

Effectiveness of Specialized Cervical Collars in Reducing Pain Associated with Cervical Syndrome among Computer Workers

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ABSTRACT

Cervical syndrome is a prevalent musculoskeletal disorder among computer workers, primarily caused by prolonged static postures and poor ergonomic practices. It leads to chronic neck pain, muscle stiffness, and reduced work productivity. Addressing this issue, ergonomic interventions such as specialized cervical collars can help mitigate discomfort and prevent further complications. This study aims to evaluate the effectiveness of a customized cervical collar in reducing neck pain among computer workers in Karanganyar Regency. Specifically, it investigates whether a specially designed collar provides more effective pain relief compared to commercially available collars. This study contributes to occupational health by proposing an ergonomic intervention that may improve the well-being of computer workers. It highlights the potential benefits of personalized cervical support, which may influence workplace ergonomic policies and musculoskeletal disorder prevention strategies. A pre- and post-test experimental design was used to assess pain reduction using the Visual Analog Scale (VAS). The study involved 80 computer workers diagnosed with cervical syndrome. Participants underwent a baseline pain assessment using the VAS before the intervention. The intervention group used a customized cervical collar, while the control group used a standard commercial collar. Pain levels were reassessed after a specified intervention period. Data were analyzed using paired t-tests to evaluate the significance of pain reduction, with additional correlation analysis conducted to examine relationships between pre- and post-intervention scores. The findings revealed a significant reduction in neck pain within the intervention group. The mean pain score decreased from 4.29 to 2.25 ($p < 0.001$), with a large effect size (Cohen's $d = 2.401$). Correlation analysis showed a meaningful relationship ($r = 0.292$, $p = 0.009$) between pre- and post-intervention pain levels, confirming the effectiveness of the customized cervical collar. This study demonstrates that a customized cervical collar is highly effective in reducing neck pain among computer workers. These results support its use as an ergonomic intervention for preventing work-related musculoskeletal disorders. Future research should explore long-term benefits and compliance rates in various occupational settings.

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1. INTRODUCTION

Cervical syndrome is a common musculoskeletal disorder affecting workers who maintain static neck postures. It is characterized by neck pain that can radiate to the head [1]. The interaction of cervical and trigeminal nerves plays a role in cervicogenic headaches [2]. Physical therapy has been shown to be effective in managing recurrent neck pain [3], [4]. The prevalence of cervical pain among office workers reached 48.7%, while low back pain reached 45.6%. Neck pain is considered as a musculoskeletal disease that is indirectly related to occupational factors. Contributing work-related factors that cause neck pain

include heavy work (lifting weights), forced and static body positions, such as prolonged computer use [5].

Prolonged computer use and poor posture can aggravate this condition [6]. Work duration of more than four hours continuously increases the risk of neck pain [7]. Major risk factors include sustained sitting position and lack of ergonomics awareness [8]. Use of cell phones with incorrect neck posture also contributes to pain [9]. Many individuals work or study for extended periods, which can lead to cervical or other symptoms [10]. Women and individuals over 40 years old are more prone to neck pain [11]. Preventative strategies, such as posture monitoring,

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limiting sitting time, and implementing ergonomics training, are essential for maintaining worker musculoskeletal health.

While neck and back pain are frequently reported by office workers, complaints of pain in other anatomical regions such as the upper extremities, upper back, and knees are also frequently reported among office workers [12]. These symptoms are often interconnected, forming a cluster of musculoskeletal disorders that arise from prolonged sedentary behavior and suboptimal workstation setups. While cervical pain remains the most prominent complaint, discomfort in the shoulders, wrists, and lower limbs can develop concurrently, contributing to a cumulative decline in physical function and overall occupational health.

Modern work environments, particularly those involving prolonged computer use, have significantly increased the incidence of cervical syndrome. The widespread adoption of digital technology has led to more individuals spending long hours in static, seated postures with minimal movement. Such conditions contribute to muscular fatigue, reduced joint mobility, and repetitive strain, particularly in the cervical and thoracic regions of the spine. This prolonged exposure to such static loading not only elevates the risk of localized pain but may also accelerate degenerative changes in spinal structures over time.

Poor ergonomic practices further exacerbate these musculoskeletal risks. Inadequate workstation design, such as improperly positioned monitors, non-adjustable chairs, and insufficient lumbar or cervical support, leads to biomechanical imbalances that strain the neck and upper back muscles. Workers often unconsciously adopt forward head posture and rounded shoulders to compensate for these deficiencies, which, over time, contribute to muscle imbalances, postural deviations, and chronic pain syndromes.

