Percentiles & Z-Scores

- Lesson 2.1 -

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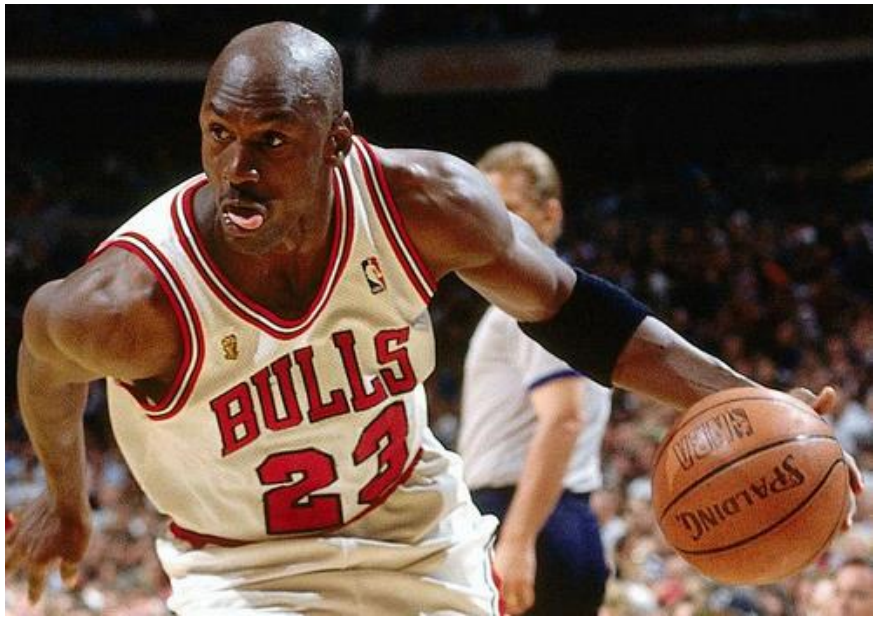
Paul Vathis, AP Images

Wilt - 1960’s



Jordan - 1990’s

LeBron - 2010’s

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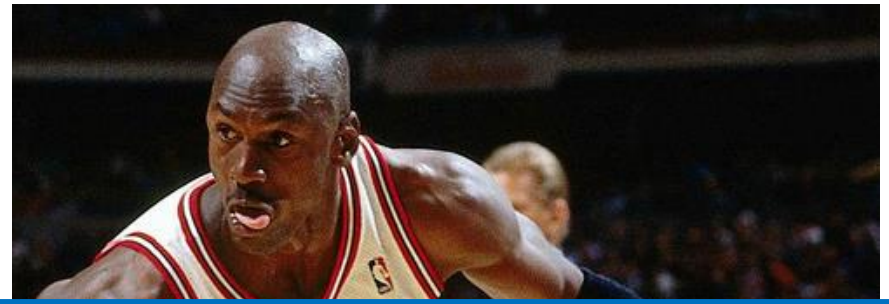

Paul Va

Today's Key Analysis

Who was the G.O.A.T at scoring?

n - 2010's

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Lesson 2.1
Guided Notes

Handout: *skewthescript.org/2-1*

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Topics

1. Percentiles
2. Cumulative Relative Frequency
3. Standardized Scores (Z-Scores)

Topics

1. **Percentiles**
2. Cumulative Relative Frequency
3. Standardized Scores (Z-Scores)

Who did better on their SAT?

Mr. Young-Saver
Statistician, Math Teacher

VS.

Guy Fieri
Chef, Mayor of Flavortown

Who did better on their SAT?

Mr. Young-Saver
Statistician, Math Teacher

1050

out of

1600

SAT

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Who did better on their SAT?

They don’t offer the SAT in Flavortown, USA!

Guy Fieri

Chef, Mayor of Flavortown

Who did better on their SAT?

They don't offer the SAT in Flavortown, USA!

Mr. Fieri took the ACT

Guy Fieri

Chef, Mayor of Flavortown

Who did better on their SAT?

ACT

23

out of

36

Guy Fieri

Chef, Mayor of Flavortown

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Who should Flavortown College select?

Who should Flavortown College select?

SAT: 1050

VS.

ACT: 23

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Who should Flavortown College select?

VS.

SAT: 1050

1050/1600 = **66%**

ACT: 23

23/36 = **64%**

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Who should Flavortown College select?

VS.

It's not that simple!
The tests use different scales and scoring systems.

SAT: 1050
1050/1600 = 66%

ACT: 23
23/36 = 64%

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Who should Flavortown College select?

VS.

SAT: 1050

1050/1600 = 66%

ACT: 23

23/36 = 64%

It's not that simple!
The tests use different scales and scoring systems.

How to compare?

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Percentiles

Percentile: the percent of data **less than or equal to** a certain data value.

Percentiles

Percentile: the percent of data **less than or equal to** a certain data value.

Note: Sometimes it's just "less than," but in AP Stats it's "less than or equal to"

Percentiles

Percentile: the percent of data **less than or equal to** a certain data value.

Salaries at a company (thousands of $)

29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185

Percentiles

Percentile: the percent of data **less than or equal to** a certain data value.

Question: At what percentile is the person who makes a salary of $43,000?

29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185

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29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185

“less than or equal to”

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Percentiles

Percentile: the percent of data **less than or equal to** a certain data value.

Question: At what percentile is the person who makes a salary of $43,000?

29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185

10 salaries at or below $43,000

Percentiles

Percentile: the percent of data **less than or equal to** a certain data value.

Question: At what percentile is the person who makes a salary of $43,000?

29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185

10 / 12 ≈ 83%

Percentiles

Percentile: the percent of data **less than or equal to** a certain data value.

Question: At what percentile is the person who makes a salary of $43,000?

29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185

10 / 12 ≈ 83% → The salary of $43,000 is at the 83rd percentile of salaries.

