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Validity and Reliability of Boston Carpal Tunnel Questionnaire in Telehealth among Patients with Carpal Tunnel Syndrome

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KEYWORDS

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DECLARATIONS

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ABSTRACT

Background: Carpal tunnel syndrome is a prevalent condition resulting from compression of the median nerve as it passes through the wrist, causing hand discomfort, numbness, and tingling. Affecting around 5% of the general population, this is the most common peripheral nerve entrapment, with work-related prevalence varying from 1 to 61% depending on the occupation. **Objective:** To evaluate the validity and reliability of the Boston Carpal Tunnel Questionnaire among patients with carpal tunnel syndrome using a telehealth approach. **Methodology:** This cross-sectional study was conducted over four months and included 84 diagnosed patients of carpal tunnel syndrome recruited from Madina Teaching Hospital, Allied Hospital, and DHQ Hospital in Faisalabad. After obtaining informed consent, data collection was carried out in two separate online sessions. The first session was conducted by Researcher 1, and the second by Researcher 2, during which participants completed the Boston Carpal Tunnel Questionnaire. Both researchers were blinded to each other's results. Researcher 2 later assessed the data to evaluate the validity and reliability of the questionnaire. Descriptive analysis included frequency and mean, and standard deviation. Pearson correlation measured inter-rater and intra-rater reliability and criterion validity, while internal consistency was assessed using the Cronbach alpha test. **Results:** The Symptom Severity Scale of the Boston Carpal Tunnel Questionnaire demonstrated excellent internal consistency, with a Cronbach's alpha of 0.99, indicating strong validity. The inter-rater reliability of Researcher 2, when administering the SSS at two different locations using the same tool, was 0.99, reflecting excellent reliability. A high degree of agreement was also observed between the assessments conducted by Researcher 1 and Researcher 2 using the SSS. Similarly, the Functional Status Scale showed high internal consistency, with a Cronbach's alpha of 0.98. Its inter-rater reliability, assessed by Researcher 2 at two locations, was 0.97, also indicating excellent reliability. **Conclusion:** The findings demonstrate that the Boston Carpal Tunnel Questionnaire has excellent validity and reliability when used in a telehealth setting. Both intra-rater and inter-rater reliability of the Boston Carpal Tunnel Questionnaire were found to be exceptionally high.

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INTRODUCTION

Carpal Tunnel Syndrome (CTS) is one of the most commonly documented cases of compression of the median nerve, a prevalent medical ailment. CTS occurs when the median nerve gets compressed or tight as it goes through the wrist. Hand discomfort, numbness, and tingling along the median nerve's distribution are the most common signs of the illness.[1] The most common peripheral nerve entrapment condition, carpal tunnel syndrome, affects thousands of people globally. There have been reports that CTS affects 5% of the general population. The prevalence of work-related CTS varies, ranging from 1% to 61% in various occupational studies. Industrial workers who primarily used grinding tools had the highest CTS prevalence (61%), although 1% of workers who used vigorous but little repetitive hand motion also experienced CTS.[1]

The cause may be attributed to an accident, a hereditary susceptibility, or recurrent exposure to vibrations or strong angular motions. When patients exhibit classic symptoms, including numbness, tingling, nocturnal paresthesia, or neuritic pain, the diagnosis is primarily clinical. Both genders are observing this problem. [2] Risk factors for CTS include pregnancy, inherited obesity, frequent wrist activity, and rheumatoid inflammation.[1] Individuals are subjected to a wide range of risk factors in the workplace. Their health may suffer as a result of these causes. The independent influence of the worker's non-occupational, working, and personal predispositions results in their health state. One of the most frequent causes of work-related impairments is CTS. The impact of employment and the working environment, which play a major role in the disease's development, is a significant aspect in CTS as an occupational disease.

