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Influence of hand and smartphone anthropometric measurements on hand pain and discomfort

A cross-sectional study

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Abstract

A good mobile phone design may increase the productivity of users, as well as their comfort. To achieve mobile users' satisfaction, there is a need to come up with an ideal measurement that would not strain the human's body parts used to control the devices.

To investigate the correlation between smartphone and hand anthropometry measurements and the development of hand discomfort and pain.

89 Ahlia University students between the ages of 17- and 30-year-old participated in this study. Participants completed a demographic data sheet and had both of their hand dimensions and grip strength measured.

A total number of 89 participants were recruited in this study with (57.3%) females and (42.7%) males. 38% have had hand pain recently while 61.8% did not experience any hand pain. There was weak negative correlation between the phone size ($r=-0.04$, $P=.7$), hand size ($r=-0.08$, $P=.5$), and the hand grip strength ($r=-0.03$, $P=.7$) all with the reporting of hand pain. For the phone screen size and the hand lengths ($r=0.22$, $P=.13$) there was weak positive correlation.

Mobile phone manufacturers should take into account the users' comfort when designing their phones as this could lead to hand pain and other musculoskeletal problems. Furthermore, hand pain is multifactorial so hand size; phone size and grip strength may be taken into account.

Abbreviation: RSI = repetitive strain injuries.

Keywords: anthropometric measurements, hand discomfort, hand pain, smartphone

1. Introduction

Mobile phones are long range, portable, and wireless electronic device of communication. Recently smartphones have been replacing regular cell phones in satisfying a person's needs.[1] As the world is progressing the need for faster communication became a need, this led to the wide spread use of the latest technology. This led to designing the smartphone which is a single unit that contains new forms of communication.[2]

Smartphones are replacing computers in our daily lives and this will lead to the appearance of various negative effects of smartphones.[3]

Using the mobile phone over a prolonged period of time could affect the thumbs and fingers to operational stresses beyond the function what they are intended to do. This may lead to pain and musculoskeletal disorders.[4]

Mobiles size has been increased in order to provide designs that can be easily used by everyone.[5] Due to this ongoing trend, leading phone companies are manufacturing phones with larger dimensions; however, studies have shown that performance was generally better for smaller devices than for larger ones. Even if that's the case, people still lean on purchasing what is trending rather than what is more suitable for one's health.[6]

Phone design characteristics have been giving concerns regarding its impact on body mechanics and the musculoskeletal system.[7] With the use of smartphones, people tend to maintain awkward postures which add strain to the body over a long period of time causing diseases such as herniated cervical discs, hand, foot, and shoulder tingling,[2] and Upper Crosses Syndrome.[8] Furthermore, mobile phone users have a risk of developing various repetitive strain injuries (RSI) and carpal tunnel syndrome.[9,2]

Sharan et al[10] reported that pain in the thumb and forearm were the most common symptoms due to the long use of handheld devices and it was associated with burning and tingling around the thenar aspect of the palm.

On the other hand, using the mobile phone have many benefits which includes providing students with freedom of time and location, increase the speed of teaching and learning, enabling

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Our study was performed in accordance with the ethical standards of the institutional research committee and guidelines of Helsinki Declaration 1964.

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one to one learning, encouraging a group discussion setting, the use of wireless handsets in seminar increases the participation and the number of ideas generated.[11]

An online survey was conducted on anesthetists and results showed 59% owned iPhones while 80% used medical apps. Out of those 80%, 60% found that they were useful for clinical practice while the remaining found it useful for educational purposes.[12] In addition, mobile phones were used to monitor 22 heart failure patients at home for 6 months to assess daily weight and blood pressure readings and ECGs once a week.[13] It is so clear that mobile phones have different uses in different disciplines, and this promotes the idea of long use.

Therefore, the aim of the study was to investigate the relationship between smartphone and hand anthropometry measurements and hand grip strength in order to spread awareness when purchasing mobile phones that match users hand measurements for optimum comfort use.

2. Materials and methods

2.1. Subjects

This pilot study design was observational cross-sectional study and conducted on 89 students (17–30 years) who were recruited from Ahlia University, Bahrain. The study assured following the STROBE guidelines and ethics of research and maintains the participants, rights, and dignity. So, the study was approved by the physiotherapy department research committee. All subjects were informed about the aim of the study. Those who agreed to participate in the research were then asked to sign a consent form. All participation was voluntary, and subjects could withdraw from the study at any point of time.