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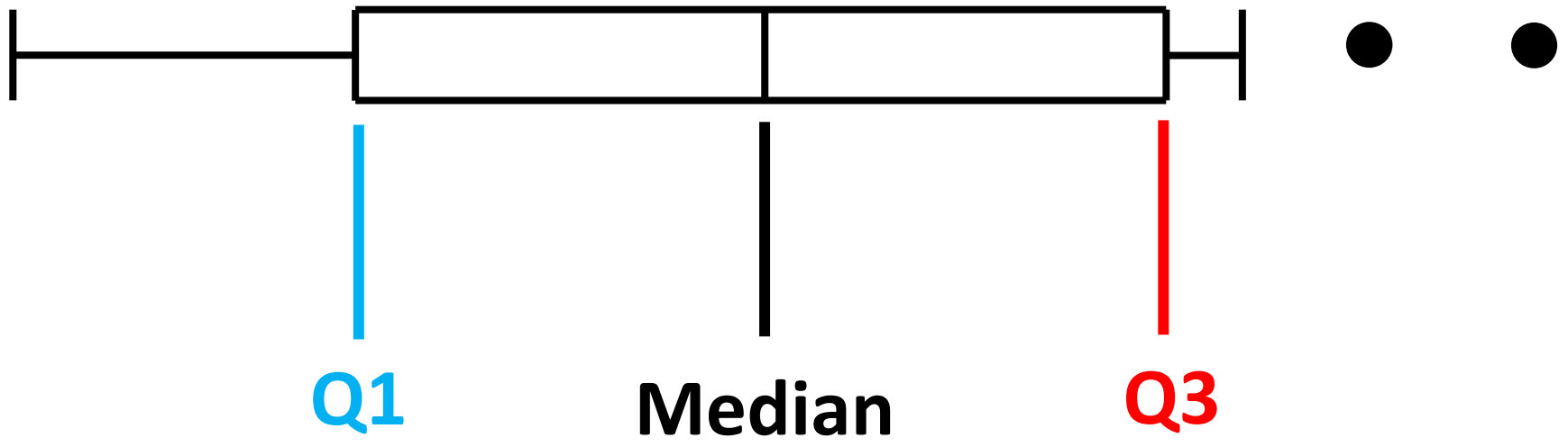
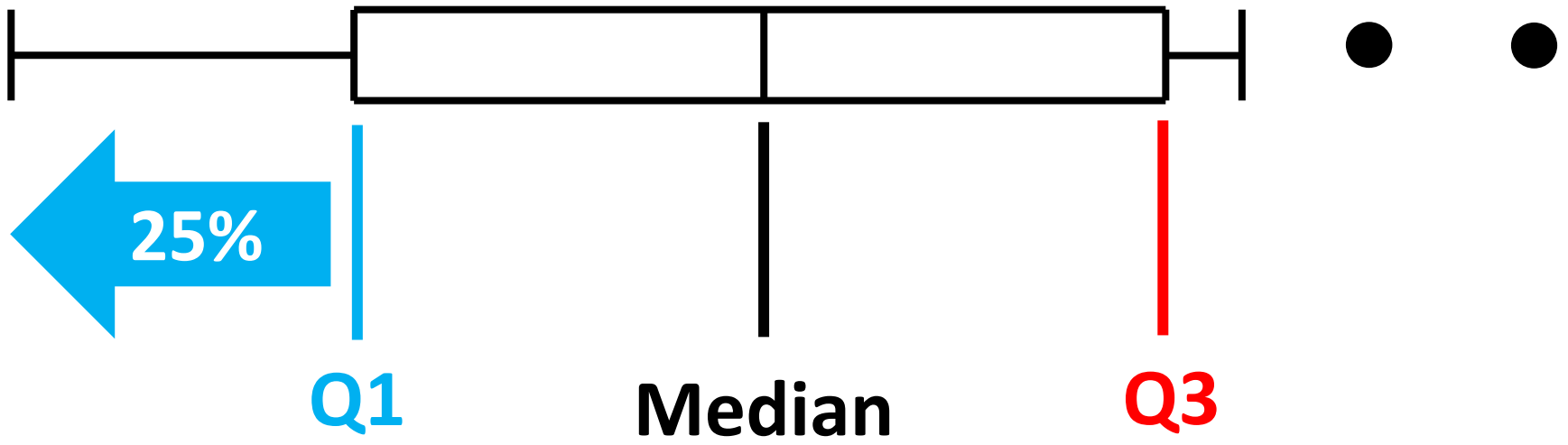
Percentiles and Boxplots



For large datasets…

Percentiles and Boxplots



For large datasets…

Q1 is at the 25th percentile.

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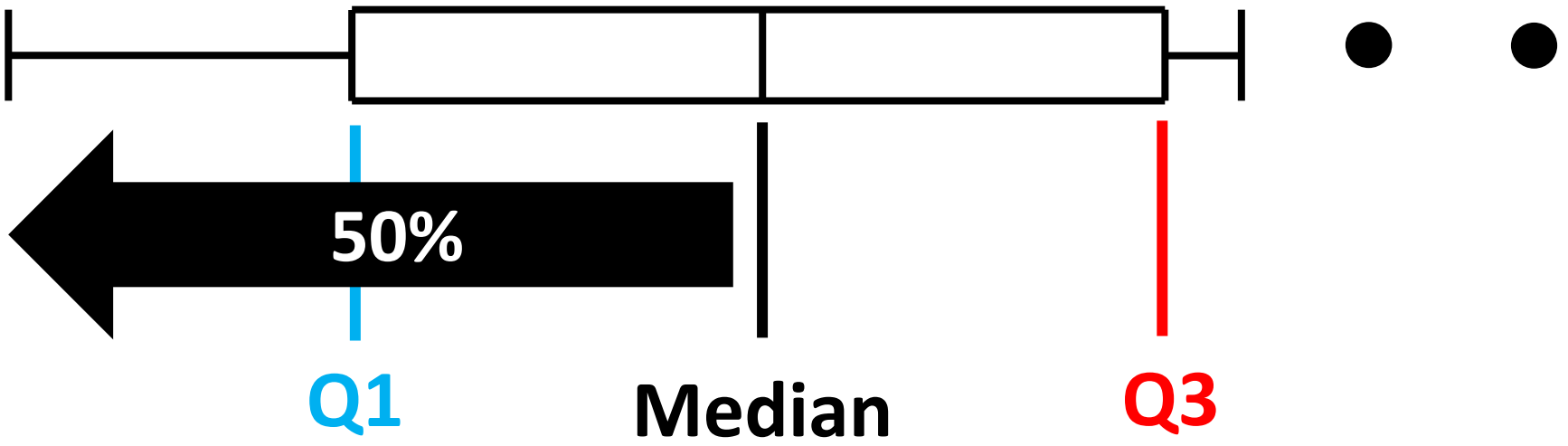
Percentiles and Boxplots



For large datasets…

The median (Q2) is at the 50th percentile.

