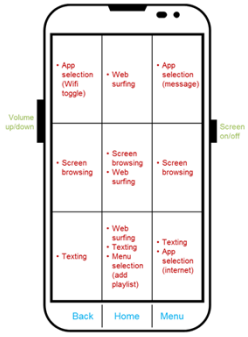
Tasks	Specific actions
Answering a call	1. Grasp the phone 2. Answer a call by flicking the screen 3. Turn volume up/down by ***volume key***
Listening to music	1. Turn volume up/down by ***volume key*** 2. Scroll up/down 3. Show menus 4. Select a menu 5. Turn volume up/down by ***volume key***
Texting	1. Turn screen on by ***power key*** 2. Navigate screens 3. Select a message app 4. Send a message 5. Return home
Browsing the web	1. Turn screen on by ***power key*** 2. Turn Wi-Fi on/off 3. Select a web browser app 4. Browse the internet 5. Turn screen off by ***power key***

Measurement of Grip Postures

- Videotaped by **2 web cameras** (LifeCam Studio, Microsoft Co. Ltd., USA) **placed above and below the hand** while participant performed the tasks in standing

2 cameras recording participants hand from above and below the hand

Demo: Hard Key Operation Tasks



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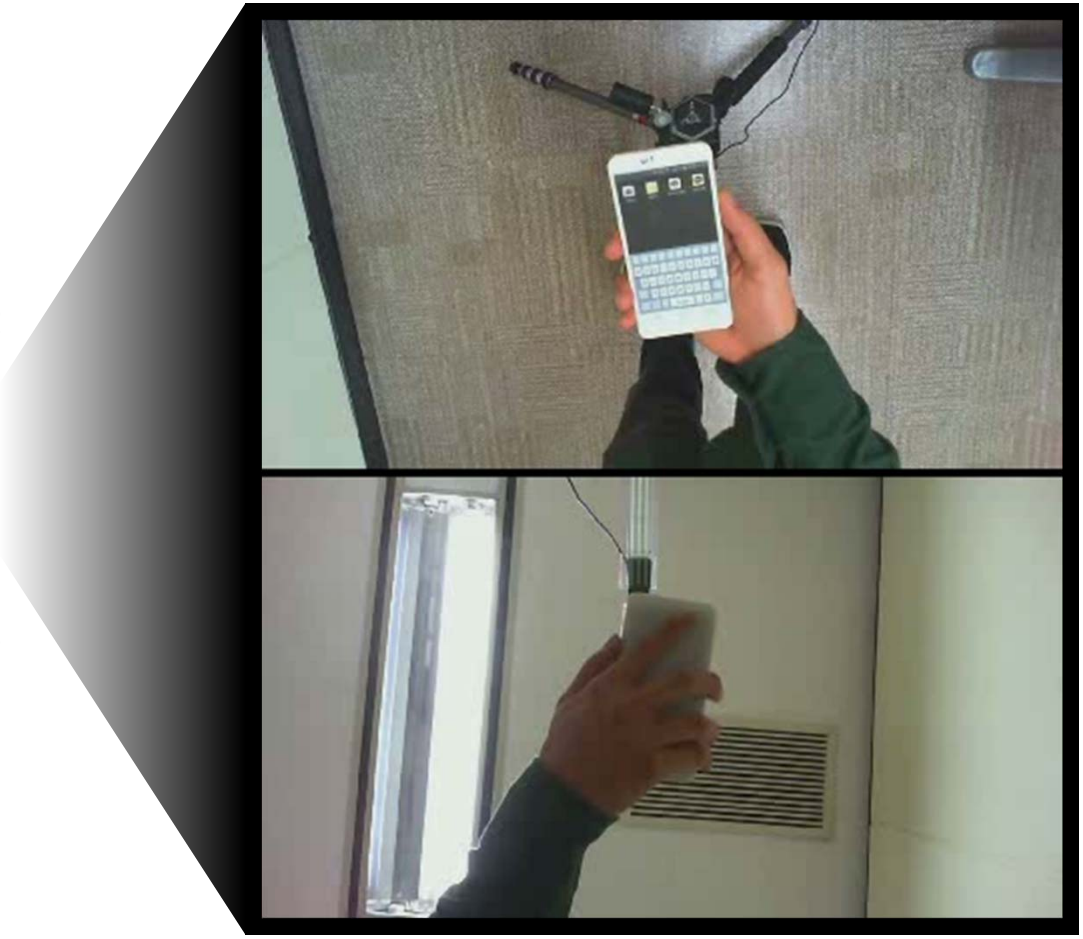
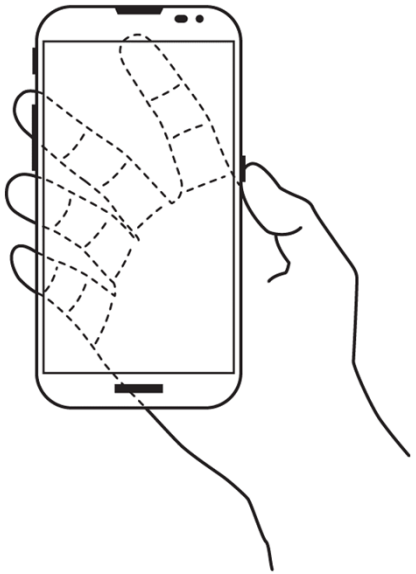