However, it is important to consider the influence of non-occupational factors. Personal risk factors that contribute to CTS are still poorly understood, though. According to several studies, CTS is linked to several illnesses and/or conditions, including diabetes mellitus (DM), a higher body mass index (BMI), thyroid and cardiovascular conditions, hormonal agent use, pregnancy, rheumatoid arthritis, traumas, and factors related to one's place of employment. When two or more of these risk factors are present, the likelihood of having CTS is increased for each of the specific variables. Because of this, this study aimed to investigate the relationship between the prevalence of CTS related to work and personal variables and non-occupational risk factors.[3] It primarily involves compression of the median nerve as it passes through the carpal tunnel, though in most instances, the cause is unknown. This nerve entrapment can occur due to several factors along its course. Two common sites where compression often occurs include the tunnel outlet beneath the flexor retinaculum and near the hook of the hamate bone. The most frequent contributing factor is the thickening of synovial tissue surrounding the flexor tendons of the forearm, often as a result of inflammation. This inflammation may arise from repetitive wrist movements, previous injuries, or underlying inflammatory disorders such as arthritis.[4] Increased pressure within the carpal tunnel can further worsen nerve compression.

Although physical examination results are typically used to confirm the diagnosis of CTS, nerve conduction studies are also necessary to corroborate the diagnosis. Comparing clinical tests to nerve conduction and electromyographic examinations, which quantify the damage to the median nerve, they are thought to be less sensitive.[5] According to clinical guidelines, people with mild to moderate CTS should get conservative treatment to manage their symptoms and loss of function.[5,6] Telehealth has become a quickly growing service that facilitates efficient, economical, and physically remote patient-provider connections. "The use of telecommunications and information technology to provide access to health assessment, diagnosis, intervention, consultation, supervision, and information across distance" is how the Centers for Medicare and Medicaid Services (CMS) defines telehealth.

Telehealth can be delivered synchronously, with patients and clinicians communicating in real time, or asynchronously, with clinicians receiving data trends or messages regularly or using the technology for remote patient monitoring.[7] The use of telemedicine in the treatment of upper extremities has grown. Although telemedicine programs have garnered more attention recently, the COVID-19 epidemic has caused a sharp rise in the use of video-based medical services. Telemedicine initiatives in hand and upper extremity surgery have concentrated on routine postoperative visits, follow-up fracture care, and emergency department evaluations. Telemedicine

contacts are expected to reduce travel burdens, improve patient convenience, and save costs for patients and health care systems. Because telemedicine visits seem to result in lower overall visit charges than in-person appointments, recent research has raised concerns about decreasing profits.[8] Although there is a tendency towards more telemedicine use in upper-extremity surgery, there are still legitimate and potential issues with using it in place of traditional, in-person consultations. The limits of this technology concerning physical examinations have been the subject of several criticisms. The inability to directly inspect the patient may restrict the evaluation of more complex disorders, even though video examinations seem to be sufficient for lower-complexity postoperative treatment.

Previous authors have proposed that some provocative manoeuvres and tests that are used to evaluate CTS are not well suited for telemedicine evaluations and cannot be administered reliably. There are very few studies explicitly comparing the accuracy of the virtual hand examination to the traditional, in-person examination, despite the recent surge in telemedicine-related publications.[9] Moreover, it is yet unclear if management strategies developed in the course of a telemedicine consultation are impacted by an onsite evaluation later on.[8] Telehealth and tele-rehabilitation, when paired with therapy, have demonstrated viable and successful outcomes in the treatment of CTS patients.[10] Despite the industrial revolution, obstacles to the adoption of telerehabilitation may include a lack of technological resources, a lack of digital literacy, and specific patient conditions, but it minimises the risk of communicable disease transmission, involves minimal physical contact and increases accessibility through the use of telehealth and tele-rehabilitation.[11,12]

