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SYSTEMATIC REVIEW

Non-invasive methods of computer vision in the posture evaluation of adolescent idiopathic scoliosis

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Summary *Purpose:* Reviewing techniques for non-invasive postural evaluation of adolescent idiopathic scoliosis (AIS) based on information extraction from images based on computer methods.
Methods: The Scopus, Web of Science, MEDLINE, ScieLo and PubMed databases were used, for the period 2011–2015.
Results: 131 articles were found based on keyword of which 15 articles met the established eligibility criteria. Of these, 4 were based on photogrammetry, and 11 based on laser, structured light, ultrasound, and Moiré projection. In these studies, the methodological quality varied from low to high.
Conclusions: The findings indicated diversity in methodologies; 14/15 articles reviewed were limited to the evaluation of the topography of the posterior back. A study, using two-dimensional photogrammetry, presented a whole body postural evaluation. As the asymmetry

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in AIS can be extended to the whole body, more attention should be given to develop full body assessment techniques to provide important additional data to aid in treatment decisions.

Introduction

The vertebral spine is the main structure of loading and load distribution in the human body (Panagiotopoulou, 2009), which under pathological or dysfunctional conditions, may be subjected to adaptive alterations in search of equilibrium (Stemper et al., 2010). The basic condition for correct posture is minimum stress; however, if this stress is increased for some reason, adaptive postural configurations can arise (Filipovic and Ciliga, 2010). Adolescent idiopathic scoliosis (AIS) is a highly complex spinal disease, whose main feature is an impairment of the spinal structure generating important changes in load distribution. It is considered the most common vertebral deformity in the world. It affects 2%—4% of young individuals, predominantly female, during the process of bone maturation (Driscoll et al., 2009; Komeili et al., 2014; Han et al., 2015). The main characteristic of AIS is a three-dimensional (3D) alteration in the alignment of the vertebral segments, which may lead to biomechanical changes along the entire corporal structure. The position of a vertebral segment affects other segments as well as the whole body posture (Smidt et al., 1984). It is not rare and has great esthetical impact, leading the young individuals to serious physical and psychosocial disturbances (Han et al., 2015). Cranial and pelvic adaptations are commonly found in cases of AIS. In a review study (Saccucci et al., 2011), the authors concluded that there is plausible evidence for an increased prevalence of unilateral Angle Class II malocclusions associated with scoliosis, and an increased risk of lateral crossbite and midline deviation in children affected by scoliosis. In addition, associations found between a reduced range of lateral movements and scoliosis are convincing.

The causes of AIS have not yet been well established. In any case, it is known that, regardless of the reason causing the deformation, its progress is a question of biomechanics (Van der Plaats et al., 2007). According to Kowalski et al. (2014), monitoring tests of body posture in schoolchildren revealed that 50—60% of adolescent schoolchildren had postural abnormalities, with 10% of this group at risk of progressive spine deformity. According to Cheung et al. (2015), early screening and observation of scoliosis can apparently mitigate the surgical risk. Furthermore, a timely diagnosis of AIS prevents an excessive progression to a pathological postural adaptation.

Since the 1940's, the X-ray exam, using the Cobb angle, has been considered the gold standard in the diagnosis and follow-up of the aforementioned vertebral alteration in youths (Komeili et al., 2014). Based on radiological evaluations, only 10% of the scoliosis cases will require some type of treatment. In routine medical conduct, a scoliosis with a Cobb angle from 10° to 20—25° is considered "light", and requires no treatment but only radiological follow-up to monitor the evolution of the curve; an angle from 25° to 40—45° is considered "moderate", and conservative treatment using a brace is recommended; and an angle greater than 45—50° is considered to be "serious", and surgical intervention is indicated for vertebral correction and stabilization (Bettany-Saltikov et al., 2012; Komeili et al., 2015). Despite its high relevance in the diagnosis of the deformity, the use of this exam has suffered increasing criticism. Many studies have presented (Enríquez et al., 2014) and demonstrated the deleterious effects on the young from the innumerous sessions of ionizing radiation to which they are subjected for the scoliosis control (Levy et al., 1994; Goldberg et al., 1998; Doody et al., 2000; Bone and Hsieh, 2000; Ron, 2003; Berrington de Gonzales and Darby, 2004). Additionally, the X-ray exam, being mainly an exam of pathological diagnosis, is not an adequate tool for the evaluation of the biomechanical dysfunction related to the unbalance of vertebral curves, which is explained by kinetic and kinematic variables. Complementary postural exams, which permit the investigation of this postural asymmetries, do not constitute as common practice in the monitoring and follow-up of scoliosis. Postural assessment is a standard and essential component of examining individuals with neuromusculoskeletal disorders (Brink et al., 2011). Similar values of Cobb angles may present very distinct whole postural asymmetries, and significant asymmetries may be associated to low Cobb angles. Hence, most cases of scoliosis are classified as "light" and are considered not eligible for medical treatment, even when being associated with multiple asymmetries in several body segments. Han et al. (2015), in a study on the quality of life of postoperative patients with scoliosis, stated that the radiological exam should no longer be the only therapeutic indicator in AIS, and that new systems of evaluation should be developed focused on the quality of life of the patients.

Posture and posture asymmetries

In 1947, the American Academy of Orthopedic Surgeons defined posture as "... the relative arrangement of parts of the body, where muscular and skeletal equilibrium is responsible for adequate positioning and muscular efficiency" (Subasi, 2014). The position of one segment affects other segments and the overall posture (Magee, 1992). Corporal plane asymmetries are frequently associated to inadequate loading of the musculoskeletal structure, and in many cases may represent a risk of pain and lesions (Singla and Vegar, 2014, 2015). Idiopathic scoliosis is characterized by the presence of significant asymmetries in the structure of the trunk, in addition to asymmetries that extend to the entire body. However, a well-defined pattern for these

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