

INNOVATION OF FORWARD HEAD POSTURE ORTHOSIS WITH KYPHOSIS BRACE

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Abstract

Background: Forward head posture associates with kyphosis and rounded shoulder in nowadays young as well as geriatric population due to increasing usage of digital device. Aim: The purpose of this study is to test forward head posture orthosis does have effect in reducing the abnormal cranio-cervical angle as well as its complications. Design: Pilot study. Method: A quantitative research model in the form of pilot study is carried out. Five participants with neck pain accompany with forward head posture are involved in this study. Each day, samples need to wear orthosis estimate 6 hours per day. Data will be collected with measurement of craniovertebral angle and Northwick Park Neck Pain Questionnaire before wearing the orthosis and one week interval after wearing the orthosis with 4 weeks consecutively. Study site: Hospital Sultan Abdul Halim, Kedah, Malaysia. Result: Craniovertebral angle for first visit is 49.7° [95% confidence interval (CI) and it improved to 51.3°. [95% confidence interval (CI). NPNPQ before and after the intervention with forward head posture orthosis. Pa is 0.136 (Pa < 0.05) which has no significance. Discussion: Forward head posture orthosis with kyphosis brace has significant effect on restoration of normal cervical curve and correcting kyphotic posture. Pain score was reduced after 1 month of intervention compared to pre-intervention.

Keywords: forward head posture, postural orthosis, Northwick Park Neck Pain Questionnaire, geriatric, craniovertebral.

INTRODUCTION

Rising population of forward head posture is commonly seen in individual who has frequent usage of media devices like computers and smartphones. Based on the study done by concerning the prevalence of common postural disorders, FHP was the most prevalent abnormal posture (85.4%), followed by rounded shoulder (68.8%). In addition, this study has revealed a high prevalence of these poor postures among dental staff (Vakili, L et al. 2016). A forward head posture (FHP) is defined as increased flexion of lower cervical vertebrae and the upper thoracic region as well as increased extensions of upper cervical vertebrae and extension of the occiput on C1 (Taiichi Koseki et al. 2019). The

concomitant problems co-exist with FHP are hyperextension of the upper cervical spine, flattening of lower cervical spine, rounding of upper back, and elevation and protraction of shoulders. In other description, forward head posture can be referred to as anterior head translation with poking chin when viewing it from the side. In the examination, any decrease in craniovertebral angle would indicate increasing of forward head posture (Lau HM et al. 2010). That being said, FHP will put extra workload and compressive forces on the muscles that attached to the cervical spine especially the facet joints and ligaments which are required to maintain the head in equilibrium.

Individual with FHP commonly reports symptoms of neck pain, headache, temporomandibular pain and musculoskeletal disorders. Consequent effects of FHP in musculoskeletal system are shortening and tightening; weakening and elongated muscles that will develop over time in neck and shoulder girdle muscles. The main neck extensor muscles, semispinalis cavities muscle will have less thickness progressively and reduction in extensor force based on the length tension relationship if forward head posture is not corrected (Goodarzi, F et al. 2018).

Risk factors for development of forward head posture are occupational posture like forward or backward leaning of head adopted for long durations, slouched or relaxed sitting and faulty sitting posture while using computer or screen. Sleeping with head elevated too high will also leads to anterior head translation. Texting posture which is prevalent nowadays that maintained for long durations has high tendency of developing forward head and kyphotic posture (Worlikar AN et al. 2019). Back muscle strengthening is important to maintain the alignment of neck and preventing it from adopting bad inappropriate posture.

Common muscles that become long and weakened are deep cervical flexors located along the front of neck which when weakened contributes to poking chin and shoulder blade retractors, the middle trapezius and rhomboids which plays important role in preventing hunched shoulders that caused by forward head posture. In addition, muscles that become shortened and tightened are suboccipital muscles, pectoralis muscles as well as levator scapulae muscles. The forward head posture may also leads to expansion of upper thorax and contraction as well as mobility reduction of lower thorax which decreases respiratory function due to diaphragm dysfunction.

Rene Cailliet M.D., famous medical author and former director of the department of physical medicine and rehabilitation at the University of Southern California states: "Head in forward posture can add up to thirty pounds of abnormal leverage on the cervical spine. This can pull the entire spine out of alignment. Forward head posture may result in the loss of 30% of vital lung capacity. These breath-related effects are primarily due to the loss of the cervical lordosis, which blocks the action of the hyoid muscles,

especially the inferior hyoid responsible for helping lift the first rib during inhalation."