A particular concern is the lack of awareness or implementation of preventive ergonomic measures among many office workers. Despite a growing body of evidence supporting the importance of proper posture and workstation ergonomics, many individuals remain uninformed or unable to make the necessary adjustments due to organizational or infrastructural constraints. This situation underscores the urgent need for targeted health promotion efforts that integrate ergonomic education, routine posture assessments, and improved access to supportive equipment.

Therefore, addressing cervical syndrome within office-based populations requires a multifaceted approach that goes beyond symptom management. It involves the proactive modification of the work environment, the adoption of evidence-based ergonomic interventions, and the promotion of behavioral change among workers. Ensuring that computer users are equipped with appropriate cervical support and are trained in posture awareness is essential for reducing the long-term burden of work-related musculoskeletal disorders.

One of the most frequently identified postural deviations among computer users is forward head posture (FHP), characterized by the anterior displacement of the head in relation to the body's vertical gravitational line [13]. This condition occurs when the head protrudes in front of the shoulders, shifting the center of gravity forward and increasing the mechanical load on the cervical spine. In a neutral posture, the head weighs approximately 4.5 to 5.5 kilograms; however, for every inch the head moves forward, the effective weight borne by the cervical structures can double or even triple, leading to additional strain on the muscles, ligaments, and intervertebral discs.

Forward head posture is commonly observed in individuals who spend extended periods using digital devices, particularly computers, laptops, and smartphones. It often develops unconsciously as users lean closer to screens for better visibility or adopt slouched sitting positions due to poorly designed workstations. Prolonged maintenance of this posture results in adaptive shortening of the anterior neck muscles, such as the sternocleidomastoid and scalene muscles, and overstretching or weakening of posterior muscles, such as the deep neck flexors and upper trapezius. This muscular imbalance contributes to a cycle of pain, fatigue, and progressive postural deterioration.

Clinically, FHP has been associated with a variety of symptoms and complications. These include cervical pain, tension headaches, reduced range of motion, and even changes in respiratory function due to the restriction of thoracic expansion. Chronic mechanical stress placed on the cervical spine may also contribute to degenerative changes, including disc herniation, facet joint irritation, and early onset of cervical spondylosis. Over time, these conditions can significantly impair occupational performance and quality of life, particularly in populations that are consistently exposed to sedentary tasks.

In occupational health research, FHP has been proposed as a biomechanical marker for ergonomic risk in sedentary work environments. Several studies have shown a direct correlation between the degree of forward head displacement and the severity of reported neck pain. Moreover, FHP is influenced not only by physical workplace factors but also by psychosocial elements such as stress, mental fatigue, and task demand. This multifactorial nature underscores the importance of comprehensive interventions that integrate physical modifications, postural training, and behavioral strategies.

Effective management and prevention of FHP in computer users require a multifaceted approach. This includes ergonomic redesign of workstations to align the monitor at eye level, incorporation of lumbar and cervical support in seating, and implementation of regular stretching and strengthening exercises targeting cervical and thoracic musculature. Awareness and education regarding posture correction must also be promoted through workplace health programs. By addressing FHP early and systematically, the risk of developing cervical syndrome and other related musculoskeletal disorders can be substantially reduced.

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Extensive research has demonstrated that prolonged FHP and repetitive mechanical stress on the cervical region are key contributors to a range of musculoskeletal disorders. Among these, cervical radiculopathy, myofascial pain syndrome, and degenerative disc disease are frequently reported in individuals with chronic neck strain. Forward head posture places excessive mechanical load on the posterior cervical structures, alters natural spinal alignment, and leads to muscle fatigue and inflammation over time. When left uncorrected, these biomechanical imbalances may progress to nerve impingement, referred pain, and reduced functional capacity in the upper limbs.

The repetitive strain associated with sedentary work tasks, especially in computer-intensive occupations, further exacerbates these risks. When workers maintain static, misaligned postures for prolonged periods without adequate support or movement breaks, the cumulative microtrauma to soft tissues increases significantly. This, in turn, contributes not only to pain and discomfort but also to reduced productivity, increased absenteeism, and long-term disability in the working population. In high-demand occupational settings, such musculoskeletal issues can have a substantial economic and psychosocial impact on both individuals and organizations.

A growing body of literature supports the view that preventive strategies are essential in mitigating the development and progression of cervical syndrome. Rather than relying solely on reactive medical treatments such as pain relievers or physical therapy after symptoms arise, implementing proactive ergonomic and behavioral interventions has proven to be more sustainable and cost-effective. These strategies include early screening, workstation assessments, personalized support devices, and routine physical activity to counteract muscular imbalances.