Classification of Grip Postures

- Encoded by indicating **locations of the fingers on the mock-up** and **the number of fingers at corresponding location**

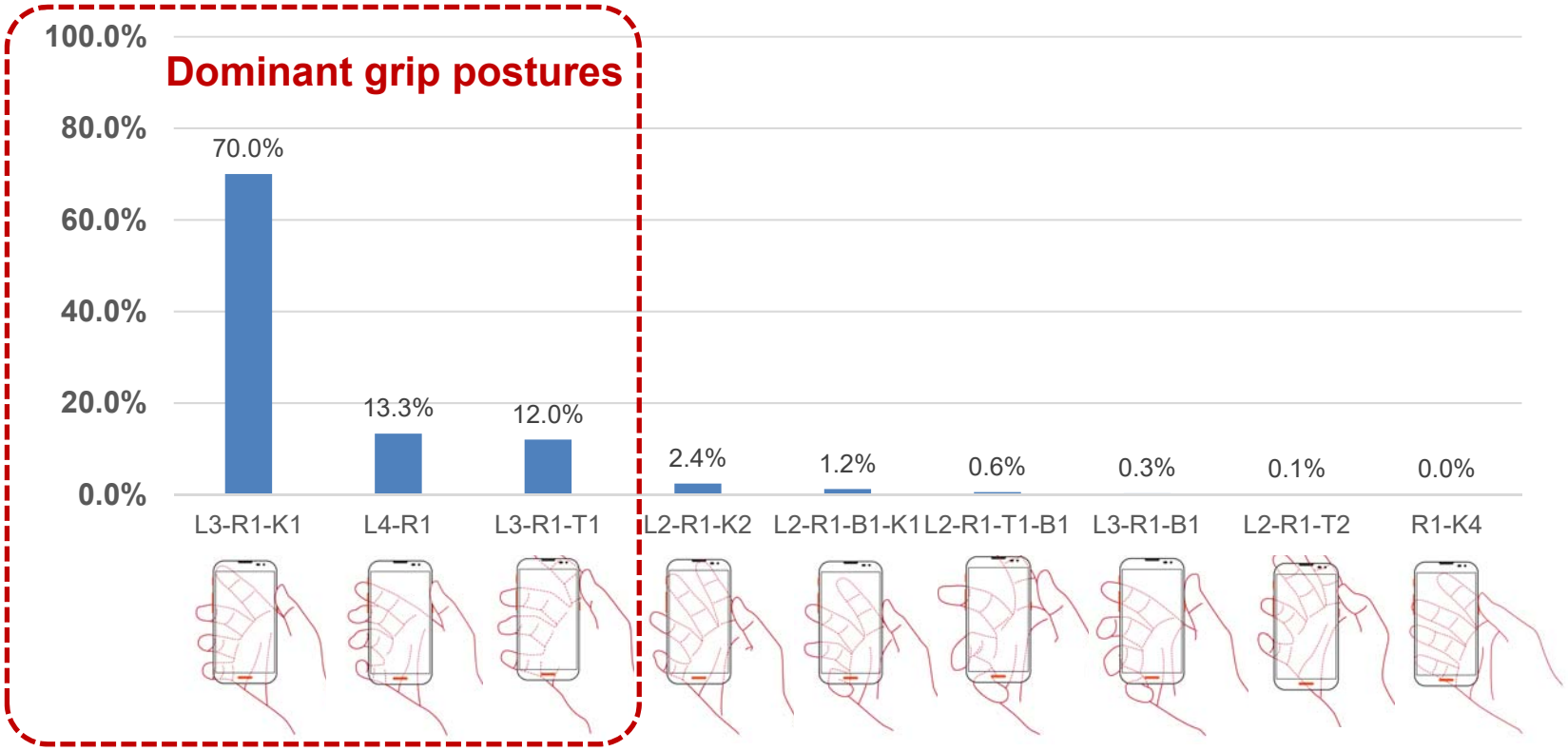
Location	Left (L)	Right (R)	Top (T)	Bottom (B)	Front (F)	Rear (K)
# of fingers	3	1	0	0	0	1