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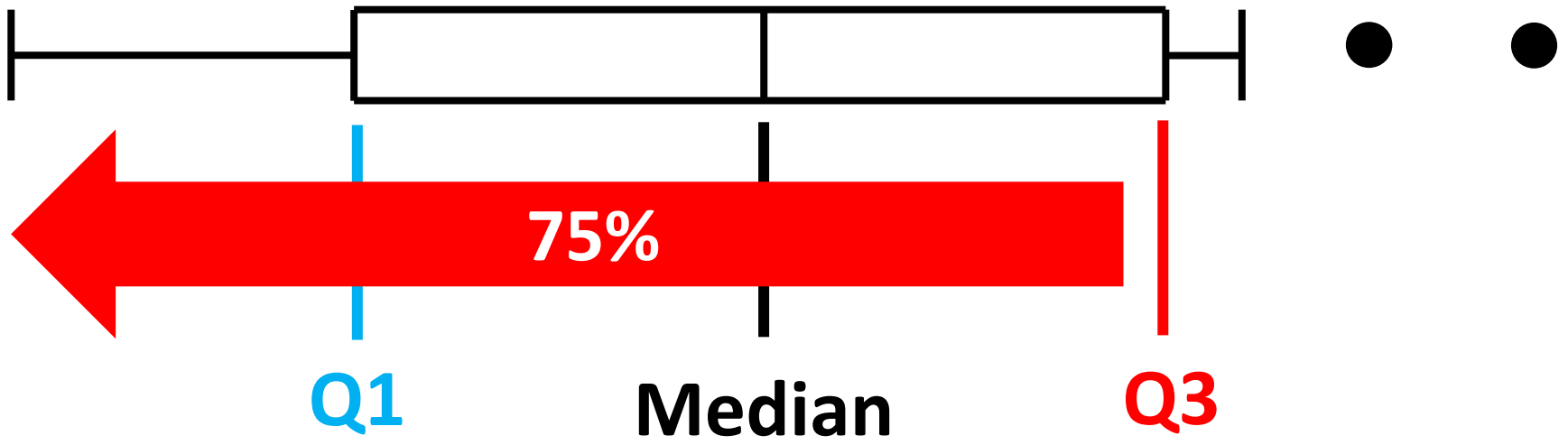
Percentiles and Boxplots



For large datasets…

Q3 is at the 75th percentile.

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Who should Flavortown College select?

VS.

SAT: 1050

ACT: 23

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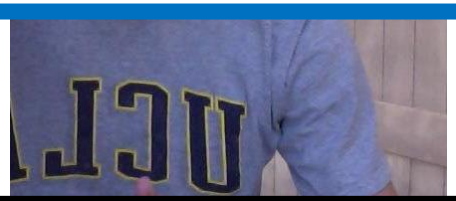
Who should Flavortown College select?

What percent of people did each test-taker outscore?



SAT: 1050

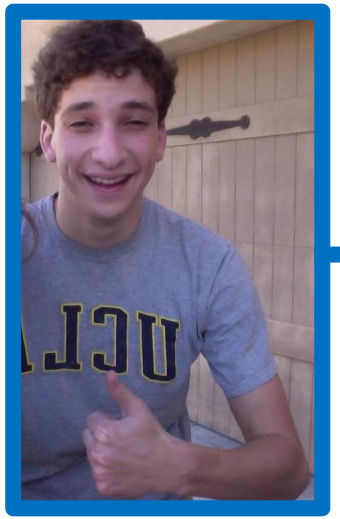
VS.

ACT: 23

SAT	Percentile
1600	100%
1550	99.3%
1500	98%
1450	95%
1400	93%
1350	89%
1300	84%
1250	78%
1200	71%
1150	62%
1100	53%
1050	45%
1000	35%
950	26%
900	19%
850	13%
800	8%
750	5%
700	3%
650	2%
600	1%

ACT	Percentile
36	100%
35	99.9%
34	99.0%
33	98%
32	97%
31	95%
30	93%
29	91%
28	88%
27	85%
26	82%
25	78%
24	74%
23	69%
22	64%
21	58%
20	52%
19	46%
18	40%
17	33%
16	27%
15	20%
14	14%
13	9%
12	4%
11	1%
10	1%

From 2019-2020 school year test reports



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1450	95%
1400	93%
1350	89%
1300	84%
1250	78%
1200	71%
1150	62%
1100	53%
1050	**45%**
1000	35%
950	26%
900	19%
850	13%
800	8%
750	5%
700	3%
650	2%
600	1%

ACT	Percentile
36	100%
35	99.9%
34	99.0%
33	98%
32	97%
31	95%
30	93%
29	91%
28	88%
27	85%
26	82%
25	78%
24	74%
23	**69%**
22	64%
21	58%
20	52%
19	46%
18	40%
17	33%
16	27%
15	20%
14	14%
13	9%
12	4%
11	1%
10	1%

From 2019-2020 school year test reports

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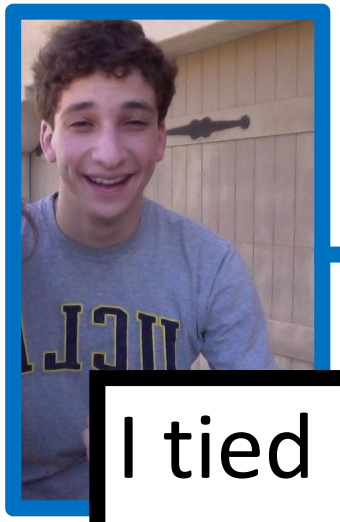

SAT	Percentile
1600	100%
1550	99.3%
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1400	93%
1350	89%
1300	84%
1250	78%
1200	71%
1150	62%
1100	53%
1050	**45%**
1000	35%
950	26%

I tied or outscored 45% of SAT test takers

ACT	Percentile
36	100%
35	99.9%
34	99.0%
33	98%
32	97%
31	95%
30	93%
29	91%
28	88%
27	85%
26	82%
25	78%
24	74%
23	**69%**
22	64%
16	27%
15	20%
14	14%
13	9%
12	4%
11	1%
10	1%

Mr. Fieri tied or outscored 69% of test takers

From 2019-2020 school year test reports

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Who should Flavortown College select?

SAT: 1050

VS.

ACT: 23

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Who should Flavortown College select?

VS.

SAT: 1050

45th Percentile

ACT: 23

69th Percentile

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Who should Flavortown College select?

VS.

Guy Fieri's score is the more impressive one.

