Critical Review: The Effects of Cervical Bracing on Swallowing

Branco, C.
M.Cl.Sc. (SLP) Candidate
School of Communication Sciences and Disorders, U.W.O.

This critical review focused on examining the effects of cervical bracing on swallowing in adults. The study designs included in this review are repeated measures designs and case studies. Overall, the studies provide preliminary evidence indicating that cervical bracing can alter the swallowing mechanism in adults with no known risk of developing dysphagia.

Introduction

Cervical orthoses are used to immobilize the cervical spine (Schneider et al., 2007) while treating a range of neck impairments from muscle spasm to serious instability (Johnson et al., 1977; Johnson et al., 1981), such as after cervical spine surgery (Schneider et al., 2007) and spinal cord injury (Johnson et al., 1981; Stambolis et al., 2003). There are many different cervical orthoses available that can be divided into four general categories of support (Johnson et al., 1981; Stambolis et al., 2003). The first is the collar, which extends from the head to upper part of the thorax. An example is the Philadelphia collar (Johnson et al., 1977; Johnson et al., 1981; Stambolis et al., 2003). The second type is the poster brace, which is more rigid than the collar, and has padded mandibular and occipital supports (Johnson et al., 1977; Johnson et al., 1981; Logemann, 1998). The third category is the cervicothoracic brace, which extends further down the trunk than the poster brace (Johnson et al., 1977; Johnson et al., 1981; Schneider et al., 2007; Stambolis et al., 2003). Examples of this include the sternal occipital mandibular immobilizer (SOMI) (Johnson et al., 1981; Schneider et al., 2007; Stambolis et al., 2003) and the Minerva cervicothoracic orthosis (Schneider et al., 2007; Odderson & Lietzow, 1997). The final category is the halo ring, which is the ultimate orthoses, providing rigid fixation of the head (Johnson et al., 1977; Johnson et al., 1981; Stambolis et al., 2003).

The effectiveness of cervical orthoses is generally based on their ability to restrict cervical motion (i.e., flexion, extension, lateral bending and rotation) (Johnson et al., 1981), patient comfort, and potential patient compliance (Schneider et al., 2007), with no consideration given to their effect on one's ability to eat and/or swallow.

Cervical orthoses would appear to hinder one's oral and laryngeal mobility, but a review of the literature needs to be completed to determine the effects cervical bracing can have on the normal swallow. In addition, it would be important to establish the possible effects of cervical orthoses on those who already have swallowing difficulties. Understanding the potential effects of cervical orthoses on swallowing is important because decisions about bracing and modifications during eating, especially for those who are already at risk of developing dysphagia, can be informed by this knowledge.

Objectives

The objective of this paper is to critically evaluate the literature on the effects of cervical bracing on swallowing. Recommendations for addressing cervical orthoses in relation to the development or exacerbation of dysphagia and suggestions for future research will also be provided.

Methods

Search Strategy

Computerized databases, including CINAHL, Cochrane Library, Medline, Pubmed and AMED were employed, utilizing the following search strategy: (dysphagia OR deglutition disorders) OR (swallowing OR deglutition) AND (cervical bracing) OR (cervical orthoses). The search was limited to articles written in English.

Selection Criteria

Studies that were selected for inclusion in this critical review paper were required to evaluate the effects of cervical bracing (i.e., cervical orthoses, cervicothoracic orthoses, and/or halo-rings) on swallowing function in

healthy individuals, individuals suffering from trauma, or patients following cervical spine surgery. No limits were set on the demographics of research participants or outcome measures.

Data Collection

Results in the literature search yielded four articles meeting the above criteria: repeated measures design (2), and case study (2). These articles further yielded two studies for which only the abstracts were available.

Results

Repeated Measures Design

Stambolis et al. (2003) evaluated the effects of cervical orthoses on swallowing in 17 healthy volunteers with no known swallowing, neurological or spinal deficits. Each subject's swallow was evaluated under videofluoroscopy while wearing no cervical orthosis, and subsequently with three different cervical orthoses (Philadelphia collar, SOMI, and a halo-vest brace). Two speech-language pathologists (S-LP) independently evaluated each swallow based on several parameters, such as penetration and aspiration, the presence and amount of pharyngeal residue, hyoid movement, oral and pharyngeal transit time and diameter of the oropharyngeal opening. The results revealed no significant differences in the durational measurements, while changes in some of the other swallowing parameters were observed under all three bracing conditions when compared to the non-braced condition. The SOMI brace and halo-vest brace appeared to have the greatest impact, and more changes appeared with liquid boluses than solid boluses. The authors concluded that cervical bracing alone could change the swallowing mechanics in healthy adults.

