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Review

Gait kinetics in children with clubfeet treated surgically or with the Ponseti method: A meta-analysis

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ABSTRACT

Background: Currently, the Ponseti method is the gold standard for treatment of clubfeet. For long-term functional evaluation of this method, gait analysis can be performed. Previous studies have assessed gait differences between Ponseti treated clubfeet and healthy controls.

Research question/purpose: The aims of this systematic review were to compare the gait kinetics of Ponseti treated clubfeet with healthy controls and to compare the gait kinetics between clubfoot patients treated with the Ponseti method or surgically.

Methods: A systematic search was performed in Embase, Medline Ovid, Web of Science, Scopus, Cochrane, Cinahl ebsco, and Google scholar, for studies reporting on gait kinetics in children with clubfeet treated with the Ponseti method. Studies were excluded if they only used EMG or pedobarography. Data were extracted and a risk of bias was assessed. Meta-analyses and qualitative analyses were performed.

Results: Nine studies were included, of which five were included in the meta-analyses. The meta-analyses showed that ankle plantarflexor moment (95% CI -0.25 to -0.19) and ankle power (95% CI -0.89 to -0.60, were significantly lower in the Ponseti treated clubfeet compared to the healthy controls. No significant difference was found in ankle dorsiflexor and plantarflexor moment, and ankle power between clubfeet treated with surgery compared to the Ponseti method.

Significance: Differences in gait kinetics are present when comparing Ponseti treated clubfeet with healthy controls. However, there is no significant difference between surgically and Ponseti treated clubfeet. These results give more insight in the possibilities of improving the gait pattern of patients treated for clubfeet.

1. Introduction

A clubfoot (talipes equinovarus) is a three dimensional congenital deformity of the foot involving equinus, varus, adductus, and cavus [1]. The goal of treatment is to correct clubfeet and come to a functional, pain-free foot with good mobility and no need to wear modified shoes [2]. Initial severity and short-term treatment success is often evaluated with the Pirani and/or Dimeglio score [3,4]. For long-term functional evaluation of treatment gait analysis focusing on gait kinetics and kinematics is frequently applied [5]. Gait kinematics describe the motion of body segments during the stance and swing phase of the gait cycle [6]. This includes the position and orientation of body segments, the angles of the joints, and the corresponding velocities and accelerations [6]. Gait kinetics give information about the contribution of the muscle groups to a movement and is often reported as joint moment, power, and work [6]. Joint moments determine the amount of force that is produced by a muscle group around a joint and are defined as the force multiplied by the moment arm of the muscle. Work in a joint is the mechanical energy produced by the muscle during a movement. Joint power is the rate at which this mechanical energy is produced. Differences in gait characteristics can lead to an impaired gait pattern, including a lower walking speed, impaired push-off, and less balance [7–9]. Information on impaired gait characteristics are important for setting out targeted treatment for the patient, for example physiotherapy or secondary surgery.

Previous studies show that clubfeet initially treated by extensive

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surgery – i.e., posteromedial release – show differences in gait kinematics and kinetics compared to healthy controls [10–12]. Differences in gait kinetics include for example lower ankle plantarflexor moment and lower ankle power [13–16]. Nowadays, the Ponseti method is the gold standard for the treatment of clubfeet [17,18]. The Ponseti method is a less-invasive method that uses several plaster casts, mostly combined with an Achilles tenotomy, followed by a brace period until the age of four to maintain the foot in the corrected position [12]. High success rates based on clinical examinations and surveys, including a functional foot with good mobility, are reported as the outcome of the Ponseti treatment [19–22]. However, small but distinct differences in gait kinematics and kinetics compared to healthy controls do exist [e.g., [23,24]. It is unclear what causes the differences in gait kinetics between treated clubfeet patients (surgical or with the Ponseti method) and controls. Lower ankle power and ankle moment could be secondary to triceps surae insufficiency as a result of surgical interventions [12,25]. Furthermore, these kinetic differences could also be influenced by a lower ankle range of motion, for example as a result of a flat top talus [26].