SAT: 1050

45th Percentile

ACT: 23

69th Percentile

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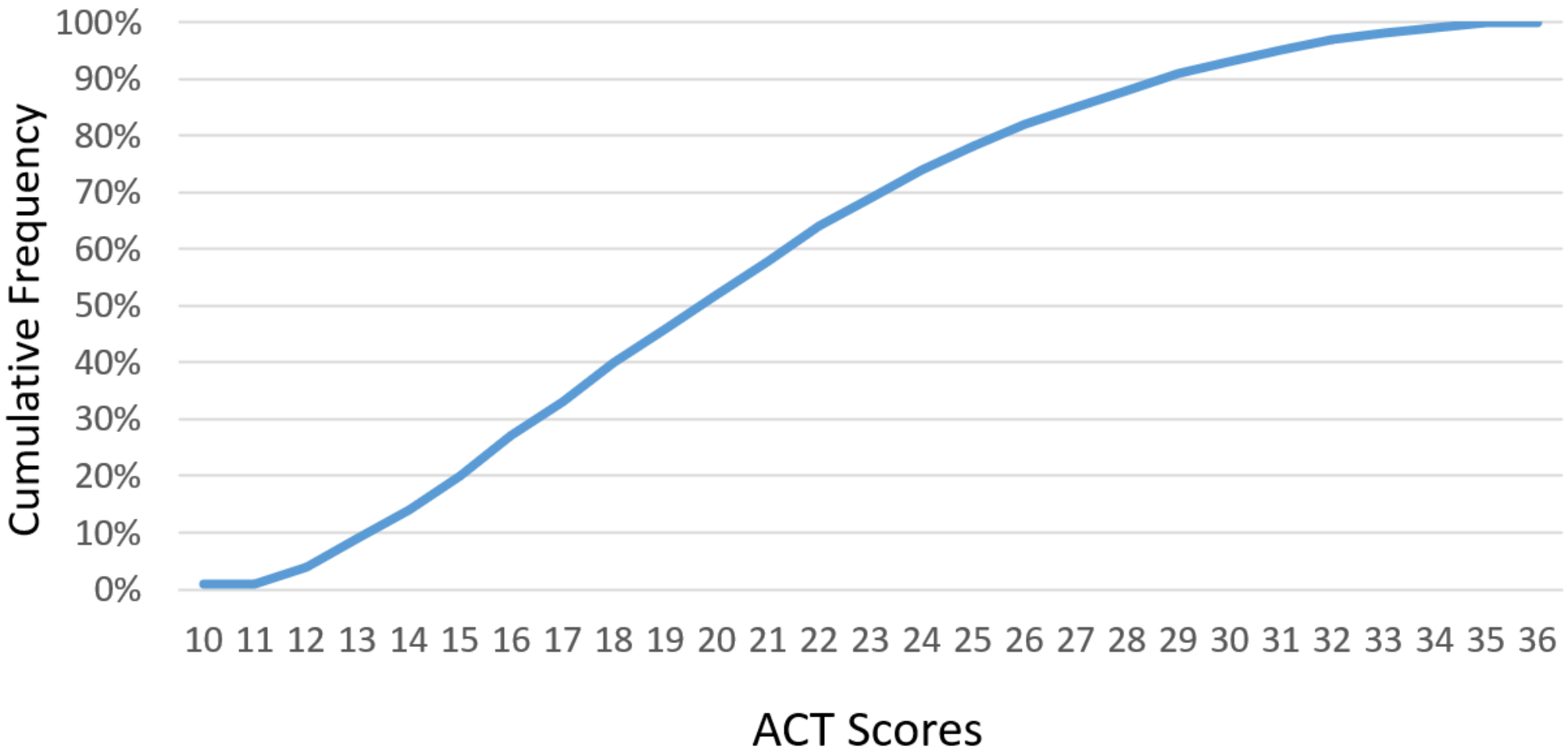
Topics

1. Percentiles
2. **Cumulative Relative Frequency**
3. Standardized Scores (Z-Scores)

Cumulative Relative Frequency Charts



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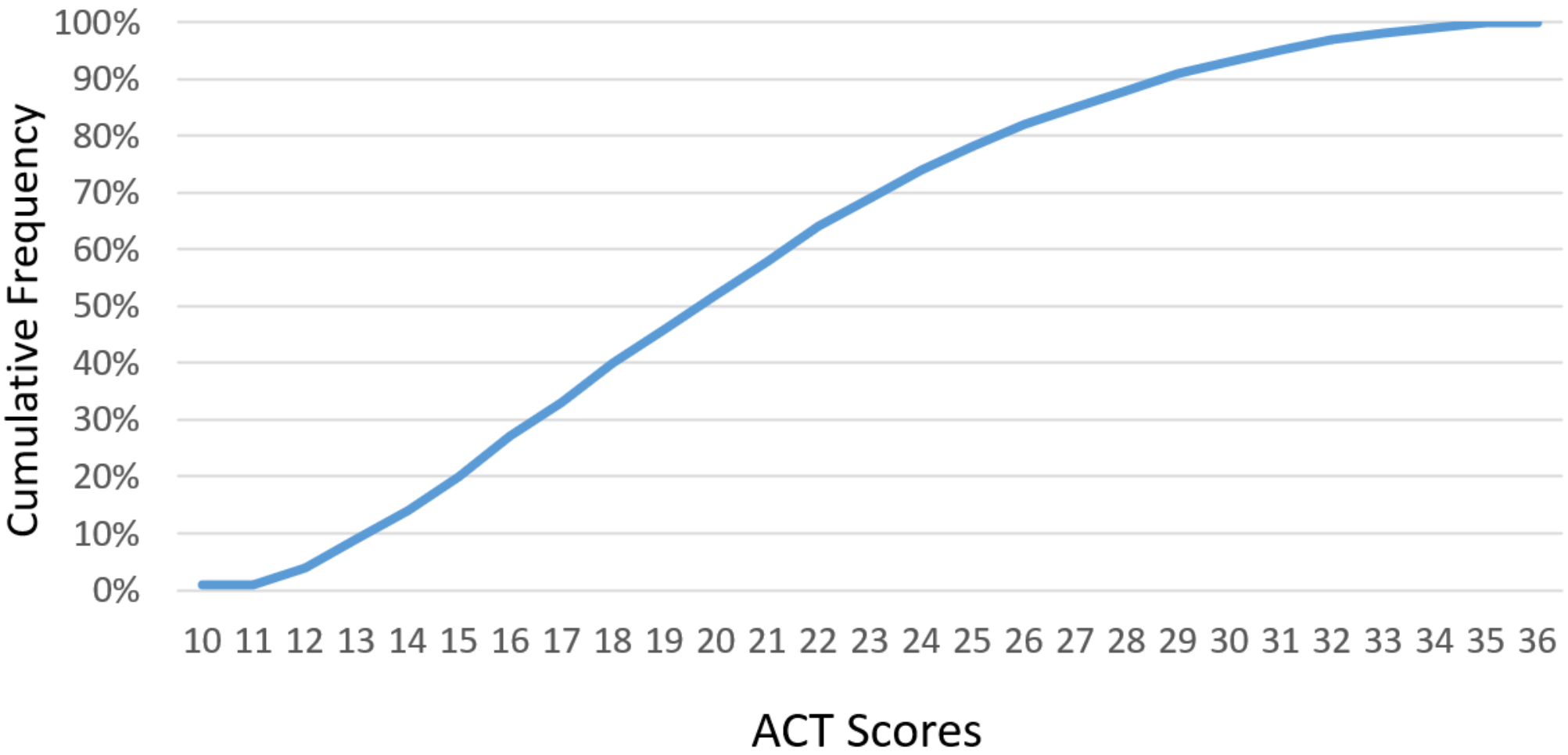
Cumulative Relative Frequency Charts

