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ORIGINAL PAPER

Relationship between the incidence of de Quervain's disease among teenagers and mobile gaming

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Abstract

Objective To assess the relationship between the incidence of de Quervain's disease (DD) and mobile gaming.

Methods We conducted an experimental cross-sectional study and surveyed specialized students with different majors from Xingtai Technician Institute. We applied the stratified clustered sampling method to recruit 500 students aged 16 to 20 years as survey respondents. We diagnosed DD by conducting Finkelstein's test. Chi-square test or Fisher's exact test was used to determine the correlation between different variables and Finkelstein's test results. SPSS 20 statistical software was used to perform all the statistical analyses.

Results Among the five hundred students providing the valid data, there were 302 males and 198 females, with a male-to-female ratio of 3:2. Of them, 216, 159, 77, and 48 reported they played mobile games for < two, two to four, four to six, and > six hours per day, respectively. A total of 246 students (49%) had a positive result in Finkelstein's test. Three hundred and five (61.0%) students played mobile games with their wrist in dorsiflexion position, and among them, 192 had a positive result in Finkelstein's test. The statistical analyses showed that more frequent play, prolonged mobile gaming time per day, and changes in wrist position were significantly correlated with the positive rate of Finkelstein's test ($p < 0.05$).

Discussion Our results show that the incidence of DD in students in the school was 49.0%. More frequent play, prolonged duration of mobile gaming, and change in wrist position were associated with higher risk of DD. We advocate the restricted time to less than 2.25 hours per day and the frequency in mobile gaming to prevent or reduce DD.

Keywords De quervain's disease · Finkelstein's test · Teenager · Mobile game · Cross-sectional study

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Introduction

Inflammatory hand and wrist tendon lesions are increasingly common, with the development of electronic products. In 1892, Tillaux firstly proposed and described the first dorsal compartment tenosynovitis as "wrist sprain of washerwomen" in the 13th edition of *Gray's Anatomy* [1–4]. In 1895, de Quervain published a report on five cases of first dorsal compartment tenosynovitis, and since then the disease has been designated as de Quervain's disease (DD) [2, 5–8]. DD is the most common inflammatory wrist tendon lesion, and individuals aged 50–60 years are the most easily involved population. Despite absence of anatomical differences of the wrist bone and soft tissue structure between male and female [9], females were reported to be six to eight times more likely to suffer from DD than males [8, 10–14].

The formation mechanism of DD is well-accepted and repeated thumb movement is the most contributing cause. During ulnar deviation when the wrist is in dorsiflexion position, friction between supporting bands causes microdamage and promotes swelling and stenosis [8, 15]. Pain and tenderness in the first dorsal compartment are positive manifestations of DD. Finkelstein et al. [16] firstly proposed a test for evaluating DD, the notable Finkelstein's test that was a diagnostic and objective examination, on the basis of the clinical pain symptom produced when the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) abdominal muscles enter the first dorsal compartment [16–18].

During the past decade, the use of mobile phones and mobile games has become the greatest popularity due to its convenience, entertainment, and the ease to operate. Moreover, the traditional keyboard phone has been replaced by the full-touch phone in almost all the population, except for those living in rural areas. A report by the China Internet Network Information Center (CNNIC) stated that by June 2017, the number of mobile internet users in China has reached 724 million and that of mobile game users has reached 422 million; among mobile game users, 54% are aged 11 to 20 years (http://cnnic.com.cn/). A recent survey by the market research firm Niko Partners and Quantic Foundry reported that professional gamers in China spend an average of 42 hours per week playing mobile games, whereas amateurs spend an average of 12 to 16.5 hours. Prolonged mobile gaming generally would result in thumb overuse among teenagers, and a certain proportion of them complained of wrist discomfort.

Although the incidence of DD among teenagers is on the rise, few studies have attempted to validate the relationship between DD and mobile gaming. Given the popularity of mobile gaming among teenagers, the relationship between the incidence of DD in this population and mobile gaming warrants investigation.

