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Review

Effects of contracture on gait kinematics: A systematic review

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ABSTRACT

Background: Contractures of a major joint in the lower limbs may impair human walking in addition to other daily living activities. A contracture is defined as the inability of a joint to perform the full range of motion and excessive resistance during passive mobilization of the joint. Few studies have reported methods describing how to evaluate contractures. Understanding the association among all of these studies seems essential to improve patient management. Therefore, we conducted a systematic review on this topic to elucidate the influence of contractures on gait kinematics.

Methods: An electronic search in the literature will be conducted. Studies were screened by title and abstract and full texts were evaluated secondarily for definitive inclusion. The quality of the included studies was assessed independently by the two review authors with the Modified Quality Assessment Checklist. The included studies were separated into three categories: pathological contracture versus healthy controls (descriptive), simulated contracture versus healthy controls (experimental), and pre- and post-kinematics after surgical muscle lengthening (surgery).

Findings: From a total of 4402 references, 112 original articles were selected, and 28 studies were identified in this systematic review. No significant difference between raters was observed on the total score of the Modified Quality Assessment Checklist.

Interpretation: Contractures influence walking depending on the location (muscle) and the contracture level (muscle–tendon length). After giving a definition of contracture, this review identified some contracture alterations, such as plantarflexion, knee flexion and hip flexion contractures, with a kinematic description and presented possible different compensations.

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1. Introduction

A contracture is defined as the inability of a joint to perform the full range of motion and excessive resistance during passive mobilization of the joint (Gaudreault et al., 2009). The structures involved in contractures include ligaments, capsule, tendons and muscles for which the extensibility is limited and the stiffness is increased (Prabhu et al., 2013). Moreover, Perry and Burnfield (2010) differentiate between elastic and rigid contractures. An elastic contracture yields to the forceful stretch of an examiner or body weight, whereas a rigid contracture resists considerable force (stiffness) and is able to support body weight. Causes of contracture can be a result of different factors. Generally, a contracture is a common complication of many neurological and musculoskeletal conditions (Prabhu et al., 2013).

Contractures of a major joint in the lower limbs may impair human walking in addition to other daily living activities (Hoang et al., 2014; Prabhu et al., 2013).

Contractures have a high incidence in neurological and orthopedic conditions (Farmer and James, 2001), including ligament and joint capsule shortening, intra-articular adhesions, fibro-fatty tissue proliferation into the joint and muscular shortening (Fox et al., 2000), muscle retraction, tendinous adherence, skin or subcutaneous tissue loss, joint capsule thickening or a combination of these factors (Roberson and Giurintano, 1995). The primary factors that cause suffering from contractures are burns, spinal cord injuries, cerebral palsy, strokes, and advanced age (Hoang et al., 2014). The association among contracture, muscle weakness and spasticity is generally accepted, although it has not been demonstrated scientifically (Hoang et al., 2014).

The main effect of contractures is a limitation of joint range of motion resulting from soft tissue stiffness (Hoang et al., 2014), but contractures can also cause pain, sleep disturbances, pressure ulcers, and deformities (Fox et al., 2000; Prabhu et al., 2013). A limited range

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of motion affects mobility and daily life activities. Among these activities, walking is a primordial activity of daily living. Patients and therapists ranked "moving around indoors" as the most important activity to preserve/restore in patients (Chiou and Burnett, 1985). Contractures induce gait deviations and limit a person's ability to walk (Hoang et al., 2014). In children with Duchenne muscular dystrophy, joint contracture represents the second most often occurring major clinical impairment that results in gait deviations (Gaudreault et al., 2009). In cerebral palsy, the commonest orthopedic deformity is equinus deformity caused by the contracture of the triceps surae (Galli et al., 2005). To choose the best therapeutic strategy in relation to gait deviations, it is mandatory to understand the gait deviations and to distinguish the primary deviation (directly resulting from the pathology) and the secondary deviation (compensatory mechanisms) (Schmid et al., 2013). Therefore, understanding the effects of contractures on gait deviations is important to support the therapeutic choice. In the literature, different approaches have been used to elucidate the effect of contractures on gait.