scary



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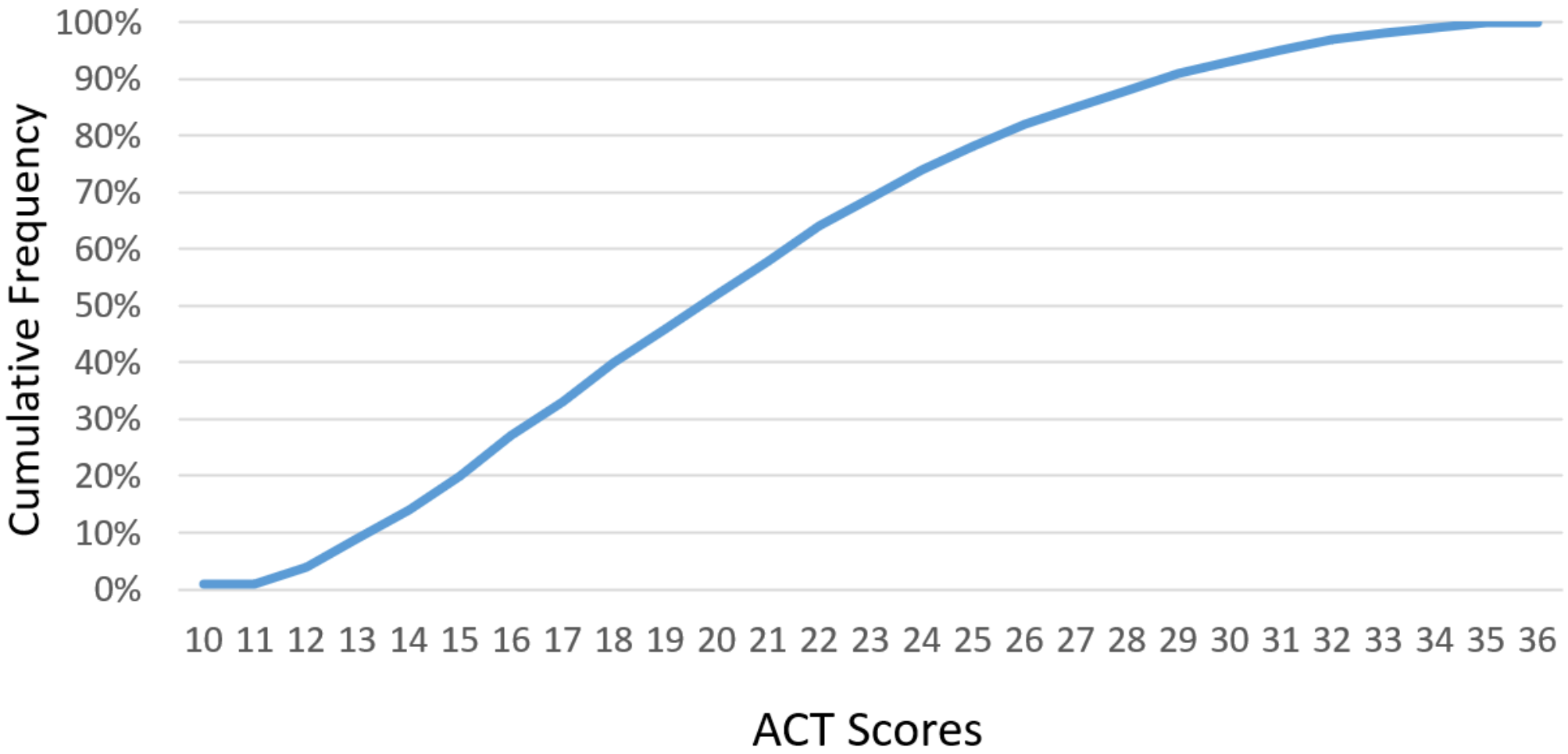
Cumulative Relative Frequency Charts

= Percentile



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Cumulative Relative Frequency Charts

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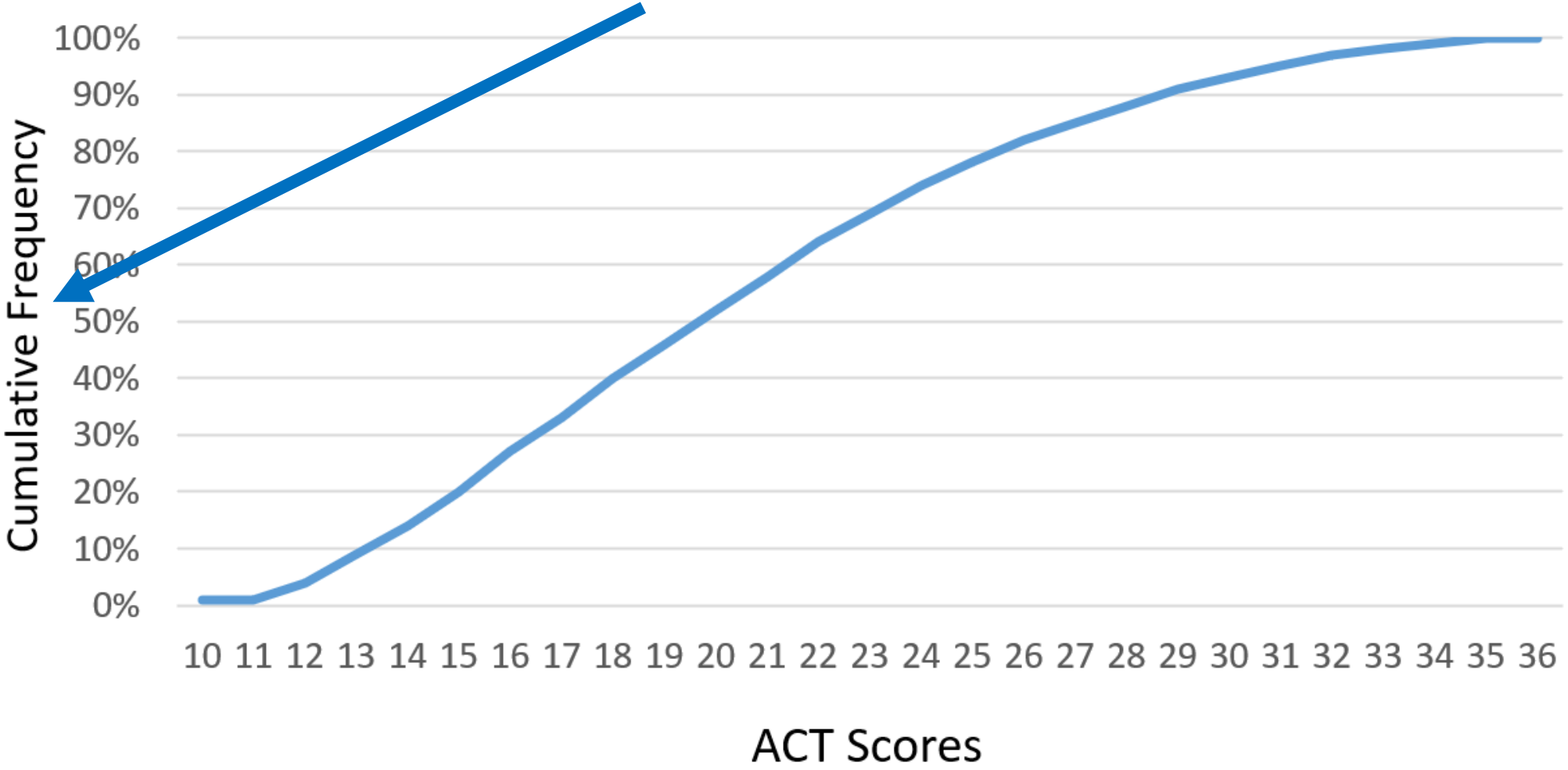