Given the effects outlined above, we have decided to propose this innovation named forward head posture orthosis with kyphosis brace. As the name indicated, it is specialized for people who are having forward head posture and kyphosis. It is an adjustable orthosis which can fit to variety of anthropometric

The Orthosis aimed to correct the abnormal curve of cervical region and

Problem statement

Most of the orthosis applies Jordan principle which can be more effective in correcting the posture. There are several devices which are made for forward head posture and are readily to be purchased in the market. A device called posture pump which is a stationary brace that should be used at home or at the office and claimed that it eliminates the pressure on the neck and upper back parts. However, it is only for stationary use and it requires plenty of space. Besides, in certain circumstances, neck collar is also prescribed to correct forward head posture but it has the cons of low level posture correction and the user need some time to get used to it. These devices do have their own advantages but to the best of my knowledge there is no evidence yet to prove which device is more superior to any others. Therefore, we are going to design a new orthosis that targets forward head posture and its concomitant kyphosis which can provides better comfortability and more practicable.

Purpose

To investigate the effectiveness and functionality of this newly designated orthosis for forward head posture and kyphosis.

Objectives

To treat and prevent neck pain that either caused by constant looking down at laptop or cell phone and neck complications like cervical disc herniation, cervical spondylolisthesis. Forward head posture orthosis also aim at treating upper back and shoulder muscles soreness and headache.

Methodology

Parameters

A Northwick Park Neck Pain Questionnaire which contains a list of questions is given to the participants to collect the informations. The questions are listed in a printed questionnaire with 5 multiples choices for them to choose. The participants needs to fill in the survey questionnaire after they used the 'Forward Head Posture Orthosis with Kyphosis' brace. This NPNQ measures the neck pain and the consequent patient disabilities. It provides an objective measure to evaluate outcome and to monitor symptoms in patients with acute or chronic neck pain over time.

The questionnaire consist of 10 section which consist of pain intensity, pain in sleeping, pins, needles or numbness in arms at night, duration of symptoms, carrying, reading and watching TV, working or housework, social activities, driving, compared with the last time respondent answered this question, is neck pain.

Each parameter is divided in five answer possibilities with points from 0 till 4. 0 is significant for no pain and 4 is significant for worst pain. There is only one answer per parameter possible. The neck pain score is the sum of the points scored for the first nine questions. Question 9 (about the driving) is not applicable if the patient doesn't drive a car in good health.

The interpretation is done by the physiotherapist. The minimum score is 0. The maximum score is 36 if all nine questions were answered and 32 if only the first eight questions were answered. The percentage ranges from 0% to 100%. The higher the percentage, the greater the disability and the pain.

Study setting

Hospital Sultan Abdul Halim

Study design

Pilot study

Sample/study population

5 subjects will be selected, mainly from office worker

Study duration

Half a year

Treatment duration

Each patient who received the orthosis will wear it for 1 month.

Selection criteria

Inclusion criteria:

Age group: 20-65 years old ,Adult with muscle strain of upper back due to poor posture, cervical disc herniation, cervical radiculopathy and cervical arthritis, thoracic kyphosis ,For individual with 'Text Neck' which occurs when looking down at an electronic device and Individual with craniocervical angle less than 42.5 degree.

Exclusion criteria:

Torticollis, Individuals present with defects of anterior/posterior arches of C1, fused cervical vertebrae, (Klippel Feil syndrome), and Cervical spine surgery.

Procedure

Participants will be included based on inclusion criteria and forward head posture angle will be measure by using photogrammetry. Consent will be obtain by explaining the aim of the study and the benefits of using the forward head orthosis then get the participants to sign for the consent form. Data will be collected after 1 month for each participant. Participant is advised to wear the orthosis at least half of the day, could be take off before and during sleep. Participants will be keeping in view for 1 months. The wearing instructions are:

1. Wear the forehead strap first and adjust to own head circumference accordingly then position the chin pad comfortably like a helmet protector strap and adjust the length of strap with the buckle so this will control the head through chin pad and supports at the back of the occiput.
2. The posterior part, which is the semi-rigid head support is with the kyphosis brace. The kyphosis brace is then wear after you have fixed the FHP brace. Just slip both the shoulder strap under the armpit like you are carrying a bag. Then tap the strap over the back onto the Velcro strap fasteners.

Outcome measure Northwick park neck pain questionnaire were used pre and post

intervention and same goes to measuring the craniocervical angle.

Statistical tools

The data was analysed by SPSS version 26.0 with significance set at $P < 0.05$. Descriptive statistics were used for gender and age. Friedman test was used to analysed the improvement in craniocervical angle from the first visit to the fourth visit whereas Wilcoxon signed rank test was used to analysed the Northwick Park Neck Pain Questionnaire before and after intervention of applying the orthosis.

