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MOTION ANALYSIS
EDITORIAL

Instrumental motion analysis: from the research laboratory to the rehabilitation clinic

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The purpose of this Special Section is to describe the state of the art in the clinical application of methods and instruments for the quantitative assessment of gait and motion of other body segments in people with motor disability.

Advanced technologies for motion analysis (MA) conventionally consist of stereophotogrammetric devices to measure body segments and joint kinematics, force plates for measuring forces at joints, electromyographic systems to evaluate muscular activity during motion. Appropriate protocols are used for human body capture, modelling and rendering of biomechanical information in clinically meaningful terms.[1-3]

Research in the field of human motion is very active, and many scientific papers are available both on methodological issues and on clinical research. While originally MA was widely used for assessing gait abnormalities (gait analysis, GA), clinical interest in the motion of other human body segments such as the upper extremities and the trunk has grown in the last few years and a number of scientific articles have been published.

Unfortunately, results of research have not always been systematically transferred to the clinic. Up to now, the use of MA techniques as a diagnostic tool able to influence the clinical decision-making process in a clinical context has been demonstrated only in a few pathologies, particularly gait abnormalities using GA in cerebral palsy children.[4-6]

The applied use of these advanced health technologies in clinical practice thus continues to be challenging. A list of research priorities in the field have been identified by the Research Committee of the Gait and Clinical Movement Analysis Society (GCMAS) [7, 8] in terms of efficacy of GA as a clinical decision-making tool and as a functional outcome measure, as well as in terms of education and data sharing.

In a previous EU project, CAMARC I-II (Computer Aided Movement Analysis in a Rehabilitation context) [9, 10] the potential of a standardised MA approach for clinical use had already been introduced. In recent years several reviews have been carried out to address research priorities in GA, investigating both data reliability [11] and proof of the effectiveness of GA as a clinical tool in specific groups of patients.[12-26]

Efforts are currently underway in countries with more experience in the gait analysis field, to guarantee quality standards in clinical services. A Consensus Conference on gait analysis in Rehabilitation was held in Italy, under the aegis of the Italian Society of Movement Analysis (SIAMOC, www.siamoc.it), the UK and Ireland movement analysis society (CMAS, http://cmasuki.org): Clinical Gait Analysis Standards were agreed. The US now have a Commission for Motion Laboratory Accreditation (http://www.cmlainc.org). Recently a master's degree programme in clinical movement analysis (www.CMAster.eu) was implemented.

To summarize the role MA plays in a clinical context, three main areas have been explored in terms of its ef-

fectiveness: support in decision making, improvement of outcome for patients, and reduction of health costs.[2]

The Commission for Motion Laboratory Accreditation defines Motion Analysis as "a standard diagnostic laboratory procedure present in many clinical facilities which treat patients with gait dysfunction or other disorders of human movement. The ultimate goal of these clinical laboratories is to evaluate individuals for quantifying their movement disorder and determining the specific anatomic, physiologic or functional cause of their movement pattern".

A recent review on GA [27] concluded that there is strong evidence for the technical, diagnostic accuracy, diagnostic thinking and treatment efficacy of gait analysis, also indicating some efficacy at the higher levels of patient outcomes and societal cost-effectiveness. However, it is not clear how advanced technologies for human motion analysis are used in the clinical routine of European countries, and how they impact on health care systems. Furthermore, if GA is a well-established tool included in clinical practice with a good cost/effectiveness ratio, no evidence has been provided, up to now, that MA of other body segments, such as shoulder motion analysis [28-30] or trunk motion assessment,[31-33] has an impact on clinical decision making.