Methods

This study was approved by the Ethics Committee Board of the Orthopedics Hospital of Xingtai City. All the students and guardians involved in this study provided written informed consent. It was designed as a cross-sectional survey of students in a local college. The stratified clustered sampling method was used to recruit 500 students as survey respondents from Xingtai Technician Institute. The age, gender, grade, and majors were considered primary factors. The error range was set as less than 5% and the reliability was set as above 95%. The inclusion criteria were students aged 16–20 years and voluntarily providing valid data on their playing the mobile games. Exclusion criteria were students with history of surgery on the wrists for any reason, past diagnosis of carpal disease other than DD, and those involuntary to participate in this study.

A total of 644 students were initially selected, and based on our criteria, 144 questionnaires were excluded, with 500 left in this study for data analysis. DD was diagnosed through Finkelstein's test [16–18]. In this test, the thumb is placed in the palm. Pain is induced upon ulnar deviation when the EPB abdominal muscle enters the first dorsal compartment. Pain is considered a positive result. The absence of pain is considered a negative result. Students who had positive Finkelstein's test results were directed to complete a specific action, including the comfort in thumb and wrist movement with possible response of no, mild, or severe and difficulty in pinching, griping, and buttoning with the possible response of either difficulty or no difficulty.

The contents of the questionnaire that was used to collect data including age, gender, grade, the history of any disease in wrists, the history of wrist surgery for any reason, the type of mobile phone used (full-touch or keyboard-style phones), the screen size of the mobile phone, the frequency of playing mobile game, the number of hours playing mobile game per day, the feeling and dyskinesia of the thumb and wrist, the completion of designated movements, and the posture of the wrist when playing on mobile phones. To facilitate the data analysis, we made definitions of the above variables. The screen size was divided into < 5.0, 5.0–5.9, and ≥ 6.0 in. The frequency of students playing mobile game was divided into < one/month (never), one to four/months (occasional), one to six/week (often) and > one/day (frequently). The number of hours spent in playing mobile game was divided into four groups: < two hours, two to 3.9 hours, 4.0–5.9, and ≥ 6.0 hours. The screen size of the mobile phone was divided into < 5.0, 5.0–5.9, and ≥ 6.0 in.

Statistical analysis

For comparison of continuous variables (age, surgical duration, volar tilt, radial inclination, radial length, ulnar variance, and articular step-off), Student's *t* test or Mann-Whitney *U* test was used, based on their data distribution status As for categorical variables (gender, handedness, injury mechanism, complications), Pearson chi-square test or Fishers' exact test was used, if appropriate. A p value < 0.05 was considered statistically significant. The odds ratio (OR) was used to indicate the strength of correlation between different various variables and positive result of Finkelstein's test.

A total of 246 students was tested as significant, a receiver operating characteristic (ROC) curve and the corresponding area under the curve (AUC) were performed to test for discrimination. The cut-off value was determined when the sum of sensitivity and specificity was maximum. Subgroups were further divided, based on the cut-off value, and Chi-square test was used to evaluate the difference for their effect on the outcome variable.

All the analyses were performed using the SPSS 21.0 software (IBM, Armonk, NY, USA).

Results

All of the 500 recruited students were junior college students with different majors at Xingtai Technician Institute. Among them, 302 (60%) were male and 198 (40%) were female, with male-to-female ratio of 3:2. Their mean age was 17.9 years (standard deviation (sd) 1.4 years), with a non-significant difference between males (17.9 ± 1.4 years) and females (17.8 ± 1.4 years) ($p = 0.977$).

Among them, 488 students reported they used full-touch phones and 12 reported use of keyboard-style phones, not significantly different with respect to the positive rate of Finkelstein's test ($p = 0.784$).

