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Proposal of an Alternative to the AMA Guidelines for the Evaluation of the Cervical ROM

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Abstract: The cervical spine is one of the most frequently injured joints in a car accident. References for the range of motion (ROM) that should be expected in a person are needed to stage the injuries. The two main objectives of this paper are to clinically validate a measuring device for the cervical spine, and to assess if the use of different ROM reference values will render different results from the American Medical Association (AMA) ROM guidelines. The present study is divided into 2 phases, a validation phase with 55 subjects and a case-control phase with 80 subjects. A BTS (Bioengineering Technology and System) system and the EBI-5 (estudio biomecánico integral) system were used for the present investigation. The intraclass correlation agreement value between both measuring devices is considered very good with a Cronbach alpha up to 0.9 in every dimension. Correlations (r) between variables are very high, not showing any values lower than 0.887. All comparisons between using AMA ROM guidelines or normative values presented significant differences ($p < 0.05$). The EBI-5 system has exhibited good accuracy being paired to a photogrammetric system. The use of guidelines adjusted to age constitute an alternative to the use of the AMA cervical ROM guidelines. Professionals should use age-normalized guidelines as an alternative to the AMA guidelines.

Keywords: cervical spine; AMA; normative data; range of motion; traffic injuries; accelerometry

1. Introduction

Traffic car accidents are responsible for an estimated 20 to 50 million injuries each year all over the world and while the survivability has increased, so has morbidity [1,2]. One of the most frequently diagnosed and studied injuries amongst traffic car injured is whiplash associated disorder (WAD) [3]. In western countries it is estimated that from 235 to 300 new whiplash cases arise for every 100,000 inhabitants per year [4]. This information can vary greatly between countries, with some like the USA with 328 cases every 100,000 inhabitants or others like Australia with 114 cases per 100,000 inhabitants [5–7]. In Spain, between the year 2002 and 2004, 12% of patients injured in traffic accidents were diagnosed with WAD [8], and countries like Japan 37.7% from a sample of 127,956 patients were diagnosed with WAD [9].

The differential diagnosis of WAD based on the symptoms of the patient represents a challenge for health professionals. In a study conducted in northern Sweden, 57% of patients diagnosed with WAD were wrongly diagnosed according to the ICD-10 (international classification of diseases) [6]. To ease this task, the Quebec Task Force (QTF) presented a scale of severity to grade people with

WAD. However, rating the impairment from whiplash injury is complicated when symptoms/signs do not exceed grade II of the QTF [10]. Moreover, the typical diagnosis is based solely on the complaints reported by the victims, combined with information indicating they have been involved in a collision. Complaints cannot be unambiguously verified even in a specialized physical or psychological examination [11].

Insurance fraud related to whiplash injuries is a widespread problem worldwide. Whiplash injury is easy to fake and difficult to disprove, leading to a high proportion of fraudulent claims. As there are usually no demonstrable pathoanatomical signs to be detected, WAD patients have a poor reputation [12]. This scheme poses another challenge for the clinical evaluators in order to differentiate the injured people from the uninjured ones.

Evaluators have classically relied upon visual inspection or inaccurate tools such as the goniometer, however these tend to reflect the subjective beliefs of the evaluator [13]. New trends among the professionals trained in biomechanics are surpassing this way of evaluation, promoting accurate tools such as photogrammetric systems or accelerometry [14–17]. Photogrammetric systems constitute a good source for this information, nevertheless their cost and high dependency on trained human resources make them unaffordable for widespread clinical use. There is a need for a cheaper evaluation system which can yield as much accuracy as a photogrammetric system. Inertial motion unit systems (IMUs) have demonstrated clinical validity in other joints in static and dynamic assessments of the range of motion [16]. However, the other systems rely only on the use of one recording probe and, therefore, the movement of other parts of the body artifacts can occur. The use of two reference probes could solve this problem [18,19].

Furthermore, despite the use of such tools, a good standard to compare the obtained results with is also needed.

The American Medical Association (AMA) guidelines of cervical range of motion (ROM) constitute one of the first intents to determine how much ROM should be expected in the cervical spine of an individual [20]. These guidelines have widespread use amongst clinical practitioners and legislators but are flawed in their understanding of human physiology. The AMA reference values just offer cut-offs for the minimal ROM to be expected for the cervical spine, and do not take into account variability present in the general population nor the loss of ROM due to aging [21]. With multiple studies reporting that age and the previous health status are main risk factors for the development of chronic WAD [22], it seems of great importance to adjust the references of movement to the variability present in the common population. These new references should include enough individuals in each age group to act as representative normative data of the population. Some authors have presented normative data from the cervical spine [21,23–25], however, it remains unknown if these normative data can be used across populations from different countries.

This article has three main purposes:

- To assess if the selected IMU system is valid for clinical practice.
- To assess if the use of different ROM reference values will render different results to the AMA ROM guidelines.
- To determine the cut-off where the ROM should be considered pathologically limited. Over 90% of healthy subjects should be considered as healthy.

2. Materials and Methods

2.1. Study Design

This study was divided into 2 phases. In the first phase, the precision of the measuring device was clinically validated, and in the second one, a case-control study was conducted to face the other 2 objectives.

A total of 55 subjects were initially measured for the validation phase of the study. To address how many more subjects would be needed, sample size calculations were performed with preliminary data.