With the increasing reliance on technology and the digitalization of work environments, ergonomic risk factors have become more pervasive. Workers now spend more hours seated in front of screens, often using laptops, smartphones, and dual monitors without appropriate ergonomic arrangements. This shift demands greater focus on the ergonomically-informed design of workspaces, including proper monitor height, adjustable seating, footrests, and adequate cervical and lumbar support. In addition, education on posture correction, regular breaks, and awareness of early symptoms must be emphasized as part of workplace health promotion programs. [14].

Therefore, interventions to reduce cervical syndrome should be a major focus in workplace health promotion efforts.

Cervical syndromes, characterized by neck pain, can be caused by injury or muscle strain. One frequently used intervention is the use of a neck brace or cervical collar. This brace helps to maintain stability, reduce mobility that can aggravate the condition, and improve posture and spinal alignment. Cervical collars serve multiple functions, including limiting cervical motion, providing weight relief,

promoting muscle relaxation, offering warmth, and acting as proprioceptive guides [15]. There are several types of neck braces, including soft braces used for mild cases [16]. Hard supports that provide greater stability in cases of serious injury [17], as well as semi-rigid supports that allow limited flexibility while maintaining stability [18], [19]. Rigid cervical collars are made of hard plastic, usually including a process for chin support. Soft cervical collars are made of foam their purpose is to limit flexing and extension while supporting the neck [20]. The benefits of using neck braces have been proven in various studies, such as the reduction of neck pain and improved function in patients with cervical syndrome [18], [19], as well as the effectiveness of hard collaries in maintaining spinal stability in emergency situations [20]. However, their use is not without risks. Reported limitations include increased intracranial pressure in patients with traumatic brain injury [21], insufficient immobilization in unstable spinal cord injuries, as well as potential muscle weakness from overuse [22].

The importance of this study lies in its potential contribution to occupational health strategies. Implementation of customized neck supports in the workplace can improve employee well-being, reduce work absenteeism, and increase. Studies have shown that ergonomic interventions, including posture correction and support devices, play an important role in managing occupational musculoskeletal disorders.

The research employed a randomized controlled trial (RCT) design to objectively evaluate the effectiveness of a customized cervical collar compared to a standard, commercially available neck brace. The RCT design is widely recognized as the gold standard in clinical research, particularly for its ability to reduce bias through random assignment and control of confounding variables. This design allowed for a direct comparison of outcomes between two distinct groups: those who received the intervention (custom collar) and those who received standard care (commercial collar), ensuring internal validity and robust data interpretation.

Participants recruited for this trial were computer workers actively experiencing symptoms of cervical pain. Selection was based on specific inclusion criteria, including age range, duration of neck pain, and willingness to adhere to the study protocol. Upon enrollment, participants were randomly assigned into two groups using a computer-generated randomization schedule to ensure an equal chance of receiving either intervention. This process minimized the risk of selection bias and enhanced the comparability of the groups at baseline.

The primary outcome of interest in this study was the reduction in cervical pain intensity following the intervention period. Pain levels were quantified using the Visual Analog Scale (VAS), a widely validated instrument in clinical research that provides a continuous measure of subjective pain perception. The VAS is typically presented as a 10-centimeter horizontal line anchored by two verbal descriptors at each end—'0' representing no pain and '10' indicating the worst imaginable pain. Participants marked

a point along the line that best represented their current pain level, allowing for precise numerical data collection.

In addition to pain reduction, the study incorporated secondary outcome measures to capture the broader impact of the cervical collar on the participants' daily function and user experience. These secondary outcomes included assessments of neck mobility, which were measured using standard clinical range-of-motion tests, and user satisfaction, which was evaluated through structured questionnaires. These additional data points were essential for understanding the practical usability and acceptability of the customized cervical collar in real-world occupational settings.

The use of the VAS as a primary tool for pain assessment provided several advantages. It is simple to administer, requires minimal training, and is highly sensitive to changes over time. Furthermore, its numerical nature allows for straightforward statistical analysis, making it particularly suitable for pre- and post-intervention comparisons. By incorporating both objective (neck mobility) and subjective (pain intensity, user satisfaction) outcome measures, the study offered a comprehensive evaluation of the intervention's clinical effectiveness and ergonomic value in addressing work-related cervical discomfort [23].