L3-R1-K1

Grip Postures for Hard Key Use

- **9 grip postures** were identified for operating **the power key and volume key**
- **L3-R1-K1 (70.0%), L4-R1 (13.3%), and L3-R1-T1 (12.0%)** were found dominant with **95% of use frequency.**

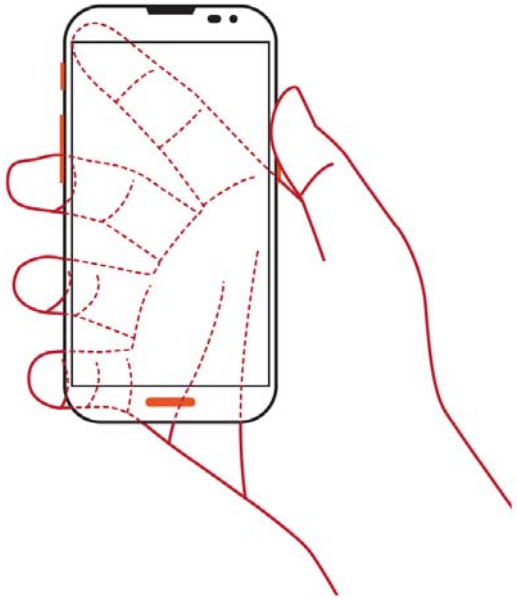


Dominant Grip Postures

Holding from the **left and right side** of a smartphone while supporting the **back** with the index finger

