ORIGINAL ARTICLE

IMPACT OF SMARTPHONE SCREEN SIZE ON DE QUERVAIN TENOSYNOVITIS EPIDEMIOLOGY

ANALIZA WPŁYWU ROZMIARU EKRANU TELEFONU KOMÓRKOWEGO NA EPIDEMIOLOGIĘ ZESPOŁU DE QUERVAIN

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ABSTRACT
Introduction
De Quervain tenosynovitis is an inflammation of the 1st wrist extensor compartment sheaths, usually caused by overuse. Numerous studies suggest that mobile phone use can be a causative factor of de Quervain tenosynovitis.

Aim
Since the relevancy of smartphone screen size is not clear, authors aimed to assess its impact on the incidence and severity of de Quervain tenosynovitis.

Material and methods
An online questionnaire survey was conducted. The respondents specified model of a used smartphone and then determined the intensity of pain in right wrist on the thumb side during the modified Eichhoff test. The inclusion criteria were: 18–25 years of age, right-handedness, being a student. Excluded were people with: previous wrist injury, inflammatory joint diseases, de Quervaine tenosynovitis in the family's medical history, pregnancy or lactation, lateral epicondylitis, regular golf or tennis participation and paid employment.

Results
652 people responded to the survey, 402 of them (265 females, 137 males) met study criteria. Among people without pain in the modified Eichhoff test (163 people), the average screen diagonal was 5.2461 inches <SD ± 0.5619>, in the group with pain (239 people) it equaled 5.2442 inches <SD ± 0.5585>. The difference was not significant (OR = 1.0, 95%CI = 0.65–1.53; p = 0.9913). There was no correlation between severity of pain and diagonal phone screen size (r = 0.0401, p = 0.4224). There were also no statistically significant associations in analyses excluding people regularly playing a musical instrument, playing video games or practicing any sport.

Conclusion
Smartphone screen size does not affect the risk of development and severity of de Quervain tenosynovitis.

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STRESZCZENIE
Wstęp
Zespół De Quervain jest stanem zapalnym pochewek ścięgien pierwszego kanału prostowników nadgarstka, powstającym zazwyczaj na skutek przeciążenia. Liczne badania sugerują, że używanie telefonu komórkowego może być czynnikiem wywołującym zespół de Quervain.

Cel
Ponieważ istotność rozmiaru ekranu telefonu komórkowego w rozwoju choroby nie jest jasna, celem badania było określenie jego wpływu na występowanie i nasilenie zapalenia zespołu de Quervain.

Materiał i metodyka
Przeprowadzono ankietę online. Respondenci określili model używanego telefonu komórkowego, a następnie określili intensywność bólu w prawym nadgarstku po stronie kciuka podczas zmodyfikowanego testu Eichhoffa. Kryteriami włączenia były wiek 18–25 lat, praworęczność, bycie studentem. Wykluczono osoby z wcześniejszym urazem nadgarstka, zapalnymi chorobami stawów, występowaniem zespołu de Quervain w rodzinie, ciążą lub laktacją, zapalaniem nadkłykcia bocznego kości ramiennej, regularnym uczestnictwem w golfie lub tenisie oraz płatnym zatrudnieniem.

Wyniki
652 osoby odpowiedziało na ankietę, 402 z nich (265 kobiet, 137 mężczyzn) spełniło kryteria badania. Wśród osób bez bólu w zmodyfikowanym teście Eichhoffa (163 osoby) średnia przekątna ekranu wynosiła 5,2461 cali <SD ± 0,5619>, w grupie z bólem (239 osób) wyniosła 5,2442 cali <SD ± 0,5585>. Różnica nie była znacząca (OR = 1,0, 95%CI = 0,65–1,53; p = 0,9913). Nie stwierdzono korelacji między nasileniem bólu a przekątną ekranu telefonu (r = 0,0401, p = 0,4224). Nie wykazano również statystycznie istotnych powiązań pomiędzy przekątną ekranu telefonu a obecnością i nasileniem bólu w analizach wyłączających osoby regularnie grające na instrumencie muzycznym, grające w gry wideo lub uprawiające sport.

Wnioski
Rozmiar ekranu smartfona nie wpływa na ryzyko rozwoju i nasilenie zespołu de Quervain.