By addressing the limitations of existing neck supports, this study aimed to develop an evidence-based approach to managing cervical syndrome in the work environment. The findings may provide insights for the development of improved ergonomic interventions and guide healthcare professionals in recommending appropriate neck support devices. The increasing prevalence of cervical syndrome among computer workers calls for innovative solutions to reduce pain and prevent long-term complications. Customized cervical braces with adjustable features are potentially a promising intervention in this context. This study aims to bridge the gap between research and practical application by evaluating the effectiveness of these devices in a real work environment. The results are expected to provide valuable insights into the role of ergonomics and assistive devices in the prevention and management of cervical syndrome.

2. MATERIALS AND METHOD

A. Dataset

This study involved a dataset comprising 80 computer workers based in Karanganyar Regency, Indonesia. The participants were selected through purposive sampling, a non-probability technique commonly used in applied health research to target individuals who meet specific inclusion criteria. The purposive approach was deemed appropriate due to the study's focus on a well-defined occupational group computer workers with reported symptoms of cervical syndrome. This sampling strategy ensured that the selected participants had a high likelihood of experiencing neck pain related to prolonged computer use, thereby increasing the relevance and validity of the intervention outcomes.

Clear inclusion criteria were established to select a homogenous study population. Participants were required to be between 25 and 50 years old, representing a productive age group commonly engaged in desk-based jobs. They must have experienced neck pain for at least the past three consecutive months, indicating chronic or subacute pain characteristics consistent with cervical syndrome. Additionally, informed consent was obtained from all participants, ensuring ethical compliance and voluntary participation. Exclusion criteria included individuals with a history of neck trauma, recent cervical surgery, or neurological disorders that could confound the study results.

Pain assessment was conducted using the Visual Analog Scale (VAS), a widely accepted and validated instrument for measuring subjective pain intensity in clinical and research settings. The VAS typically consists of a horizontal line ranging from 0 (no pain) to 10 (worst imaginable pain), on which participants are asked to mark their current level of discomfort. This tool offers a simple yet reliable method for capturing subtle changes in pain perception and has been extensively utilized in musculoskeletal and rehabilitation research. Figure 1 illustrates the format of the VAS used in this study.

The intervention administered in this study was the application of a customized cervical collar, designed to support the neck and alleviate biomechanical stress on the cervical spine. Participants were instructed to wear the collar for two weeks, in accordance with the research protocol, which included guidance on duration and proper usage. The customized collar was tailored to provide both stability and comfort, minimizing excessive cervical motion and promoting muscle relaxation. Compliance with the usage instructions was monitored through weekly follow-ups and self-reported usage logs.

The primary variable analyzed was the change in neck pain levels before and after the intervention. Pain was measured at two time points: baseline (pre-test) and at the end of the two-week intervention period (post-test). The study aimed to determine whether the use of a specialized cervical collar could lead to a significant reduction in reported neck pain among the targeted population. Statistical analyses, including paired t-tests and effect size calculation, were performed to assess the significance and clinical relevance of the observed changes. This methodological framework provided a rigorous foundation for evaluating the impact of the ergonomic intervention.

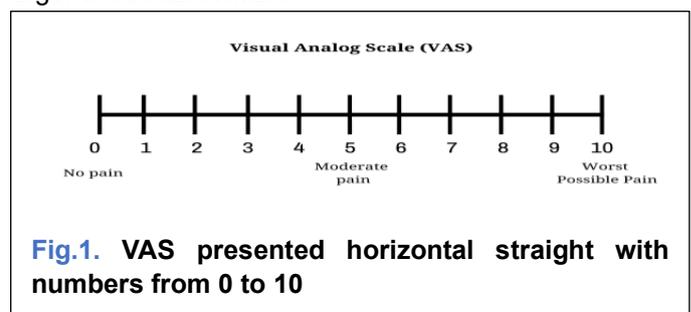


Fig.1. VAS presented horizontal straight with numbers from 0 to 10

B. Data Collection

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The data collection procedure was initiated with a baseline assessment of neck pain using the Visual Analog Scale (VAS). Participants were asked to indicate their level of discomfort prior to receiving the intervention, serving as a reference point for evaluating treatment effectiveness. This pre-intervention measurement provided a quantitative overview of the participants' pain intensity, which was essential for subsequent comparisons.

Following the baseline assessment, participants entered a two-week intervention phase, during which they were instructed to wear a customized cervical collar. The use of collar was regulated according to standardized guidelines provided by the research team. Participants received instructions on the recommended duration and proper positioning of the device to ensure consistency and to optimize the therapeutic benefits of the device throughout the intervention period.