Subjects

There appears to be a reasonable number of participants in this study; however, it is unknown whether a power analysis was conducted to determine the probability of a Type II error. It is unknown if the participants were randomly selected. If they were not, then participant selection bias may have taken place. Age confounds were unlikely due to the narrow age range of the participants (30-49). This is important as the swallowing anatomy and physiology changes in healthy adults as age increases (Logemann, 1998). The exclusion criteria controlled for potential confounds from the participants' health history and ensured some similarity between the participants.

Procedure

The nature of the design controlled for intersubject differences, as the subjects acted as their own controls. Order effects were controlled for by the randomization of the bracing condition and the presentation of the bolus for each subject. The authors provided detailed operational definitions for the parameters used to evaluate the swallows. The size and consistency of the bolus and the subjects' alignment while wearing the SOMI and halo-vest orthoses were controlled for between trials, which improved the reliability of the results. Although the pharyngeal phase of the swallow is a relatively automatic process, performance bias still might have occurred if the subjects were not blinded to the purpose of the study. It is unknown whether the physician fitting the orthoses and the S-LPs evaluating the swallows were blinded to the purpose of the study. If they were not blinded, then experimenter bias may have occurred. Instructing the participants to swallow the thin boluses reduces the content validity since it does not provide a true representation of a normal swallow. The authors followed through with the original intent of the experiment. The procedure was clearly outlined in this study, allowing for reproducibility.

Measurements

Having S-LPs evaluate the swallows improves the reliability of the measurements as they have expert knowledge in assessing swallowing function. Since the S-LPs rated the swallows independently from each other, their measurements were uninfluenced by each other's. Inter-rater reliability was addressed and proved to be adequate. Several relevant parameters were chosen to evaluate the swallows. Content validity could have been improved if the degree of epiglottic deflection, and thus airway protection, was considered. Also, the location of residue could have contributed to the content validity, since one could infer the affected structures based on the location of the residue. To measure bolus flow, using the 8-Point Penetration-Aspiration Scale instead of simply indicating whether aspiration or penetration occurred would have given the reader information about the level the bolus reached in the larynx and whether the bolus was ejected. Videofluoroscopy is not a standardized tool; however, it is used most frequently in

assessing oropharyngeal swallows (Logemann, 1998). The reliability or validity of the measurement tools were not discussed.

Statistical Analysis

The authors used a balanced one-way ANOVA and a paired t-test to analyze continuous data, which was appropriate. Descriptive statistics were used to discuss the nominal data, thus preventing the authors from generalizing the results to the target population. Either using nonparametric tests or collecting continuous data for these parameters would have allowed the authors to make conclusions about the significance of the observed changes as well as generalize the results to the target population.

Level of Evidence

The design of this study was a repeated measures design, which generally yields a moderate level of evidence. The authors attempted to control for many confounds, and they provided a rigorous description of the procedure. Thus, this study provides a moderate level of evidence that cervical bracing can effect swallowing in adults.

Morishima et al. (2005) evaluated the effects of halo-vest orthoses on swallowing in six healthy, neurologically intact volunteers. Each subject's swallow was examined in three different positions: the neutral position without the halo-vest brace (N-HV), the neutral position with the halo-vest brace (N+HV), and in a hyperextended (52^{o}) position with the halo-vest brace (E+HV). The swallow was evaluated under videofluoroscopy based on a variety of swallowing parameters, such as pharyngeal transit time, initial hyoid position, maximal vertical and anterior hyoid movement, integral electromyography from the suprahyoid muscles and the presence of aspiration and penetration. The results indicated no statistically significant differences between the swallowing parameters in the N-HV and N+HV positions. However, the following statistically significant differences in swallowing parameters were found when in the E+HV position: 1) greater pharyngeal transit time, 2) lower initial hyoid position, 3) prolonged vertical hyoid movement, and 4) increased integral electromyography measurements. The subject who demonstrated laryngeal penetration in the N-HV and N+HV positions, demonstrated laryngeal aspiration in the E+HV position. All subjects indicated difficulty swallowing in the E+HV position. The authors concluded that mechanical changes in the swallowing of normal, healthy adult volunteers occurred as a result of cervical hyperextension with the halo-vest brace.