Słowa kluczowe: zespół de Quervaine, epidemiologia, nadgarstek, uraz przeciążeniowy telefony komórkowe, ekran, rozmiar ekranuplease complete

Introduction

De Quervain tenosynovitis is chronic inflammatory disease of the 1st wrist extensor compartment tendon sheaths. Tendons enclosed in that compartment are: extensor pollicis brevis (EPB) and abductor pollicis longus (APL). It was shown in numerous studies that repetitive thumb movements, performed while using smartphone, can predispose to developing de Quervain tenosynovitis (Ali *et al.*, 2014; Ashurst *et al.*, 2010; Eapen *et al.*, 2014; Karim, 2009; Nisa *et al.*, 2017; Sharan and Ajeesh, 2012; Williams and Kennedy, 2011).

Risk of disease was described to increase with frequency of smartphone using, female

sex, inflammatory joint diseases, strenuous occupational activities, pregnancy and previous wrist trauma (Ali *et al.*, 2014; Stahl *et al.*, 2015). However, none of these studies assessed whether the smartphone diagonal screen size is a separate risk factor for de Quervain tenosynovitis. There are many examples of repetitive excessive range of motion impacting joint biomechanics and anatomy, for example Glenohumeral Internal Rotation Deficit (GIRD) in throwers (Johnson *et al.*, 2018). Authors hypothesized that increased range of thumb movements resulting from bigger smartphone screen can be a causative factor of the 1st wrist extensor compartment tendon sheaths overuse.

The most commonly used clinical test for detecting de Quervain tenosynovitis is Eichhoff test (Goubau *et al.*, 2013; Ilyas *et al.*, 2007). A patient puts the thumb inside the fist and flexes other fingers. Afterwards, the ulnar deviation is introduced. If a pain on the radial side of wrist occurs, the test is considered

time, hand using phone (left/right; all included respondents were right-handed, so this contradistinction can be also expressed as nondominant/dominant hand), finger using phone (1st/2st), regular video games play and regular music play.

Materials and methods

An online questionnaire survey was conducted. The questionnaires were distributed among medical students in Poland, using online medical groups of interests. The following inclusion criteria were age of the subject between 18–25 years old, right-handedness and being a student. Exclusion criteria were previous wrist injury, inflammatory joint diseases, diagnosis of de Quervain tenosynovitis in the family, pregnancy or lactation, diagnosed lateral epicondylitis, regular golf or tennis participation and paid employment (namely, full- or partial-time employment that can be associated with repeated wrist motions) (Figure 1).
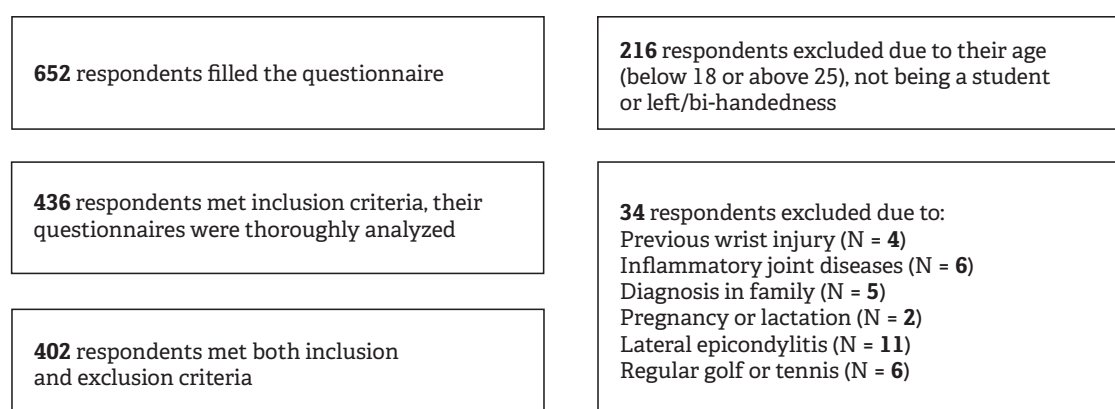

652 respondents filled the questionnaire

436 respondents met inclusion criteria, their questionnaires were thoroughly analyzed

402 respondents met both inclusion and exclusion criteria

216 respondents excluded due to their age (below 18 or above 25), not being a student or left/bi-handedness

34 respondents excluded due to:
Previous wrist injury (N = **4**)
Inflammatory joint diseases (N = **6**)
Diagnosis in family (N = **5**)
Pregnancy or lactation (N = **2**)
Lateral epicondylitis (N = **11**)
Regular golf or tennis (N = **6**)

Figure 1. Flowchart of the study.

to be positive. Eichhoff test was reported to be sensitive for detecting de Quervain tenosynovitis (Nisa *et al.*, 2017).

