Gait & Posture 50 (2016) 151–158

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Full length article

High-demand motor tasks are more sensitive to detect persisting alterations in muscle activation following total knee replacement

Pieter Severijns[a,b,c,*], Manon Vanslembrouck[c], John Vermulst[c], Barbara Callewaert[d], Bernardo Innocenti[e], Kaat Desloovere[c,d], Hilde Vandenneucker[a,b], Lennart Scheys[a,b]

[a] Institute for Orthopaedic Research and Training (IORT), University Hospitals Leuven, Belgium
[b] Department of Regeneration and Development – Organ Systems Cluster, KU Leuven/Division of Orthopaedics, University Hospitals Leuven, Belgium
[c] Department of Rehabilitation Sciences, KU Leuven, Leuven, Belgium
[d] Clinical Motion Analysis Laboratory, University Hospitals Leuven, Belgium
[e] BEAMS Department (Bio Electro and Mechanical Systems), École Polytechnique de Bruxelles, Université Libre de Bruxelles, Brussels, Belgium

ARTICLE INFO

Article history:
Received 4 January 2016
Received in revised form 5 August 2016
Accepted 5 September 2016

Keywords:
Total knee replacement
Osteoarthritis
Kinetics and kinematics
Electromyography (EMG)
Functional motor tasks

ABSTRACT

Knee osteoarthritis is one of the most frequent indications for total knee replacement (TKR). Unfortunately, many patients still have difficulties during daily life activities after TKR. As the underlying causes of these difficulties are still not fully understood, especially with regard to the role of aberrant muscle activation profiles, the purpose of this study was to examine to what extent muscle activation patterns return to normal after TKR. Furthermore, we aimed to further discuss remaining differences by linking them to pre- and post-operative measurements of the knee and hip kinetics and kinematics during multiple functional motor tasks.

Therefore, muscle activity, kinetics and kinematics of knee and hip were measured and analyzed in seven patients during a number of functional tasks by using electromyography and three-dimensional motion analysis. Measurements were performed one week before and one year after surgery. Results were compared to seven matched healthy controls. The analyzed functional tasks included walking at self-selected speed, walking followed by a crossover and a sidestep turn, step descent and ascent.

This study suggested that, while muscle activation profiles in patients one year after TKR did return to normal during walking, this was not the case during more demanding motor tasks. These findings may have direct implications for the design of future rehabilitation programs in order to result in faster recovery and ultimately more functional patients after TKR.

1. Introduction

In 2008, 18439 patients received total knee replacement (TKR) in Belgium, mostly due to knee osteoarthritis (OA). In 2012 the number of TKRs reached 22070, an increase of 20% in four years [1]. Although TKR is generally seen as a successful treatment in OA, still one-third of these patients are predicted to have residual pain two years post-operatively [2]. Moreover, despite clinical improvements in muscle strength and range of motion (ROM), patients show persisting functional difficulties such as increased joint loading and altered muscle activation during gait [3]. Studies based on three-dimensional (3D) motion analysis showed that post-operatively, knee joint loading was increased during stance [4], and knee flexion was reduced during gait [5]. One year after TKR persisting asymmetrical movement patterns and weakness were still present, although improvements were observed compared to pre-operatively [6]. Despite these studies there is still a lack of insight in underlying causes and mechanisms of persisting functional difficulties following TKR.

Only few studies reported electromyography (EMG) measurements pre- and post-TKR during functional motor tasks. Mizner and Snyder-Mackler showed that asymmetry in quadriceps strength and recruitment was related to poor functionality with altered loading and movement patterns of both knees after TKR during gait and sit-to-stand [7]. Yoshida et al. demonstrated that three months after TKR muscle recruitment of the quadriceps in the operated limb was reduced during loading response [8]. Increased activity of trunk muscles during gait and prolonged activity of knee muscles during stance phase two years after TKR

* Corresponding author at: Weligerveld 1 blok 2, box 7001, 3012 Pellenberg, Belgium.
E-mail address: pieter.severijns@kuleuven.be (P. Severijns).

http://dx.doi.org/10.1016/j.gaitpost.2016.09.003
0966-6362/

were also reported, however only walking and stair climbing were assessed [3].

It can be concluded, there is lack of literature comparing pre- and post-operative results on muscle activity, kinetics and kinematics during functional motor tasks to healthy controls. Integrating functional tasks leads to a better view on functionality of patients after TKR, which is strongly related to their satisfaction [9]. Therefore, this study aims at improving our insight in the functionality of the knee joint both pre- and post-TKR by examining to what extent muscle activation returns to normal one year after TKR and compare these throughout a variety of functional motor tasks. Furthermore, we aimed to further explore persisting differences by linking them to pre- and post-operative measurements of knee and hip kinetics and kinematics. 3D kinematic, kinetic and EMG data were collected in patients, before and after TKR, and healthy controls during multiple daily life motor tasks.

2. Materials and methods

2.1. Subjects

Inclusion criteria were subjects scheduled for receiving a Genesis-II PS or Journey BCS version 1.0 knee replacement system (Smith&Nephew Inc., Memphis, TN, USA) due to end-stage unilateral symptomatic primary OA, aged between 55 and 70 years. Exclusion criteria were inflammatory arthritis, immunosuppressed, previous major knee surgery or total hip replacement, infection, BMI >30 and symptomatic contralateral knee-, hip-, ankle joint. Seven patients (3 male, 4 female; age: 61 ± 8; body-mass index (BMI): 25,7 ± 1,1) underwent measurements before and one year post-TKR and were matched to seven controls (4 male, 3 female; age: 62 ± 7; BMI: 24,5 ± 2,7) according to age and BMI. All subjects signed an informed consent.

