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SEVERITY SCORING OF SYMPTOMS ASSOCIATED WITH CARPAL TUNNEL SYNDROME BASED ON RECALL OF COMPUTER GAME PLAYING EXPERIENCES

[1]NURUL HIDAYAH MAT ZAIN, [2]AZIZAH JAAFAR, [3]FARIZA HANIS ABDUL RAZAK
[1,3]Faculty Computer and Mathematical Sciences, University Technology MARA (UiTM), MALAYSIA
[2]Assoc. Prof., Institute of Visual Informatics, National University of Malaysia, MALAYSIA
E-mail: [1]nurulmz@tmsk.uitm.edu.my , [2]aj@ftsm.ukm.my , [3]fariza@tmsk.uitm.edu.my

ABSTRACT

The purpose of the present study was to investigate the severity scoring of symptoms that are often associated with carpal tunnel syndrome (CTS). The symptoms were identified based on participants' recalled experiences of computer game playing, specifically on desktop computer platforms. We conducted the assessment among Malaysian university students by using the Boston Carpal Tunnel Questionnaire. The data were collected from 120 students in the age range of 18-25 years. The results indicated that the mean score for symptom severity was 1.59, the standard deviation was 0.49 and most of the cases were mild (N = 88, 73.3%). Meanwhile, the mean score for functional severity was 1.33, the standard deviation was 0.52 and half of the participants described having hand functions affected (N = 62, 51.7%). The same participants were also required to answer questions pertaining to their perceptions of desktop computer gaming. The results showed the participants' agreement with the proposition that a user interface for special needs, such as the needs of hand-impaired users, should be designed (75.0%). There was a significant association between students who were less interested in computer game playing and a feeling of hand discomfort ($p < 0.001$). This study shows that even though the incidence of symptoms associated with CTS among students is predominant, the symptom severity is in the mild category.

Keywords: *Carpal Tunnel Syndrome (CTS), Boston Carpal Tunnel Questionnaire (BCTQ), Computer-Game Playing, Computer Game, University Students*

1. INTRODUCTION

Computer games have become a major component of entertainment activities and are particularly appealing to university students [1]. This pattern of usage occurs because computer games offer enjoyable activities while at the same time requiring users to follow a set of rules in order to accomplish some challenging objectives [2].

Rapid developments in computer technology have resulted in many genres of computer games being formed, such as: military games [3], [4], educational games [5], [6], health-related games [7], [8] as well as serious games [9]. Computer gaming can increase a student's engagement in the learning process when it is used appropriately [10].

As well as the positive aspects of computer gaming, concerns have been raised relating to health effects, such as poor cardiovascular fitness, musculoskeletal disorders and carpal tunnel syndrome (CTS) [11]–[13]. A limited number of studies have investigated the severity scoring of the symptoms often associated with CTS from computer game playing. The repetitive and forceful hand movements performed while computer game playing might be one of the risk factors associated with CTS. However, the fact remains that there are no real data available to assess this factor. Therefore, the main purpose of this study was to investigate the severity scoring of symptoms commonly associated with CTS based on recall of experiences playing computer games.

2. BACKGROUND STUDY

Many research findings have supported the use of computer games to accompany traditional lectures in order to enhance students' learning [14]–[16]. It has been well documented that computer gaming has the potential to encourage students to explore beyond the prescribed boundaries, to be proactive and to become self-reliant learners [17]. The computer games create engaging and immersive learning experiences while delivering specified

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learning goals and outcomes [18]. Bourgonjon et al. [5] discussed how students' perceptions regarding the usefulness, ease of use, learning opportunities and personal experiences directly affected students' preferences for using computer games. An extensive body of literature indicates that the use of computer games may also improve thinking and the effectiveness of education [19], [20].

Recent studies also suggest that computer games can be associated with adverse health consequences [21], [22], such as aggressive thoughts and behaviour patterns [23], an inactive lifestyle, being overweight [24] and musculoskeletal disorders [13]. A study by Chang et al. [25] reported that daily computer usage of longer than three hours' duration had a significant association with the incidence of musculoskeletal disorders. One of the most generally reported work-related musculoskeletal disorders is CTS [26], [27]. CTS occurs due to compression of the median nerve where the nerve passes through the carpal tunnel in the wrist [28]. Early detection of the symptoms is considered important for the prevention of CTS and offers a better chance to minimise the risk [29].