Aim

The primary aim of the study was to assess the impact of smartphone screen size on the incidence and severity of de Quervain tenosynovitis separately from confounding risk factors. The secondary aim was to assess other risk factors: sex, daily usage

The study protocol was approved by Institutional review boards of Medical University of Lodz (decision number RNN/329/19/KE).

In the questionnaire, respondents specified the model of a smartphone they use. After collecting all surveys, the models were categorized accordingly to their diagonal screen size. Then the respondents indicated whether they use their thumb or index finger while working with the telephone. The question was designed to receive the results

in a scale from 0 to 10, where 0 means only the 1st finger and 10 only the 2nd finger . They were also asked to point on a 10-point scale, where 0 meant using only left hand and 10 only right hand if they are holding the phone in the left hand, right hand or in both handsAnother part of the questionnaire was the pain during the modified Eichhoff test. The modification was that the respondents performed it by themselves without external force, accordingly to provided instruction. The instruction consisted of a simple picture and short text: "Please extend your hand forward so that your thumb is pointing up ("ok sign"). Then fold your fingers into a fist, placing your thumb inside the fist (as in the picture). Without changing your position, please bend the palm of the wrist so that the palm points down. (As in the picture) Attention! Please do not move your forearm or arm while performing the test." (Figure 2). Afterwards, they determined the intensity of pain in right wrist on the thumb side during the modified Eichhoff test using a scale from 0 to 10. "0" score was deemed as negative test and "1" to "10" scores were deemed as positive test. Assessed were right wrists, because left and bi-handed respondents were excluded due to the possibility of differences in motion patterns of everyday living activities.

For univariate variable analysis, the following statistical methods were used: Shapiro-Wilk test of normality, Levene's test of homoscedascity, Chi square test, Spearman's rank-order correlation and Mann-Whitney U test. Afterwards, simultaneous impact of multiple factors was assessed using multivariate analysis with linear regression test or logistic regression. test., accordingly to the type of the assessed variable. The significant *p* value was set at < 0.05.

The first statistical analysis concerning de Quervain tenosynovitis risk factors was performed in the group of all included respondents. The second statistical analysis was performed after excluding participants regularly playing a musical instrument. In order to fully diminish the impact of confounding variables, third statistical analysis was performed excluding also people who played video games regularly.

Results

2438 people were present in online medical groups of interests, where questionnaires were distributed. 652 of them responded to the survey and completed authors' self-designed questionnaire. 402 respondents (265 females, 137 males) met both inclusion and exclusion criteria. Mean screen diagonal
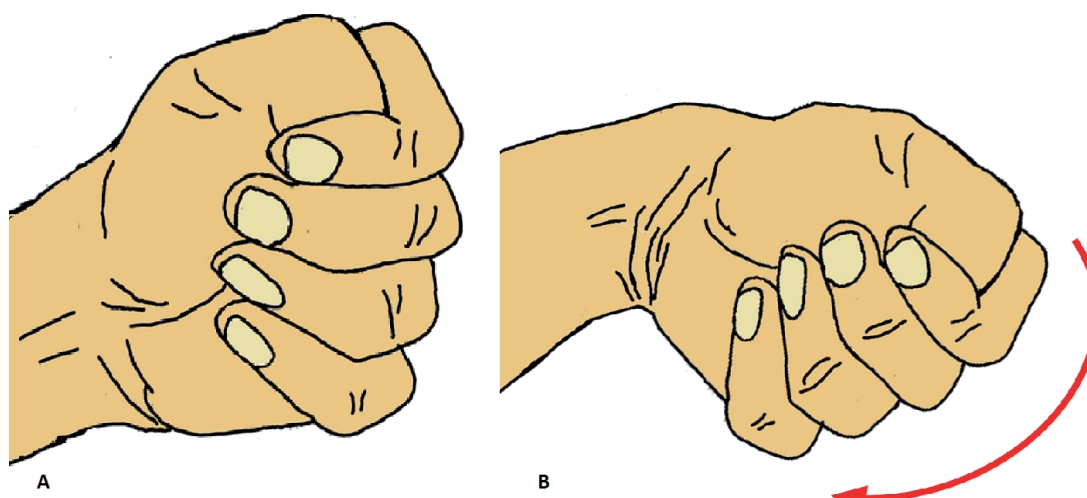
Figure 2. Instructions on performing modified Eichhoff test provided to participants.

