ESTIMATING UNBIASED INJURY RATES: A COMPENDIUM OF INJURY RATES CALCULATED BY ATHLETE EXPOSURE AND ATHLETE AT RISK METHODS.

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Participating in regular physical activity provides important benefits (e.g. mental and physical health, and well-being).[1] However, injuries sustained during sports or sporting activities/events can have adverse effects on the athlete and the team.

Injury surveillance systems provide essential data to help develop and then evaluate injury prevention strategies. The main outcome of interest in injury research studies is the "injury rate," which can be expressed as the number of injuries per unit of person time.[2] The definition of time in the assessment of sports injuries is fraught with challenges and researchers have been inconsistent. In studies using the United States National Collegiate Athletic Association's (NCAA) Injury Surveillance Program, injury rates were generally reported using athlete exposures (AE) as the unit of time, whereby each player who participated in a game or practice is counted as having had one athlete exposure.[3 4]

Although the AE method is widely used, when it comes to game-time exposures, it violates a basic epidemiological principle. When calculating risk or rate, the denominator should only include those participants who are actually at risk for injury.[2] However, the AE method attributes a full exposure to each player regardless of the time spent on the field. This method was developed because investigators did not have data on the time each individual was involved in the game and has been adopted by many investigators across many sports.[2]

When individual participation times are available, epidemiological principles suggest one should sum the total of all minutes played by all players (i.e. the total time at risk) to calculate the true rate. Stovitz and Shrier showed that this total time can be calculated by multiplying the number of players on the field times the duration of the game.[2] They called this the Athletes at Risk (AAR) method.[2] Therefore, the AAR method is generally identical to the gold standard of individual player time, but will slightly underestimate injury rate in sports where a team may have to play some minutes without a player because of a penalty (e.g. ice hockey) .[2] However, this is an improvement over the AE method which grossly underestimates the gold standard of individual player time whenever some players being counted as exposed are not on the field of play at all times.[2]

Although the AAR method is generally similar to using individual player time, most published studies use the AE method, and investigators using AAR might have difficulty comparing their results to previous studies. The purpose of this editorial is to provide a compendium of both AAR and AE injury rates across a wide variety of sports so future investigators can compare their results to the literature using different methods. When available, the compendium includes results for preseason, in-season and postseason games and practices.

Our compendium is available through the Open Science Foundation [https://osf.io/82vsf/wiki/home/]. We converted the results from 27 NCAA studies on male and female sports, 15 which used data between 1988 and 2004, and 12 which used data between 2004 and 2014. We will expand the compendium to include reports from studies which focus on other major sports competitions such as the Olympic games.5 Because individual sport competitions are not affected by AAR and AE (everyone is participating in the competition), both AAR and AE methods are identical.[2]
In some studies, authors report injury rates with the AE method, but not the number of injuries (necessary to calculate an AAR injury rate) and/or total AE used in the calculation. We estimated these values through back-calculations based on relevant information. In some cases, the number of injuries

was not provided for the entire group but only numbers for subgroups (e.g. Division 1, Division 2). In these cases, we used a weighted average of the different numbers provided for each subgroup. We then validated our AAR calculations by using our estimated numbers to re-calculate injury rates based on AE and compare them to the reported AE injury rates.

Overall, the AAR injury rate is consistently higher than the AE injury rate in games. For example, the injury rate in men's soccer games is 1.5 x higher with both the AAR and the gold standard individual player time methods compared to the AE method (27.3 inj/1000 AAR vs 18.8 inj/1000 AE)[6]. This occurs because only two-thirds of the players on the game roster are actually on the field at once (1/0.67 = 1.5). The AE method will generally be ½ the injury rate calculated using individual player time in basketball, 1/3 in hockey, and just over 1/5 in football. Finally, because the AE method correctly assesses practice injury rates (everyone is practicing), the difference between the true game and practice injury rates are even greater than previously reported using the AE method.

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