Subjects

The sample size in this study was small with only six participants, and it is unlikely that a power analysis was performed to determine the chance of making a Type II error. Thus, the results of this study may have limited power. The inclusion criteria controlled for potential confounding factors regarding the subjects' medical history and ensured some similarity between the participants. The age of the participants fell between a narrow range (24-33 years old), controlling for potential age confounds. The subject recruitment process was not described. Participant selection bias may have occurred if the subjects were not randomly selected. Since it is unknown from where the subjects were selected, the external validity of the study is also unknown.

Procedure

The nature of the design controlled for inter-subject differences, since the subjects acted as their own controls. It is unknown whether the bracing conditions for each participant were randomized. If they were not, then order effects may have occurred. Performance bias may have taken place if the subjects were not blinded to the purpose of the study. The authors performed the evaluations; therefore, they were not blinded to the purpose of the study. As a result, experimenter bias may have occurred. Instructing the participants to swallow the bolus may have reduced the validity of the results since this is not a true representation of a normal swallow. The bolus size and consistencies were controlled for in each trial, helping to improve the reliability of the results. The authors operationalized each of the parameters that were used to evaluate the swallow. The authors followed through with their original intent of the experiment. However, they did not provide an adequate description of their procedure, and thus, the experiment is not reproducible.

Measurements

Several valid parameters to measure the swallow were selected; however, there are some parameters that could have contributed to the content validity of the study if they were considered. These parameters include measuring epiglottic deflection and identifying and comparing the location and amount of residue. In

addition, using the 8-Point Penetration-Aspiration Scale would have been useful to universally qualify the existence and extent of penetration and aspiration. Videofluoroscopy was used to view the swallow. This is judged to be reliable and valid since videofluoroscopy is used most frequently in assessing oropharyngeal swallows (Logemann, 1998). There was no discussion of the reliability or validity of the measurement tools used throughout the study.

Statistical Analysis

To measure the significance of the results, the authors used a Wilcoxon signed rank test on each variable. The reason for using a non-parametric test instead of a parametric test was not discussed, although one could assume it was due to the small sample size.

Level of Evidence

The design of this study was a repeated measures design, which generally provides a moderate level of evidence. However, there are many factors that are unknown about the procedure of this experiment, leading one to question the reliability and validity of the results. Therefore, the evidence provided by this study that cervical bracing can effect swallowing in adults is suggestive.

Case Study

Odderson and Lietzow (1997) described the effects of the Minerva cervicothoracic brace on a neurologically intact, 83-year old women's swallowing ability. They found that the symptoms of her dysphagia and aspiration pneumonia resolved when the Minerva brace was removed and replaced with a halo-vest brace. The authors concluded that dysphagia and aspiration pneumonia may be caused by wearing a cervicothoracic orthosis.

Subjects

The results of this paper have little external validity, as only one subject was included.

Procedure

It is unknown whether the S-LP conducting the evaluation was blinded to the purpose of the study, thus experimenter bias may have occurred. An operational definition of dysphagia was not provided. The authors' conclusion that dysphagia and aspiration pneumonia may be caused by cervicothoracic orthosis is inappropriate since one cannot infer causation from a non-experimental design.

Measurements

The authors did not discuss the reliability and validity of the swallow evaluations. However, having a S-LP conduct the swallow evaluations increases the reliability of the measurements since they are experts in swallowing. The thoroughly described results of the swallow evaluations increases the validity of the measurements, as the swallow evaluation conducted with the brace in place indicated several signs of swallowing difficulty, and the swallow evaluation conducted after the removal of the brace indicated an amelioration of many of those signs. The authors did not state whether the same S-LP conducted both swallow evaluations. If a different S-LP conducted the second swallow evaluation, then inter-rater reliability should be questioned.

Statistical Analysis

There were no statistical analyses conducted in this study, which was appropriate since the observations were qualitative in nature.

Level of Evidence: Although the observations were rigorously presented, a case study can only provide a low level of evidence. Therefore, this study provides weak evidence that cervical bracing can effect swallowing in adults.