Responses were further analyzed statistically, using *Statistica 13.1 and GPower 3.1.*

size was 5.2140 inches <Standard Deviation (SD) ± 0.5500> with no statistically significant

difference between females (5.1825 inches) and males (5.2753 inches). Respondents used their phones on an average 3.52 hours a day <SD ± 1.56> with no statistically significant difference between females (3.55 hours a day) and males (3.46 hours a day). 1st finger was used more often than the 2nd finger with mean value = 2.5647 <SD ± 2.4295>. Right (in case of study's respondents – dominant) hand was used more often than left (nondominant) hand with mean value = 7.4826 <SD ± 1.9369>. There were no significant differences between females and males in these variables. 69 respondents (17.16% of group) played video games regularly. There were significantly more males playing video games regularly than females (males, 46 out of 137; females, 23 out of 265; p < 0.00001). 39 respondents (9.70% of the group) played music regularly. There was no significant difference between males and females (males, 16 out of 137; females, 23 out of 265; p > 0.05).

Risk factors, group of all included respondents
In the group of all included respondents), the average screen diagonal was 5.2461 inches <SD ± 0.5619> among participants without pain in the modified Eichhoff test (163 individuals and 5.2442 inches <SD ± 0.5585> among participants with with pain (239 individuals) it was As shown in the Table 1, screen diagonal size was not associated with pain presence (p > 0.05). Female sex was associated with pain presence in univariate analysis (Odds Ratio [OR] = 1.56; 95% Confidence Interval [95%CI] = 1.02–2.40; p = 0.0413), but not in multivariate analysis (p > 0.05). Regular music play was a protective factor against pain presence both in univariate (OR = 0.33, 95%CI = 0.11–0.94; p = 0.0389) and multivariate (OR = 0.33, 95%CI = 0.11–0.96; p = 0.0451) analysis. As mentioned before, the frequency of regular music play did not differ between females and males (p > 0.05). Daily smartphone usage time, hand and finger used and regular video games play did not influence the risk of pain (p > 0.05).

After pain presence analysis, linear regression was used to assess risk factors for pain intensity. However, all of variables turned out to be irrelevant (screen diagonal, p = 0.6865; female sex, p = 0.4145; daily usage time, p = 0.8676; hand using phone (left/right), p = 0.1183; finger using phone (1st/2st), p = 0.0829; regular video games play, p = 0.5346; regular music play, p = 0.0864).

Risk factors, 1st subgroup
For the analysis excluding participants regularly playing a musical instrument, 39 respondents (16 out of 137 males and 23 out of 265 females, p > 0.05) were excluded, 363 remained (121 males, 242 females). The only relevant risk factor in this analysis was female sex. Surprisingly, it turned out to be significant only in multivariate analysis (OR = 1.85, 95%CI = 1.04–3.29; p = 0.0365), but not in univariate analysis (p > 0.05). It turned out that males played video games more frequently (43 out of remaining 121 males and 19 of remaining 242 females, p < 0.00001). None of other variables (screen diagonal, daily usage time, hand and finger using phone) differed between females and males. Exact results were shown in the Table 2.

As previously, after pain presence analysis, pain intensity was assessed in this subgroup. Once again, all variables were irrelevant (screen diagonal, p = 0.6220; female sex, p = 0.5446; daily usage time, p = 0.9392; hand using phone (left/right), p = 0.1624; finger using phone (1st/2st), p = 0.0652; regular video games play, p = 0.9579).

Risk factors, 2nd subgroup
In third statistical analysis, in which 62 respondents (43 out of remaining 121 males and 19 of remaining 242 females, p < 0.00001) who played video games regularly were excluded, remaining 301 respondents (78 males, 223 females). None of variables (screen diagonal, daily usage time, hand and finger using phone) differed between females and males. In this most strict subgroup none of the variables reached statistical significance, as shown in the Table 3.

