Journal of Science and Medicine in Sport 18 (2015) 469–474

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

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

Review

The effect of vision on knee biomechanics during functional activities – A systematic review

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ARTICLE INFO

Article history:
Received 26 September 2013
Received in revised form 16 May 2014
Accepted 15 June 2014
Available online 26 June 2014

Keywords:
Vision
Biomechanics
Knee
Anterior cruciate ligament
Kinematics/kinetics
Adults

ABSTRACT

Objectives: The objective of this study was to assess the effect of occluded vision on lower limb kinematics and kinetics of the knee joint during functional tasks including drop landing (single or double leg), squatting (single or double leg), stepping down, cutting movement and hopping in healthy individuals, or individuals who had an ACL reconstruction or deficiency with no vision impairments.
Design: A systematic review was conducted.
Methods: A systematic review was conducted and electronic databases were searched between March 2012 and April 2013 for eligible papers. Methodological quality of each study was assessed using the Downs and Black revised checklist.
Results: Six studies met the eligibility criteria and a wide variation in methodological approaches was reported. This small evidence base indicated equivocal evidence about the effect of vision on knee biomechanics in individuals with healthy and compromised somatosensory function post an ACL reconstruction or injury.
Conclusions: Clinicians should consider innovative, individualised ACL rehabilitation strategies when prescribing exercises which involve visual occlusion. Further research to increase the relatively small evidence base for the effect of vision on knee biomechanics is warranted.

1. Introduction

Human movement is based on sensorimotor control, a dynamic interaction between sensations of sensory stimuli, processing of information in the central nervous system (CNS) and motor behaviour.[1] In this model, sensory information provides the possibility to adjust to and interact with the environment. Visual stimuli, together with proprioception and vestibular sensory information, therefore play an important role as sources of information and provide sensorimotor feedback during the planning and execution of movement.[2,3] Impairment of any of these three sensory systems will however demand compensation by the rest of the sensory triad.[3] Accentuated, compensatory feedback from the visual and vestibular systems will thus be required in individuals with compromised somatosensory post injury.[4]

It is thought that the visual system is the primary sense required for planning of voluntary movement and thus crucial for feed-forward planning of motor behaviour.[5] Visual information is transferred from the receptors in the eye via the optic nerve to the primary visual cortex in the posterior area of the occipital cortex.[5] Once the relevant information is processed, it is sent to the associated areas of the posterior parietal cortex (PPC). The PPC receives input from different uni-modal sensory systems and provides multimodal relevant information for the intended voluntary movement within specific environments.[5] Therefore, precise movements are dependent on uni-modal sensory systems (somatosensory, visual and vestibular) and multimodal merging of relevant information in the PPC to ensure safe and successful functional performance.[6]

Evidence suggests that sensorimotor control is impaired post an ACL injury or reconstruction.[7] The ability to actively or passively produce precise movements in the knee joint appears to be diminished or reduced, rendering these individuals to an increased injury risk.[7] In such circumstances, visual information is expected to play a

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http://dx.doi.org/10.1016/j.jsams.2014.06.009
1440-2440/

bigger role in order to compensate for this deficit in proprioceptive feedback from the somatosensory system.[8] The PPC plays an important role in these compensations which will not only be required during the initial stages of movement planning, but on-going visual feedback during the functional tasks may be necessary.[9] Increased burden is thus placed on the visual system to provide information to facilitate safe functional performance.[10–13]

During the rehabilitation process following a reconstruction or injury of the ACL, it is common practice to include balance activities to optimise the function of the somatosensory system in order to force the CNS (especially the PPC) to adjust to a changing environment.[14] These rehabilitation strategies include the use of wobble boards or other dynamic surfaces while performing rehabilitation exercises. In addition, it is also well-accepted practice to occlude vision by performing these therapeutic exercises with the eyes closed.[15] To date, there is no evidence to suggest that rehabilitation programmes which include some form of visual occlusion are superior to programmes which do not. It is within the interest of rehabilitation specialists to explore and understand the impact of vision during functional tasks and identify how movement is altered when vision is compromised. Rehabilitation programmes for individuals with a deficient or reconstructed ACL injury can consequently be optimised.