Statistical analysis and results

Table 3: Baseline Data of Study Samples

	Mean (SD)	Frequency	Percentage (%)
<u>Gender</u>			
Male		3	60
Female		2	40
<u>CVA measurements</u>			
First visit		5	20
Subsequent visits		20	80
<u>NPNPQ items</u>			
Pre-intervention		45	50
Post-intervention		45	50
Age	45.4 (16.5)		

Note: SD: Standard deviation; CVA: Craniocervical angle; NPNPQ: Northwick Park Neck Pain Questionnaire

Data collected was been analyzed by using SPSS version 26.0. Baseline data of study samples are shown in Table 3. The total amount of subjects recruited in the study was 5 individuals. From table 3, the mean calculated for the age of subjects is 45.4 with standard deviation of 16.5. Craniocervical angle (CVA) measurement was 5 times in the first visit which means every subject was underwent measurement once respectively. This give the frequency of 20 which indicates each and every subject had been taken measurement of CVA for four times.

Table 4: Results of Craniocervical Angle from First (Pre-Intervention) to Subsequent Visits (Post-intervention)

Visit	Mean	SD	SEM	95%CI Lower-Upper	χ^2 (df)	P ^a
1 st visit	49.6580	1.7657	0.7896	47.4655-51.8505		
2 nd visit	49.9780	1.6692	0.7465	47.9053-52.0507		
3 rd visit	50.4760	1.6477	0.7369	48.4300-52.5220	19.360 (4)	0.001
4 th visit	50.9200	1.6704	0.7470	48.8459-52.9941		
5 th visit	51.3220	1.9407	0.8679	48.9123-53.7317		

Note: SD; Standard deviation; SEM; Standard error of mean; CI: Confidence interval; df: degree of freedom; Friedman test

After one month of intervention, we have noticed the increased of craniocervical angle to normal value which neck pain has also reduced. From Table 4, a Friedman test was used to determine the changes in craniocervical angle from first (pre-intervention) to the craniocervical angle in the subsequent visits (post-

intervention). Craniocervical angle for first visit is 49.658° [95% confidence interval (CI) = 47.4655-51.8505, χ^2 (df) = 19.36, $P_a = 0.001$] and it improved to 51.322° . [95% confidence interval (CI) = 48.9123-53.7317, χ^2 (df) = 19.36 $P_a = 0.001$].

Table 5: Minimal Detectable Change for Craniocervical Angle Measurements

CVA	Mean	SD	ICC	SEM	MDC
1st visit	49.6580	1.7657			
2nd visit	49.9780	1.6692			
3rd visit	50.4760	1.6477	0.846	0.2653	1.1626
4th visit	50.9200	1.6704			
5th visit	51.3220	1.9407			

Note: SD; Standard deviation; ICC: Intra-class correlation; SEM; Standard error of measurement; CVA: Craniocervical angle; MDC: Minimal detectable change.

Minimal detectable change (MDC) was calculated by the formula, $MDC = 1.96 * \text{SQRT}(\text{Number of measurement}) \& \text{SEM}$. Minimal detectable change

calculated had shown that the craniocervical angle is increased in each individual that had been prescribed with orthosis. From Table 5, the MDC is 1.1626 ($\Phi \geq 0.90$) which means the result has significant changes. From an average of 49.658° for craniocervical angle to 51.322° in the last visit of treatment session, thus our innovated product provides preliminary support

for the use of an orthosis in correcting forward head posture and rounded shoulder by applying principle and counteracting forces to the misaligned compartments to prevent

deterioration in poor posture and its concomitant complications. This study also demonstrated good test-retest reliability (ICC= 0.846, SEM= 0.2653). The result of craniovertebral angle obtained has high reliability.

Table 6: Reliability Coefficient and Minimal Clinically Important Difference for NPNPQ

NPNPQ	Mean	SD	α	SEM	MCID
NPNPQ-Pre-Intervention	1.8889	0.3424	0.866	0.3312	0.9182
NPNPQ-Post-Intervention	1.4667	0.3460	0.872		

Note: NPNPQ: Northwick Park Neck Pain Questionnaire; SD: Standard deviation; SEM: Standard error of measurement; MCID: Minimal Clinically Important Difference.

Northwick Park Neck Pain Questionnaire (NPNPQ) consists of 10 questions. The subjects were required to complete the questionnaire at the first visit (pre-intervention) and at the last visit of intervention. From Table 6, the Cronbach's alpha for NPNPQ pre-intervention is 0.866 whereas for post-intervention is 0.872. Outcome measure is subjectively answered thus it can vary from time point to time point. Wyrwich and Tardino described the MCID as "a difference in score that is large enough to have an implication for the patient's treatment or care." Distribution-based calculation of MCID used either standard deviation (SD) or standard error of measurement (SEM). MCID equation we used to calculate was: $MCID = 1.96\sqrt{2} * SEM = 2.77 * SEM$.