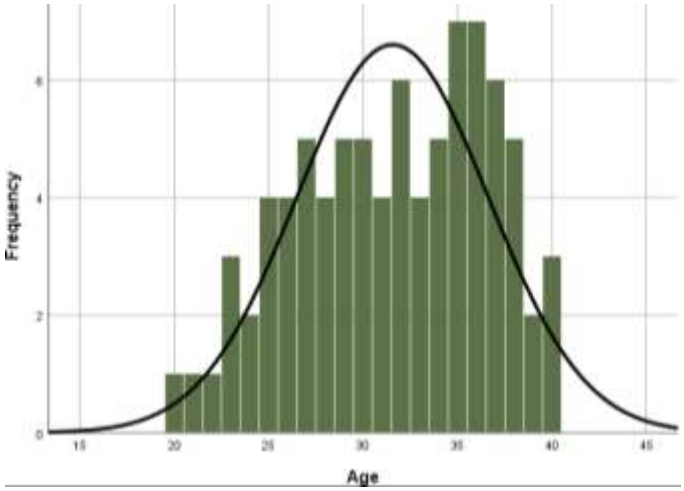
The Boston Carpal Tunnel Syndrome Questionnaire (BCTQ) in recent years has been recognised by the scientific community, and in CTS patients, it is commonly used as a standard. Compared to other comparable instruments, the majority of them believe it to be more reliable for diagnosing and assessing the severity of CTS. Numerous studies on the diagnosis and management of CTS with BCTQ are also available in the literature. Numerous authors contend that its application is practically required in the CTS domain. This questionnaire has the advantage of including analysis of pain and sensation-related symptoms as well as the degree of hand function preservation in patients with CTS, yielding two types of data: a severity status scale and a functional status scale.[13] By establishing the questionnaire's validity and reliability in a remote setting, healthcare providers can confidently utilise telehealth platforms for accurate diagnosis and monitoring of carpal tunnel syndrome, enhancing accessibility and efficiency in patient care. This investigation is particularly timely given the increasing adoption of telehealth services, emphasising the need to validate assessment tools to maintain the quality of healthcare in evolving medical practices. Therefore, the objective of this study was to determine to check the validity and reliability of the BCTQ in tele-health.

There is limited availability of studies assessing the effectiveness of BCTQ specifically for tele-health contexts. While prior studies have validated BCTQ in various languages and populations and tested its psychometric properties, few have evaluated its application in remote, tele-health settings. Moreover, existing research has focused largely on in-person administration of the BCTQ, lacking data on its reliability and validity when used remotely, which is increasingly relevant with the rise of telemedicine. This study aimed to fill this gap by evaluating the BCTQ's effectiveness in a tele-health environment, establishing it as a potentially valid and reliable tool for remote assessments of CTS.

METHODOLOGY

This was a cross-sectional study, which was conducted at Madina Teaching Hospital, Allied Hospital, and DHQ Hospital. Data was collected over four months following the approval of the synopsis. The sample size was calculated using Epitool, and participants were recruited through convenient sampling. Participants were screened using a predefined criteria questionnaire, and only those meeting the inclusion criteria were included. Data was sourced from Madina Teaching Hospital, Faisalabad, Allied Hospital, Faisalabad, and DHQ Hospital, Faisalabad. Inclusion criteria consisted of both genders aged 20-40 years, diagnosed CTS patients, those with clinical symptoms for more than three months, and individuals who had not undergone surgical treatment. Exclusion criteria included previous wrist surgery, recent upper extremity fracture, cervical issues (C6 & C7), and neurological

Figure 1: Age distribution



disorders, upper limb musculoskeletal disorders, rheumatoid arthritis, scaphoid instability, pregnant females, and acute trauma within the past 3 months. All participants provided informed consent, ensuring they were aware of the study methods and that their participation was voluntary. The BCTQ is a two-component approach that is compatible with two subscales for function and symptoms, as confirmed by exploratory and confirmatory factor analysis. The first subscale, known as symptom severity scale (SSS), has 11 items, with 5 score for each item. So, the total score of part 1 is 55. While the second subscale, functional status scale (FSS), has 08 items, 5 scores for each item. So, the total score for part 2 is 40. It is free, simple to use, and available in multiple languages.