L3-R1-K1

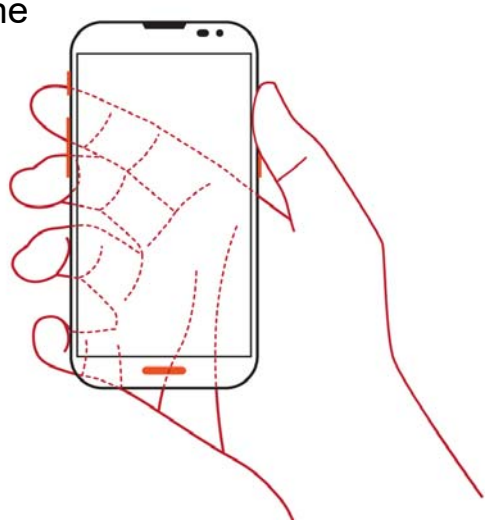
70.0%



Holding from the **left and right side** of a smartphone

L4-R1

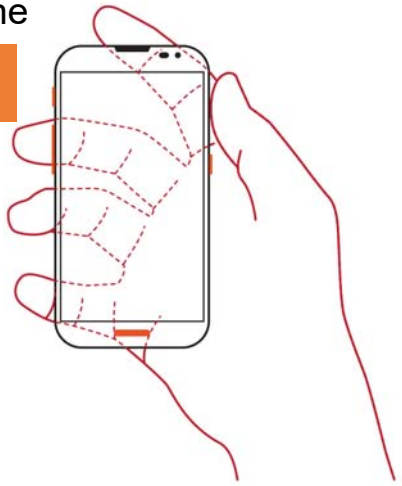
13.3%



Holding from the **top, left, and right side** of a smartphone

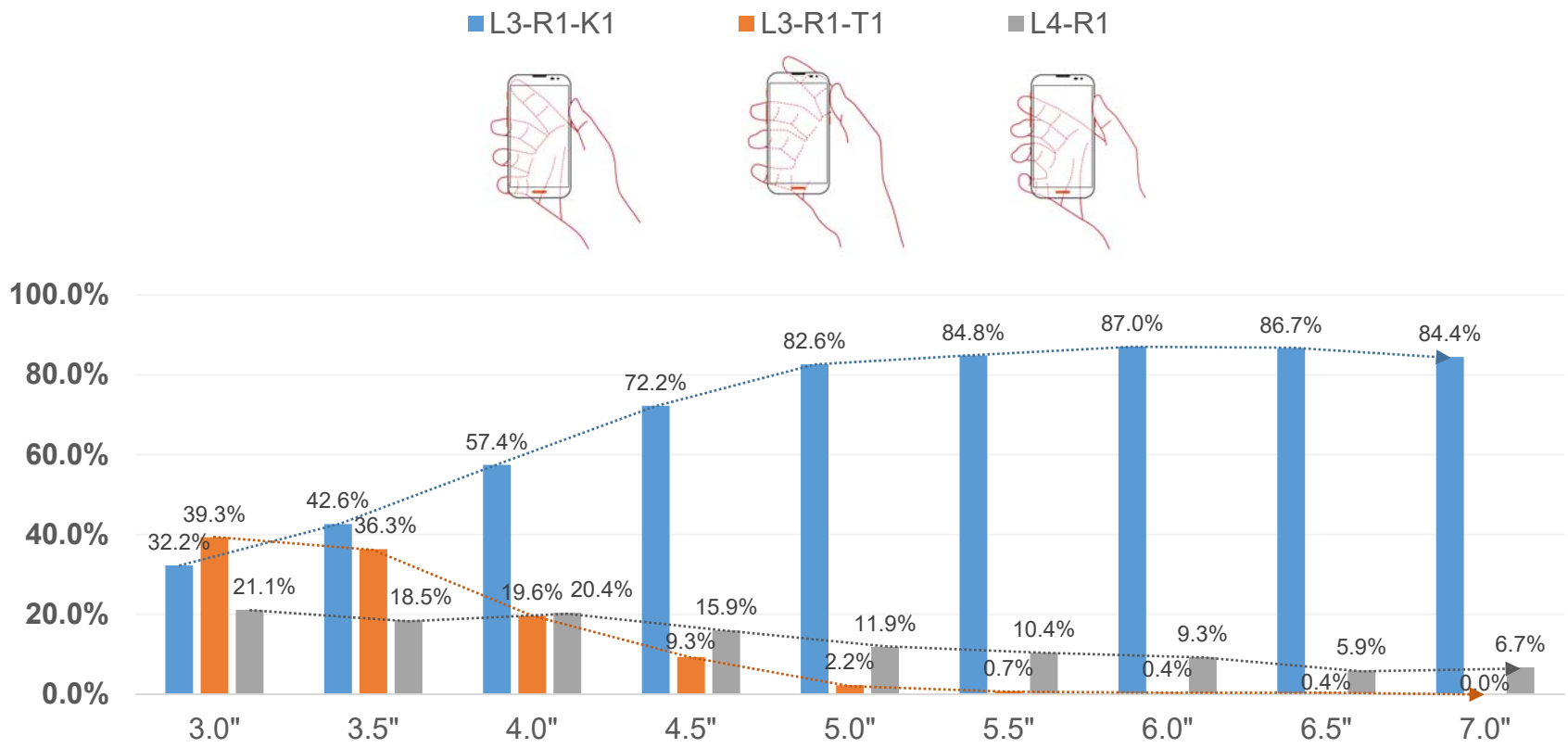
L3-R1-T1

12.0%



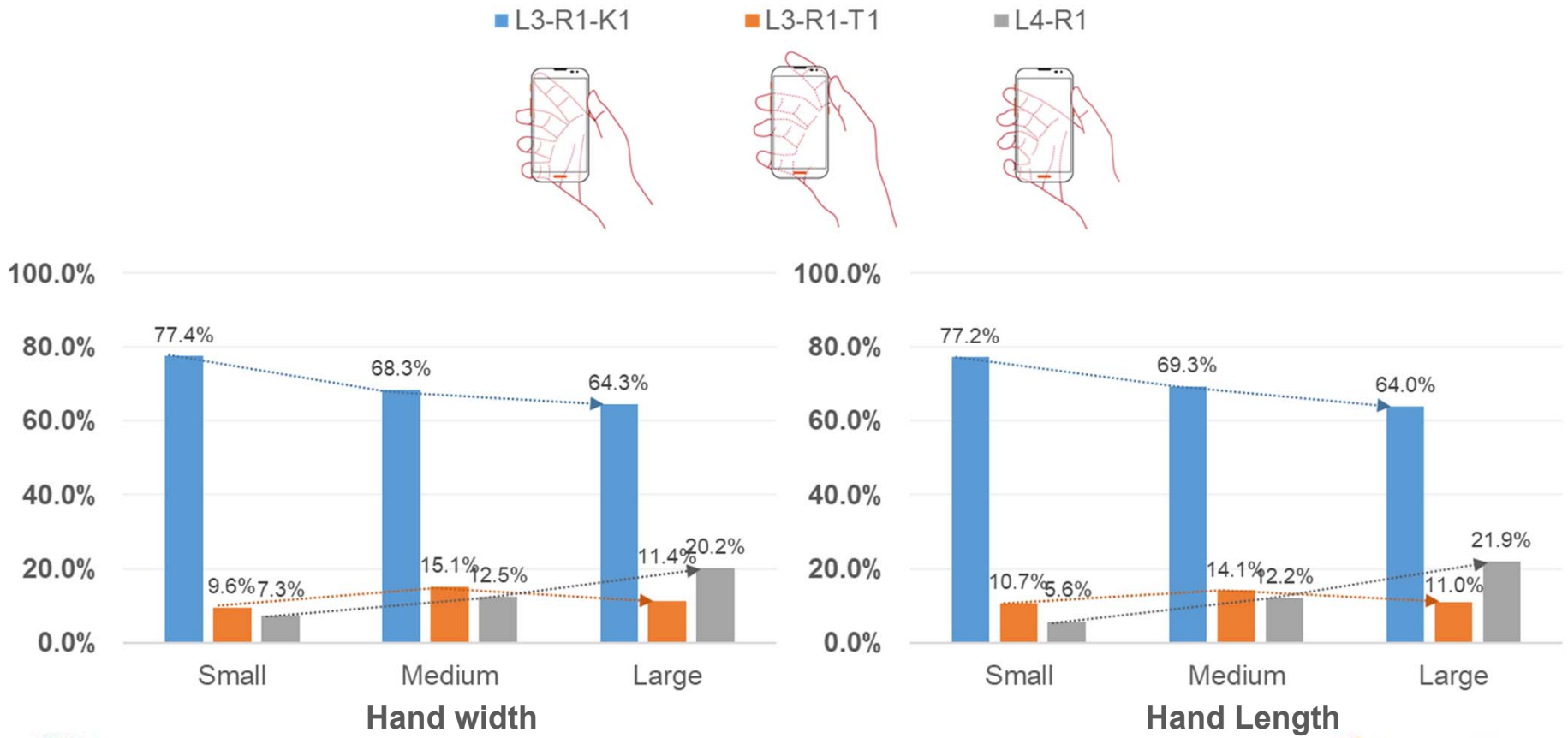
Dominant Grip Postures by Device Size

- The use frequency distribution of **grip posture varied significantly by smartphone size** ($\chi^2(12) = 674.8$, $p < 0.001$)



Dominant Grip Postures by Hand Size