Table 1. Analysis of pain presence in all respondents. Impact of listed variables was assessed between participants without pain during modified Eichhoff test ("0" score) and participants with pain during modified Eichhoff test ("1" to "10" score). Univariate analysis was performed using Chi square test (sex, regular video games play and regular music play) and Mann-Whitney U test (screen diagonal, daily usage time, hand using phone and finger using phone).

Variable:	Mean value in group without pain vs. group with pain/ percentage of variable-divided group with and without pain:	OR; 95%CI univariate analysis:	p value:	OR; 95%CI multivariate analysis:	p value:
Screen diagonal (inches)	5.215<SD ± 0.56> in no pain group vs. 5.212<SD ± 0.53> in pain group	0.99; 0.65–1.50	0.9629	1.0; 0.65–1.53	0.9913
Female sex	70/265 (26.40%) of females had pain vs. 28/137 (20.44%) of males	**1.56; 1.02–2.40**	**0.0413**	1.63; 0.94–2.82	0.0799
Daily usage time (hours)	3.492<SD ± 1.56 > in no pain group vs. 3.607<SD ± 1.56> in pain group	0.97; 0.86–1.09	0.6169	0.97; 0.86–1.10	0.6871
Hand using phone (left/ right on 0 [only left] to 10 [only right] scale)	7.401<SD ± 1.97 > in no pain group vs. 7.735<SD ± 1.81> in pain group	1.10; 0.97–1.25	0.1396	1.08; 0.95–1.23	0.2133
Finger using phone (1st/ 2st on 0 [only 1st] to 10 [only 2nd] scale)	2.691<SD ± 2.55 > in no pain group vs. 2.174<SD ± 1.97> in pain group	0.90; 0.82–1.01	0.0688	0.91; 0.81–1.01	0.0777
Regular video games play	19/69 (27.5%) of video players had pain vs. 79/333 (23.72%) of people not playing video games	1.22; 0.68–2.19	0.5025	1.44; 0.76–2.73	0.2685
Regular music play	4/39 (10.3%) of music players had pain vs. 94/363 (25.90%) of people not playing music	**0.33; 0.11–0.94**	**0.0389**	**0.33; 0.11–0.96**	**0.0451**

OR – Odds Ratio, CI – Confidence Interval

Table 2. Analysis of pain presence, respondents regularly playing music excluded. Impact of listed variables was assessed between participants without pain during modified Eichhoff n test ("0" score) and participants with pain during modified Eichhoff test ("1" to "10" score). Univariate analysis was performed using Chi square test (sex and regular video games play) and Mann-Whitney U test (screen diagonal, daily usage time, hand using phone and finger using phone).

Variable:	Mean value in group without pain vs. group with pain/ percentage of variable-divided group with and without pain:	OR; 95%CI univariate analysis:	p value:	OR; 95%CI multivariate analysis:	p value:
Screen diagonal (inches)	5.218<SD ± 0.56> in no pain group vs. 5.22<SD ± 0.53> in pain group	1.01; 0.66–1.56	0.9528	1.03; 0.66–1.59	0.9008
Female sex	69/242 (28.50%) of females had pain vs. 25/121(20.66%) of males	1.53; 0.91–2.58	0.1089	**1.85; 1.04–3.29**	**0.0365**
Daily usage time (hours)	3.622<SD ± 1.58> in no pain group vs. 3.545<SD ± 1.60> in pain group	0.97; 0.86-1.10	0.6286	0.99; 0.87–1.12	0.8279
Hand using phone (left/ right on 0 [only left] to 10 [only right] scale)	7.465<SD ± 2.00> in no pain group vs. 7.692<SD ± 1.83> in pain group	1.06; 0.94–1.21	0.3342	1.06; 0.94–1.21	0.3489
Finger using phone (1st/ 2st on 0 [only 1st] to 10 [only 2nd] scale)	2.703<SD ± 2.51 > in no pain group vs. 2.223<SD ± 2.00> in pain group	0.91; 0.82–1.02	0.0972	0.91; 0.82–1.02	0.1114
Regular video games play	18/62 (29.0%) of video players had pain vs. 76/301 (25.25%) of people not playing video games	1.21; 0.66–2.22	0.5362	1.52; 0.78–2.96	0.2219

OR – Odds Ratio, CI – Confidence Interval

Table 3. Analysis of pain presence, respondents regularly playing music or video games excluded. Impact of listed variables was assessed between participants without pain during modified Eichhoff test ("0" score) and participants with pain during modified Eichhoff test ("1" to "10" score). Univariate analysis was performed using Chi square test (sex) and Mann-Whitney U test (screen diagonal, daily usage time, hand using phone and finger using phone).