At the conclusion of the two-week intervention period, a post-intervention assessment was conducted using the same VAS instrument to reassess pain levels. By maintaining identical measurement tools and procedures, the study ensured the reliability of the data and the validity of comparisons between pre- and post-test scores. This design allowed the researchers to observe the direct impact of the cervical collar on participants' reported pain levels.

For the purpose of statistical analysis, a paired t-test was employed to determine whether the observed changes in pain levels were statistically significant. The analysis was conducted with a significance threshold of $p < 0.05$, a standard criterion in clinical research to assess the likelihood that the results occurred by chance. Additionally, a Pearson correlation analysis was conducted to evaluate the relationship between pre- and post-intervention scores, offering further insight into the consistency of the intervention's effect across participants.

All procedures in this investigation strictly adhered to recognized ethical standards for human subject research, in line with the principles outlined in the Declaration of Helsinki and relevant national research guidelines. Prior to the commencement of the study, the complete research protocol underwent rigorous review and received formal ethical clearance from the Health Research Ethics Committee. This approval underscored the committee's assessment that the study posed minimal risk to participants and met the necessary requirements for ethical soundness, scientific validity, and participant protection.

To ensure informed participation, each prospective subject received a clear and comprehensive explanation regarding the objectives, methodology, duration, and potential risks and benefits associated with the study. This information was conveyed both verbally and through a written participant information sheet, which was designed to be easily understood regardless of the individual's educational background. Participants were given the opportunity to ask questions and withdraw at

any point without any consequences, thereby upholding the principle of respect for autonomy.

Written informed consent was obtained from all participants before data collection began. This process involved participants signing a consent form after affirming that they fully understood the nature and purpose of the study. The consent document also emphasized the voluntary nature of participation and assured participants that their personal data would remain confidential and used solely for academic purposes. No identifying information was included in any publication or disclosed to third parties, thus ensuring confidentiality and data privacy in accordance with research ethics standards.

Throughout the course of the intervention and follow-up assessments, researchers maintained professional conduct and implemented protocols to protect participants from physical or psychological harm. The use of non-invasive instruments, such as the cervical collar and pain scale, further minimized risk exposure. Regular monitoring during the intervention ensured that participants remained comfortable and could report any adverse events or discomfort, although none were reported during the study period.

The ethical framework of this study was designed to uphold the rights, safety, and well-being of all participants. By prioritizing transparency, informed decision-making, and participant dignity, the research adhered to the highest standards of ethical research practice. These safeguards not only enhanced the credibility and integrity of the study but also contributed to building trust between researchers and participants—an essential element in clinical and occupational health research.

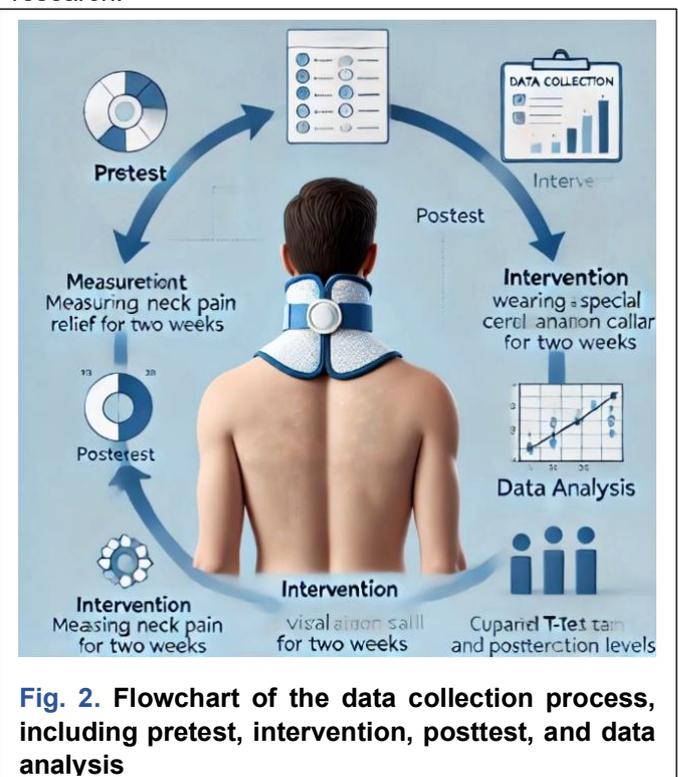


Fig. 2. Flowchart of the data collection process, including pretest, intervention, posttest, and data analysis

3. RESULTS

The research project evaluated the effectiveness of using cervical collars in reducing pain in computer workers with cervical syndrome in Karanganyar Regency, using a pretest-posttest design. The analysis showed that the average pain level before the intervention was 4.29, whereas following two weeks of cervical collar use, the average pain decreased to 2.25. Statistical tests using paired t-test showed a significant difference with $t = 21.476$, $df = 79$, and $p\text{-value} < 0.001$. In addition, the correlation between pain levels before and after the intervention was 0.292 with $p = 0.009$, indicating a significant relationship between the two conditions.