- The use frequency distribution of **grip posture varied** significantly by **hand width and hand length with a similar pattern** ($\chi^2(4) = 75.3$, $p < 0.001$ for hand width and $\chi^2(4) = 75.3$, $p < 0.001$ for hand length)



Discussion (1/5)

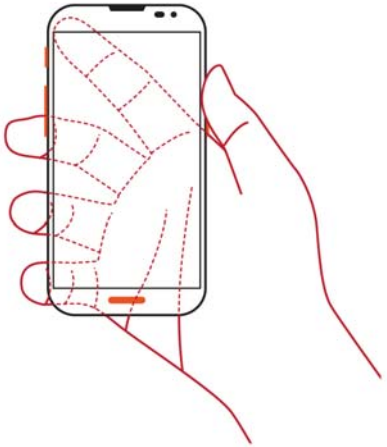
- Analyzed **preferred grip postures in one-handed operations** of smartphone hard keys
- L3-R1-K1 posture was the most preferred

  ⇐ for **efficiency in operation** of hard keys and **stability in grip**

Holding from the **left and right side** of a smartphone while supporting the **back** with the index finger

L3-R1-K1

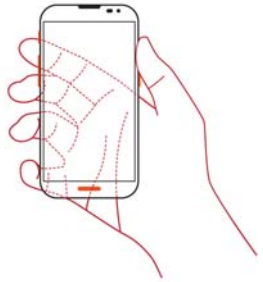
70.0%



Holding from the **left and right side** of a smartphone

L4-R1

13.3%



Holding from the **top, left, and right side** of a smartphone

L3-R1-T1

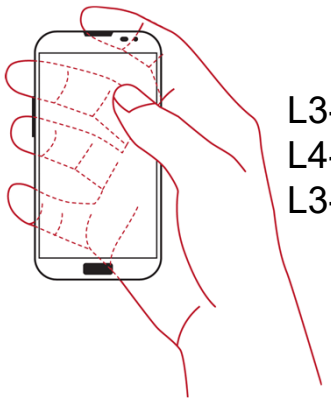
12.0%

Discussion (2/5)

- Dominant grip postures changed by device size
  - 3.0” ~ 4.0”: L3-R1-K1, L4-R1, and L3-R1-T1
  - 4.5” ~ 5.5”: L3-R1-K1 and L4-R1
  - 6.0” ~ 7.0”: L3-R1-K1

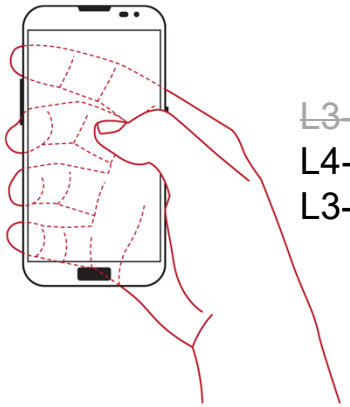
⇒ users tend to **move their index finger for secure grip and support**.