Variable:	Mean value in group without pain vs. group with pain/ percentage of variable-divided group with and without pain:	OR; 95%CI univariate analysis:	p value:	OR; 95%CI multivariate analysis:	p value:
Screen diagonal (inches)	5.189<SD ± 0.56> in no pain group vs. 5.21<SD ± 0.53> in pain group	1.07; 0.67–1.73	0.7724	1.07; 0.66–1.73	0.7908
Female sex	61/223 (27.35%) of females had pain vs. 15/78(19.23%) of males	1.58; 0.84–2.99	0.1574	1.63; 0.85–3.09	0.1389
Daily usage time (hours)	3.697<SD ± 1.61> in no pain group vs. 3.478<SD ± 1.53> in pain group	0.97; 0.84–1.11	0.6589	0.99; 0.86–1.14	0.8812
Hand using phone (left/right on 0 [only left] to 10 [only right] scale)	7.431<SD ± 1.97> in no pain group vs. 7.605<SD ± 1.87> in pain group	1.05; 0.91–1.20	0.5000	1.04; 0.91–1.20	0.5449
Finger using phone (1st/2st on 0 [only 1st] to 10 [only 2nd] scale)	2.778<SD ± 2.53 > in no pain group vs. 2.158<SD ± 1.82> in pain group	0.88; 0.78–1.00	0.0524	0.89; 0.78–1.01	0.0630

OR – Odds Ratio, CI – Confidence Interval

Also in this subgroup there was no association between any assessed risk factor and intensity of pain (screen diagonal, p = 0.7495; female sex, p = 0.4477; daily usage time, p = 0.9908; hand using phone (left/right), p = 0.2779; finger using phone (1st/2st), p = 0.0663).

Discussion
Diagonal screen size
The primary aim of the study was to assess the impact of smartphone diagonal screen size on the incidence and severity of de Quervain tenosynovitis. It was not significantly associated with pain presence or intensity in any of performed analyses. The possible reason may be that while greater screen diagonal increases thumb range of motion, this increase is not big enough to cause tendon sheaths to overuse. Another possibility is that while screen diagonal varies, distance between buttons displayed on the screen is similar in different smartphone models. As to impact of potential confounding factors, authors believe that the study design is reliable. Study criteria were very strict and only 402 out of 652 survey respondents were included

in the study, leaving 38.34% of respondents out of the analyses. The remaining group was very homogenous: all included respondents were non-working, 18 to 25 years, right-handed students. Therefore the impact of age and occupational activities was greatly diminished. It is important, because many authors confirmed age as risk factor for de Quervain tenosynovitis (le Manac'h *et al.*, 2011; Stahl *et al.*, 2015; Wolf *et al.*, 2009). What is more, that disease figures on the lists of occupational diseases published by European Union, The International Labour Organization and World Health Organization (European Commission., 2009; International Labour Office, 2010; Karjalainen A., 1999).

What is more, two another confounding factors: regular music play and regular video games play, were excluded. However playing wideo games was not significantly associated with pain presence in our study, such association was reported in the literature (Bonis, 2007; Brasington, 1990; Reinstein, 1983; Suttle and Wallace, 2011). As to the examination method, it is unsure how the self-testing modification influenced the diagnostic characteristics of original Eichhoff

test. We are not aware of any study analyzing self-performed Eichhoff test diagnostics characteristics. Such research would hold value, because both Eichhoff and Finkelstein test, two tests most commonly used in de Quervain syndrome diagnosis, require presence of examiner. While in Eichhoff test the fist with thumb inside is deviated ulnarly by examiner, in Finkelstein test the examiner hold the patient's hand in neutral position and then pulls the thumb longitudinally and slightly ulnarly not allowing wrist movement. While self-testing may result in differing strength used by patients to deviate their fist, modified Eichhoff test is relatively easy to perform when provided with instruction. Due to authors' knowledge, this is the first study to assess smartphone screen diagonal size as a risk factor for de Quervain tenosynovitis and therefore the results of this study needs further confirmation. As most of people use smartphones nowadays, authors believe the issue holds importance when considering which smartphone model to buy.

