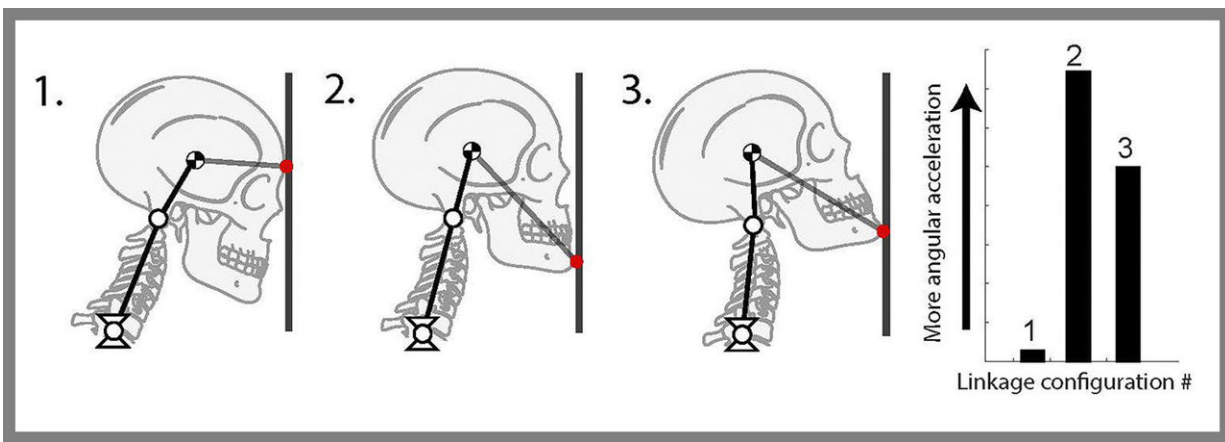


Head and neck positioning affects concussion risk

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Three of the head and neck alignments modeled by the researchers (with hits simulated at the red dot) shows how small differences affect angular acceleration, also called rotational acceleration. Greater angular acceleration increases the likelihood of concussion. Credit: Michael Fanton

If you're about to run headfirst into something, your reflex might be to tense your neck and stabilize your noggin. But according to new research from Stanford University that may not be the best way to stave off a concussion. Instead, the findings suggest that your head's position is more important than whether you are tensing your neck.

It all comes down to controlling how your [head](#) accelerates backward after impact, which some think is the major factor controlling

[concussion](#) risk. The work was published Aug. 20 in *IEEE Transactions on Biomedical Engineering*.

"We found it really interesting that your soft tissue – muscles, ligaments and tendons – isn't doing much to dictate how your head is rotating immediately after an impact," said Michael Fanton, lead author on the paper and graduate student in the lab of David Camarillo, assistant professor of bioengineering. "Whereas even a few degrees of change in your head-neck angle can really alter how much your head is rotated and therefore, probably, your risk of concussion."

The researchers made their discovery in a model of the human head and neck, but confirmed what they found in a similar model of a woodpecker, which can endure extreme accelerations when pecking holes. It turns out they too may be protected in part by the angle of their pecking.

A big surprise

In a previous [study](#) led by Calvin Kuo, who is a co-author on the new paper and graduated with his Ph.D. this spring, the group tied miniature weights to people's heads to tilt them backward. They then monitored how the head moved after participants either relaxed or tensed their necks. From this, the group constructed a simple computer model that recreated the way the head tilts forward and backward.

The researchers ran simulations with this model that replicated low-impact forces and found tense [neck muscles](#) slightly reduced head acceleration. But they also extended those simulations to include higher-force impacts – the kinds that could lead to concussion, such as what someone might experience falling off a bike – with much different results. When looking at fast, hard impacts, it does not seem to matter whether the neck muscles are tensed or relaxed.

"Originally, we thought your neck muscles could affect head acceleration and we wanted to figure out if that offered another strategy for reducing brain injury," Fanton said. "It was surprising that in these shorter-duration impacts, the neck muscles are not doing a whole lot."

The importance of positioning

The researchers were also curious whether head and neck positioning could alter front-to-back acceleration after a hard, fast hit. They ran their simulations with the head positioned at a wide variety of angles and found that small variations in position could mean the difference between high and low concussion risk. Their results showed that both the angle of the head and where it is hit affect the subsequent rotation of the head.

All this raised the question of how woodpeckers are able to withstand so much pounding – thought to produce head-on accelerations 10 times greater than those that cause severe concussions in athletes. So, the researchers created a simplified head and neck model of a woodpecker and ran it through the same positioning tests they had run in the human simulations. What they found is that small changes in position could substantially change the head acceleration the bird experienced. When the researchers aligned their model in the way real woodpeckers hold themselves as they peck, they noticed very low rotational acceleration.

However, the group cautioned that position alone likely doesn't explain the woodpecker's ability to withstand these forces. Scientists have suggested the size of their brains and features of their beak may be mitigating factors.

Focusing on prevention

Although the Camarillo lab and others in the field are finding that the neck muscles and ligaments might not prevent the kinds of head movement that lead to concussions, [neck](#) positioning is not a simple solution. Positions that could prevent concussions might make people more susceptible to other injuries, such as paralysis, and what protects one person could potentially raise the injury risk of another person involved in the same impact.

"Discovering how sensitive the head is to slight changes in positioning has implications on design of helmets and other protective equipment," Camarillo said. "For example, could the facemask in football be offering a lever arm that adds to the rotation of the head and therefore risk of concussion? Are downhill mountain bike helmets protecting the chin at the cost of the brain? We hope to use this model we have developed to determine better design geometry of helmets and potentially for input to coaching on how to brace for impact."

Ultimately, Camarillo is hoping this kind of modeling work can aid in developing better ways of preventing head injuries.

More information: Michael Fanton et al. Dependency of head impact rotation on head-neck positioning and soft tissue forces, *IEEE Transactions on Biomedical Engineering* (2018). [DOI: 10.1109/TBME.2018.2866147](#)

Provided by Stanford University

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