A total of 246 students had positive Finkelstein's test results. As shown in Table 1, there was a significant difference in the frequency of mobile gaming between the students with and without positive result of Finkelstein's test ($p < 0.001$). There were 216, 159, 77, and 48 students who played mobile games for < 2, 2–3.9, 4–5.9, and ≥ six hours per day, respectively. The mean duration of mobile gaming was 3.7 ± 2.3 hours for those with a positive result in Finkelstein's test results, significantly longer than that of those with a negative result (2.2 ± 1.5 h, $p < 0.001$). The positive rate of Finkelstein's test in students who played mobile games for < 2, 2–3.9, 4–5.9, and ≥ six hours per day was 33.3%, 49.1%, 71.4%, and 85.4%, respectively, and the difference was significant ($p < 0.01$). The ROC curve was used to further evaluate the effect of time spent in playing mobile game per day on the positive Finkelstein's test results. And the results showed the good prediction of risk in development of positive Finkelstein's test results: area under the curve (AUC) was 0.693 (95%CI, 0.647 to 0.739). The cut-off value was determined as 2.25 h, when the sum of sensitivity (0.707) and specificity (0.567) was maximum. Students who spend over 2.25 hours in playing mobile game per day had 3.16 times increased risk of positive Finkelstein's test results, compared with those who spent less than 2.25 hours (OR, 3.16; 95%CI, 2.19 to 4.58; $p < 0.001$). The positive rate Finkelstein's test was 0.33 (72/216) in those with <2.25 hours of mobile gaming and 0.61 (174/284). The ROC is presented in Fig. 1.

The mobile phone with screen size < 5.0 in. was used by 48 students, 5.0–5.9 in. by 329 students, and ≥ 6.0 in. by 123

Table 1 Investigation results of Finkelstein's test and hand movement

Finkelstein's test		Positive ($n = 246$)		Negative ($n = 254$)		p
		n	%	n	%	
How often use mobile phone for the game	Never	8	3	6	2	
	Occasionally	18	7	50	20	
	Often	85	35	95	37	
	Frequently	135	55	103	41	< 0.001
Time spent playing mobile games per day	< 2 h	72	29	144	57	
	2–3.9 h	78	32	81	31	
	4–5.9 h	55	22	22	9	
	≥ 6 h	41	17	7	3	< 0.001
Screen size (inches)	< 5.0	17	17	31	12	
	5.0–5.9	169	69	160	63	
	≥ 6.0	60	24	63	25	0.118
Uncomfortable with thumb and wrist	No	224	91	244	96	
	Mild	22	9	10	4	0.01
Wrist position	Dorsiflexion position	192	78	113	44	
	Function position	54	22	141	56	<0.001
Difficulty in pinching in past 2 weeks	No difficulty	218	89	242	95	
	Difficulty	28	11	12	5	0.005
Difficulty in gripping in past 2 weeks	No difficulty	227	92	246	97	
	Difficulty	19	8	8	3	0.019
Difficulty in buttoning in past 2 weeks	No difficulty	232	94	248	98	
	Difficulty	14	6	6	2	0.046

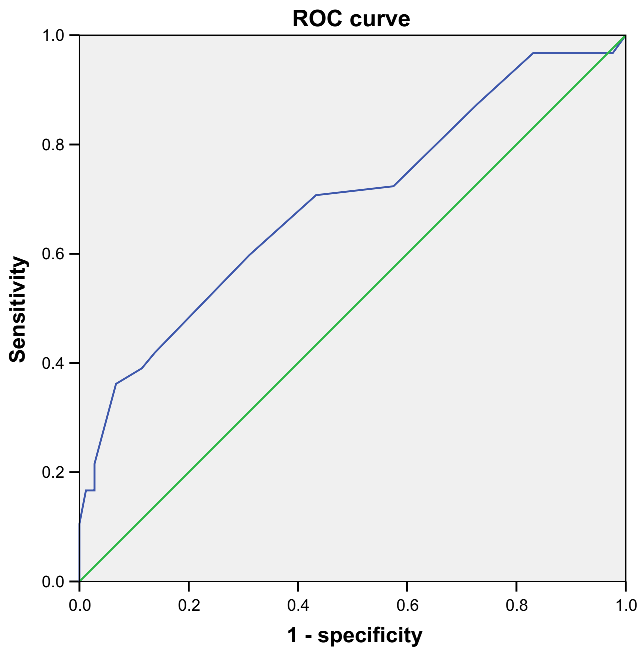


Fig. 1 ROC curve for the duration of mobile gaming per day. Prediction of risk of positive result of Finkelstein's test: ROC curve (ROC): area under the curve (AUC) = 0.693, (95%CI, 0.647 to 0.739). The cut-off value was determined as 2.25 h, when the sum of sensitivity (0.707) and specificity (0.567) was maximum

students, in whom 17, 169, and 60 had the positive result in Finkelstein's test, respectively. The difference was not statistically significant ($p = 0.118$).