3.0” ~ 4.0”



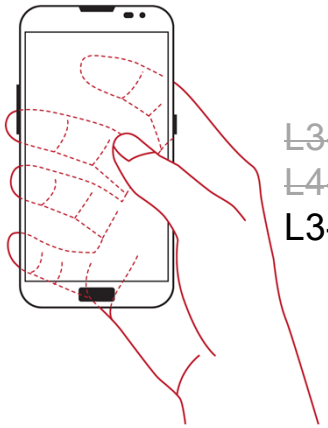
L3-R1-T1
L4-R1
L3-R1-K1

4.5” ~ 5.5”



~~L3-R1-T1~~
L4-R1
L3-R1-K1

6.0” ~ 7.0”



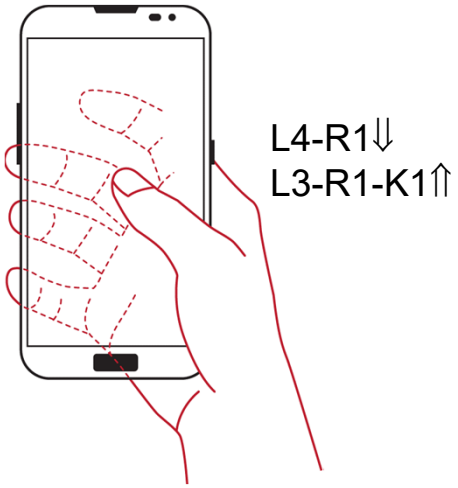
~~L3-R1-T1~~
~~L4-R1~~
L3-R1-K1

Discussion (3/5)

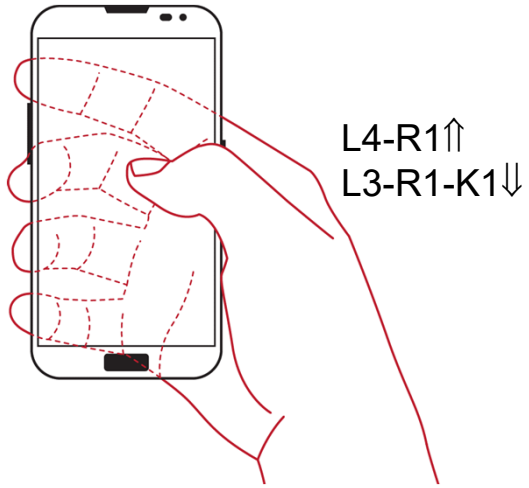
- Dominant grip postures changed by hand size
  - Hand width small → large: L4-R1, 12.9%⇑ and L3-R1-K1, 13.1%⇓
  - Hand length small → large: L4-R1, 16.3%⇑ and L3-R1-K1, 13.2%⇓

⇒ Users usually **grasp a smartphone along a diagonal direction of their hand** with a straight wrist posture while keeping the smartphone display vertical

