



Efficacy of the Head Up collar in facilitating functional head movements in patients with Amyotrophic Lateral Sclerosis



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ARTICLE INFO

Keywords:

Amyotrophic Lateral Sclerosis
Motor Neurone Disease
Inertial magneto units
Neck muscle weakness
Cervical orthosis

ABSTRACT

Background: The Head Up collar is a cervical orthosis designed to be adaptable to a patient's needs using adjustable removable supports. The aim of this study was to characterise the ability of this orthosis to provide head support and facilitate the control of head movements in people living with Amyotrophic Lateral Sclerosis.

Methods: Thirteen patients (6 females, age range: 45–74 years old, Amyotrophic Lateral Sclerosis Functional Rating Scale range: 13–44) with neck muscle weakness due to Amyotrophic Lateral Sclerosis were enrolled in the study. An additional inclusion criterion was the presence of enough residual muscle strength to enable the performance of the test procedure. Participants were asked to perform a series of head movements with and without wearing the collar. Two parameters (mean angular velocity and ratio of movement coupling) were extracted from recorded angular velocities, to quantify changes in the execution of the movement between the two conditions.

Findings: Participants exhibited different levels of impairment in performing different movements. When wearing the collar self-selected movement velocity was preserved and significant improvement in the control of lateral flexion movement was observed (median ratio of movement coupling value reduced from 1.1 to 0.84, $P = 0.013$). A lower ratio of movement coupling was also observed in 4 out of 7 individuals that were fitted with anterior supports.

Interpretation: The heterogeneity observed in the level of impairment and residual function highlights the need for personalized interventions. The Head Up was effective in enabling more controlled movements and maintaining the natural velocity of head movement.

1. Introduction

Amyotrophic Lateral Sclerosis (ALS)/motor neuron disease (MND) is a neurodegenerative disease that affects upper and lower motor neurons leading to progressive muscular atrophy and eventually death (Hobson and McDermott, 2016). As with other neuromuscular pathologies (Gourie-Devi et al., 2003), presentations of ALS may include neck muscle weakness and head drop (Martin et al., 2011). Head drop exacerbates problems with swallowing, communicating and breathing,

causing significant difficulties in performing activities of daily living and is negatively associated with survival time (Nakamura et al., 2013).

Using a quantitative biomechanical approach, neck movements in ALS patients are characterized by a lower velocity, are less smooth and present an increased amount of so called “coupled movements”, compared to age-matched healthy subjects (Pancani et al., 2017). The latter are undesired out of plane movements that are associated with the intended primary movement. Due to the morphology of the cervical spine, even in healthy individuals, when a gross rotation is performed, a

Abbreviations: ALS, Amyotrophic Lateral Sclerosis; plwALS, Patients living with Amyotrophic Lateral Sclerosis; ALSFRS-R, ALS Functional Rating Scale - Revised; NP, neutral position; E, extension; F, flexion; AR, axial rotation; LF, lateral flexion; IMUs, Inertial magneto units; ω_m , mean angular velocity; RMC, ratio of movement coupling; ICC, interclass correlation coefficient; P, participants

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<https://doi.org/10.1016/j.clinbiomech.2018.06.016>

Received 15 July 2017; Accepted 25 June 2018

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small coupled lateral flexion to the same side occurs. Similarly, when lateral flexion is the primary movement performed, a small coupled ipsilateral rotation is observed (Panjabi et al., 1992). However, this mechanism is physiological and does not impede the intended movement. On the contrary, in the specific case of a weak neck in ALS, pure lateral-flexion is associated with a significant unwanted coupled out of plane axial rotation, which makes the intended movement more difficult (Pancani et al., 2017).

Patients living with Amyotrophic Lateral Sclerosis (plwALS) that experience neck muscle weakness are advised to wear a cervical orthosis to improve their posture, their ability to perform daily activities and ease discomfort. However, most commonly adopted cervical orthoses often provide inadequate support or are uncomfortable and are frequently rejected by the patients (Reed et al., 2015). The main limitation of those orthoses is that they have not been designed for the specific needs of plwALS (Reed et al., 2015). The Head Up collar (previously known as the Sheffield Support Snood) is a cervical orthosis which was designed in collaboration with plwALS to meet the needs of those with ALS who are affected by neck muscle weakness. The orthosis consists of a snood-like base, made of stretchable fabric. Onto the snood base a range of polypropylene supports can be attached through a Velcro hook and loop mechanism. The supports can be placed in any position to adapt the support offered, according to the task performed and the plwALS's level of functional limitation (Fig. 1) (Baxter et al., 2016). Furthermore, by varying the number and type of supports applied, the level of support offered during the progression of the disease can be changed.

Previous assessments on healthy individuals quantified objectively the restriction of movement and support the Head Up collar can provide. Of particular note was the ability to enable selected targeted head movements without limiting others (Pancani et al., 2016). Additionally, the mechanical support offered by the Head Up collar was comparable to that of more rigid and/or bulkier orthoses traditionally used by plwALS (Pancani et al., 2016). The acceptability of the Head Up has

been evaluated, with plwALS reporting a number of benefits including the ability to provide support while allowing a satisfactory range of motion, flexibility of use, the appearance and the comfort offered (Baxter et al., 2016). However, the effectiveness of the Head Up collar in improving the amount and quality of the head movements in ALS patients has not yet been investigated quantitatively.

The aim of this study was to observe head movements in plwALS and to perform a quantitative evaluation of the effects of the Head Up. In particular, this study aimed to establish if the Head Up collar facilitated more controlled and less coupled movements of the head, without limiting the natural velocity at which movements are performed. As a direct investigation of the motion of the cervical spine could not be performed, movements of the neck were investigated through the assessment of the movements of the head with respect to the trunk.

2. Methods

2.1. Participants

Participants gave informed written consent prior to the participation in the study, which was approved by the local ethics committee (REC number STH18733). Recruitment was carried out for 18 months among plwALS attending the Sheffield ALS clinic. Inclusion criteria were: definite diagnosis of ALS (modified El Escorial criteria (Brooks, 1994)) and neck muscle weakness as assessed by a physician (any neck muscle scoring less than MRC score 5, as assessed at the time of their first referral). Additional inclusion criteria were: ability to understand instructions and to perform the testing procedures. Individuals that were not able to raise their head from their chest in a sitting position were excluded from the study, as well as individuals for which a suitable size of the Head Up collar was not available (very small or large neck sizes). Thirteen plwALS were recruited and baseline characteristics are provided in Table 1. The same specialist nurse rated the



Fig. 1. The Head Up collar. a) From left to right: stretchable fabric snood, frontal Z-shape supports to be placed under the jaw, frontal A-shape support to be placed under the chin, straight support to be placed on the back of the neck, lateral support to be placed over the shoulder; b) Head Up collar with an A-shape support, frontal view.

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