Students who volunteered were from across the university and represented different colleges and specialties. The inclusion criteria included the students who were sending at least 5 emails or text messages/day and playing games or surfing the internet for more than 1 hour/day using touch screen mobile phones. The exclusion criteria included students with current injury (less than 6 months) to the hand or upper extremity and students who were diagnosed with any degenerative, inflammatory, musculoskeletal, neuromuscular, and congenital conditions of the upper extremity or hand that affect the use of the extremity in the activities of daily living.

This study data was in form of quantitative (hand anthropometric measurements, hand grip strength) and qualitative data (presence of pain).

2.2. Instruments/tools

1. Demographic data sheet
2. Cloth measuring tape
3. Hydraulic Hand Dynamometer ("SH5001" SAEHAN Corporation, Korea)

2.3. Procedures

89 students of Ahlia University who were regular touch screen mobile users were invited into to participate in the study after explaining its aims and procedures, and then they were asked to fill a demographic data sheet. Hand measurements (hand length, hand breadth (metacarpal), palm length, and maximum spread) were then measured using a cloth measuring tape. Grip strength was then measured using a hand dynamometer. Furthermore, hand length was chosen to group the participants into 3 groups of hand size, small, medium, and large. Phone models were also grouped into 3 groups as small, medium, and large phone size based on their screen size which was measured using a ruler.

2.3.1. Hand measurements were measured according to the following procedures.

- Hand length: Was measured as the straight distance from the midpoint of the most distal point on the styloid process of the radius bone and the most distal point of the styloid process of the ulna bone to the most forwardly projecting point on the middle finger.[1]
- Palm length: The straight distance between the midpoint of the wrist crease and the highest point on the head of the third metacarpal.[1]
- Hand breadth (metacarpal): Was measured from the straight distance between the base of the second metacarpal bone to the base of the fifth metacarpal bone.[1]
- Maximum hand spread: Was measured from the tip of the thumb to the tip of the small finger with the hand opened as wide as possible.[14]

All measurements were taken while the participants sat on a chair and their hands were kept on a horizontal platform. Fingers were kept close to each other except when measuring the maximum spread, participants were asked to open their hands as wide as they can.

2.4. Hand length groups

The hand lengths of both males and females were grouped based on their averages as shown in Table 1. The average hand length of males is 7.4 inch and of females is 6.8 inch.

2.5. Grip strength

Grip strength was measured using a Hydraulic Hand Dynamometer. Participants were asked to sit on a chair with their elbows fully extended and close to their body. Instructions on how to use the dynamometer were then explained to them and maximal grip strength was measured 3 times on each hand with a resting interval of 1 minute between every trial. The average of the 3 trials was then calculated for each hand.[15]

2.6. Phone model groups

Touch screen's size was measured in inches from one corner of the screen diagonally across to the opposite corner.[16] 11 touch screen phones were used, 5 models from iPhone Apple, and 6 models from Samsung Galaxy. The screen sizes were measured

Table 1

Female and male hand length groups.

Small	Medium	Large
Average female size = 6.8 inch		
Female hand category		
Below 6.3	6.3–7.3	Above 7.3
Average male size = 7.4 inch		
Male categories		
Below 6.9	6.9–7.9	Above 7.9

Table 2

Phone model sizes.

	Small 4–4.7 inches	Medium 4.8–5.1 inches	Large 5.2–5.7 inches
Screen size model	Iphone 5	Samsung S3	Iphone 6 plus
	Iphone 6	Samsung S4	Iphone 6s Plus
	Iphone 6s	Samsung S5	Galaxy note 2
			Galaxy note 3
			Galaxy note 4

using a standard 30 cm ruler diagonally across the screen. Then, based on the screen size, mobile phones were grouped into small, medium, and large phone sizes as shown in Table 2.

2.7. Statistical analysis

All data were calculated using software SPSS v23 to find the descriptive statistics in terms of mean, standard deviation, and percentages for all measured variables. In addition to inferential statistics, *t* test was used to compare between all variables in males and females subjects. Lastly, Pearson's Correlation was used to correlate between hand size groups, phone size groups, grip strength groups, and presence of pain. *P*-value was set to .05.