Small hand



Large hand

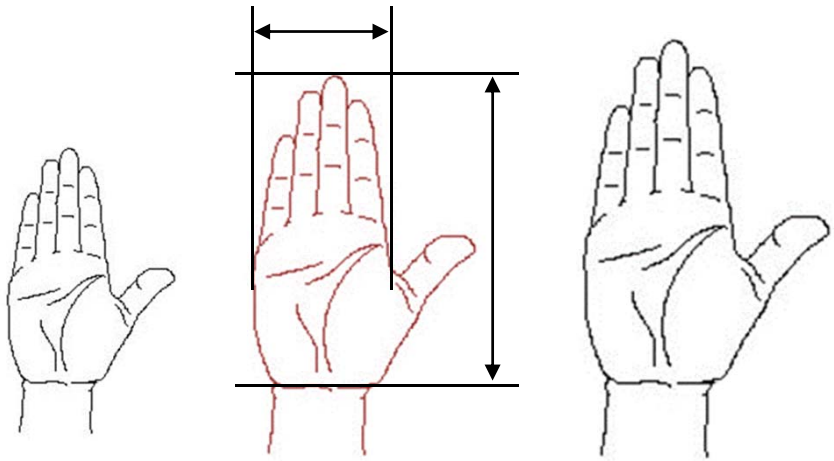


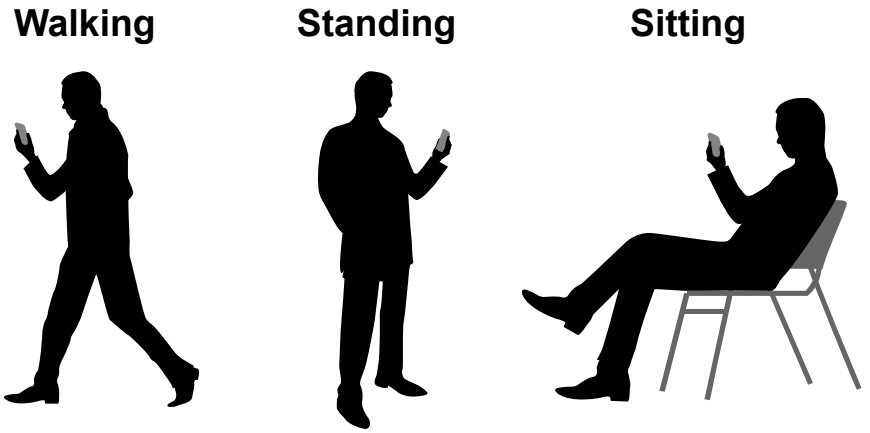
Discussion (4/5)

- Need to be verified for users with more diverse hand sizes than those of the present study and consider more use contexts other than standing

⇒ Users having **smaller and larger hand sizes** needs to be considered

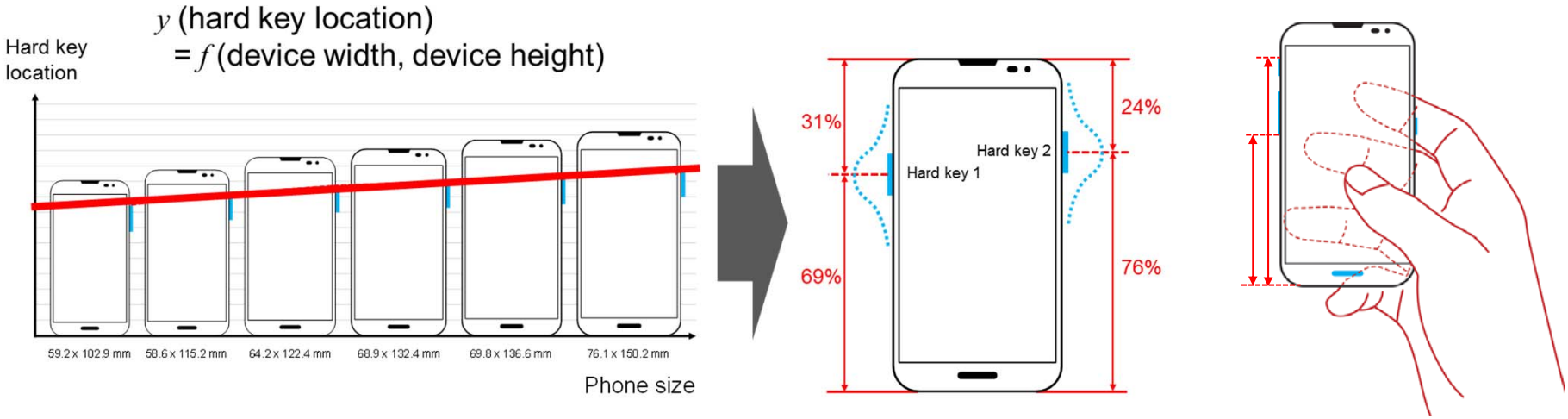
⇒ **Sitting and walking contexts** can be considered





Discussion (5/5)

- The identified dominant grip postures can be used for **determination of proper locations of hard keys on a smartphone**
  - The proper locations of hard keys can be designed by **investigating the preferred hard key control area** determined by the dominant grip postures of various hand sizes
  - An ergonomic **evaluation of the performance** of the designed hard key locations can be performed in terms of **time efficiency, accuracy, and comfort**.



Thank you

for your attention