NATA RESEARCH & EDUCATION FOUNDATION

Grant Information Summary:

The Effect of Lower Extremity Limb Alignment on Neuromuscular Timing and Activation Patterns at the Knee

Practical Significance:

Our findings indicate that subjects with increased pronation or quadriceps angle demonstrate different muscle reflex activation patterns around the knee following a weight-bearing, rotational stress compared to those with a more neutral lower extremity alignment.

Background

The thigh and calf muscles are the primary active stabilizers of the knee joint during functional, weight-bearing movements (e.g. cutting, jumping and pivoting), protecting against excessive joint motion and ligament strain. The influence of lower extremity malalignments (e.g. excessive foot pronation and quadriceps angle) on neuromuscular function at the knee is relatively unknown. To better understand how static postural faults may impact functional joint stability and injury risk, the aim of this study was to examine how differences in static lower extremity alignment may affect neuromuscular control at the knee under functional, weight-bearing conditions.

Objective

This study investigated the effects of quadriceps angle (QA) and navicular drop (ND) on muscle activation patterns at the knee following a lower extremity perturbation in a functional, single leg weight-bearing stance.

Design and Setting

A lower extremity perturbation device designed to produce a forward and either internal (IR) or external rotation (ER) of the trunk and femur on the weight-bearing tibia evoked a reflex response in the medial and lateral quadriceps, hamstring and gastrocnemius muscles. A mixed model, repeated measures design compared four groups with varying measures of ND and QA on reflex activation patterns.

Subjects

Participants were 20 with neutral alignment (NT) (20.0$\pm$1.3yrs, 171.3$\pm$7.5cm, 71.2$\pm$7.3kg, 3.7$\pm$1.2 mmND, 11.6$\pm$3.2°QA), 20 with increased navicular drop (ND) (19.2+1.3yrs, 172.6$\pm$7.7cm, 71.7$\pm$ 9.9kg, 9.3$\pm$2.1mmND, 12.2$\pm$2.8° QA), 20 with increased Q-angle (QA) (20.1$\pm$1.3yrs, 170.6$\pm$6.7cm, 69.2$\pm$8.7kg, 3.6$\pm$2.0mmND, 19.3 $\pm$2.1°QA), & 19 with increased ND and QA (NDQA) (19.3$\pm$1.1yrs, 170.0$\pm$6.0cm, 69.2$\pm$7.8kg, 9.3$\pm$1.8 mmND, 18.8$\pm$1.6°QA).

Measurements

Long latency reflex times (LLRT= msec) and peak amplitude (R_{Amp}=%MVIC) were recorded via surface EMG.

Results

For LLRT, groups differed by rotation (p=.039) and muscle by rotation (p=.011). Post hoc comparisons (repeated contrasts within, Tukey's HSD between) revealed differences primarily in hamstring activation patterns. The NT group showed an activation order of MG=LG=MH<LH <MQ=LQ for ER and MG=LG= MH<LH=MQ=LQ for IR, as a result of slower LH (95 vs. 77 msec) and faster LQ (93 vs. 106 msec) and MQ (88 vs 100 msec) times for IR vs. ER. The ND group demonstrated different patterns and increased variability in the MH [ER (81$\pm$45 vs. 69$\pm$10 msec), IR (77$\pm$40 vs. 68$\pm$10 msec)] and LH [ER (98$\pm$49 vs. 77$\pm$11 msec), IR (89$\pm$27 vs. 95$\pm$24 msec)] compared to the NT group, with the MH (12 msec) and LH (21msec) being significantly slower in the ND group on ER. Consequently, activation order for ND was MG<LG=MH= LH=MQ<LQ for ER and MG<LG= MH=LH=MQ<LQ for IR. While the QA group responded similarly to NT on ER, faster LH (78$\pm$23 vs. 95$\pm$24 msec) and slower MQ (97$\pm$27 vs. 88$\pm$8 msec) and LQ (105$\pm$26 vs. 93$\pm$11 msec) times for the QA group resulted in an altered activation order for IR (MG<LG=MH= LH<MQ=LQ). Groups NDQA and NT showed similar activation orders, except for slower LQ times in NDQA group on IR (105 vs. 93 msec), resulting in a different quadriceps activation order for NDQA on IR (MQ<LQ). A separate ANOVA for R_{Amp} revealed no differences between groups (p=.958) or within groups by rotation (p=.398), groups by muscle (p=.148) or groups by muscle by rotation (p=.371).

Conclusions

Excessive ND and QA have been implicated as potential risk factors in ACL injury. Our findings suggest static alignment may influence functional knee joint stabilization by altering dynamic reflex control. When present independently, increased ND and QA appear to have the greatest impact on hamstring muscle activation patterns, depending on the direction of rotational stress applied. Given the critical role of the hamstrings in preventing excessive anterior and rotary tibial translation, further research is needed to fully elucidate the impact of these and other lower extremity alignments on neuromuscular and biomechanical function at the knee.

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Presentations

S.J. Shultz, C.R. Carcia, B.M. Gansneder & D.H. Perrin. Lower extremity Alignment Effects Muscle Activation Patterns at the Knee Following a Weight-Bearing Perturbation.
National Athletic Trainers' Association Annual Meeting & Clinical Symposium, Dallas, TX - June 2002.

S.J. Shultz, C.R. Carcia & D.H. Perring. Performance Consistency of Reflex Response Times Following a Lower Extremity Functional Perturbation.
American College of Sports Medicine Annual Meeting & Clinical Symposium. Baltimore, MD - June 2001. Med Sci Sports Exer 2001; 33(5(:S89

Financial Support By:

NFL Charities

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