Other risk factors
Since assessing the impact of other risk factors was just the secondary aim of the study, most of them were excluded during collecting the study group, leaving: sex, regular music play, regular video games play, daily usage time and hand and finger using phone. Authors decided to include respondents playing music and video games in the first analysis, but afterwards analyses excluding them were also performed. None of risk factors was associated with pain intensity.

Female sex
Female sex was significantly associated with risk of pain presence in univariate analysis performed within whole group and in multivariate analysis performed within 1st subgroup (respondents playing music excluded). However, it is important to mention that these associations were on the edge of significance with OR = 1.56, 95%CI = 1.02–2.40 and OR = 1.85, 95%CI = 1.04–3.29.

Those ORs are not far from reported by Stahl (OR = 2.7, 95%CI = 1.2–6.3), but le Manac'h reported OR as high as 4.9, 95%CI = 2.4–10.1 and Wolf reported RR = 4.45, 95%CI = 4.28–4.62 (le Manac'h *et al.*, 2011; Stahl *et al.*, 2015; Wolf *et al.*, 2009). One of the reasons may be higher age in le Manac'h and Wolf study that in this study (average age, la Manac'h, 38.7 years; Wolf used age groups) (le Manac'h *et al.*, 2011; Wolf *et al.*, 2009). However, the average age in Stahl's study was 52 years in group of cases and 43 years in group of controls (Stahl *et al.*, 2015). Another important reason of such results may be that none of females was pregnant or during lactation and, due to young age, probably none or very low percent of them was after pregnancy and lactation. It is also possible that some differences between males and females (for example difference in ratio of respondents playing music, difference in mean diagonal screen size etc.), although each one of them below statistical significance, could cumulatively create a significant effect (analysis within 1st subgroup) or annihilate effect significant in univariate analysis (analysis within whole group).

Regular music play
Regular music play was with a protective factor against pain presence both in univariate and multivariate analysis. Unfortunately, the data about type of musical instruments are not available. While some authors suggested that playing music can be a risk factor for de Quervaine tenosynovitis, in Stahl's study such association was not found (Karim, 2009; Sakai *et al.*, 2006; Stahl *et al.*, 2015). In this study, association of regular music play and pain presence rate was on the edge of significance. As the subgroup of music players was only 39 respondents and only 4 of them suffered from pain, the reliability of this result is limited.

Daily usage time, hand and finger using phone, regular video games play
These variables were not associated with

pain presence.

Strong and weak sides of the study
The study holds several limitations. The first one is self-testing modification of Eichhoff test., with possible decline in diagnostic value. The second weak side of the study is that we assessed the diagonal screen size without assessing how it influenced the distances between buttons displayed on the screen. The third limitation is that de Quervain syndrome presence was not confirmed with use of imaging methods. However, purely clinical diagnosis was often utilized in the previous literature. As to the strong sides of the study, the first one was that the study inclusion and exclusion criteria were very strict, resulting in homogenous group. What is more, we performed statistical analyses in different subgroups in order to fully exclude the impact of potential confounding factors. The third strong side of the study are multivariate tests, analyzing the simultaneous impact of multiple factors. Authors believe that there is also a merit in the fact that is is the first study to analyze the association between diagonal screen size and de Quervain syndrome.

Conclusions
The smartphone diagonal screen size is unlikely to be associated with de Quervain tenosynovitis development Young, non-pregnant, non-lactating females may not be under greater risk of developing de Quervain tenosynovitis than young males.