3. Results

The demographic characteristics of the subjects are presented in Table 3. The current study included 38 (42.7%) males and 51 (57.3%) females. It was shown 81 (91.0%) participants were right-handed and 8 (9.0%) were left-handed. Specifically, out of the 38 male participants, 34 (89.5%) were right-handed and 4 (10.5%) were left-handed, while out of the 51 female participants, 47 (92.2%) were right-handed and 4 (7.8%) were left-handed.

Furthermore, 78 (87.6%) participants used their phone mostly for texting in different mobile applications such as "WhatsApp", 11 (12.4%) participants used their phone mostly for calling. Regarding the amount of texts that participants type on a daily basis, 12 (13.5%) wrote that they send less than 5 texts a day, 13 (14.6%) they send 5 to 10 texts a day, 16 (18%) participants send 10 to 20 texts a day, and the majority 48 (54%) participants send more than 20 texts a day.

Table 3

Demographic characteristics of the subjects.

Category	Frequency (n)	Percentage (%)
Gender		
Females	51	57.3%
Males	38	42.7%
Hand dominance		
Left hand	8	8.9
Right hand	34	86.8
Phone size		
Small	55	61.8%
medium	14	15.7%
Large	20	22.5%
Hand length		
Small	6	6.7%
Medium	55	61.8%
Large	15	16.9%

Table 4

Frequency of hand usage in handling mobile phones.

	Right hand	Left hand	Both
Hold the phone	28	4	57
Touch the screen	43	13	33

Regarding the hand use in handling the phone, right hand was the most common one to touch the screen 43 (48.3%) while majority 57 (64%) used both hand to hold their phone as presented in Table 4.

For hand pain, 34 (38.2%) answered yes and 55 (61.8%) answered no. Hand grip strength was grouped as weak, normal, and strong. Out of the 76 participants, 22 (28.9%) had weak grip strength, 47 (61.8%) had normal grip strength, and 22 (28.9%) participants had strong grip strength.

Male subjects showed significant differences (P value $< .05$) in all hand anthropometric measurements and the grip strength in comparison to female subjects as presented in Table 5.

For Pearson's Correlation, there were no significant correlations among the following associations: mobile phone size and hand pain ($r = -0.04$, $P = .7$). Furthermore, no correlation between hand size and hand pain ($r = -0.08$, $P = .5$), hand grip strength and hand pain ($r = -0.03$, $P = .7$), hand grip strength and hand size ($r = 0.03$, $P = .9$), and no correlation between screen size and hand length ($r = 0.22$, $P = .13$).

Table 5

Hand anthropometric measurements comparison in both males and females.

	Mean	*t*-value	*P*-value
Rt hand length			
M	19.58 ± 1.83	6.39	.001
F	17.68 ± 0.95		
Lt hand length			
M	19.62 ± 1.25	7.62	.001
F	17.77 ± 0.86		
Rt palm length			
M	9.22 ± 0.74	5.51	.001
F	8.45 ± 0.60		
Lt palm length			
M	9.16 ± 0.64	6.83	.001
F	8.29 ± 0.50		
Rt hand breadth			
M	8.89 ± 0.60	9.17	.001
F	7.70 ± 0.44		
Lt hand breadth			
M	8.80 ± 0.54	8.80	.001
F	7.67 ± 0.45		
Rt maximum spread			
M	20.92 ± 1.78	6.32	.001
F	18.36 ± 1.42		
Lt maximum spread			
M	21.35 ± 1.68	7.80	.001
F	18.53 ± 1.44		
Rt grip strength			
M	99.24 ± 23.08	9.78	.001
F	52.31 ± 17.28		
Lt grip strength			
M	89.50 ± 20.13	9.93	.001
F	47.42 ± 14.75		

F = female, Lt = left, M = male, Rt = right. Significant at P value $< .05$.

