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Review

Gait and gait-related activities of daily living after total hip arthroplasty: A systematic review

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ABSTRACT

Background: Differences in the performance of gait and gait-related activities of daily living are known to persist after total hip arthroplasty compared to healthy controls, but the specific underlying deficits (spatiotemporal, kinematics and kinetics) are not completely understood. This review aimed to map the differences between patients and controls, and between the operated and non-operated limbs during various activities of daily living.
Methods: A computerized search with broad search terms was performed in the MEDLINE database. Primary inclusion criteria were: primary osteoarthritis as indication, comparison with healthy controls or comparison between the operated and the non-operated limbs, and follow-up period at least six months after surgery.
Findings: The literature search yielded 2177 citations, of which 35 articles were included. Compared to controls, reductions were identified in the operated hip in sagittal range of motion, peak extension, sagittal power generation, abduction moment and external rotation moment. During stair ascent, these reductions did not become more apparent, although deficits in hip kinetics in all three planes were found. Walking speed and step length were reduced compared to controls at longer-term follow-up, but not at short-term follow-up.
Interpretation: The hip abduction moment deficit was present both in level walking and in stair ascent in total hip arthroplasty patients compared to controls. Reduced sagittal hip power generation and external rotation moment were also found, of which the clinical relevance remains to be established. Due to a low number of studies, many of the longer-term effects of THA on gait and gait-related ADL are not yet accurately known.

1. Introduction

Total hip arthroplasty (THA) is a surgical procedure commonly performed in patients with osteoarthritis. Even though THA is very successful in achieving its primary objective of relieving pain (Bennett et al., 2009), functional limitations may persist after surgery (Johanson et al., 1992; Laupacis et al., 1993). The ability to successfully perform common activities of daily living (ADL) is important for safe mobility, societal participation, and ultimately, quality of life. It is not surprising that besides pain, limitations in ADL (e.g. reduced ability to walk and to negotiate stairs) are important complaints in patients before THA (Wright et al., 1994). After THA, the ability to perform ADL generally improves (Foucher et al., 2008; Lamontagne et al., 2012; Shrader et al., 2009), but some activities such as stair climbing and rising from a chair may still be challenging (Foucher et al., 2008; Talis et al., 2008).

The outcome of THA is traditionally measured with clinical scoring systems such as the Merle d'Aubigné and Postel score (D'Aubigne and Postel, 1954) and the Harris hip score (Harris, 1969). These scoring systems are subjective, and do not include objective measurements of human functioning. Thus, in order to obtain a complimentary objective evaluation of function after hip surgery, it is necessary to employ quantitative measurement techniques such as gait analysis (Lindemann et al., 2006; Nantel et al., 2009; Rosler and Perka, 2000; Saleh and Murdoch, 1985). Such instrumented methods can also be employed to measure other ADL, such as stair negotiation, chair rising and sitting, and stepping over obstacles.

Walking after THA has been extensively investigated. Generally, walking is known to improve after THA, but does not reach a level that would be considered normal (Bennett et al., 2006, 2009; Foucher et al., 2007; Perron et al., 2000). Ewen et al. summarized the findings

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of seven studies in this area in a review and meta-analysis, and found reductions in walking velocity, stride length, sagittal hip range of motion (RoM) and hip abduction moment, whilst hip flexion and extension moments were increased compared to healthy controls (Ewen et al., 2012). In spite of those comprehensive findings, many kinematic and kinetic parameters were not included. Moreover, several interesting studies have been published since and a number of relevant issues remained unaddressed.

First, walking at self-selected comfortable speed arguably does not reflect a patient's full motor capacity. Other functional tasks may be more suitable to test performance at higher capacity levels and thereby identify possible functional limitations. Other gait-related ADL (e.g. stair negotiation) may place different or higher demands on the operated limb compared to level walking (Aqil et al., 2013; Chamnongkich et al., 2012; Foucher et al., 2008; Lamontagne et al., 2012; Shrader et al., 2009). Yet, research into other ADL besides level walking has been scarce in patients who underwent THA (Aqil et al., 2013; Benedetti et al., 2010; Chamnongkich et al., 2012; Foucher et al., 2008; Lamontagne et al., 2009, 2011a, 2011b, 2012; Majewski et al., 2005; Perron et al., 2003; Queen et al., 2013; Shrader et al., 2009; Stansfield and Nicol, 2002; Talis et al., 2008; Vissers et al., 2011), and the findings have not previously been categorized, interpreted or summarized.