Using traditional test theory, it has undergone comprehensive testing for test-retest reliability and concurrent validity. Item response theory was used to create a condensed version of the symptom severity scale, known as the CTS-6, which consists of just 6 items instead of the original 11 items.[14] This was a cross-sectional study. Data was collected from CTS patients after taking consent from all the individuals with the help of the BCTQ. All participants went through two assessment sessions. The first session was conducted via Zoom tele-health conferencing, after taking consent face-to-face from 3 hospitals (Department of Physical Therapy and Orthopaedics, Allied Hospital, Madina Teaching Hospital and DHQ Hospital of Faisalabad). The second session was conducted face-to-face, scheduled on the spot after the initial assessment. Both assessments were conducted by two different researchers, and to reduce bias, they were both blinded to the results made by each of them. After a week, the same researcher who assessed face-to-face assessment and re-rated the recorded Zoom meetings for intra-rater reliability.[15]

The primary outcome measure was CTS. The BCTQ has two components, the first subscale known as SSS. The second subscale, FSS, validated by exploratory and confirmatory factor analysis and available in multiple languages, was used for data collection. A condensed version, CTS-6, was created using item response theory. Data was collected from CTS patients at the three hospitals using BCTQ. Participants underwent two assessment sessions: one via Zoom telehealth and the other face-to-face. Different researchers conducted each session, blinded to each other's results. Intra-rater reliability was assessed by re-rating recorded Zoom meetings after a week. Data from three hospitals were organised, and data analysis was conducted using SPSS version 23. Descriptive analysis included frequency and mean, and standard deviation. Pearson correlation measured inter-rater and intra-rater reliability and criterion validity, while internal consistency was assessed using the Cronbach alpha test.

Ethical considerations included the issuance of a data collection letter by the University, obtaining consent from the hospitals, assuring patients that data was for research purposes only, providing information to patients before consent, informing patients of their right to withdraw at any time, adhering to ethical guidelines in the informed consent process, explaining potential risks before consent, providing contact information for questions or concerns, and ensuring compliance with ethical standards and relevant regulations.

RESULTS

The mean and standard deviation of age were 31.56±5.07 (Figure 1). Highest percentages were held by women (76.19%) and men (23.81%) (Figure 2). Maximum percentages were of the right hand that were 50%, the left hand was 36%, and bilaterally CTS was 14% (Figure 3). The mean and SD values of SSS rated by the 1st investigator (online assessment) were 32.65±4.86, and FSS rated by the 1st investigator were 23.17±2.73 (Figure 4). The mean and standard deviation values of SSS rated by the 2nd investigator (face-to-face) were 32.69±4.68, and FSS rated by the 2nd investigator was 22.86±2.61 (Figure 5). The mean and standard deviation values of SSS rated by the

