In the 2015 football AFC championship game between the New England Patriots and the Indianapolis Colts, it was found that 11 of 12 footballs provided by the New England Patriots were inflated to a pressure of 10.5 psig as opposed to the NFL required pressure range of 12.5 – 13.5 psig. Accusations of cheating were made since the Patriots quarterback, Tom Brady, had previously made statements that he (and, in fact, most quarterbacks) preferred under-inflated footballs since they're easier to grip. This event became known as "Deflate-gate" or "Ballgazi" (http://en.wikipedia.org/wiki/Deflategate).

If the footballs were at the minimum NFL-required pressure of 12.5 psig while in an indoor room at a temperature of 68 °F, what would be the gauge pressure of these same footballs when used outdoors at a temperature of 51 °F, which was the temperature at the start of the game? The atmospheric pressure at the start of the game was 14.64 psia.

SOLUTION:
First determine whether or not the ideal gas law is accurate for modeling the behavior of air at the given conditions. The relative pressure and relative temperature are approximately,

$p_R = p/p_{cr}$, (1)

$T_R = T/T_{cr}$, (2)

where,

$p \approx (12.5 + 14.64)$ psia = 27.14 psia (approximate pressure)
$T \approx (59.5 + 459.67)$ °R = 510.67 °R (approximate temperature)
$p_{cr} = 547$ psia, (Table A-1E, Moran et al., 8th ed.)
$T_{cr} = 239$ °R (Table A-1E)
=> $p_R = 0.0496$ and $T_R = 2.14$

Using the compressibility chart, $Z \approx 1$, which warrants the use of the ideal gas law.

Apply the ideal gas law to the football noting that the mass of air remains the same whether the ball is indoors or outdoors. Moreover, assume that the ball's volume remains the same, which is quite reasonable since the ball is not made of stretchy material (like a balloon, which would stretch and change volume as the pressure changes),

$pV = mRT \Rightarrow p_1/T_1 = p_2/T_2 \Rightarrow p_2 = p_1(T_2/T_1)$. (3)

Recall that when using the ideal gas law, one must use absolute pressures and temperatures,

$p_1 = (12.5 + 14.64)$ psia = 27.14 psia
$T_1 = (68 + 459.67)$ °R = 527.67 °R
$T_2 = (51 + 459.67)$ °R = 510.67 °R
=> $\boxed{p_2 = 26.3 \text{ psia} = 11.6 \text{ psig}}$

The analysis suggests that the footballs could certainly be underinflated due to the change in temperature; however, the reported pressure of 10.5 psig is smaller than what is predicted by the ideal gas law. One possibility is that the room in which the footballs were stored was warmer than 68 °F. To reach a 10.5 psig pressure at game conditions, the indoor room would have needed to be at approximately 91 °F, which is unlikely. Another possibility is that if the ball had moisture on it that evaporated, it could have lowered the effective temperature of the ball. To reach the reported pressure of 10.5 psig (assuming a room temperature of 68 °F), the ball temperature would have had to have been approximately 29 °F. Again, this scenario is unlikely.