From Table 6, the standard error of measurement for NPNPQ is very low (SEM = 0.332) which indicates minimal error occurrence between each data recorded. The reliability of NPNPQ is high for measuring neck pain in forward head posture. It is reliable due to the high value of Cronbach Alpha's ($\alpha > 0.7$). The minimal clinically important difference (MCID) for NPNPQ is 0.9182 which had shown significant minimal clinically important difference between pre and post-intervention and it is reliable in assessing pain reduction by answering Northwick Park Neck Pain Questionnaire.

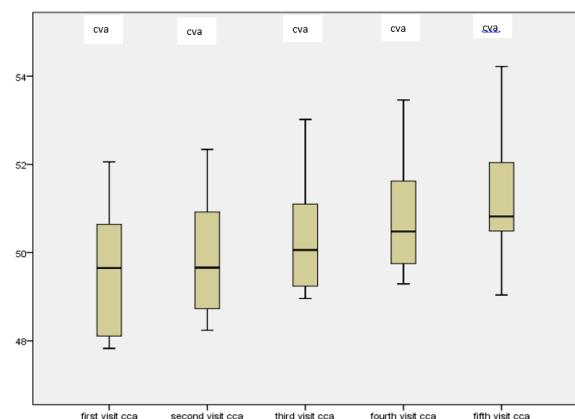
Table 7: Results of NPNPQ Before and After Intervention with Forward Head Posture Orthosis

NPNPQ	Mean	SD	Percentiles		Z	Pa
			25 th	75 th		
NPNPQ-Pre-Intervention	1.8889	0.3424	1.6667	2.2222	-1.490	0.136
NPNPQ-Post-Intervention	1.4667	0.3460	1.1667	1.7778		

Note: NPNPQ: Northwick Park Neck Pain Questionnaire; SD: Standard deviation; aWilcoxon signed ranks test

In Table 7, Wilcoxon signed ranks test was used to analyze NPNPQ before and after the intervention with forward head posture orthosis. Pa is 0.136 ($P_a < 0.05$) which has no significance due to fewer amounts of subjects recruited for NPNPQ and it might causes bias in the result of the questionnaire.

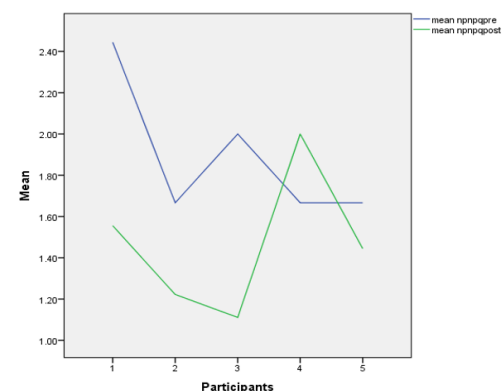
Graph 1: The distribution of craniovertebral angle measurements from first visit to subsequent visits



Note: CVA: Craniovertebral angle

Increase of craniovertebral angle is distributed in Graph 1 whereas the mean of pain score pre and post intervention of forward head orthosis wearing is distributed in Graph 2 which is depicted with line graph.

Graph 2: The distribution of mean Northwick Park Pain Score in pre-intervention and post-intervention of forward head posture orthosis



Note: npnpqpre: Northwick Park Neck Pain Questionnaire pre-intervention; npnpqpost: Northwick Park Neck Pain Questionnaire post-intervention.

Discussion

Forward head posture which is manifested by the anterior displacement of the ear's vertical line to the shoulder will lead to formation of thoracic kyphotic posture and progress to thoracic hyperkyphosis. Despite the aesthetic issues of forward head and kyphosis posture, its mortality rate has to be overseen. Apart from young population, this kind of posture is commonly found in geriatric population as well.

Variety of orthosis for correction of kyphosis is commonly available in market while forward head posture orthosis corrector is still lacking and certain occupational fields have high demand for it. The purpose of carrying out this study was to determine and evaluate whether the innovated product— Forward head posture orthosis and kyphotic brace is effective in realign the cervical spine curvature to normal and rounded shoulder posture as well as the neck pain perceived by the patient.

Forward head posture with abnormally reduction of craniovertebral angle that maintained for a longer period of time has correlation with neck pain. In the study conducted by Kim, D. H et al. (2018) it has been reported that if the craniovertebral angle is 5° less than that reported in individuals who do not have forward head posture, then it can increase the stress in the posterior area of neck.