Second, many studies comparing gait characteristics between THA patients and controls did not match walking speeds between the groups. As walking speed influences kinematic and kinetic gait parameters (McCrory et al., 2001; Mockel et al., 2003; Perron et al., 2000), previously reported differences after THA might have in fact been epiphenomena of a reduced walking speed. Several recent papers, therefore, reported group comparisons at matched or imposed walking speeds, whereas other studies investigated differences in gait parameters between the operated and the non-operated limbs. The latter methodology may reveal compensatory strategies implemented by the non-operated limb.

The primary goal of this review was to provide an overview of the differences in spatiotemporal, kinematic and kinetic parameters between patients who underwent THA more than six months ago and healthy controls, and between the operated and non-operated limbs of the patients during gait and gait-related ADL. The secondary goal was to define areas to be focused on in rehabilitation protocols as well as in future research.

2. Methods

2.1. Eligibility criteria

Studies were eligible if they 1) included THA patients with primary osteoarthritis as the indication for surgery, 2) reported spatiotemporal and/or kinematic and/or kinetic parameters during gait or gait-related ADL, 3) compared the results with a control group of healthy subjects or compared the operated limb with the non-operated limb, and 4) had a follow-up period of at least six months post surgery. Our argument for the latter criterion was that most improvement in gait is generally reported to be achieved within that time frame, which was based on a preliminary literature search before the review was performed (Casartelli et al., 2013; Lavigne et al., 2010; Nantel et al., 2009; Perron et al., 2000; Rasch et al., 2010). Furthermore, most rehabilitation programmes end at six months or sooner, after which the rate of recovery is presumed to decrease (Nantel et al., 2009; Perron et al., 2000; Sicard-Rosenbaum et al., 2002).

Studies were excluded if the control group was not comparable with regard to age (within ten years). In addition, the language of the publication had to be English, Dutch or German. Furthermore, comments, guidelines, abstracts, protocols and review studies were excluded. Selection of studies was unconstrained regarding subject age and sex, type of implant used and surgical approach.

2.2. Literature search

A computerized literature search was conducted in the MEDLINE database on July 8th, 2013. The search strategy was based on medical subject headings (MeSH) terms, words in the title or abstract, and Boolean operators, and was phrased as follows: (Postoperative Period [MeSH] OR Posture [MeSH] OR Postural Balance [MeSH] OR Movement [MeSH] OR chair [tiab] OR sit [tiab] OR sitting [tiab] OR Stair [tiab] OR Gait [tiab] OR Stairs [tiab] OR obstacle [tiab] OR obstacles [tiab] OR barrier [tiab] OR barriers [tiab]) AND (hip arthroplast*[tiab] OR Total Hip[tiab] OR Hip Replacement[tiab] OR Hip Prosthesis[tiab] OR "Arthroplasty, Replacement, Hip"[Mesh]).

These broad search terms were used to minimize the chance of missing relevant articles. Additionally, the reference lists of eligible articles were scanned for potentially relevant articles, missed by the computerized search.

2.3. Selection procedure

The titles and abstracts of the studies found by the literature search and the scanning of reference lists were screened on possible eligibility for inclusion by SK, MM and GB. In the case of disagreement about inclusion, an independent reviewer, VW, was consulted. The study was discussed until complete consensus was reached.

2.4. Data extraction

A predefined data extraction form was used to aid in extracting data from included papers. This form included data fields of follow-up period, surgical approach, number of patients and controls, age of patients and controls, and reported outcome measures.

2.5. Primary outcomes

The primary outcome measures investigated in this review were spatiotemporal, kinematic and kinetic parameters during gait and gait-related ADL. If a parameter was reported in fewer than three studies, we chose not to include it in this review. Spatiotemporal parameters were walking speed, stride length, cadence, step length, stance duration, single support time, double support time, step width and cycle duration. Kinematic parameters comprised hip RoM in the sagittal plane, peak hip flexion and extension angles, hip RoM in the frontal plane, peak hip abduction and adduction angles, and pelvic tilt RoM. Kinetic parameters were peak hip flexion and extension moment, peak hip power generation and absorption in the sagittal plane, peak hip abduction and adduction moment, peak hip external and internal rotation moment, and total hip power generation.

3. Results

3.1. Study inclusion

The study screening and inclusion process are shown in Fig. 1. Of the 35 included articles, 28 investigated gait and seven investigated stair negotiation. Sit-to-stand/stand-to-sit and ramp ascent/descent were each investigated by one study. The study characteristics are listed in Table 1. Some studies performed subgroup analyses for patients operated on by different surgical approaches (Kiss and Illyes, 2012; Varin et al., 2013), implant varus/valgus angles (Hodge et al., 1991), or follow-up times (Berman et al., 1991; Kiss and Illyes, 2012; Lavigne et al., 2010). In those cases, the findings were split accordingly and treated as separate results. Some studies used data from the same patient cohort (e.g. Lamontagne et al., 2009, 2011a), in which case the findings were combined.