Previous studies have widely accepted that exposure to a combination of repetitive and forceful hand movements due to keyboarding and mouse tasks may also be a cause of CTS [28]. With the increasing use of computers, it has been a matter of concern that computer game playing could also be a risk factor in the development of CTS. Similar to general computer usage, computer game playing may involve highly repetitive and forceful hand movements and prolonged static body postures [30], [31]. It is well known that prolonged static posture and high muscle tension associated with computer use can contribute to the incidence of CTS [32]–[34].

Earlier studies have provided evidence of the association between repetition and CTS, which has been quantitatively measured [35]–[37] or observed [38]–[40]. Furthermore, research studies have been carried out with regard to the classification of repetitive hand and wrist movements in terms of: 1) the frequency of tasks pertaining to the hand/wrist; 2) the ratio of work-time to recovery time; 3) the percentage of the workday spent on repetitive activities; and 4) the amount of work done in a given time frame [41].

3. METHODOLOGY

3.1 Criteria for Participation

The participants in the present study were students in the Faculty of Computer and Mathematical Sciences, Universiti Technologi MARA, Malaysia. Before being accepted into the study sample, the respondents needed to have actively played computer games at least once a month and needed to have experienced hand discomfort while game playing. The respondents also must not have suffered from lumps in the hand or wrist, diabetes mellitus, hypertension or trauma at the hand or wrist. A total of 120 respondents met the study inclusion criteria, which are presented in Table 1.

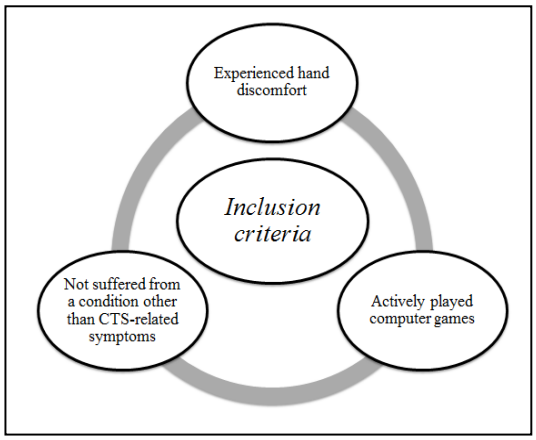

Figure 1: Inclusion Criteria

3.2 Instrument

The instrument for this study was adapted from the Boston Carpal Tunnel Questionnaire (BCTQ) [42]. The BCTQ is a self-administered questionnaire containing 11 questions concerning the severity of symptoms and hand function difficulty. The BCTQ is part of a well-recognised and validated outcome instrument, specifically designed for use in the field of CTS. It has been compared with different outcome measures [43] and has been validated in other languages [42]. It comprises two sections, namely, the symptom severity scale and the functional severity scale.

3.2.1 Symptom severity

The BCTQ symptom severity scale evaluates symptoms based on the severity, frequency, time and type of symptom. The symptom severity scale is comprised of 11 questions. Each question has five symptom severity levels, namely, no symptoms, mildly severe, moderately severe, severe and very severe. The symptom severity

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scores are totalled and categorised into five groups: no symptoms (total scores:11), mild (total scores: 12-22), moderate (total scores: 23-33), severe (total scores: 34-44) and very severe (total scores: 45-55) [42].

3.2.2 Functional severity

The BCTQ functional severity scale assesses how the syndrome affects daily life. The functional status is explored through eight questions, with each question corresponding to a functional activity such as writing, buttoning clothes or holding a book while reading. Each task has five degrees of difficulty, namely: no difficulty, mild degree of difficulty, moderate degree of difficulty, severe degree of difficulty, and very severe degree of difficulty. The functional severity scores are totalled and grouped into categories: no difficulty (total scores: 8), mild difficulty (total scores: 9-16), moderate difficulty (total scores: 17-24), severe difficulty (total scores: 25-32) and very severe difficulty (total scores: 33-40) [42].

3.2.3 Perceptions of desktop computer gaming

The participants were required to indicate their agreement with items related to perceptions of desktop computer gaming. The items were adapted from previous research studies. Significant items of interest were as follows: 1) Symptoms cause users to become less interested in computer game playing [44]; 2) Symptoms will appear after prolonged computer game playing [45]; 3) A user interface for special needs should be designed [46]; 4) Users should be involved in designing the interface for computer games [47]; and 5) Enjoyment is one of the important factors to be taken into consideration when designing a computer game [48].

