The biomechanical effects of anticipation during a stop-&-back run task to screen high-risk athletes for non-contact ACL injury.

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The purpose of this study was to determine the role of anticipation on the lower extremity and trunk kinematics, and the height of the center of mass during a stop-&-back run task. Collegiate athletes (n=18) were recruited and completed three tasks; anticipated stop, unanticipated stop, and anticipated stop with a badminton net in front of their face. Three video cameras were used, and the trunk and extremity kinematics, and the height of center of mass (COM) for the second step before the complete stop (deceleration step) and the step of the complete stop (stopping step) were analyzed. At the initial contact of the deceleration step, the height of the COM was greater and the knee position was more posterior in the unanticipated condition than the other two conditions ($p<.05$). The results showed the height of the COM was higher during unanticipated stop-&-back run task, which has important implications for future ACL injury screening.

KEY WORDS: anterior cruciate ligament injury, kinematics, screening.

INTRODUCTION: Anterior cruciate ligament (ACL) injury causes severe problems to the injured athletes due to the long recovery time and enormous costs. Improvements of screening high-risk athletes are required to establish a more effective injury prevention strategy.

Drop vertical jump (DVJ) task is the most popular screening task for ACL injury due to high repeatability and simplicity. Hewett (2005) showed the associations between ACL injury risk and knee abduction moment during DVJ. Although frontal motion of the knee has drawn greater attention in recent years, kinematics in the sagittal plane must be taken into consideration because it affects the load on the ACL.

ACL injury often occurs on decreasing speed or changing a direction, and posterior COM may be a risk factor (Bahr 2004, Cugat 2009, Boden 2012). Unanticipated cutting showed a decrease in knee flexion as compared with anticipated cutting (Meinerz 2015). However, the trajectory of the COM in the sagittal plane, which may be a good indicator of knee and hip flexion angles, has not been studied. The purpose of this study was to reveal the role of anticipation on the kinematics.

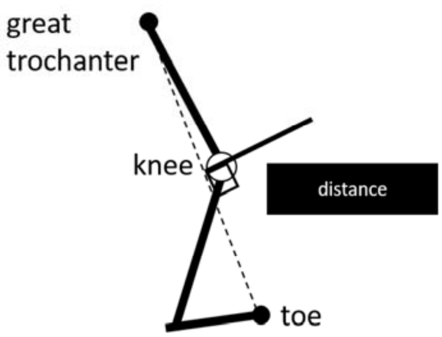
METHODS: This study was an IRB-approved, cross-sectional study. Subjects were recruited in our University. Inclusion criteria were; (1) age between 18-25 and (2) playing basketball or soccer. Exclusion Criteria were; (1) prior surgeries to the lower extremities, (2) history of ACL injury. Eighteen participants (six females and 12 males, average age: 20.1 ± 0.3 years) provided a written informed consent.

Participants performed (a) anticipated stop-&-back run at the point indicated previously (SB_normal), (b) anticipated stop-&-back run in front of a badminton net (SB_net), and (c) unanticipated stop-&-back run on the flash light (SB_light). Participants practiced each task twice, then performed three trials for each.

Three 2D-video cameras (Casio EX-FH25, CASIO COMPUTER CO, LTD, JAPAN. 30Hz) were used to capture the motion of the three tasks in the frontal and sagittal planes. Reflective markers attached to the acromion, anterior superior iliac spine (ASIS), greater trochanter (GT), center of the patellar, lateral epicondyle of the femur, the mid-point of the medial and lateral malleoli, and the lateral malleolus. Lower extremity and trunk kinematics, the height of the GT

(HGT), and the knee position relative to the line connecting the GT and toe (KP) using Dartfish (Dartfish Japan Co., Ltd. Japan). Selected were the images at the initial contact (IC) and 60ms after IC (IC60) of the second step before the complete stop (deceleration step) and the step with the complete stop (stopping step).

To reveal differences in knee and trunk kinematics between three tasks, Kruskal-Wallis test were utilized. To determine if there were any associations between HG and lower extremity kinematics, simple linear regression analysis was performed. The level of statistical significance was set at $p<.05$. All analyses were performed using SPSS statistical software (version 21.0; IBM Corp, Armonk, NY, US).



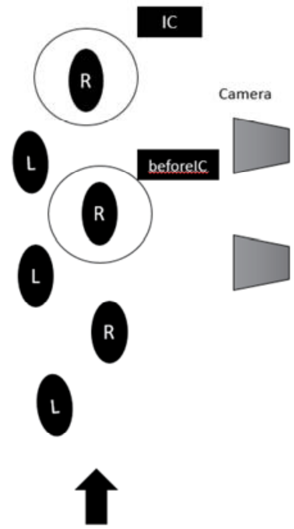


Figure 1: Camera setting in association with the steps.

Figure 2: Definition of the knee position (KP).

RESULTS: There are no significant differences between the tasks in hip, knee, and ankle kinematics. HGT during the unanticipated stop was greater than that in the other tasks at IC of the deceleration step. KP during the unanticipated stop was more posterior than other tasks at ICs of the deceleration step and stopping step. The associations between HGT and (1) hip flexion existed at IC of the deceleration step ($p<.05$, $r=-0.516$), (2) HGT at IC of the deceleration step ($p<.05$, $r=0.629$), (3) hip flexion at IC of the stopping step ($p<.05$, $r=-0.561$) and (4) ankle dorsiflexion at IC of the stopping step ($p=0.014$, $r=-0.332$).