Minimal detectable change for craniovertebral angle

Minimal detectable change (MDC) calculated had shown that the craniocervical angle is increased in each individual that had been prescribed with orthosis. It has 1.1626 which means the result has significant changes (ICC= 0.846, SEM= 0.2653). From an average of 49.658° for craniocervical angle to 51.322° in the last visit of treatment session, thus our innovated product provides preliminary support for the use of an orthosis in correcting forward head posture and rounded shoulder by applying principle and counteracting forces to the misaligned compartments to prevent deterioration in poor posture and its concomitant complications. The results of craniovertebral angle from pre-intervention to post-intervention which analyzed by Friedman test had shown significant changes with $p=0.001$.

Reliability Coefficient and minimal clinically important difference for NPNPQ

The concept of MCID is useful and necessary in setting numerical thresholds for clinically meaningful improvement for PROMs that are increasingly used in clinical studies. The most appropriate metric of reliability that should ideally be used to determine SEM for calculation of MCID is test-retest reliability.

The reliability of NPNPQ is high for measuring neck pain in forward head posture. Cronbach's alpha, while a measure of reliability, is a reflection of internal consistency on how well the individual items of a patient reported outcome measure (PROM) are reflective of the outcome they purportedly measure. It is reliable due to the high value of Cronbach Alpha's, $\alpha=0.866$ for pre-intervention and $\alpha=0.872$ for post-intervention ($\alpha > 0.7$). Minimal clinically important difference obtained had shown that it has reliability changes in the pain level is calculated.

The pain score for neck after one month of intervention was significantly decreased with the orthosis wear. (MCID = 0.9182) but the result of NPNPQ before and after the intervention has no significant difference ($p > 0.05$). From the results obtained from Wilcoxon signed rank test regarding the pain score in NPNPQ pre and post intervention, $P_a = 0.136$ which demonstrated no significance. This is probably due to the insufficient number of subjects recruited for answering the questionnaire that altered the result.

From Graph 2, the mean pain score recorded by Northwick Park Questionnaire was distributed where there is one odd phenomenon seen for the fourth patient whom the pain level averagely increased post-intervention compared to the first visit. Due to her occupation's nature which works as a dentist, she has to bend her head downward more often during her working shift. The patient will wear the orthosis only after she got back from work, instead of pain reduction, this patient had pain score increased post-intervention. Therefore, the pain score documented from this patient will alter the statistical analysis.

Reliability and validity of photogrammetric method in accessing craniovertebral angle

The craniovertebral angle in this study was measured by using photogrammetric method. Photogrammetric method of measuring craniovertebral angle has high examiner reliability value ($ICC = 0.89-0.9$) from a study done by Salahzadeh, Z. et al. (2014). The photogrammetric method had excellent inter and intra rater reliability to assess the head and cervical posture thus craniovertebral angle accuracy has an undeniable role in detecting FHP.

Craniovertebral angle is a good indicator for measuring FHP, although it cannot reflect the upper cervical spine position. The normal craniovertebral angle range was 53.2–56.8 degrees, reducing, ranges 40.7–43.2, and 46.9–49.1 degrees in subjects with moderate-severe FHP and slight FHP, respectively based on the study done by Raine S et al. (1997).

Efficacy and reliability of Northwick Park Neck Pain Questionnaire

Northwick park neck pain questionnaire that used in our study has high internal consistency and sensitivity to change and provide an MCID that allows participants with varying levels of severity to demonstrate improvement. In the study carried out by Sim, J et al. (2006), the study had concluded that the Northwick Park neck pain questionnaire can be used currently to determine individual change using the derived MCID.

The results and data analyzed shown are matched with our hypothesis and objectives which the orthosis has restore the cervical curve to normal and pain perceived by the patients at the neck area was been reduced. Apart from that, we strongly advocate that future studies can have wide coverage for different aspects of orthosis design and its efficacy and effectiveness in treating forward head posture patients so that higher level of evidence based practice can be incorporated into the treatment interventions.

Conclusion

The findings from the study demonstrated that forward head posture and kyphotic posture brace is effective and has significance in increasing the craniovertebral angle to normal. In addition, the minimal clinically important difference calculated for the

pain score in the NPNPQ has indicated that the result has high reliability coefficient and pain score documented has minimal clinically important difference after 1 month of intervention compared to pre-intervention. Research study related to forward head posture is lacking so the health care professionals are encouraged and recommended to conduct study regarding forward head posture and the usage of orthosis as the intervention of treatment.

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