3.3 Procedures

On the day of the assessment, consent forms and detailed guidelines were given to the participants prior to distribution of the questionnaires. The researcher was present if the participants had any enquiries. The participants were informed that the assessment would involve responding to questions related to symptoms that are often associated with CTS using the BCTQ instrument.

In the next phase, the same participants were required to respond to the items related to their experiences of desktop computer gaming. The demographic questionnaire included data on the participants' level of experience in computer game playing, preferred genre of computer games, frequency of computer game playing and the motivation to play computer games. The participants were required to respond to four items, with each item having four options for the response on a scale from 1 (strongly disagree) to 4 (strongly agree).

It was expected that the survey would take approximately 5-10 minutes to complete. Confidentiality and anonymity were protected at all times. The participants were informed that the data would only be disclosed with the participants' permission, and in no way would be used outside the current research. The participants were also informed that the data obtained from their completed questionnaire would be assigned a subject number that would not be paired with any personal details. Figure 2 shows the procedureinvolved in this study.

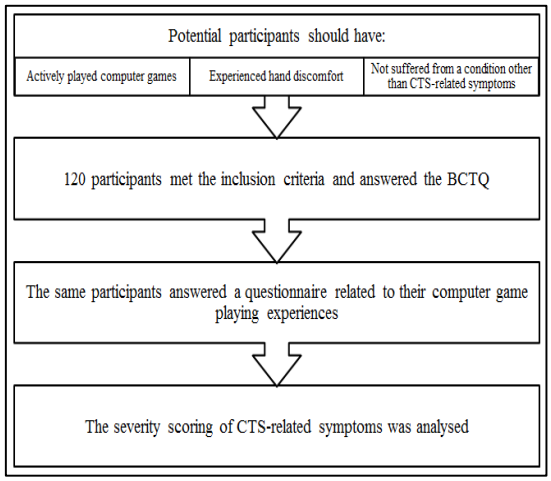

Figure 2: Procedure Involved In This Study

4. RESULTS

The data results were analysed using the SPSS 19 software tool. In order to estimate the frequency (%), standard descriptive statistical methods were used for the variables. The symptom severity and functional difficulty scores were also summed up in set totals, as proposed by Storey et al. [49].

4.1 Severity Scoring of Symptoms

In total, 120 students participated in this study and all of them were computer game users. As shown in Table 1, the participants were distributed in the age groups of 18-19, 20-22, 23-25 and >25 years, with only a small percentage being 18-19 and >25 years. This profile was fairly typical of undergraduates in the Malaysian population [50]. The demographic data also showed that about 50 (41.7%) of the participants had moderate experience, 44 (36.7%) had some experience and 25

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(20.8%) were very experienced in computer game playing. The levels of experience in computer game playing were identified by the participants themselves. Regarding the dominant hand classification, the numbers of right hand and left hand users were 110 and 10, respectively. The detailed demographic data are shown in Table 1.

The mean scores for each item of symptom severity and the frequency (%) of responses are presented in Table 2. The results show that the most common CTS-related symptom suffered by the participants was numbness. The mean scores for each item of functional severity and the frequency (%) of responses are presented in Table 3. The function that had the highest score for CTS-related symptom severity was carrying grocery bags, followed by writing activities.

The participants responded to the questions about symptoms that are commonly associated with CTS by recalling their experiences of computer game playing. As shown in Table 4, 88 participants (73.3%) were categorised as mildly severe cases, followed by 18 participants (15%) who were categorised as moderately severe cases. There were 2 cases (1.7%) of severe symptoms, while no very severe cases were found. The data on the frequency of functional severity showed that 58 participants (48.3%) had no functional difficulties, whereas 50 participants (41.7%) had mild difficulties, 10 participants (8.3%) had moderate difficulties and 2 participants (1.7%) had severe functional difficulties. None of the participants had very severe functional difficulties.

4.2 Perceptions Of Desktop Computer Gaming

A summary of the descriptive analysis of the participants' desktop computer gaming activities is shown in Table 5. As shown in the table, 38 participants (31.7%) played computer games a few times per week. More than half of the participants agreed with the statement that they played computer games because they found the experience enjoyable. The most preferred genres of games were action and adventure.

As shown in Table 6, the participants agreed that hand discomfort occurred during prolonged sessions of computer game playing (N = 82, 68.3%). Only nine participants (7.5%) strongly disagreed with this. More than half of the participants (N = 90, 75.0%) agreed that a user interface for special needs users should be designed. The participants also agreed that users should be involved in designing the interface of computer games (N = 88, 73.3%).

