diagnostic conclusion, we must correct the true positive rate by the false positive rate. This is our **positive likelihood ratio (LR+)**:

$$LR+ = \frac{\text{true positive rate}}{\text{false positive rate}} = \frac{\text{sensitivity}}{1-\text{specificity}}$$

The LR+ will tell us how many times more likely a positive test will be seen in those with the disorder than in those without the disorder. *A good test will have a high positive likelihood ratio.*

Negative Likelihood Ratio

Now let's assume the patient has a negative test. With a perfect test we would be sure this patient did not have a fracture. But because we are concerned about the possibility of a false negative, we need to determine if a negative test improves our diagnostic conclusion by looking at the ra[illegible] negative rate to the true negative rat[illegible]**gative likelihood ratio (LR–)**:

change both to negative

$$LR- = \frac{\text{false positive rate}}{\text{true positive rate}} = \frac{1-\text{sensitivity}}{\text{specificity}}$$

The LR– will tell us how many times more likely a negative test will be seen in those with the disorder than in those without the disorder. *A good test will have a low negative likelihood ratio.*

Likelihood ratios *always refer to the likelihood of the disorder being present.*[19] That's why we would like to see a high LR+ to indicate that the disorder is likely to be present with a positive test. A very low LR– means that the disorder has a small probability of being present with a negative test.

Interpreting Likelihood Ratios

The value of the likelihood ratio is somewhat intuitive, in that a larger LR+ indicates a greater likelihood of the disease, and a smaller LR– indicates a smaller likelihood of the disease. These values have been interpreted according to the scale shown in Figure 33-3.[20] A LR+ over 5 and a LR– lower than .2 represent relatively important effects. Likelihood ratios between .2 to .5 and between 2 to 5 may be important, depending on the nature of the diagnosis being studied. Values close to 1.0 represent unimportant effects. A likelihood ratio of 1.0 means the true-positive and false positive (or true-negative and false negative) rates are the same, making the results of the test useless.

> For the height loss data, the LR+ = 3.71. Therefore, with a positive test, the likelihood of a patient having a VFx is increased by almost four times. This represents a potentially important value. The LR– = .27, which represents a less important value. Based on these data, height loss should help to improve our confidence with a positive test.

Going back to the concepts of **SpPin** and **SnNout**:[13]

- A large LR+ (>10) indicates that a positive test is good at ruling the disorder **IN**.
- A low LR– (<.01) indicates that a negative test is good at ruling the disorder **OUT**.
- A LR close to 1.0 does not contribute to the probability that a person has or does not have the disorder.

We can confirm these guidelines by looking at posttest probabilities.

A Nomogram to Determine Posttest Probabilities

A nomogram has been developed based on Bayes' theorem that can be used to determine posttest probabilities using pretest probabilities and likelihood ratios for positive and negative tests (see Fig. 33-4).[21] To use the nomogram, we start on the left by marking the pretest probability, based on the known prevalence of the condition. For our example, we will use the sample prevalence to get a pretest probability of 41%. The positive and negative likelihood ratios are identified on the center line. If we draw lines from the pretest probability through these points, extending them to the right margin, we can estimate the posttest probabilities associated with a positive and negative test. The posttest probability is about 72% for a positive test and 16% for a negative test.

Therefore, if we obtain a positive test we have substantially improved our confidence in the patient being at risk for VFx, going from 41% to 72%. If we obtain a

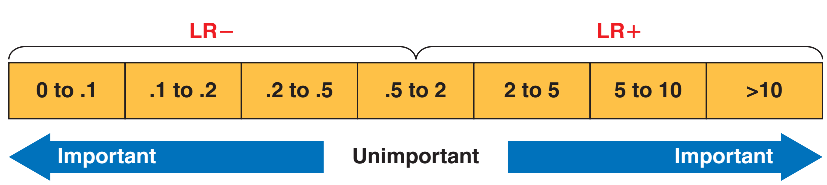

Figure 33–3 Scale for interpreting the relative importance of positive and negative likelihood ratios.