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Letter to the editor regarding “Effect of low pass filtering on joint moments from inverse dynamics: implications for injury prevention”

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A recent study performed by Kristianslund et al. highlights the importance of selecting appropriate filtering cutoff frequencies when analyzing kinematic and kinetic data collected using modern three-dimensional motion capture systems (Kristianslund et al., 2012). The authors posit that the choice of cutoff frequency significantly influences the magnitude of the peak knee abduction moment (KAM) measured during a running sidestep-cut (run-cut)

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Conflicts of interest statement

None

task with particular implication on the validity of existing anterior cruciate ligament (ACL) injury prediction paradigms. How one decides to filter and analyze motion data is both an art and science that requires careful consideration of both the tasks being analyzed and the outcome variables of interest. For these reasons, there are several subtleties and some possible flaws in Kristianslund's study that warrant clarification.

Our research team understands the benefits of filtering kinematic and kinetic data at matched cutoff frequencies and we have been filtering our motion data at matched frequencies for several years (Ford et al., 2010; Ford et al., 2007; Cowley et al., 2006). However, universally dismissing studies that use unmatched cutoff frequencies or suggesting that earlier conclusions should be reconsidered—specifically, those from our 2005 study—is unfounded. Kristianslund et al. failed to acknowledge the power of the prospective case-cohort design used in our 2005 study. Principally, that prospective design prevented us from potentially biasing our sample because we filtered data uniformly for all of our subjects: those who eventually went on to suffer an ACL injury and those who did not. Thus, our choice of cutoff frequency could not have invalidated our findings.

Kristianslund et al. calculated different filtering conditions for only one movement, a run-cut task. It is incorrect for the authors to assume that differences in moment calculations for this movement directly relate to all other movements that involve high-impact accelerations, such as a drop vertical jump (DVJ). All movement tasks that are subject to large forces and accelerations fall victim to a certain degree of artifact when filtering is applied; however, large artifacts are typically reserved for the planes of motion in which these large forces and accelerations occur. A run-cut task is subject to much larger frontal-plane forces and segment accelerations than a DVJ task; therefore, KAM measured during a run-cut is likely more sensitive to cutoff frequency than KAM measured during a DVJ. Kristianslund et al. reported a mean peak KAM between 75 and 150 Nm during a run-cut task whereas we reported mean peak KAM between 15 and 45 Nm during a DVJ. We also previously compared a DVJ to a jump stop side-cut movement and reported significant differences in knee abduction moment and angle between the two movements (Cowley et al., 2006). A preliminary analysis of our most recent DVJ data indicate that filtering frequency may have only a small effect on the magnitude of peak KAM, and a negligible effect on the relative ranking of subjects based on peak KAM. Hence, we remain highly confident in the findings from our 2005 study.

Kristianslund et al. reported that peak KAM occurred approximately 50 ms after initial contact during a run-cut, a time at which joint moment artifacts are likely to occur. Conversely, peak KAM during a DVJ does not always occur soon after initial contact when large artifacts are likely to occur. Considering the stance time of a typical DVJ is approximately 400 ms (Ford et al. 2005), the peak KAM would occur closer to 100 ms and therefore not located where impact artifacts occur during a run-cut. This is why we reported peak KAM across the entire stance phase in our 2005 study. Additionally, Kristianslund reported KAM for one trial per subject whereas we attempted to mitigate the effects of potential moment artifacts by reporting the peak KAM averaged across three trials per subject.

Kristianslund et al. suggest that the effects of filtering render the KAM less reliable as an ACL-injury tool than previously thought. The authors state, "...as can be seen from our results the different filtering of force and movement can lead to considerable errors in joint moments, making them less reliable". We would like to clarify that Kristianslund et al. did not report the reliability of their data. They simply reported the differences in peak joint moments using different cutoff frequencies; thus, their conclusions should be interpreted with caution.

In order to properly assess the validity of Kristianslund et al.'s overextended, and misplaced conclusions one would need to track injuries prospectively before a run-cut task could be effectively used for injury risk assessment. Their study was not properly designed to answer the question upon which they speculated. A properly designed study would require an approach that includes an apples-to-apples comparison of our 2005 study to Kristianslund's study using identical data collection, reduction techniques, injury tracking methods and analyses. Replication of any study is important for gaining widespread acceptability. ACL injury risk factors have proven to be complex and multifaceted with mechanical, biological, hormonal, and psychosocial components. KAM and knee abduction angle are certainly prominent, predictive markers for ACL injury risk, and have been repeatedly validated (Myer et al., 2010; Myer et al., 2011; Padua et al., 2009), but are only two of many important factors. We have new data that indicates that knee abduction angle may be as strong as a predictor as KAM. These data are important as we move forward with our secondary kinematic two-dimensional analyses and develop more comprehensive and generalizable clinic-based predictive models.

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