A total of 32 students experienced discomfort in their thumbs and wrists during the test. Among these students, 22 and 10 had positive and negative Finkelstein's test results, respectively, significantly different from that in those who did not experience discomfort ($p = 0.017$).

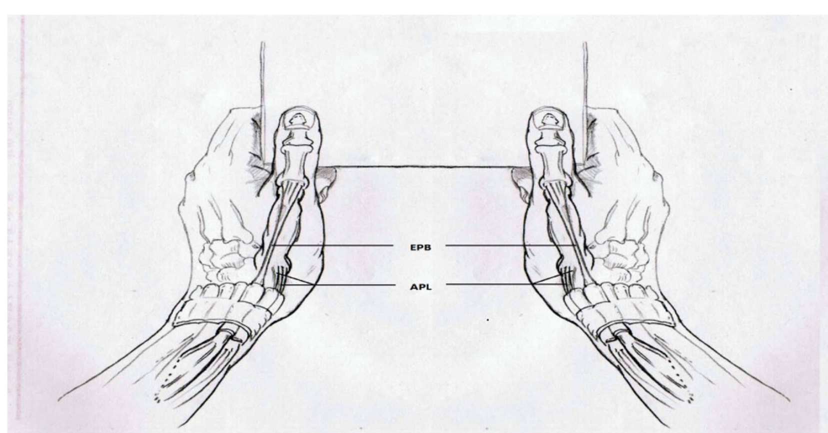
Among the 246 students with positive Finkelstein's test results, 218 did not report restricted pinching, whereas 28 showed varying degrees of restriction, with a significantly different result from those with negative Finkelstein's test results ($p = 0.005$). A total of 227 students reported that they had a satisfactory grip item, whereas19 students did not, also differing from with negative Finkelstein's test results ($p = 0.019$). There were 14 students who reported they have difficulty in performing buttoning actions.

As shown in Table 1, 305 students played mobile games with their wrists in the dorsiflexion position (Fig. 2), and the remaining students played with their wrists in the functional position. The positive rate of Finkelstein's test was 63% among the students who played mobile games with their wrists in the dorsiflexion position and 28% among the students who played mobile games with their wrists in the functional position, with a significant difference ($p < 0.01$).

Discussion

The frequency of mobile phone use among teenagers continues to increase every year [19].The CNNIC reported that in China 228 million teenagers play mobile games (data available at http://www.cnnic.net.cn/) and of them students comprise the predominant part. The most common cause of DD is repeated thumb movement, which is influenced by wrist dorsiflexion position and ulnar deviation [8, 15]. This movement causes repeated microdamage to collagen fibres that ultimately results in drastic damage, and repair reactions are initiated [20–22].The incidence of DD has increased in recent years with the increased prevalence of new activities [23],such as working on computers and mobile phones for long periods, golfing, and weightlifting. Previous reports have shown a relationship between DD and texting [24, 25]. With the development of technology, however, voice input and video calling have gradually replaced the traditional SMS mode of mobile communication. Nevertheless, the market share of mobile games continues to increase annually, which, in theory, might have negative effect on some musculoskeletal disorders, such DD [26].

Fig. 2 Wrist in dorsiflexion position to play mobile games



In this study, we used a questionnaire survey to evaluate the incidence of DD in teenagers; all were students in school, in whom over 57% spent two hours or more in playing mobile game. We found the incidence of DD was 49% and the wrist position and the more time in play game were significantly correlated with this disease. We also determined the cut-off value of time in playing game as 2.25 hours, and students who spent over this value had significantly higher risk of DD (OR, 3.16; $p < 0.001$).