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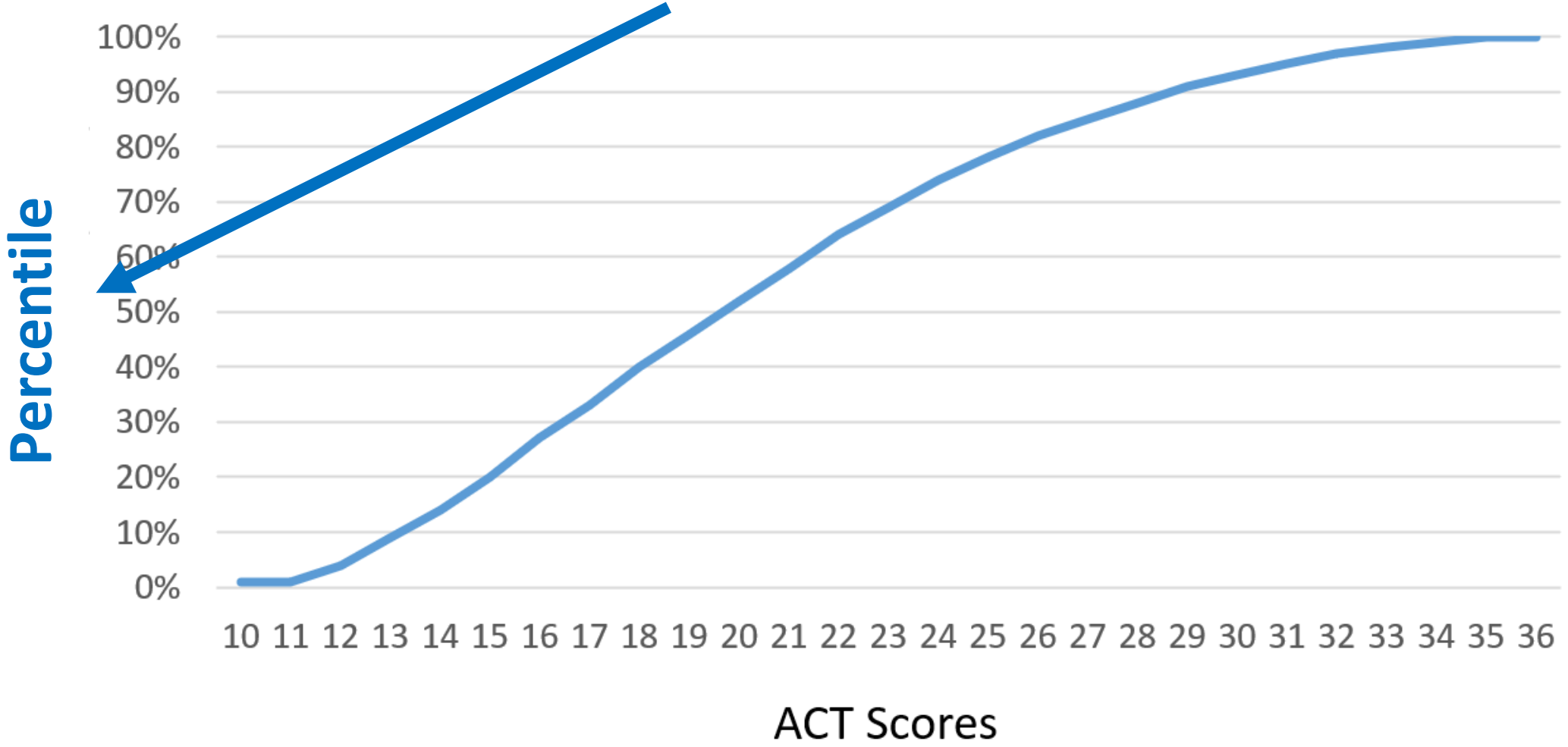
Cumulative Relative Frequency Charts

= Percentile



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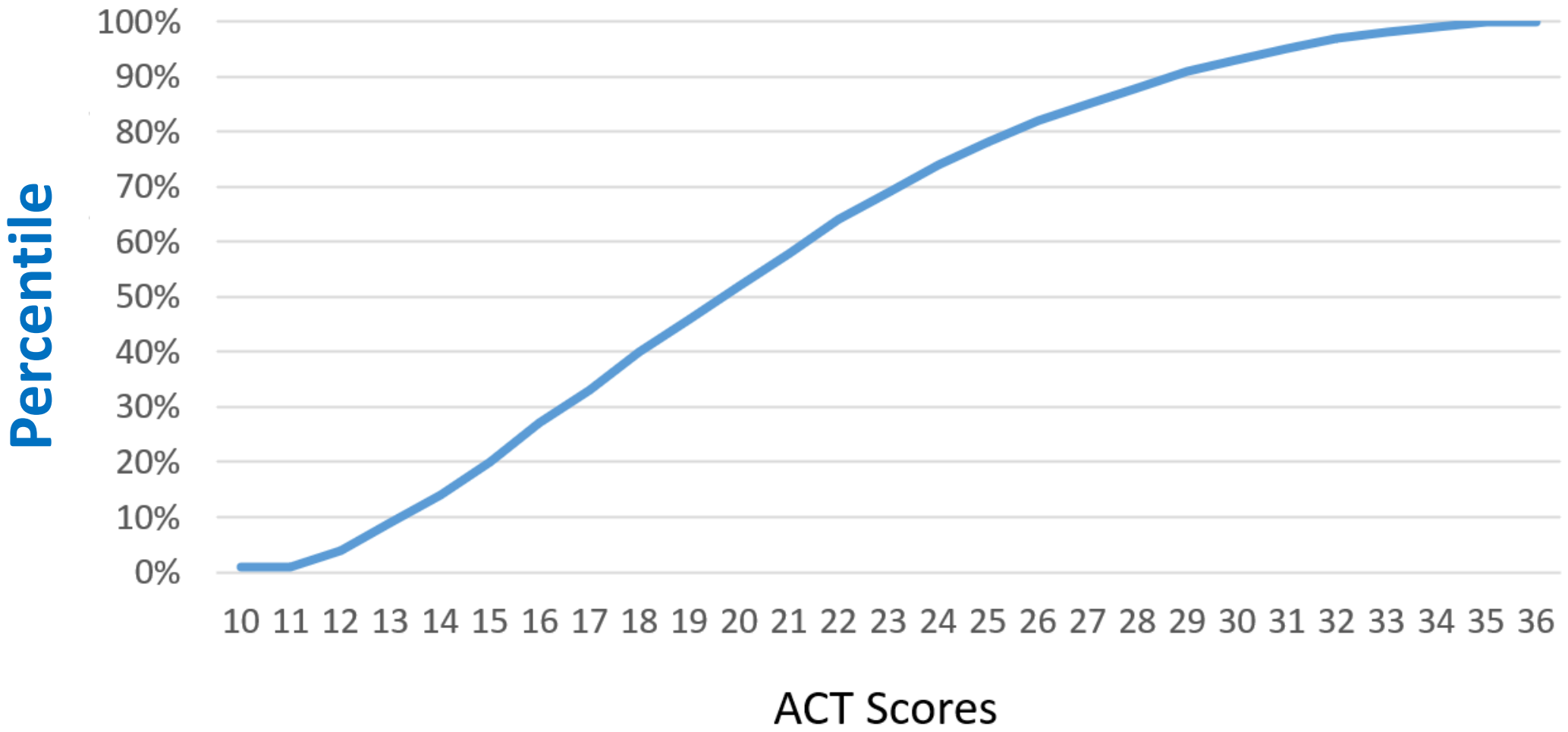
Cumulative Relative Frequency Charts