Figure 2: Gender distribution

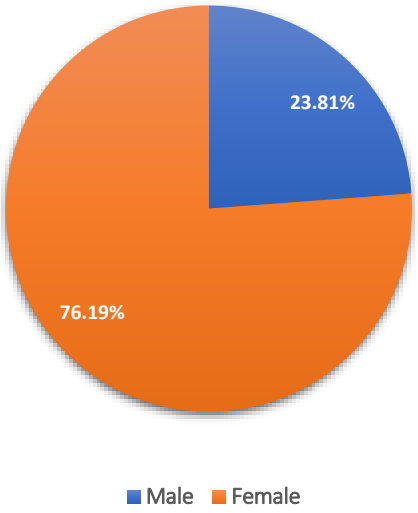


Figure 3: Hands affected due to CTS

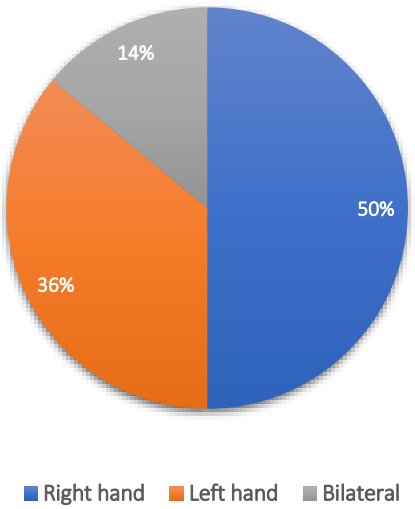


Figure 4: Descriptive statistics of online assessment of BCTQ by the 1st investigator

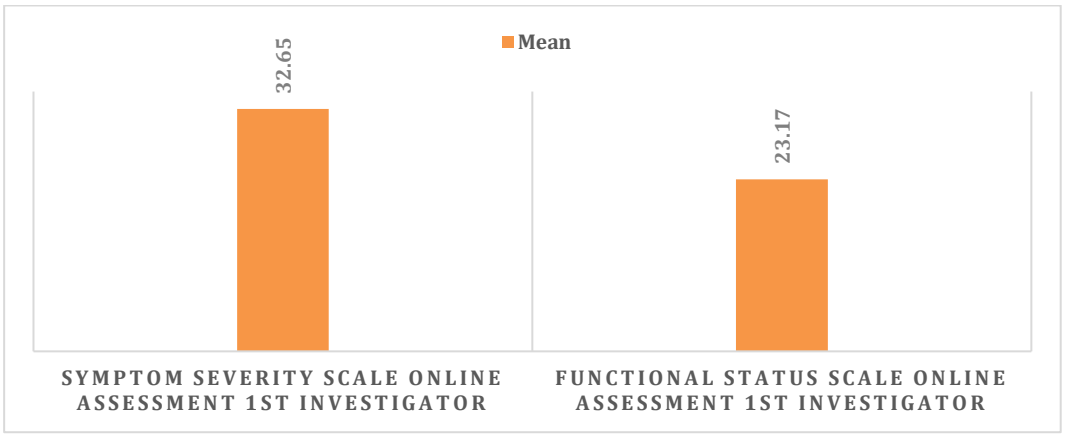
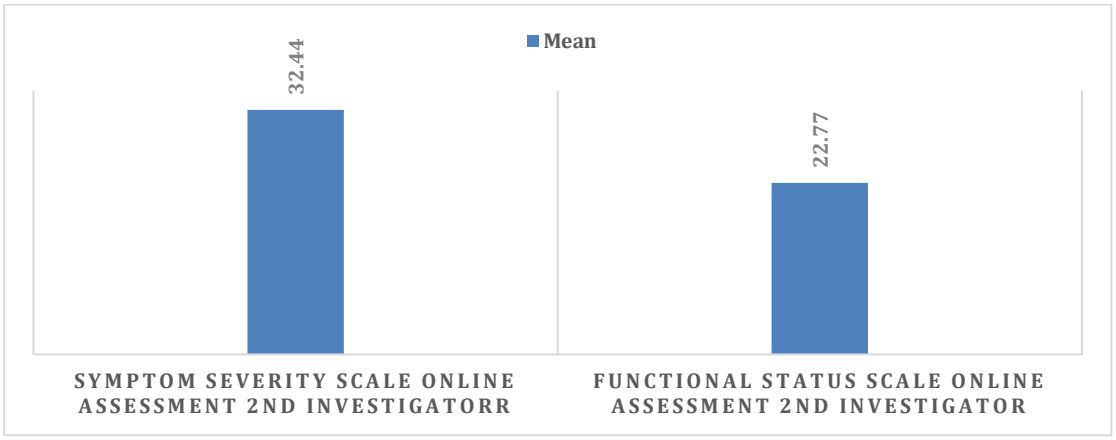