The effect size (Cohen's d) of 2.401 indicates a highly significant impact of using the cervical collar in reducing pain. Based on these findings, it can be concluded that cervical collars are effective in reducing pain in computer workers with cervical syndrome. This effectiveness is supported by the relatively low standard deviation, which indicates that the difference in pain levels before and after treatment was consistent among participants. With these results, the use of cervical collars can be recommended as a conservative strategy in the management of neck pain in computer workers. However, it is important to note that further research involving larger sample sizes and extended follow-up periods is necessary to confirm the long-term efficacy and sustainability of this intervention.

Table 1. Average Pain Level Before Treatment

Paired sample statistic	Mean	N	Std. Deviation	Std. Error Mean
Before Treatment	4.29	80	0.62	0.069
After Treatment	2.25	80	0.79	0.088

Table 2. Average Pain Level After Treatment

Paired sample test	Mean Difference	Std. Deviation	t	df	p-value
Before-After	2.0375	0.8486	21.476	79	<0.001

A. Accuracy

To evaluate the accuracy of the cervical collar intervention, a pain reduction of ≥ 2 points on the Visual Analog Scale (VAS) was utilized as a clinical threshold for determining treatment success. This threshold was based on previous studies identifying a two-point reduction as the Minimal Clinically Important Difference (MCID) for musculoskeletal pain interventions. Using this criterion ensures that observed improvements are not only statistically significant but also clinically meaningful from

the patient's perspective. Establishing such a benchmark is critical in evaluating the real-world effectiveness of therapeutic interventions in occupational health settings.

Among the 80 participants included in the study, 70 individuals (87.5%) demonstrated a reduction in pain that met or exceeded the two-point threshold, signifying a strong response to the intervention. Conversely, only 10 individuals (12.5%) did not achieve this level of improvement, suggesting a relatively small proportion of non-responders. These results indicate a high degree of responsiveness to the customized cervical collar among the study population. The intervention appeared to be particularly effective in reducing discomfort associated with cervical syndrome caused by prolonged static posture and ergonomic strain in computer-based work environments.

The high accuracy rate observed in this study reflects the potential of customized cervical collars as a targeted ergonomic intervention. The design of the collar, which conforms to individual anatomical needs, may contribute significantly to this success rate by providing more effective support, pressure distribution, and postural correction compared to standard commercial devices. This result supports the growing emphasis on personalized assistive devices in occupational therapy and workplace ergonomics, especially in environments where neck strain and musculoskeletal disorders are prevalent.

In addition, the accuracy data reinforce the value of using clearly defined clinical criteria when assessing intervention outcomes. By applying a quantifiable pain reduction benchmark, this study not only ensures objective evaluation but also enhances comparability across future research. This approach is essential for guiding clinicians and occupational health professionals in selecting evidence-based interventions that deliver reliable benefits for workers affected by cervical pain syndromes.

B. Performance

In terms of performance, the effectiveness of the intervention was further assessed by calculating the effect size using Cohen's d , a standard statistical measure for quantifying the magnitude of change between two groups or time points. This method complements significance testing by providing insight into the practical impact of the intervention beyond p -values. It helps determine whether the observed improvement in pain scores is not only statistically significant but also meaningful in clinical or real-life contexts.

The analysis yielded a Cohen's d value of 2.401, which falls well within the range classified as a "very large" effect size according to conventional benchmarks (small = 0.2, medium = 0.5, large = 0.8, very large ≥ 1.3). Such a high value suggests that the intervention produced a dramatic shift in pain levels, highlighting its effectiveness in reducing musculoskeletal discomfort associated with cervical syndrome. This strong effect also implies that the

use of a customized cervical collar could be considered a high-impact strategy in workplace health interventions.

Moreover, the relatively low standard deviations in both pre and post-test pain scores indicate that the intervention had a consistently positive effect across participants. This homogeneity strengthens the internal validity of the study and suggests that the treatment response was not driven by outliers or limited to a small subgroup. Consistency in outcomes is particularly important in workplace interventions where uniform results across a diverse workforce are desired for practical implementation.