Since it is the mission of the European Journal of Physical and Rehabilitation Medicine (EJPRM) to publish papers of clinical interest in Physical and Rehabilitation Medicine, this special section was thought to provide support to readers for the use of motion analysis services according to the best evidence. Three papers are included. The first deals with the clinical facts of GA: methodological and educational issues related to the activity of a clinical gait service are presented together with the biomechanical features most commonly explored in the clinical management of CP children, hemiparesis, and amputation. The second paper is dedicated to the main aspects of shoulder MA, and their potential for everyday clinical practice. Shoulder motion is very complex and methodological issues had to be overcome in order to provide clinically reliable and meaningful measures and so enjoy the advantage of including quantitative motion analysis in the assessment of a patient's shoulder. Recommendations for movement assessment, an overview of the main quantitative motion analysis protocols and a description of the most commonly investigated scapulothoracic muscles are here reported. The third paper is a systematic review, whose aim is to present the current state of the art in spine MA. Similarly to the shoulder, the trunk poses modelling problems and there are, at this time, neither a shared assessment methodology, nor evidence of the usefulness of clinical application of trunk motion analysis in everyday practice. A synthesis effort is thus required in the field in order to plan future research priorities for clinical use.

References

1. Baker R. Gait analysis methods in rehabilitation. J Neuroeng Rehabil 2006;3:4
2. Baker, R., Measuring Walking: A Handbook of Clinical Gait Analysis. London: Mac Keith Press; 2013.
3. Lu TW, Chang CF. Biomechanics of human movement and its clinical applications. Kaohsiung J Med Sci 2012;28:S13eS25.
4. Narayanan UG. The role of gait analysis in the orthopaedic management of ambulatory cerebral palsy. Curr Opin Pediatr 2007;19:38-43.
5. Cook RE[1], Schneider I, Hazlewood ME, Hillman SJ, Robb JE. Gait analysis alters decision-making in cerebral palsy. J Pediatr Orthop 2003;23:292-5.
6. Lofterød B, Terjesen T. Results of treatment when orthopaedic surgeons follow gait-analysis recommendations in children with CP. Dev Med Child Neurol 2008;50:503-9.
7. Quatrano LA, Stanhope SJ, editors. Gait analysis in rehabilitation medicine. Bethesda, MD: National Center for Medical Rehabilitation Research; 1996.
8. Engsberg JR, Tucker C, Ounpuu S, Wrend TA, Sisto SA, Kaufman KR. Gait and clinical movement analysis research priorities: 2007 Update from the research committee of the gait and clinical movement analysis society. Gait Posture 2009;29:169-71.
9. Leo T, Woltring HH. The CAMARC project-An attempt to bridge the gap. J Rehab Sci 1990;3:110-1.
10. Leo T. AIM Project A2002: CAMARC-II (computer aided movement analysis in a rehabilitation context-II). Comput Methods Programs Biomed 1994;45:11-3.
11. McGinley JL, Baker R, Wolfe R, Morris ME. The reliability of three-dimensional kinematic gait measurements: a systematic review. Gait Posture 2009;29:360-9.
12. Cimolin V, Galli M. Summary measures for clinical gait analysis: a literature review. Gait Posture 2014;39:1005-10.
13. Mayich DJ, Novak A, Vena D, Daniels TR, Brodsky JW. Gait analysis in orthopedic foot and ankle surgery--topical review, part 1: principles and uses of gait analysis. Foot Ankle Int 2014;35:80-90.
14. Novak AC, Mayich DJ, Perry SD, Daniels TR, Brodsky JW. Gait analysis for foot and ankle surgeons-- topical review, part 2: approaches to multisegment modeling of the foot. Foot Ankle Int 2014;35:178-91.
15. Esquenazi A. Gait analysis in lower-limb amputation and prosthetic rehabilitation. Phys Med Rehabil Clin N Am 2014;25:153-67.
16. Ditunno J, Scivoletto G. Clinical relevance of gait research applied to clinical trials in spinal cord injury. Brain Res Bull 2009;15:35-42.
17. Kernozek T, Torry M, Shelburne K, Durall C, Willson J. From the Gait Laboratory to the Rehabilitation Clinic: Translation of Motion Analysis and Modeling Data to Interventions That Impact Anterior Cruciate Ligament Loads in Gait and Drop Landing. Critical Reviews TM Biomed Eng 2013;41:243-58.
18. Ornetti P, Mailleferta JF, Laroched D, Morisset C, Dougadose M, Gossec L. Gait analysis as a quantifiable outcome measure in hip or knee osteoarthritis: A systematic review. Joint Bone Spine 2010;77:421-5.
19. Baan H, MD, Dubbeldam R, Nene AV, PhD, van de Laar MAFJ. Gait analysis of the lower limb in patients with rheumatoid arthritis: a systematic review. Semin Arthritis Rheum 2012;41:768-88.