Currently, no gold standard diagnostic test for DD exists [27]. Finkelstein's test results are considered pathological histological results for DD [15, 28, 29] and are thus important for guiding clinical diagnosis. In this study, each student was examined twice by different researchers, and those with different response in both surveys were excluded. Therefore, the data accuracy could be guaranteed. However, one concern should be raised that all of the responders were students in school. Therefore, the conclusion might not be generalized to other population setting, such as officers, blue-collar workers, and others, and the future work should focus on different types of work.

The positive rate of Finkelstein's test increased with the prolonged duration of mobile gaming, as shown in Table 1. Repeated hand pushing, prolonged holding, and repeated thumb up and down are causes of DD [30, 31].

Our survey also showed the dorsiflexion position of wrist in playing mobile game is another important cause of DD, although its role in development of DD has seldom been investigated. In this study, 78% of the students with positive result Finkelstein's test maintained their wrists in the dorsiflexion position during gaming to stabilize their mobile phones, while only 44% for those without positive result. Kutsumi et al. [5] studied the relationship between EPB and APL friction resistance and wrist position and found that the maximum sliding resistance was obtained when the wrist was in the maximum flexion or dorsiflexion position. Increased friction resistance can easily lead to degenerative changes and mechanical damage that consequently results in DD.

Some limitations of this study deserve to be mentioned. Firstly, the gender imbalance is a concern, which was related to the uneven gender distribution of overall students in this school. However, in our analysis, we did not observe the significant difference of positive Finkelstein's test between males and females (47% vs 52%), indicating the gender was not a significant contributor. Secondly, the students recruited in this study used different mobile phone models, wherein the screen size, resolution, and thickness of the phone were different; but only screen size was considered. Thirdly, in theory, compared with other types of mobile game, the strategy type game was at lower risk of development of DD, because fewer thumb taps and moves (up and down) were required. However, that was not taken into account before the survey began. Fourth, some other factors such as high-intensity wrist activity rather than mobile gaming and prolonged computer use would also increase tendon activities and lead to DD, but were ignored in this survey. Fifth, the OR values was rude, not independent of other variables, due to the small sample not allowing us to perform the multivariate analysis. The future research should focus on addressing these issues and multicenter, large sample studies were required to verify our results.

In summary, we used a questionnaire survey to found a high positive rate (49%) of Finkelstein's test in teenaged students in a school. We also found that more frequent mobile gaming, prolonged duration per day, and wrist posture were significantly correlated to the development of DD. The best cut-off value for time in mobile gaming was determined as 2.25 hours per day. We advocate students to restrict their time as less than 2.25 hours per day and the frequency in mobile gaming.

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Author contribution Zhanyong Wu and Lihua Song designed the study; Tianxiao Ma and Shenghua Ning and Guisheng Zhang collected the data; Huiwang Wang analyzed and interpreted the data; Lihua Song and Guisheng Zhang seared the relavant literature. Tianxiao Ma wrote the manuscript and Zhanyong Wu approved the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval Permission was obtained from the Institutional Review Board.

References

1. de Quervain F (1895) Uber das Wesen und die Behandlung der Tendovaginitis. Corresp Blatt Schweizer Arzte 25:389–394
2. Littler JW, Freedman DM, Malerich MM (2002) Compartment reconstruction for de Quervain's disease. J Hand Surg Br 27:242–244
3. Loomis LK (1951) Variations of stenosing tenosynovitis at the radial process. J Bone Joint Surg Am 33:340–346
4. Phalen GS (1991) Stenosing tenosynovitis: trigger fingers, trigger thumb, and de Quervain's disease: acute calcification in wrist and hand. In: Jupiter JB, ed. Flynn,s Hand Surgery.Baltimore, MD: Williams,Wilkins, 439–447
5. Kutsumi K, Amadio PC, Zhao C et al (2005) Gliding resistance of the extensor pollicis brevis tendon and abductor pollicis longus tendon within the first dorsal compartment in fixed wrist positions. J Orthop Res 23:243–248
6. Leao L (1958) De Quervain's disease a clinical and anatomical study. J Bone Joint Surg Am 40:1063–1070
7. Lipscomb PR (1951) Stenosing tenosynovitis of the radial styloid process (de Quervai''s disease). Ann Surg 134:110–115
8. Piver JD, Raney RB (1952) De Quervain's tenosynovitis. Am J Surg 83:691–694