Figure 5: Descriptive statistics of online assessment of BCTQ by the 2nd investigator



2nd investigator (online assessment) were 32.44±4.71 and FSS rated by the 2nd investigator was 22.77±2.55 (Figure 6). The SSS of BCTQ has High internal consistency because Cronbach's alpha value was 0.993, which lies in the normal range, which was >0.9 (excellent). FSS of BCTQ has high internal consistency because the value of Cronbach's alpha was 0.983, which lies in the normal range, which was >0.9 (excellent). The inter-rater reliability of the 2nd investigator at two different locations with the same instrument of SSS was 0.99, which lies within the 0.81-1.00 range, which means it has excellent (very reliable) inter-rater reliability. Whereas the intra-rater reliability between two investigators at the same point of SSS was 0.97, which also lies within the

Figure 6: Descriptive statistics of face-to-face assessment of BCTQ by the 2nd investigator

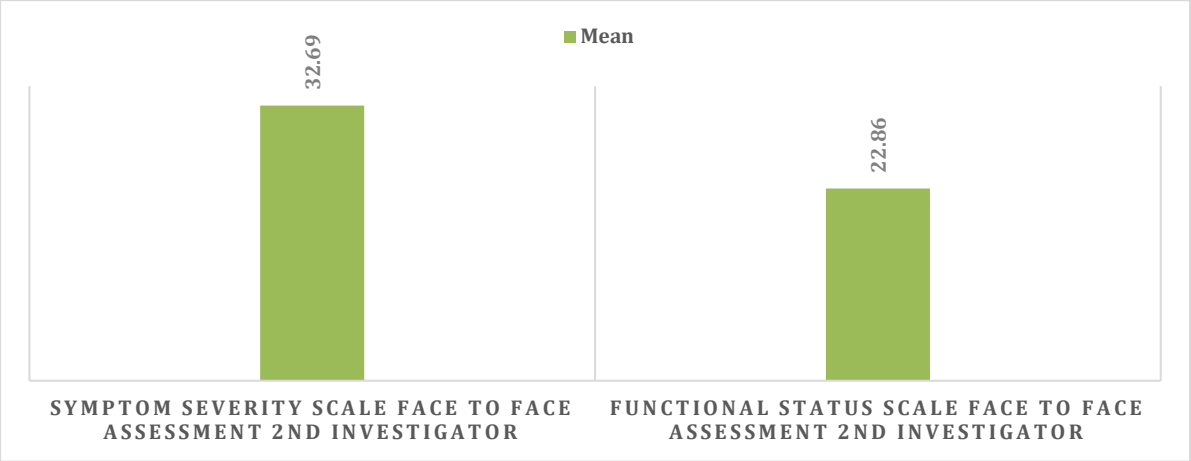


Table 1: Inter-intra rater reliability (SSS)

	Symptom Severity Scale Online Assessment 1st Investigator	Symptom Severity Scale Face-to-Face Assessment 2nd Investigator	Symptom Severity Scale Online Assessment 2nd Investigator
Symptom Severity Scale Online Assessment 1st Investigator	1.000	0.979	0.973
Symptom Severity Scale Face to Face Assessment 2nd Investigator	0.979	1.000	0.991
Symptom Severity Scale Online Assessment 2nd Investigator	0.973	0.991	1.000

Table 2: Inter-intra rater reliability (FSS)

	Functional Status Scale Online Assessment 1st Investigator	Functional Status Scale Face-to-Face Assessment 2nd Investigator	Functional Status Scale Online Assessment 2nd Investigator
Functional Status Scale Online Assessment 1st Investigator	1.000	.946	.939
Functional Status Scale Face-to-Face Assessment 2nd Investigator	.946	1.000	.971
Functional Status Scale Online Assessment 2nd Investigator	.939	.971	1.000

0.81-1.00 range, which also means it has excellent intra-rater reliability (Table 1). The inter-rater reliability of the 2nd investigator at two different locations with the same instrument of FSS was 0.971, which lies within the 0.81-1.00 range, which means it also had excellent inter-rater reliability. The intra-rater reliability between two investigators at the same point of FSS was 0.94, which also lies within the 0.81-1.00 range, which also means it has excellent intra-rater reliability (Table 2).