REFERENCES
Ali, M., Asim, M., Danish, S.H., Ahmad, F., Iqbal, A. and Ahmad, F., (2014), *'Frequency of De Quervain's tenosynovitis and its association with SMS texting'*, Muscles, Ligaments and Tendons Journal, Vol. 4 No. 1, pp. 74–78.
Ashurst, J. V, Turco, D.A. and Lieb, B.E., (2010), *'Tenosynovitis caused by texting: an emerging disease.'*, The Journal of the American Osteopathic Association, Vol. 110 No. 5, pp. 294–296.
Bonis, J., (2007), 'Acute Wiiitis', *New England Journal of Medicine*, Massachusetts Medical Society, Vol. 356 No. 23, pp. 2431–2432.
Brasington, R., (1990), *'Nintendinitis.'*, New England Journal of Medicine, Vol. 322 No. 20, pp. 1473–1474.
Eapen, C., Kumar, B., Bhat, A.K. and Venugopal, A., (2014), *'Extensor Pollicis Longus Injury in Addition to De Quervain's with Text Messaging on Mobile Phones', Journal of Clinical and Diagnostic Research*, No. May 2016
European Commission. (2009), 'Information Notices on Occupational Diseases: A Guide to Diagnosis. Luxembourg: Office for Official Publications of the European Communities'.
Goubau, J.F., Goubau, L., Tongel, A. Van, Hoonacker, P. Van, Kerckhove, D. and Berghs, B., (2013), *'The wrist hyperflexion and abduction of the thumb (WHAT) test: a more specific and sensitive test to diagnose de Quervain tenosynovitis than the Eichhoff's Test',* Journal of Hand Surgery (European Volume).
Ilyas, A., Ast, M., Schaffer, A. and Thoder, J., (2007), *'de Quervain tenosynovitis of the wrist'*, Journal of the American Academy of Orthopaedic Surgeons, Vol. 15 No. 12, pp. 757–764.
International Labour Office, (2010), 'ILO List of Occupational Diseases (revised 2010). Part I: List of Occupational Diseases. Geneva, Switzerland: International Labour Office'.
Johnson, J.E., Fullmer, J.A., Nielsen, C.M., Johnson, J.K. and Moorman, C.T., (2018), *'Glenohumeral Internal Rotation Deficit and Injuries: A Systematic Review and Meta-analysis',* Orthopaedic Journal of Sports Medicine, Vol. 6 No. 5, pp. 1–10.
Karim, S.A., (2009), *'From 'playstation thumb' to 'cellphone thumb': The new epidemic in teenagers'*, South African Medical Journal, Vol. 99 No. 3, pp. 161–162.
Karjalainen A., (1999), 'World Health Organization: International Statistical Classification of Diseases and Related Health Problems (ICD-10) in Occupational Health. Geneva, Switzerland: World Health Organization'.
le Manac'h, A.P., Roquelaure, Y., Ha, C., Bodin, J., Meyer, G., Bigot, F., Veaudor, M., *et al.*, (2011), *'Risk factors for de Quervain's disease in a French working population',* Scandinavian

Journal of Work, Environment and Health, Vol. 37 No. 5, pp. 394–401.

Nisa, Z., Umer, B. and Hassan, T., (2017), *'Prevalence of De Quervain's Syndrome Among Young Mobile Phone Users',* Journal of Riphah College of Rehabilitation Sciences, pp. 22–24.

Reinstein, L., (1983), *'de Quervain's stenosing tenosynovitis in a video games player.',* Arch Psych Med Rehabil, Vol. 64 No. 9, pp. 434–5.

Sakai, N., Liu, M.C., Su, F.C., Bishop, A.T. and An, K.N., (2006), *'Hand Span and Digital Motion on the Keyboard: Concerns of Overuse Syndrome in Musicians',* Journal of Hand Surgery, Vol. 31 No. 5, pp. 830–835.

Sharan, D. and Ajeesh, P.S., (2012), *'Risk factors and clinical features of text message injuries',* Work, Vol. 41 No. SUPPL.1, pp. 1145–1148.

Stahl, S., Vida, D., Meisner, C., Stahl, A.S., Schaller, H. and Held, M., (2015), *'Work related etiology of de Quervain' s tenosynovitis : a case-control study with prospectively collected data',* BMC Musculoskeletal Disorders, pp. 1–10.

Suttle, A.L. and Wallace, E.A., (2011), *'Disc jockey tenosynovitis',* American Journal of Medicine, Elsevier Inc., Vol. 124 No. 4, p. e1.

Williams, I.W. and Kennedy, B.S., (2011), *'Texting tendinitis in a teenager.',* The Journal of Family Practice, Vol. 60 No. 2, pp. 66–67, 1 p following 67.

Wolf, J.M., Sturdivant, R.X. and Owens, B.D., (2009), *'Incidence of de Quervain's Tenosynovitis in a Young, Active Population', Journal of Hand Surgery, Elsevier* Inc., Vol. 34 No. 1, pp. 112–115.