2.2. Surface electromyography

EMG signals were received by a 16-channel zero-wire surface EMG system (Cometa, Milan, Italy), with a minimum frequency of 1000 Hz. The system was connected to a VICON Nexus workstation (Vicon Motion Systems, UK). Sixteen pre-gelled ECG foam electrodes (hydrogel, diameter 30 mm, sensor AG/AgCl) were used. The surface electrodes were placed on the center of the muscle belly parallel to the muscle fiber orientation. Measured muscles were Rectus Femoris (REF), Vastus Lateralis (VAL), Medial Hamstrings (MEH), Lateral Hamstrings (LBIF), Tibialis Anterior (TIA), Lateral Gastrocnemius (GAS), Soleus (SOL) and Gluteus Medius (GME) (Fig. 1a) according to an EMG protocol used in literature and in this laboratory [10].

2.2.1. EMG quality control

Quality control was performed using Polygon-Vicon software (Vicon Motion Systems, Oxford, UK). Two trained physiotherapists checked visually all individual EMG signals for artefacts. Trials with signals affected by baseline shifts, ECG artefacts and interfering power hum were excluded.

2.3. Motion analysis

3D motion analysis was performed using an optical data capturing system consisting of fourteen infrared MX40 cameras connected to a workstation running Nexus 1.7.1 (Vicon Motion

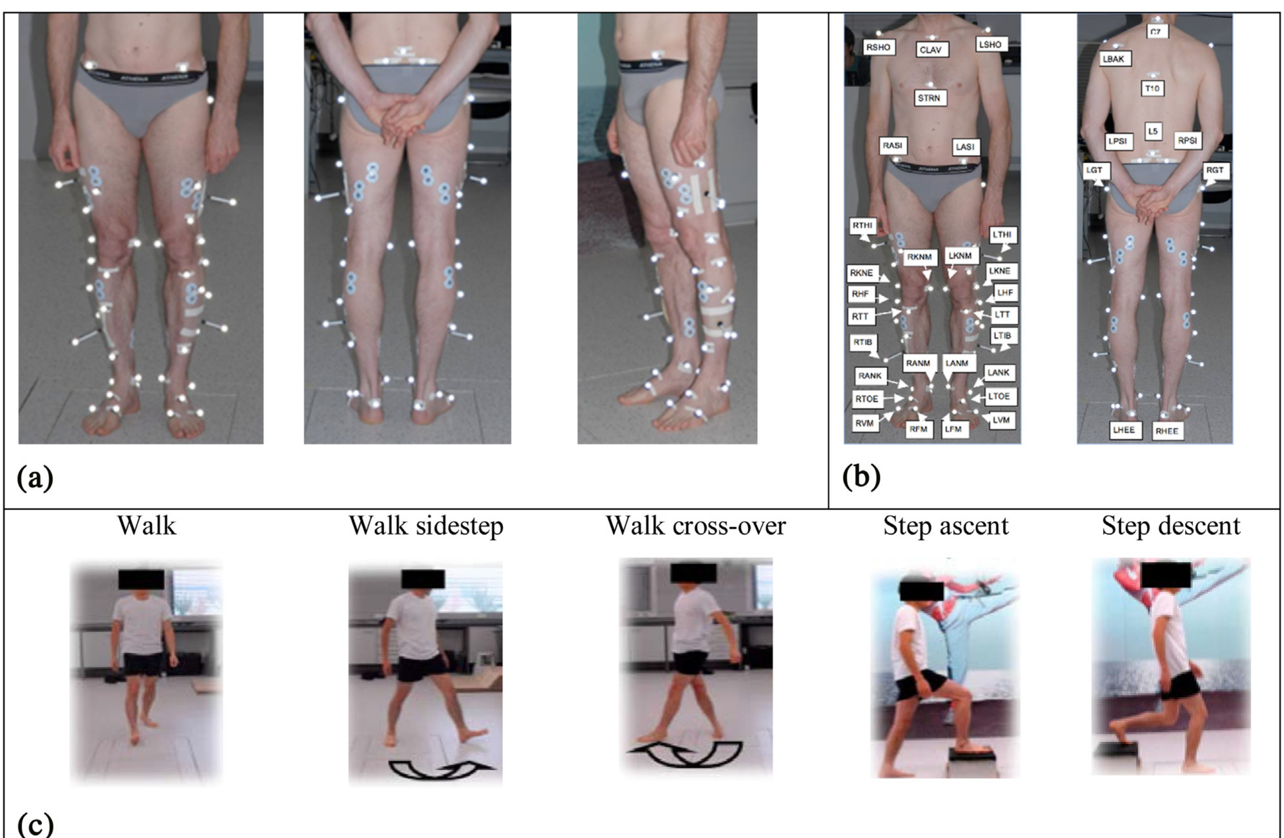

Fig. 1. Methodology for motion analysis (a) The locations of the 16 Pre-gelled ECG foam electrodes. (b) The locations of the retro-reflective markers. (c) The 5 analyzed motor tasks.