Houghton and Curley (1996) examined the effects of a hard plastic collar on the swallowing ability of a 70-year-old man who underwent cervical spine surgery and craniocervical fusion. The authors found an immediate return of normal swallowing upon removal of the brace. They suggested that cervical bracing, if fitted too tightly, can lead to swallowing complications, especially in those with prominent laryngeal outlines.

Subjects

As this paper considered only one individual, the study has little external validity.

Procedure

The authors did not provide an operational definition of dysphagia. There was no mention of a swallowing evaluation, who determined that the patient had dysphagia, nor the type of dysphagia that was experienced by this individual. As a result, the validity of these observations can be questioned. However, the authors did describe signs that often co-occur

with dysphagia and with which the individual presented (e.g., coughing, muffled voice, etc.), thereby helping to validate this diagnosis. The otolaryngologist's examination further increases the validity of these findings, as s/he provided expert information.

Measurements

Observing the subject's swallow under videofluoroscopy upon removal of the cervical collar contributes to the reliability and validity of the conclusion that the subject had a normal swallow. Videofluoroscopy is not a standardized tool, but it is used most frequently in assessing oropharyngeal swallows (Logemann, 1998). One could still question the reliability of the results since it is unknown whether an expert conducted the swallow evaluation.

Statistical Analysis

The results of this study were descriptive, and no statistical analysis was conducted, which was appropriate.

Level of Evidence

A case study can usually provide at least a low level of evidence. However, the lack of procedural data provided in this case study leads to the conclusion that the evidence from this study that cervical bracing can effect swallowing in adults is very weak.

Other

The following studies have been completed and are informing to this topic; however, the complete papers are unavailable, and so cannot be critiqued adequately.

Bisch et al. (1992) examined the effects of the SOMI brace on the oropharyngeal swallow in five normal adult males. The swallow was measured in all the subjects with and without the brace (Logemann, 1998). Logemann (1998) reported that all of the subjects felt that swallowing was less comfortable in the brace condition. The authors of this study found that the duration of airway closure was significantly longer and began significantly earlier in the bracing condition. Overall, the authors did not find any significant effects of bracing on the oropharyngeal swallow (Logemann, 1998).

Miura (2000) examined the oropharyngeal swallow of a single patient who was using a halo-vest brace in an extended position compared to a flexed position. The results showed that being in the hyperextended neck position, the strength of the swallow was reduced and the swallow was prolonged in its duration, thereby leading to dysphagia.

Recommendations

The literature suggests that wearing cervical orthoses can change the swallowing mechanism (anatomy) and function (physiology) in adults without any known risks of developing dysphagia. However, the strongest study in this review is from Stambolis et al. (2003), which only provides a moderate level of evidence. Therefore, the overall available evidence is not strong enough to allow for conclusions regarding causation to be made.

A number of weaknesses were found in the design and procedure of these studies, including small sample size, participant selection bias, a lack of sophisticated statistical analyses and a lack of discussion regarding the validity and reliability of the measurement tools used. Experimenter bias and performance bias were always a concern as well since the evaluators and participants were never blinded to the bracing condition. This reveals a limitation in the field since it will always be visually clear which brace is worn. Although evaluators and participants can be blinded to the purpose of the study, blinding to the bracing condition can never be achieved. Therefore, experimenter and performance bias may always be an issue. Due to these concerns, S-LPs should know that cervical bracing might not cause adverse effects on swallowing. However, they should be aware that potential harm might arise, even in those who otherwise have no known risk of developing dysphagia.

Further research would be beneficial to provide a better understanding of the effects that cervical bracing can have on the swallowing mechanism and function. Future research should focus on the following:

1) Collect continuous data so sophisticated statistical analyses can be completed, and so the results of the statistical tests can be generalized to the target population,
2) Consideration of the pressure the cervical orthosis has on the larynx as an outcome measure,
3) Improved control of confounds (e.g., experimenter bias, participant selection bias, etc.),
4) Examine the effects of bracing for a wider variety of food/liquid consistencies (e.g., thickened liquid,

puree, diced, mixed consistencies, etc.), and

5) Evaluate the effects cervical bracing can have on those who are already at risk of developing dysphagia (e.g., cervical spine surgery, spinal cord injury, traumatic brain injury)

Conclusions

Based on this critical review, the literature provides preliminary evidence suggesting that cervical orthoses can change the swallowing function in individuals who have no known risk of developing dysphagia. Further research should provide more information on the effects that cervical bracing can have on the swallowing function and mechanism.

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