A clear systematic overview of the effectiveness of the Ponseti method in terms of long-term correction of clubfeet and resulting in a functional, pain-free foot with good mobility and no need to wear modified shoes, is not available yet. Several studies assessed differences in gait characteristics, between children treated for clubfeet with the various methods and between children treated for clubfeet and healthy controls, as a measure of functional outcome of clubfoot treatment. This systematic review aims to (1) determine the differences in gait kinetics between children treated for clubfoot deformities with Ponseti and healthy controls and (2) determine the differences in gait kinetics between clubfoot patients treated with the Ponseti method or by extensive surgery, in an attempt to give more insight in the functional outcome of the Ponseti method as primary treatment for clubfeet.

2. Methods

2.1. Protocol and registration

The systematic review was reported and conducted according to the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines [27,28]. Study protocol was registered with International Prospective Register of Systematic Reviews (PROSPERO) with registration number CRD42015029715.

2.2. Eligibility criteria

Randomized Controlled Trials, retrospective and prospective follow-up studies, and cross-sectional studies comparing kinetic gait parameters of patients with clubfeet with healthy controls or comparing kinetic gait parameters of clubfoot patients treated with different interventions were considered. Studies were only included if they studied at least clubfeet treated with the Ponseti method. A minimum number of five participants per group was set. Studies using only pedobarography or EMG and systematic reviews or conference abstracts were excluded.

2.3. Information sources and search

An experienced information specialist performed the systematic search, until June 8th 2018 in Embase, Medline ovid, Web of Science, Scopus, Cochrane, Cinahl ebsco, and Google scholar (Appendix A shows the full Embase search as an example). Language was restricted to English, Dutch, and German. Search terms comprised of synonyms of clubfeet, treatment, gait analysis, and children. Furthermore, references of all included studies were manually searched. Duplicated articles were removed prior to study selection.

2.4. Study selection

Titles and abstracts of the search results were assessed for eligibility by two independent researchers (LO and MS). In a second step, full text of selected articles were checked for in- and exclusion criteria. A third reviewer (HK) was consulted in case of absence of consensus after reading the full text articles.

2.5. Data collection process and data items

One data extraction form was created and used by two researchers (MS and MT) to extract data of the included studies. Besides study characteristics, all reported kinetic outcome measures of the included studies were extracted. The main outcome measures were internal joint moment, impulse, power and work at the ankle, knee, and hip. A third researcher (LG) checked the extracted data for accuracy.

2.6. Risk of bias in individual studies

Two reviewers (MR and BV) independently assessed the individual studies for risk of bias. The Dutch checklist form for prognosis (Cochrane Netherlands) was used, applied with modifications to the items set to relevance of the current study objectives. Table 1 represents the risk of bias summary including checklist items. Items could be scored with 'low risk' (+), 'high risk' (-), or 'unclear' (?). The forms were then compared and discussed for final consensus.

2.7. Data syntheses and analysis

Qualitative synthesis in which outcomes were compared in a descriptive manner was performed on outcome measures discussed in two or less studies. Outcome measures reported in at least three studies

Table 1
Risk of bias of the included studies.

	No participant selection took place	Groups are comparable regarding age	Validated measuring system used	Independent (blind) determination of outcomes	Clear description of groups available
Church 2012 [12]	+	+	+	?	?
Duffy 2013 [29]	?	−	+	?	−
Jeans 2015 [24]	?	+	+	−	+
Karol 2009 [30]	−	+	+	?	+
Lööf 2016 [33]	?	+	+	?	?
Lööf 2017 [34]	?	+	+	?	+
Manousaki 2016 [25]	+	?	+	?	?
Mindler 2014 [31]	?	+	+	?	?
Smith 2014 [32]	−	−	+	−	−

+: low risk.
−: high risk.
?: unclear.