Approximately half of the participants (N = 50, 41.7%) strongly agreed that enjoyment is a major factor to be taken into account when designing computer games. In addition, a significant association was found between the participants who were less interested in computer game playing and the experience of hand discomfort ($p < 0.001$).

5. DISCUSSION

The purpose of the present study was to investigate the severity scoring of symptoms that are often associated with CTS. The severity and frequency of the symptoms were identified based on the participants' recall of experiences while playing computer games on desktop computer platforms. In addition, we examined the same participants' perceptions of desktop computer gaming.

The assessment was carried out using the BCTQ based on suggestions made in the literature [28], [38], [51]. Previous research has examined the scoring of the severity of CTS symptoms among patients and workers [28], [52]. This study, however, focused on university students. The study sample was taken from the university student population because the results in previous studies have indicated that computer game playing is one of the most popular activities among university students [53]–[56].

As expected, it was determined that, similar to general computer use, exposure to a combination of repetitive and forceful hand movements while computer game playing can cause symptoms that are often associated with CTS such as numbness. This finding is consistent with a number of previous studies [25], [57], [58]. Nevertheless, most of the cases with CTS-related symptoms in this study were in the mildly severe category (N = 88, 73.3%).

The results of the study showed that the symptom with the highest severity score reported by the participants was numbness, followed by tingling and weakness (Table 2). Rozali et al. [59] reported that the most common symptom was numbness or tingling during the daytime, which is consistent with the finding of this study. Almost half of the participants reported some degree of functional difficulty. The results indicated that the most affected activities were carrying grocery bags and writing (Table 3). The writing task was listed as one of the most affected tasks, possibly because the

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participants spent a great deal of time writing notes during lectures [60], [61].

The results also showed that the participants agreed that CTS symptoms appeared after prolonged periods of computer game playing (Table 6). This result is supported by other research [25], [62] which found that long durations of playing would increase cumulative muscle loading and contribute to musculoskeletal syndromes such as CTS. The participants agreed that a user interface for special needs, such as the needs of users who have CTS, should be designed. The participants also agreed that users should be involved in designing the interface of computer games. This finding was consistent with the literature on computer game design [47], [63], [64].

The analysis of enjoyment factors indicated a significant level of agreement among the participants that enjoyment is one of the most important factors to be taken into account when designing computer games. Fu et al. [48] discussed a similar finding in their study of a scale to measure learners' enjoyment of e-learning games. Predictably, there was an association between participants who were less interested in computer game playing and feelings of weakness in the hands or wrists ($p < 0.001$). This result is supported by the research findings in [13].

6. CONCLUSION

We used a survey method in order to effectively assess the severity scoring of symptoms commonly associated with CTS among Malaysian university students. The participants were required to answer the survey based on their recall of past experiences playing computer games. The BCTQ is a valid and reliable assessment tool for measuring symptom severity and functional severity of CTS. The results of the present study showed that the most common CTS-related symptom while playing computer games was numbness and the activity that posed the most difficulty was carrying grocery bags.

The current study also examined the severity of CTS symptoms among university students in Malaysia, with most of the cases found to be in the mildly severe category. The results emphasise the need to develop a rigorous game design for special needs users, especially users experiencing hand discomfort. At the same time, the game design could reduce the incidence of CTS symptoms arising from computer game playing.

There were several limitations in our work. First, the survey was only distributed at one university in Malaysia. This limitation will be addressed in our future work which will involve more universities in the survey distribution. Second, the participants assessed their symptoms based on their recall of experiences playing computer games. Our future work will assess the participants' symptoms immediately after they play computer games. A more thorough assessment can be done when this approach is implemented. Third, this study focused on computer games that were played on desktop computer platforms. Future research will aim to assess symptom severity while playing computer games on a mobile device platform.