9. Mahakkanukrauh P, Mahakkanukrauh C (2000) Incidence of a septum in the first dorsal compartment and its effects on therapy of de Quervain's disease. Clin Anat 13:195–198
10. Faithfull DK, Lamb DW (1971) De Quervain's disease–a clinical review. Hand 3:23–30
11. Harvey FJ, Harvey PM, Horsley MW (1990) De Quervain's disease:surgical or nonsurgical treatment. J Hand Surg [Am] 15:83–87
12. Stein AH, Ramsey RH, Key JA (1951) Stenosing tenosynovitis at the radial styloid process (De Quervain's disease). Arch Surg 63: 216–228
13. Stern PJ (1990) Tendinitis, overuse syndromes, and tendon injuries. Hand Clin 6:467–476
14. Weiss AP, Akelman E, Tabatabai M (1994) Treatment of de Quervain's disease. J Hand Surg Am 19:595–598
15. Keon-Cohen B (1951) De Quervain's disease. J Bone Joint Surg Br 33:96–99
16. Finkelstein H (1930) Stenosing tenosynovitiat the radial styloid process. J Bone Joint Surg Am 12:509–540
17. Eichhoff E (1927) Zur pathogenese der Tendovaginitis stenosans. Bruns Beitrage Z Klin Chir 139:746–755
18. Elliott BG (1992) Finkelstein's test: a descriptive error can produce false positive. J Hand Surg Br 17:481
19. Mezei G, Benyi M, Muller A (2007) Mobile phone ownership and use among school children in three Hungarian cities. Bioelectromagnetics. 28(4):309–315
20. Butler DL,Grood ES,Noyes FR,et al.Biomechanics of ligaments and tendons.Exerc Sport Sci Rev1978;6:125–181
21. Elliott DH (1965) Structure and function of mammalian tendon. Biol Rev Camb Philos Soc 40:392–421
22. Pitner MA (1990) Pathophysiology of overuse injuries in the hand and wrist. Hand Clin 6:355–364
23. Pagonis T, Ditsios K, Toli P, Givissis P, Christodoulou A (2011) Improved corticosteroid treatment of recalcitrant de Quervain tenosynovitis with a novel 4-point injection technique. Am J Sports Med 39(2):398–403
24. Yoong J (2005) Mobile phones can be a pain—text messaging tenosynovitis. Hospital Medicine (London, England: 1998) 66(6): 370
25. Ashurst JV, Turco DA, Lieb BE (2010) Tenosynovitis caused by texting: an emerging disease. JAOA: Journal of theAmerican Osteopathic Association 110(5):294–296
26. Walkinshaw E (2011) Thumbs up and down. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne 183(11):E711–E712
27. Sluiter JK, Rest KM, Frings-Dresen MH (2001) Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. Scandinavian Journal of Work, Environ- ment & health:1–102
28. Gupta AD, Mahalanabis D (2006) Study of hand function in a group of shoe factory workers engaged in repetitive work. J Occup Rehabil 16(4):675–684
29. Barr AE, Barbe MF, Clark BD (2004) Work-related musculoskeletal disorders of the hand and wrist: epidemiology, pathophysiology, and sensorimotor changes. The Journal of Orthopaedic and Sports Physical Therapy 34(10):610
30. Bruckschwaiger O (1954) Atypical De Quervain's disease. Canadian Medical Association Journal 71(3):277
31. Kamel M, Moghazy K, Eid H, Mansour R (2002) Ultrasonographic di-agnosis of de Quervain's tenosynovitis. Ann Rheum Dis 61(11): 1034–1035
32. Kuss DJ, Griffiths MD (2012) Internet gaming addiction: a systematic review of empirical research. Int J Ment Heal Addict 10(2): 278–296