4. Discussion

This study aimed to investigate the correlation between the hand and phone anthropometric measurements. 89 participants took part in this research, and 86.5% used their phones for texting on the chat applications mainly WhatsApp, while 12.4% used phone for calling. This was in contradiction with Ozkan and Gukalp-Yavuz (2015), who stated that majority 39% used their phones for phone calls and 25% used their phones mainly for messaging applications such as WhatsApp.[4]

For number of texts sent per day, the present study showed that most of participants (54%) answered more than 20 texts and the least of them (14.6%) answered less than 5 texts. Also, there is contradiction with Thomée et al (2011), who reported that least (1.5%) who sent more than 20 a day while the majority (60.5%) was sending 1 to 5 texts per day.[17] This contradiction may be contributed to the time of study application and the mobile usage at that time.

The present study showed that only 34 (38.2%) out of 89 students reported recent hand pain. While in other study, the percentage was higher as 80 (86.9%) students out of 92 had wrist and hand pain from computer use, and about 52 (65%) out of 80 students reported high intensity pain.[18] Smartphone can be used as both mobile phone and computers and they may have a major interference on the posture and musculoskeletal system but the reduced percentage of hand pain in the current study may be attributed to the majority 57 (64%) used both hands alternatively to hold their phone, unlike the computer, with no option of alternative hand use of the mouse.

Hand length, palm length, hand breadth, maximum spread were measured in the current study as hand anthropometrics were found to explain maximum variation in hand grip.[1] The results showed that 6 (7.9%) were considered small hands, 55 (76.4%) medium sized hands, and 15 (19.7%) large sized hands. Out of the 6 small hands, 4 of the were females and 2 were males, out of the 55 medium hands, 23 were males and 32 were females, and out of the large hand size 11 were males and 5 were females. The categorization of hand size in the present study was based on the hand length, while, in other study hand sizes were grouped based on hand breadth to small hand size, medium, and large. Despite of the different categorization parameter, the results were similar as it was reported that majority were 43 (39%) had medium hands out of the 110 participants, while 28 (25.5%) had small hands, and 38 (34.5%) had large hands.[19]

The mobile brands were grouped based on their diagonal screen size measurements. The results showed that 55 out of 89 participants used small sized phones, 20 participants used medium sized phones, and 14 used large sized phones. So, the majority of participants tend to use small to medium mobile phones. This can be related to the reduced number of reported hand pain as well as the awareness of the subjects to pick mobile size matches with their hand size.

There was significant difference in all the aspects measured including hand length, hand breadth, palm length, maximum spread, and grip strength between the right hand of males with the right hand of females and left hand of males with left hand of females with (P-value $< .05$) and this was supported in the literature.[20]

There was a significant difference in grip strength between males and females and the mean for left and right hand grip strength of male were 89.50 and 99.23 while in females were 47.42 and 52.31, respectively. This means that males have stronger grip strengths than females and also the dominant hand is stronger than non-dominant in both genders.[15,21] This could also be a reason why both right hands of males and females have a higher mean value since 89.5% of males have dominant right hands and 92.2% of females also have dominant right hands.

Pearson's Correlation showed negative weak correlation between hand size groups, phone size groups, and grip strength groups, all with reporting of hand pain. On the other hand, there was a weak positive correlation between hand size groups and grip strength groups, screen size, and hand length. However, all of the above correlations were not statistically significant.

Bansode et al (20140, reported that there was significant positive correlation between grip strength with height, weight, BMI, and hand span in both males and females.[14] Compared to current study, we used hand length instead of hand span (maximum hand spread) and that could have affected our results. However, another study,[22] was conducted on 400 students aged 14 to 18 and they found that there was a positive correlation between grip strength and all anthropometric measurements including hand length. This could be due to a larger number of participants compared to our study and the age group could also have an effect.

This pilot study included some limitations as small sample size and unequal representation of both genders which may limit the generalization of the current results. Further studies are needed to validate the current results especially with updates that happened in the smartphones models. In addition, the students, majors should be taken into account to see if they influence the usage of other electronic devices rather than mobile use and its impact on the hand.

5. Conclusion

Current study showed non-significant relationship between the hand and mobile phone anthropometric measurements. In the current sample, there was tendency to use small mobile size while the majority had medium hand size, and this was in line with the reduced reported hand pain. So, hand size should match the mobile phone size for better handling and less musculoskeletal disorders. Men tend to have larger anthropometric measurements of the hand and hand grip strength compared to the women. This tendency may be attributed to the model, options, and appearance of the smartphone regardless the phone–hand sizes matching. The strength of this study is the highlight about the importance of the matching between hand and phone anthropometric measurements.