To the best of our knowledge, no systematic review has attempted to collate the available evidence on the effects of visual perturbation on lower limb biomechanics. The aim of this review was thus to assess the effect of occluded vision on lower limb kinematics and kinetics of the knee joint during functional tasks including drop-landing (single or double leg), squatting (single or double leg), stepping down, cutting movements and hopping in healthy individuals or individuals who have had an ACL reconstruction or deficiency with no vision impairments. Temporal–spatial parameters were considered for studies which included subjects with an ACL deficiency or reconstruction.

2. Methodology

The following electronic databases were searched between March 2012 and April 2013: MEDLine (1950 to present), CINAHL (1982 to present), Cochrane Library (inception to present), Science Direct (1823 to present), Sports Discus (1800 to present) and Scopus (inception to present). Each database has its own indexing terms and functions, and therefore different search strategies were developed for each database. No MESH headings were used during the searches. The main search terms used for the search strategies were: vision, lower limb, knee, anterior cruciate ligament (ACL), biomechanics, kinetics, kinematics, drop landing, squatting, stepping down, cutting, hopping.

Studies were deemed eligible for inclusion if they met the following criteria: randomised control clinical trials, non-randomised controlled trials, experimental and case-studies reporting on the effect of visual perturbation on the kinetics and kinematics of the knee joint, ground reaction force during functional activity; males and females over the age of 18 years, uninjured knees or ACL lesions, or ACL reconstructions; articles published in the English.

2.1. Methodological appraisal

The methodological quality of each study was assessed independently by two reviewers using the Downs and Black[16] revised checklist. This tool is appropriate for non-randomized controlled laboratory trials. The checklist also exhibits good retest reliability ($r = 0.88$) and inter-rater reliability ($r = 0.75$).[16] Only the criteria relevant to assessing potential sources of bias in non-randomized studies were applied, leading to a modified checklist of 13 items, with a maximum score of 13 obtained when all criteria are met. Any discrepancy regarding quality assessment was resolved by a consensus meeting between the two reviewers. If this failed to resolve the issue, the opinion of a third person was sought.

2.2. Data extraction and analysis

Data was extracted from each study using a standard form specifically developed for this review by the research team. Data analyses were conducted in a narrative descriptive format, since meta-analyses were not possible due to heterogeneity.

3. Results

A comprehensive search for published research into the effect of visual perturbation on biomechanical factors of the knee joint during walking, drop landing, stepping down, hopping, and cutting movements, yielded 185 articles. A total of 178 articles were excluded as the title, abstract or full text did not conform to the objectives of the review, or duplications were present. One full text paper by Chung and Chen[17] could not be obtained from the authors. Consequently, six articles were included in this review. The database search process and results are depicted in Fig. 1

3.1. General description of studies

An overview summary of the included studies is depicted in Table 1,[5,18–22] and highlights the wide variation in study populations, functional tasks and method of visual obstruction.

The methodological scores of the identified studies are reported in Table 2. The included studies scored a mean ± SD of 9 ± 0.89 on the modified Downs and Black[16] checklist. None of the studies reported any power calculations to justify their sample sizes.

3.2. Outcomes measures

The effect of vision on the knee parameters reported in the eligible studies is presented in Table 3.

4. Discussion

This review synthesised the current evidence for visual perturbation on lower limb biomechanics during functional activities. The role of vision is of interest to all clinicians who rehabilitate clients with somatosensory deficits. In clinical practice, it is generally expected that the incorporation of some visual occlusion while performing rehabilitation exercises enhance the function of the somatosensory system. The training effect on the somatosensory function is based on the assumption that visual input is required before and during a functional activity to successfully execute the desired functional activity.

The findings of this review indicate controversial evidence about the effect of vision on knee biomechanics in individuals with healthy and compromised somatosensory function post an ACL reconstruction or injury. Based on the biomechanical variables reported in the eligible studies, it appears that individuals can generally perform the movements in a similar manner during normal and visually deprived conditions. Feedback from the vestibular and somatosensory systems may thus be adequate in ensuring usual knee biomechanics during visual occlusion.[23] Whether this implies that a “training effect” of the somatosensory system, as generally accepted by clinicians, remains unclear since many subjects included in this review had the ability to immediately perform