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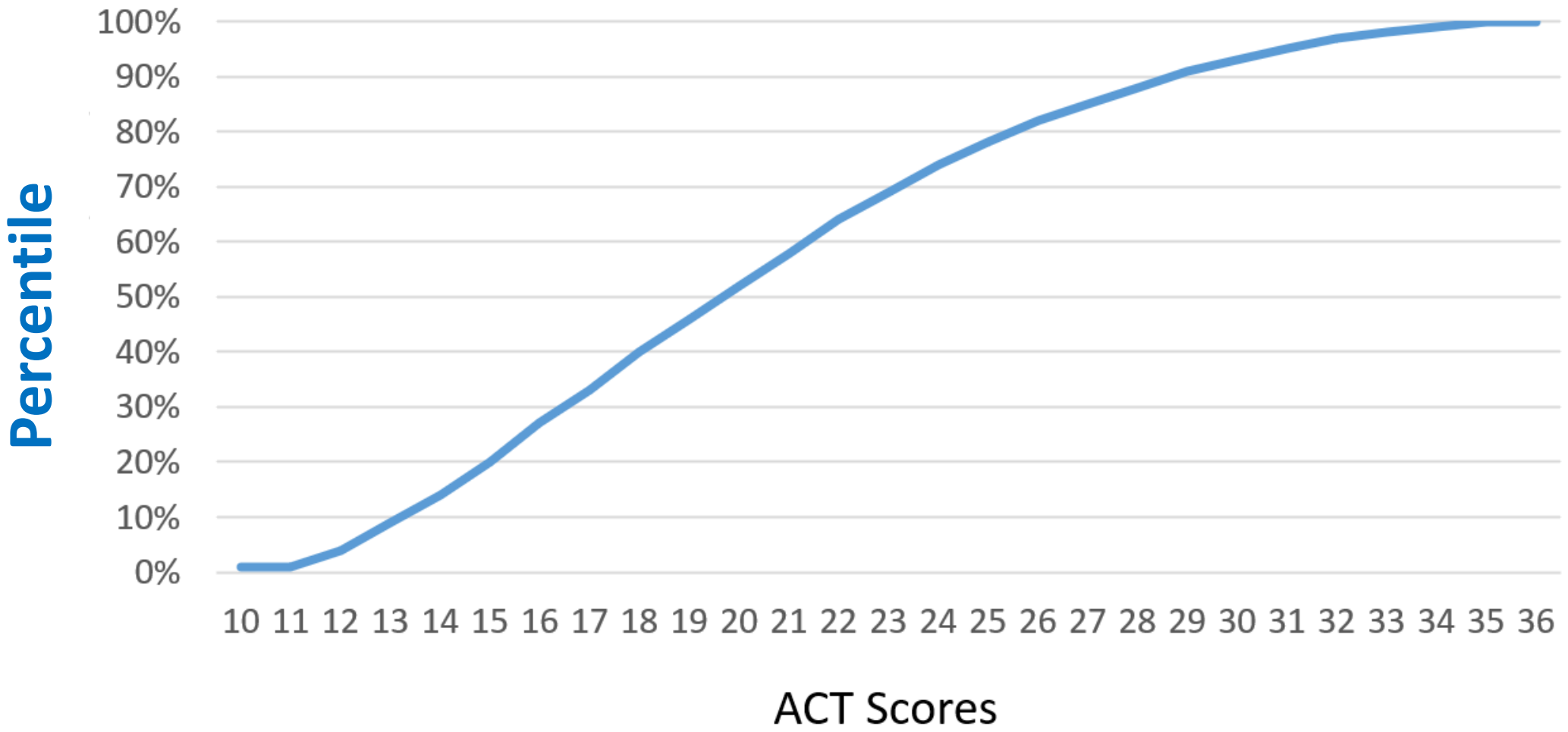
Cumulative Relative Frequency Charts

Is 18 a good ACT score?



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Cumulative Relative Frequency Charts