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Table 1: Demographic data of respondents (N = 120)

	Range	*Frequency (N)*	*Percentage (%)*
Number of game users: *N* (%)		120	100%
Gender	Male	41	34.2
	Female	79	65.8
Age distribution: *N* (%)	18-19	1	0.8
	20-22	85	70.8
	23-25	29	24.2
	>25	5	4.2
Level of experience in computer game playing: *N* (%)	Novice	1	0.8
	Moderate	50	41.7
	Experienced	44	36.7
	Very Experienced	25	20.8
Dominant hand	Right	110	91.7
	Left	10	8.3

Table 2: Mean score of symptom severity and frequency (%) of responses

Symptom Severity	*Mean Scores*	*Std. Deviation*	*No Symptoms*	*Mild*	*Moderate*	*Severe*	*Very Severe*
Numbness	1.99	0.92	34.2	40.0	19.2	5.8	0.8
Tingling	1.93	0.90	35.0	43.3	16.7	3.3	1.7
Weakness	1.82	0.88	44.2	34.2	18.3	2.5	0.8
Night time numbness or tingling	1.73	0.93	52.5	28.3	15.8	0.8	2.5
Night time pain severity	1.56	0.84	63.3	20.0	15.0	0.8	0.8
Holding a small object	1.48	0.84	68.3	20.8	7.5	1.7	1.7
Daytime pain length[&]	1.47	0.61	59.2	35.0	5.8	0	0
Daytime pain frequency	1.46	0.65	62.5	29.2	8.3	0	0
Daytime pain severity	1.43	0.68	66.7	24.2	8.3	0.8	0
Awakening tingling and numbness*	1.41	0.65	68.3	22.5	9.2	0	0
Awakening pain^	1.23	0.54	83.3	10.8	5.8	0	0
Mean symptom severity	1.59	0.49					

Scale from 1 to 5: no symptoms, mild, moderate, severe, or very severe symptoms.
[&]Pain length scale from 1 to 5: never, < 10 minutes, 10-60 minutes, > 60 minutes, constant.
*Frequency of awakening scale from 1 to 5: none, once, 2-3 times, 4-5 times, more than 5 times.

Table 3: Mean score of functional severity score and frequency (%) of responses

Functional Severity	*Mean Scores*	*Std. Deviation*	*No Symptoms*	*Mild*	*Moderate*	*Severe*	*Very Severe*
Carrying grocery bags	1.60	0.96	63.3	21.7	8.3	5.0	1.7
Writing	1.41	0.70	69.2	22.5	7.5	0.8	0
Opening a jar	1.40	0.75	73.3	19.2	6.7	0.8	0
Housekeeping	1.35	0.64	72.5	17.5	8.3	0.8	0.8
Holding a book while reading	1.33	0.62	75.0	18.3	5.8	0.8	0
Holding telephone handles	1.24	0.55	81.7	12.5	5.8	0	0
Bathing and dressing	1.21	0.53	85.0	9.2	5.8	0	0
Buttoning clothes	1.11	0.41	92.5	4.2	3.3	0	0
Mean functional severity	1.33	0.52					

Scale from 1 to 5: no symptoms, mild difficulty, moderate difficulty, severe difficulty, cannot perform functions.

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Table 4: Frequency of symptoms and functional severity according to group totals

Type	Group				
	No Symptoms	*Mild*	*Moderate*	*Severe*	*Very Severe*
Symptom Severity Scale	12	88	18	2	-
Functional Severity Scale	58	50	10	2	-

Table 5: Frequency (%) of participants' perceptions of computer game playing

Item	*Classification*	*(N)*	*%*
Frequency of computer game playing	Once a month	26	21.7
	A few times a month	21	17.5
	A few times a week	38	31.7
	Every day: < 1 hour	13	10.8
	Every day: 1-3 hours	15	12.5
	Every day: > 3 hours	7	5.8
Reasons for playing computer games	Learning	15	12.5
	Training	1	0.8
	Enjoyment	66	55.0
	Challenge mind	15	12.5
	To kill time	23	19.2
Preferred game genre	Action	36	30.0
	Simulation	15	12.5
	Adventure	36	30.0
	Puzzles	19	15.8
	Role playing	1	.8
	Strategic	10	8.3
	Others	3	2.5

Table 6: Frequency (%) of participants' perceptions of computer game playing

No.	*Item*	*Strongly Disagree*	*Disagree*	*Agree*	*Strongly Agree*
1.	Symptoms cause users to be less interested in computer game playing.	15.0	47.5	35.8	1.7
2.	Symptoms will appear after prolonged computer game playing .	7.5	15.0	68.3	9.2
3.	A user interface for special needs should be designed.	4.2	6.7	75.0	14.2
4.	Users should be involved in designing the interface of computer games.	3.3	11.7	73.3	11.7
5.	Enjoyment is one of the most important factors to be considered when designing a computer game.	5.0	3.3	50	41.7