20. Broström E, Esbjörnsson AC, von Heideken J, Iversen MD. Gait deviations in individuals with inflammatory joint diseases and osteoarthritis and the usage of three- dimensional gait analysis. Best Pract Res Clin Rheumatol 2012;26:409-22.
21. Cofré Lizama LE, Khan F, Lee PVS, Galea MP. The use of laboratory gait analysis for understanding gait deterioration in people with multiple sclerosis. Mult Scler 2016;1-9.
22. Ismail SA, Button K, Simic M,Van Deursen R, Pappas E. Three-dimensional kinematic and kinetic gait deviations in individuals with chronic anterior cruciate ligament deficient knee: A systematic review and meta-analysis. Clin Biomech 2016;35:68-80.
23. Carroll M, Parmar P, Dalbeth N, Boocock M, Rome K. Gait characteristics associated with the foot and ankle in inflammatory arthritis: a systematic review and meta-analysis. BMC Musculoskelet Disord 2015;16:134.
24. Roberts A, Stewart C, Freeman R. Gait analysis to guide a selective dorsal rhizotomy program. Gait Posture 2015;42:16-22.
25. Rosenbaum D, Macri F, Lupselo FS, Preis OC. Gait and function as tools for the assessment of fracture repair - the role of movement analysis for the assessment of fracture healing. Injury 2014;45(Suppl 2):S39-43.
26. Koga Y. Three–dimensional motion analysis and its application in total knee arthroplasty: what we know, and what we should analyze. J Orthop Sci 2015;20:239-49.
27. Wren TA, Gorton GE, Ounpuu S, Tucker CA. Efficacy of clinical gait analysis: A systematic review. Gait Posture 2011;34:149-53.
28. Franco de Moura RC, Almeida CS, Dumont AJ, Lazzari RD, Lopes JB, Duarte NA, *et al.* Kinematic upper limb evaluation of children and adolescents with cerebral palsy: a systematic review of the literature. J Phys Ther Sci 2016;28:695-700.
29. Lempereur M, Brochard S, Leboeuf F, Rémy-Néris O. Validity and reliability of 3D marker based scapular motion analysis: a systematic review. J Biomech 2014;47:2219-30.
30. Jaspers E, Desloovere K, Bruyninckx H, Molenaers G, Klingels K, Feys H. Review of quantitative measurements of upper limb movements in hemiplegic cerebral palsy. Gait Posture 2009;30:395-404.
31. Don R, Capodaglio P, Cimolin V, Benedetti MG, D'Osualdo F, Frigo C, *et al.* Instrumental measures of spinal function: is it worth? A state-of-the art from a clinical perspective. Eur J Phys Rehabil Med 2012;48:255-73.
32. Mieritz RM, Bronfort G, Kawchuk G, Breen A, Hartvigsen J. Reliability and measurement error of 3-dimensional regional lumbar motion measures: a systematic review. J Manip Physiol Ther 2012;35:645-56.
33. Swinnen E, Goten LV, De Koster B, Degelaen M. Thorax and pelvis kinematics during walking, a comparison between children with and without cerebral palsy: A systematic review. NeuroRehabilitation 2016;38:129-46.

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