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References

[1] Jain S, Pathmanathan G. Importance of anthropometry for designing user-friendly devices: mobile phones. J Ergon 2012;2:109doi: 10.4172/2165-7556.1000109.
[2] Ozkan NF, Gokalp-Yavuz F. Effects of dexterity level and hand anthropometric dimensions on smartphone users' satisfaction. Mob Inf Syst 2015;2015: Article ID 649374, 9 pages, 2015. doi: 10.1155/2015/649374.
[3] Shim J. The effect of carpal tunnel changes on smartphone users. J Phys Ther Sci 2012;24:1251–3.
[4] Jonsson P, Johnson PW, Hagberg M, et al. Thumb joint movement and muscular activity during mobile phone texting – a methodological study. J Electromyogr Kinesiol 2011;21:363–70.
[5] Chany AM, Marras WS, Burr DL. The effect of phone design on upper extremity discomfort and muscle fatigue. Hum Factors 2007;49:602–18.
[6] Rasco NP, Dytoc B, Guerrero JL, et al. A comparative analysis of the ergonomic anthropometry and usability of locally designed and foreign designed smartphones. Procedia Manuf 2015;3:5927–33.
[7] Trudeau MB, Catalano PJ, Jindrich DL, et al. Tablet keyboard configuration affects performance, discomfort and task difficulty for thumb typing in a two-handed grip. PLoS One 2013;8:e67525.
[8] Park J, Kim J, Kim J, et al. The effects of heavy smartphone use on the cervical angle, pain threshold of neck muscles and depression. Biosci Med Res 2015;91:12–7. doi: 10.14257/astl.2015.91.03.
[9] Eapen C, Kumar B, Bhat AK, et al. Extensor pollicis longus injury in addition to De Quervain's with text messaging on mobile phones. J Clin Diagn Res 2014;8:LC10doi: 10.7860/JCDR/2014/8304.5094.
[10] Sharan D, Mohandoss M, Ranganathan R, et al. Musculoskeletal disorders of the upper extremities due to extensive usage of handheld devices. Ann Occup Environ Med 2014;26:22doi: 10.1186/s40557-014-0022-3.
[11] Kim SH, Holmes K, Mims C. Mobile wireless technology use and implementation: opening a dialogue on the new technologies in education. TechTrends 2005;49:54–63.
[12] Dasari KB, White SM, Pateman J. Survey of iPhone usage among anaesthetists in England. Anaesthesia 2011;66:630–1.
[13] Seto E, Leonard KJ, Cafazzo JA, et al. Perceptions and experiences of heart failure patients and clinicians on the use of mobile phone-based telemonitoring. J Med Internet Res 2012;14:e25doi: 10.2196/jmir.1912.
[14] Bansode D, Borse L, Yadav R. Study of correlation between dominant hand's grip strength and some physical factors in adult males and females. Int J Pharm Res Health Sci 2014;2:316–23.
[15] Kubota H, Demura S. Gender differences and laterality in maximal handgrip strength and controlled force exertion in young adults. Health 2011;3:684–8.
[16] Parsons JJ, Oja D, Bunin RB. Computer Concepts. London: Course Technology; 2004.
[17] Thomée S, Härenstam A, Hagberg M. Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults – a prospective cohort study. BMC Public Health 2011;11:66.
[18] Peper E, Gibney KH. Computer Related Symptoms: A Major Problem for College Students, 1998. From http://www.tifaq.org/articles/computer-related-symptoms-peper-gibney.html.
[19] Balakrishnan V, Yeow P. Hand measurements and gender effect on mobile phone messaging satisfaction. Int J Technol Human Interact 2008;4:54–67.
[20] Dey S, Kapoor A. Hand length and hand breadth: a study of correlation statistics among human population. IJSR 2013;4:148–50.
[21] Hemberal M, Doreswamy V, Rajkumar S. Study of correlation between hand circumference and maximum grip strength (MGS). Natl J Physiol Pharm Pharmacol 2014;4:195–7.
[22] Ibegbu AO, Baita MB, Hammanm WO, et al. Evaluation of the relationship between hand grip strength with some anthropometries among Nigerian Secondary School students. Anthropologist 2014;17:921–7.