Differences in Soccer Heading Injuries between Male and Female Soccer Players May Be Due to Equal Ball Weight Causing Differences in Relative Impacts

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Editor:

We read with great interest the article by Mr Rubin and colleagues, "MRI-defined White Matter Microstructural Alteration Associated with Soccer Heading Is More Extensive in Women than Men," which was published in the November 2018 issue of *Radiology* (1). Their findings are important, and we applaud the focus on sex differences.

Having said that, we would like to suggest a possible explanation of the results. Mr Rubin and colleagues suggest that "Perhaps men and women head the ball differently…" or that "…women may be more sensitive than men to the effects of heading…." Differences, they argue, are not due to different exposures to headings as there was "similar levels of exposure" across the sexes. Although this was certainly true for number of reported headings, the relative exposure may not be as equal if we consider the following factors.

The standard-sized soccer ball for adults weighs 410–450 g (2), and this is the same for both sexes regardless of physiologic differences. We would argue that the relative impact due to sex differences in body size (notably, head mass) and neck anthropometry would be important for explaining the results of Mr Rubin and colleagues.

Schneider and Zernicke (3) modeled relative impacts of head-ball collisions for different head masses and concluded that equipment should be scaled for children (ie, a lighter ball should be used) due to their smaller head mass to reduce injury risk. The head mass of women is 15% smaller than that of men (4).

Furthermore, women's neck muscles are weaker, with the most relevant difference for headings probably being the 50% isometric flexion strength difference (4). Eckner et al (5) showed that neck strength is important for reducing the effects of impacts and, thus, an athlete's risk of concussion. In line with their findings, Tierney et al (4) found that female players exhibited greater head acceleration than male players when heading the same (450-g) ball at equal velocities.

The fact that women have more serious head injuries from a similar number of impacts suggests in itself that the ball weight should receive more attention. Thus, we would strongly promote the relative impact due to ball weight as an explanation and argue that the relative exposure across the sexes is, in fact, rather different.

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Response

From
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We thank Mr Pedersen and Ms Stalsberg for their praise of our article (1). Our study design required exposure assessment in a large longitudinal study of active players. We calibrated exposure by matching men and women for number of headers over 12 months. Our approach is of course not the only way to assess heading exposure and was motivated by three considerations. First, accurate and reliable characterization of heading biomechanics (force, linear and rotational acceleration, direction, etc) cannot presently be achieved outside of controlled experimental settings, such as that used by Eckner et al (2), whom Mr Pedersen and Ms Stalsberg cite. Second, our study requires assessment of many players over a wide geographic area and a long timeframe. Finally, findings from American football indicate that the number of impacts over time and not the magnitude of individual impacts is most predictive of longer-term risk (3). Similarly, we have reported that headings, but not larger magnitude impacts or concussion, explain neurocognitive outcomes (4).

We cannot explicitly address the potential role of biomechanical factors in the exposure-response relationship. Mr Pedersen and Ms Stalsberg articulate an intriguing mechanistic hypothesis that the interaction of ball size with neck strength and anthropometrics may account for the sex differences we identified. As we and Mr Pedersen and Ms Stalsberg note, studies have shown that equal exposure in terms of ball size and velocity resulted in different head accelerations for men and women (5,6). Studies of individual heading events, however, do not necessarily indicate that biomechanical features explain adverse effects over the longer term or at all. While the same size ball is used in men's and women's soccer, unlike in basketball, factors other than ball size, such as its material, inflation level, and hardness, may play

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a role in head acceleration (7) and the potential for brain injury. Changing the mass of the ball will decrease its mechanical momentum but may not have the desired effect if its kinetic energy increases as a result. Finally, we caution that interventions proposed to mitigate risk should be evidence-based to maximize acceptance and minimize risk for unintended consequences. We thus agree with Mr Pedersen and Ms Stalsberg that prospective assessment of biomechanics-based interventions, such as ball design, is an intriguing target for future studies.

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