2. The normal distribution requires values for μ and σ, so find those values by calculating $\mu = np$ and $\sigma = \sqrt{npq}$.
3. Identify the discrete whole number x that is relevant to the binomial probability problem being considered.

   Example: If you're trying to find the probability of getting at least 235 successes among 431 trials (as in Example 1), the discrete whole number of concern is $x = 235$. First focus on the value of 235 itself, and temporarily ignore whether you want at least 235, more than 235, fewer than 235, at most 235, or exactly 235.
4. Draw a normal distribution centered about the value of μ, then draw a *vertical strip area* centered over x. Mark the left side of the strip at $x - 0.5$, and mark the right side at $x + 0.5$.

   Example: For $x = 235$, draw a strip from 234.5 to 235.5 and *consider the entire area of the entire strip to represent the probability of the discrete whole number 235.*
5. Determine whether the value of x itself should be included in the probability you want. Shade the area to the right or left of the strip from Step 4, as appropriate; shade the *interior* of the strip *if and only if x itself* is to be included. This total shaded region corresponds to the probability being sought.

   Example: The phrase "at least 235" *does* include 235 itself, but "more than 235" *does not* include 235 itself.
6. Using either $x - 0.5$ or $x + 0.5$ in place of x itself, find the area of the shaded region from Step 5 as follows:
   - **i.** Find the z score: $z = (x - \mu)/\sigma$ (replacing x with either $x + 0.5$ or $x - 0.5$).
   - **ii.** Use that z score to find the cumulative area to the left of the adjusted value of x.
   - **iii.** The cumulative left area can now be used to identify the shaded area corresponding to the desired probability.

Example 1 Is the NFL Coin Toss Fair?

In 431 NFL football games that went to overtime, the teams that won the coin toss went on to win 235 of those games. If the coin-toss method is fair, we expect that the teams winning the coin toss would win about 50% of the games, so we expect about 215.5 wins in 431 overtime games. Assuming that there is a 0.5 probability of winning a game after winning the coin toss, find the probability of getting at least 235 winning games among the 431 teams that won the coin toss. That is, given $n = 431$ and $p = 0.5$, find P(at least 235 wins).

Solution

The given problem involves a binomial distribution with $n = 431$ independent trials. When a team wins the coin toss in overtime, there are two categories for each outcome: The team goes on to win the game or does not win. The assumed probability of winning ($p = 0.5$) presumably remains constant from game to