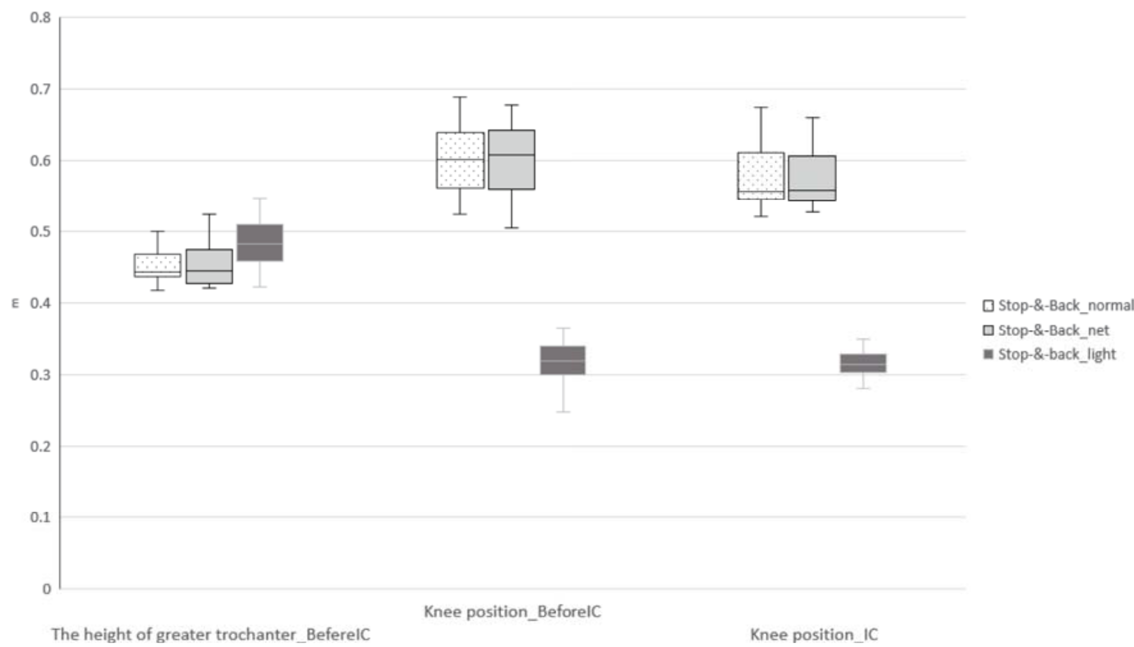


Figure 3: Comparison of HGT at IC and comparison of KP at IC and beforeIC of the deceleration step

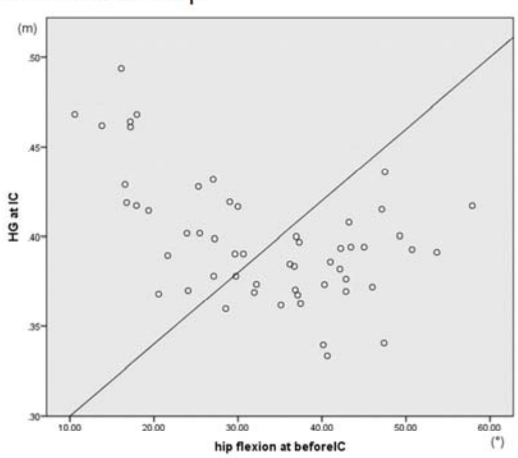


Figure 4: The association between hip flexion at IC of the deceleration step and HGT at IC of the stopping step

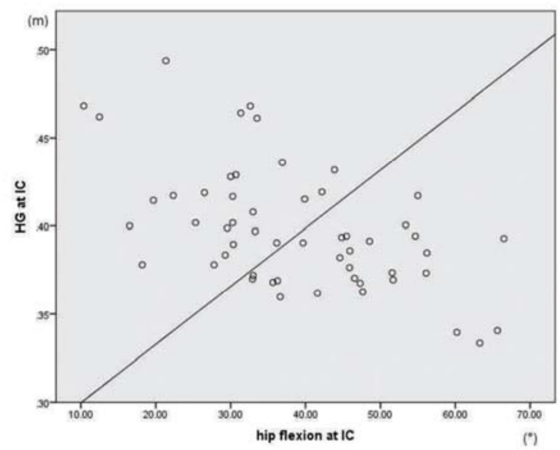


Figure 5: The association between hip flexion at IC of the stopping step and HGT at IC of the stopping step

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DISCUSSION: HGT at IC of the deceleration step was higher in SB_light than in SB_normal or SB_net. KP at ICs of the deceleration step and stopping step were more posterior than that in the other tasks. The association between HGT at IC of the stopping step and hip flexion at IC of the stopping step was significant. There were no significant differences in the lower extremity kinematics between the three tasks.

Several factors affect kinematics during deceleration tasks. Knee flexion at IC during unanticipated task was smaller than that during anticipated task (Meinerz 2015). We found greater HGT, more posterior KP and greater hip flexion may represent the deceleration step was performed with the foot far anterior from the pelvis with knee in small flexion. Trunk anterior tilt was associated with knee flexion angle (Blackburn and Padua 2008). We found there was no association between them. The presence of the badminton net did not affected the kinematics. Lowering of the HGT was observed between the last two steps, indicating that the COM was lowering. Although HGT in SB_light at IC of the deceleration step was larger than that in other tasks, there was no difference in HGT at IC of the stopping step between three tasks. These results indicated that the unanticipated condition would depend on the lower extremity kinematics to decelerate, while the anticipated condition would allow the entire body to move quickly to reduce an excessive load on the knee by lowering the COM and increasing knee flexion angle during deceleration. Accordingly, the trajectory of the COM and KP during the deceleration step should draw more attention to screen high-risk athletes of ACL injury.

CONCLUSION: The COM remained at a higher position and knee is located posteriorly relative to the hip-toe line during unanticipated stopping task. Future study should be designed to determine what causes the problematic kinematics during unanticipated task and how to fix them.

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