DISCUSSION

This study found excellent agreement between Tele-assessment and in-person assessment in both the SSS (K=0.98; 95% CI: 0.97, 0.98) and FSS (K=0.95; 95% CI: 0.92, 0.96). Tele-assessment was

performed, as well as an in-person evaluation for BCTQ in CTS patients. No prior research on tele-assessment efficacy in CTS was found, though translated BCTQ versions exist. Consistent assessments via telemedicine are crucial, particularly during the COVID-19 pandemic. These results support further tele-health assessment research and the use of tele-assessment for BCTQ in CTS patients. Lee et al. (2019) found CTS more common in women using Korea's National Health Insurance and National Employment Insurance data, with the current study showing similar results: 76.19% females and 23.81% males [16]. Mastej et al. (2023) reported BCTQ-PL's high internal consistency and reliability in assessing CTS patients undergoing extracorporeal shock wave therapy, which our study supports for tele-assessment.[17]

Jansen et al., (2019) validated BCTQ-A's reliability and responsiveness in patients aged 18-70, consistent with our findings of high agreement between tele-assessment and in-person assessment, confirming BCTQ's validity and reliability for CTS patients as it was (K=0.98; 95% CI: 0.97, 0.98) & (K=0.95; 95% CI: 0.92, 0.96) in Symptom Severity Scale and Function Status Scale respectively which concludes that BCTQ is valid, reliable and dependable tool to use for CTS patients. Previous study did not report the validity and reliability of BCTQ in CTS patients through telehealth as compared to current study that was the distinct feature but both studies found the validity and reliability of BCTQ through face-to-face assessment in CTS patients.[18] Anwar et al., (2019) validated M-BCTQ's reliability in Malay individuals with idiopathic CTS, reporting high ICCs and Cronbach alpha coefficients, similar to our study's findings.[19] Fajr et al. (2023) confirmed BCTQ's reliability and applicability as a screening tool among female CTS patients in Palestine, which our study also supports for Tele-assessment.[20] Sarilar et al. (2021) found BCTQ insufficient alone for diagnosing and treating CTS, highlighting the need for electrophysiological tests. Our study agrees, noting that BCTQ is reliable for comparing Tele-assessment with in-person assessment in diagnosed CTS patients.[21] The strength of this study includes the use of a reliable, validated tool that can be easily administered without prior training.

CONCLUSION

The study aimed to assess the BCTQ for patients using telemedicine, focusing on its validity and reliability, conducted over four months with 84 participants from various hospitals. The analytical cross-sectional study involved two BCTQ sessions administered by separate researchers to ensure unbiased assessment. The BCTQ demonstrated high internal consistency and reliability for both the SSS and FSS, indicating its effectiveness for telehealth diagnosis and evaluation of CTS. Limitations included restricted physical examination capabilities compared to in-person assessments, potential technical issues such as poor video quality or internet connectivity problems, lack of standardisation in telehealth practices, and possible distractions in the patient's environment affecting assessment accuracy. Overall, the study confirmed the BCTQ's excellent intra-rater and inter-rater reliability when used via telehealth, validating it as a reliable tool for diagnosing and evaluating CTS severity remotely. Future research should include larger sample sizes, explore other diagnostic tools beyond BCTQ, and consider specific populations like computer users. Additionally, comparisons between BCTQ and other CTS diagnostic questionnaires in telehealth settings are recommended.

DECLARATIONS

Consent to participate: Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.

Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.

Competing interests: None

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Authors' contributions: All authors read and approved the final manuscript.

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