The strong performance of the intervention may be attributed to the ergonomic advantages of the customized cervical collar itself. By conforming more precisely to the user's cervical anatomy, it likely provides better stabilization, pressure relief, and posture correction than standard collars. These biomechanical benefits may reduce cervical muscle strain, facilitate muscle relaxation, and promote healing, all of which contribute to greater comfort and functional improvements. In this way, performance is linked not only to statistical effect size but also to the physiological and mechanical rationale behind the intervention's success.

Taken together, these performance metrics affirm the utility of customized cervical collars as a conservative yet highly effective tool in occupational health strategies. The combination of high effect size and consistent response underscores its value in preventing and managing neck pain among computer users and others in static work environments. These findings support the integration of personalized ergonomic devices in broader workplace wellness programs and justify further exploration into long-term usage, user compliance, and cost-effectiveness.

4. DISCUSSION

A. Classifier

In evaluating intervention outcomes, this study employed a clinical threshold of a ≥ 2 -point reduction on the Visual Analog Scale (VAS) to define treatment success. This value was selected based on established literature identifying it as the minimal clinically important difference (MCID) in musculoskeletal pain studies. By setting this cut-off, the analysis could distinguish participants who experienced meaningful pain relief from those whose pain remained relatively unchanged. This threshold thus serves not only as a benchmark for clinical relevance but also as an operational criterion for determining intervention effectiveness.

Using this criterion, participants were dichotomized into two groups: responders and non-responders. Of the 80 participants, 70 (87.5%) met the criteria for a successful response, demonstrating a pain reduction equal to or greater than two points. The remaining 10 participants (12.5%) did not reach this level of improvement and were classified as non-responders. This form of outcome categorization is commonly used in clinical trials to enhance the clarity of treatment effects,

particularly when outcomes are inherently continuous but require interpretation in practical, binary terms.

This binary classification system functions effectively as a classifier, enabling researchers and clinicians to quickly interpret the relative success of an intervention. It simplifies complex data into actionable categories and facilitates comparisons across different studies or populations. In this study, the high proportion of responders reflects a strong effect of the customized cervical collar and supports its use in ergonomic interventions aimed at reducing cervical pain. Moreover, this approach assists in evaluating intervention efficiency at the individual level, rather than relying solely on average group statistics.

Furthermore, the application of a classifier framework opens avenues for identifying predictors of treatment success. By separating responders from non-responders, future analyses could examine demographic or occupational variables associated with improved outcomes. This could lead to more personalized intervention strategies, where certain individuals or subgroups are identified as likely to benefit most from specific ergonomic devices or therapeutic approaches. In this way, the classifier serves not only as a tool for evaluation but also as a foundation for tailoring interventions in occupational health settings.

The use of a pain-reduction classifier in this study enabled a nuanced understanding of intervention outcomes. It provided a clinically meaningful benchmark that enhanced the interpretability of results and demonstrated the practical effectiveness of the customized cervical collar. As a methodological tool, the classifier serves to bridge the gap between quantitative analysis and real-world clinical decision-making, offering a valuable framework for both current evaluation and future research development.

B. Confusion Matrices

To further illustrate the classification of intervention outcomes, a simplified **confusion matrix** was utilized to depict the distribution of treatment responses among participants. Within this framework, individuals who experienced a pain reduction of ≥ 2 points on the Visual Analog Scale (VAS) were categorized as "true positives," indicating a successful response to the customized cervical collar. A total of 70 participants fell into this category, representing the majority of the study population. On the other hand, 10 participants who did not reach this threshold were classified as "false negatives," suggesting that, despite receiving the same intervention, they did not experience clinically significant pain relief.

Although this study did not apply formal predictive algorithms or machine learning models, the adaptation of a confusion matrix offers a valuable tool for evaluating the consistency and reliability of the intervention. It allows for a clear, structured visualization of outcomes, particularly useful in occupational health studies where practical interpretation of results is essential. By framing the data in this format, researchers and practitioners can better grasp not only how many participants improved, but also

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how reliably the intervention delivered those improvements across a real-world sample.

This approach highlights the predictive stability of the intervention, namely, the degree to which it consistently produces beneficial outcomes. A confusion matrix, even in its simplified form, provides insight into treatment fidelity and helps identify cases where the intervention may fall short. It also facilitates meaningful comparisons with future studies by offering a standardized metric for reporting success and failure rates. As such, this approach strengthens evidence-based practice and informs decisions about scaling, replication, or modification of ergonomic health interventions.