The first approach is to compare the gait patterns between persons with contractures and matched healthy persons (Gaudreault et al., 2009; Svehlik et al., 2010b). The second approach is to replicate the gait patterns of a patient with contractures by having healthy participants imitate the gait patterns. To this end, the investigators ask the participants to replicate the gait pattern by imitating patients with contractures, e.g., to walk on their tiptoes to imitate a triceps contracture (Romkes and Brunner, 2007). The third approach is to replicate the gait patterns of a patient with contractures in healthy participants by induced constraints. In this case, the healthy participants are constrained in certain joint degrees of freedom with an exoskeleton (Matjacic and Olensek, 2007; Matjacic et al., 2006) or an orthosis (Houx et al., 2012, 2013). The fourth approach is to use a computer simulation to evaluate the effects of constraints induced by contractures on gait (Goldberg and Neptune, 2007; Hicks et al., 2008; Neptune et al., 2007). Finally, the fifth approach is based on the comparison of a patient's gait before and after treating the contracture (Baddar et al., 2002; Chimera et al., 2012; Galli et al., 2005, 2009; Hemo et al., 2006; Kadhim and Miller, 2014; Lofterod and Terjesen, 2008; Park et al., 2006; Tylkowski et al., 2009). These studies have demonstrated the importance of studying this subject. Associating these studies seems essential to improve patient management. Therefore, we conducted a systematic review on this topic to elucidate the influence of contractures on gait kinematics.

2. Methods

2.1. Search strategy

To provide a comprehensive overview of the literature, an electronic search will be conducted within the following databases: MEDLINE/PubMed, from January 1948 to July 2014; CINHAL (EBSCO), from January 1981 to July 2014; and EMBASE, from January 1980 to July 2014. In addition, the references of included studies will be searched to identify further studies. The search strategy will encompass the following search terms: contracture, muscle shortening, muscle length, range of motion, joint flexibility, kinematics, biomechanics, walking, gait, and locomotion. The search strategy for the databank MEDLINE will look as follows: #1 (#contracture OR # contracture* OR # muscle shortening OR # muscle length* OR # range of motion OR # joint flexibility); #2 (#kinematics OR # biomechanics); #3 (#walking OR # gait OR # locomotion); and #4 (#1 AND #2 AND #3).

2.2. Inclusion and exclusion criteria

Studies were screened by title and abstract following the rules of inclusion and exclusion criteria (Table 1). Full texts were evaluated secondarily for definitive inclusion. Two categories were selected to keep a maximum of articles, embracing concerned fields. The inclusion criteria contained articles about patient and healthy controls, as well as the simulation of contracture by different means. This review also included studies about muscle lengthening surgical intervention; these studies observed the pre- and post-outcome on gait kinematics. Two review authors independently screened the titles and abstracts. Disagreements were resolved by discussion until consensus, and when necessary, a third author arbitrated. Next, reviewers subsequently independently assessed the full-length reports for eligibility of the studies based on the inclusion and exclusion criteria. Disagreements were also discussed and arbitrated by a third author if necessary.

2.3. Data extraction and quality assessment

The two review authors independently extracted data from the included studies with a customized form. The following data were extracted: study design or aim, study population characteristics (diagnosis, age, sample size), parameters evaluated (kinematics, kinetics, EMG, etc.), major joints assessed and/or device, and main results (especially kinematics).

The quality of the included studies was assessed independently by the two review authors with the Modified Quality Assessment Checklist (Schmid et al., 2013). The checklist was first described by (Downs and Black, 1998). The authors developed this tool to assess the quality of randomized and non-randomized trials. It has a high internal consistency, good test–retest and inter-rater reliability, and good face and criterion validity. The checklist was modified to assess the quality of non-randomized observational studies (Schmid et al., 2013). The included studies are evaluated with 17 items with a total maximum score of 20 points. These 17 items were then classified in 5 categories and evaluated as follows: reporting quality (8 items, maximum 10 points), external validity (3 items, maximum 3 points), internal validity — bias (3 items, maximum 3 points), internal validity — confounding (2 items, maximum 2 points), and statistical power (1 item, maximum 2 points).

2.4. Data analysis

The extracted data were analyzed in a qualitative manner. The included studies were separated into three categories: pathological contracture versus healthy controls (descriptive), simulated contracture versus healthy controls (experimental), and pre- and post-kinematics after surgical muscle lengthening (surgery). Given that it is difficult to assess the contribution of a single surgery during a multi-level surgery (Lofterod and Terjesen, 2008), we investigated only single surgeries.

Table 1
Inclusion and exclusion criteria.

	Inclusion	Exclusion
Population	Contractures or simulated contractures and healthy controls. Pre-intervention (muscle lengthening) versus post-intervention	Acute contracture, sportsmen, animal Splint as treatment, or splint with pathology
Intervention	Observation, evaluation, interpretation, Clinical Gait Analysis	Cast, splint, stretching, botulinum toxin, multi- surgery
Outcome	Kinematics, gait deviations, compensations	No kinematics
Type of study	Original research, published in peer-reviewed scientific journals, case-study research (observational)	Conference abstracts, non peer-reviewed publications, single case, systematic review.

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