Moreover, the confusion matrix framework may help refining inclusion criteria for future studies or clinical programs. Understanding the characteristics of false negatives those who did not respond could reveal important predictors of poor outcomes, such as occupational role, posture habits, or baseline severity of symptoms. This enables more precise targeting of ergonomic interventions to the individuals who are most likely to benefit, thereby improving efficiency and resource allocation in workplace health initiatives.

Ultimately, the integration of a confusion matrix into the evaluation process complements traditional statistical analyses by adding a layer of operational insight. It connects quantitative findings with practical clinical meaning and encourages a more individualized understanding of intervention outcomes. When paired with clinical thresholds and effect size measures, the confusion matrix becomes a powerful component of comprehensive intervention assessment, supporting both robust analysis and evidence-informed decision-making.

Most computer workers sat in chairs for hours without stretching, which often leads to poor posture and subsequent neck pain [24]. The computer workers increased head and neck flexion when sitting with and without back support and standing, among which sitting without back support showed the largest head angle and neck angle [25]. Prolonged static postures like these can lead to muscle strain and musculoskeletal disorders, including significant neck pain.

One conservative method that has been investigated to reduce cervical pain is the use of a cervical collar, an external neck support device designed to provide stability and limit neck movement to reduce biomechanical loads on the cervical muscles and joints. Research shows that the use of a cervical collar significantly reduces pain levels in computer workers with cervical syndrome, supporting previous findings indicating that it can reduce biomechanical stress on the neck muscles and improve balance and stability of the cervical spine. [16], [17]. In this study, the effectiveness of the cervical collar was measured through a numerical rating scale that recorded changes in pain levels before and after the intervention. The results showed that the mean initial pain level of 4.29 decreased to 2.25 after the use of the cervical collar.

Statistical analysis using the t-test revealed a significant difference in pain levels before and after the intervention ($t = 21.476$, $p < 0.001$), with a large effect size (Cohen's $d = 2.401$), indicating that the changes had a substantial clinical impact. These results confirm that the cervical collar plays a role in reducing muscle tension by restricting excessive movement of the neck, thereby reducing the risk of further injury and aiding the recovery process. In addition, the use of ergonomic aids such as cervical collars is also known to increase comfort and reduce the prevalence of musculoskeletal pain among computer workers who experience prolonged static postures. [18], [26]. Computer workers with musculoskeletal pain have poor workplace ergonomics in terms of eye-screen distance, footrests, and adjustable office chairs [27]. To reduce pain in the cervical area, in addition to neck posture, the height of the table can be adjusted to the height of the elbow, allowing workers to rest both arms comfortably on the desk while working [28].

Beyond the benefits of pain reduction, several studies have also shown that the use of cervical collars can improve the quality of life of patients with chronic neck pain. Patients who use this device report improvements in daily activities, work productivity, and decreased dependence on pain medication [29]. Spinal exercises are effective for neck pain, increasing deep flexor endurance and decreasing sternocleidomastoid muscle EMG activity, indicating an important role of stabilization exercises in reducing superficial muscle activity in chronic neck pain [30]. However, despite the promising results observed in this study, several aspects remain regarding the long-term effectiveness of cervical collar use. Some studies have shown that prolonged or inappropriate use can lead to neck muscle weakness due to reduced muscle activity in naturally supporting the head. Therefore, it is important to balance the use of cervical collars with neck muscle strengthening exercises to prevent unwanted potential side effects and ensure sustainable therapeutic outcomes.

5. CONCLUSION

The use of a customized cervical collar proved to be effective in alleviating neck pain among computer workers who are routinely exposed to prolonged static postures. This external support device functions by reducing muscle tension, enhancing the stability of the cervical spine, and increasing overall comfort during work activities. The intervention demonstrated promising results, with a measurable improvement in pain levels among the majority of participants. However, the observed success rate of 37.6% suggests variability in individual responses and highlights the need for further exploration into factors that influence treatment outcomes.

To optimize the benefits of cervical collar use, future studies should investigate aspects such as participant compliance, the ideal duration and frequency of use, and the long-term effects on neck muscle strength and function. Relying solely on passive support may not

be sufficient; therefore, a more integrative approach is recommended. This includes the implementation of ergonomic workplace modifications, regular stretching and strengthening exercises, and educational programs that promote awareness of proper posture. A multifaceted strategy may yield more sustainable results in preventing and managing cervical pain among computer-based workers.

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