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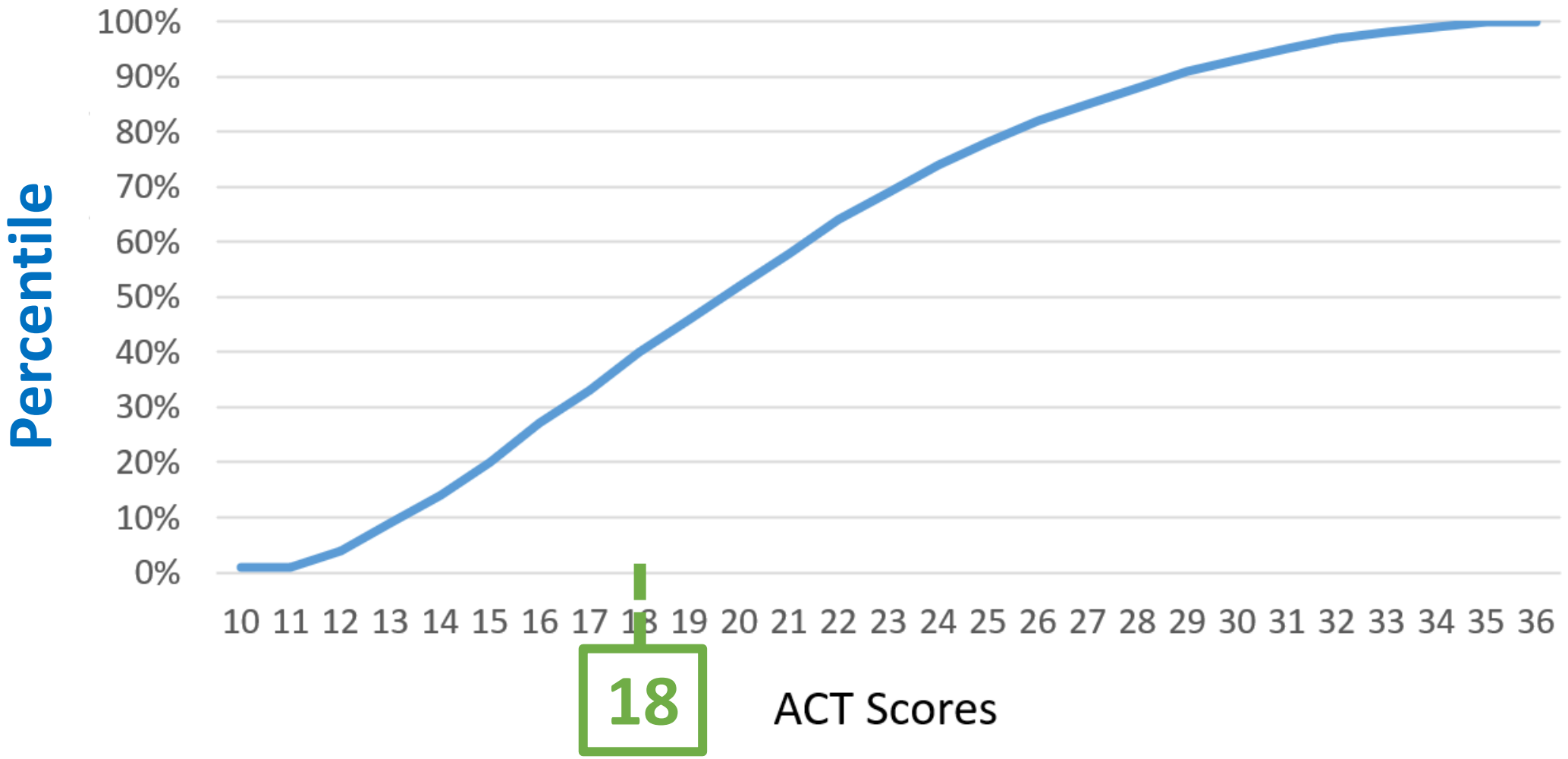

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Cumulative Relative Frequency Charts

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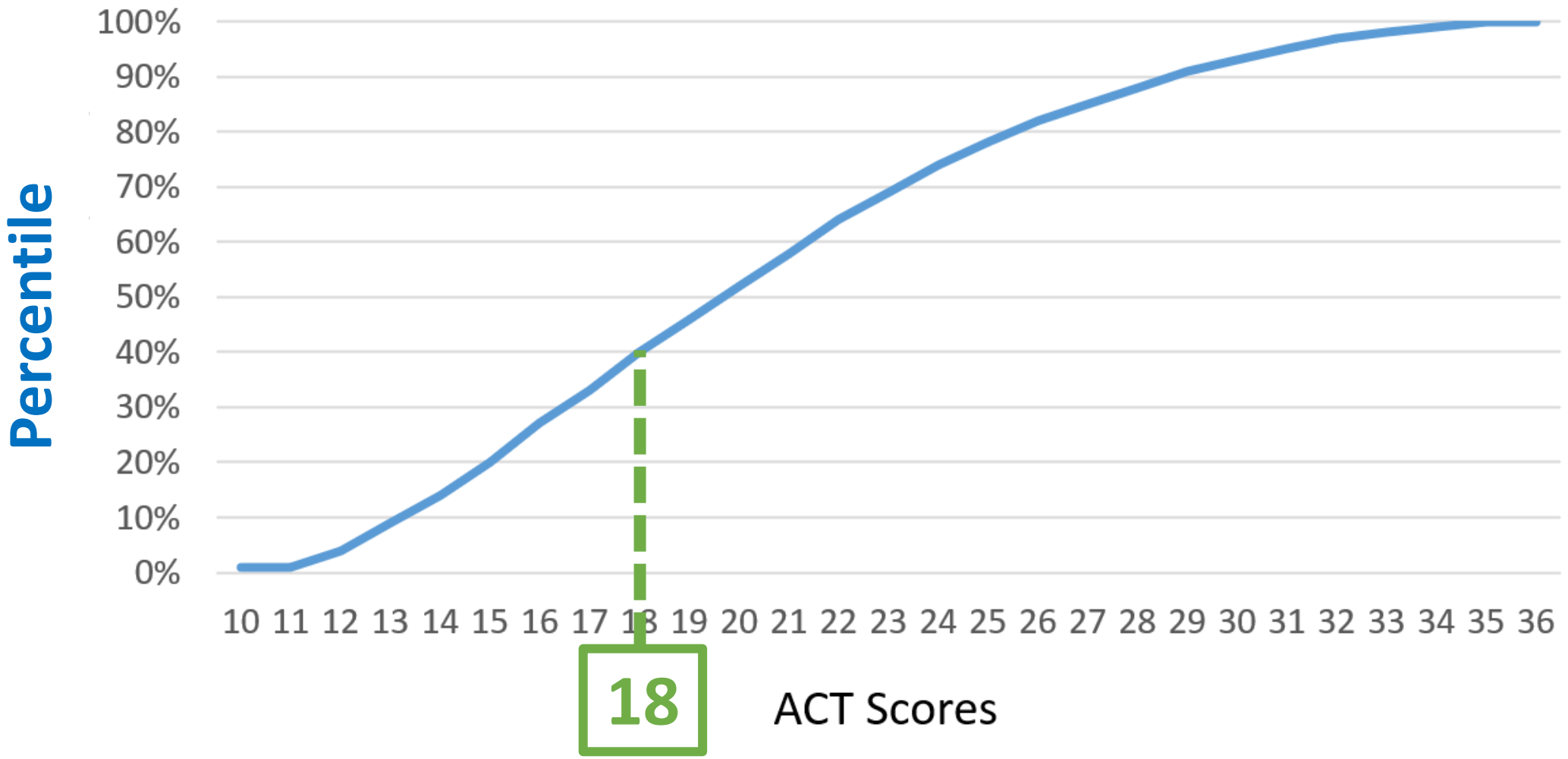

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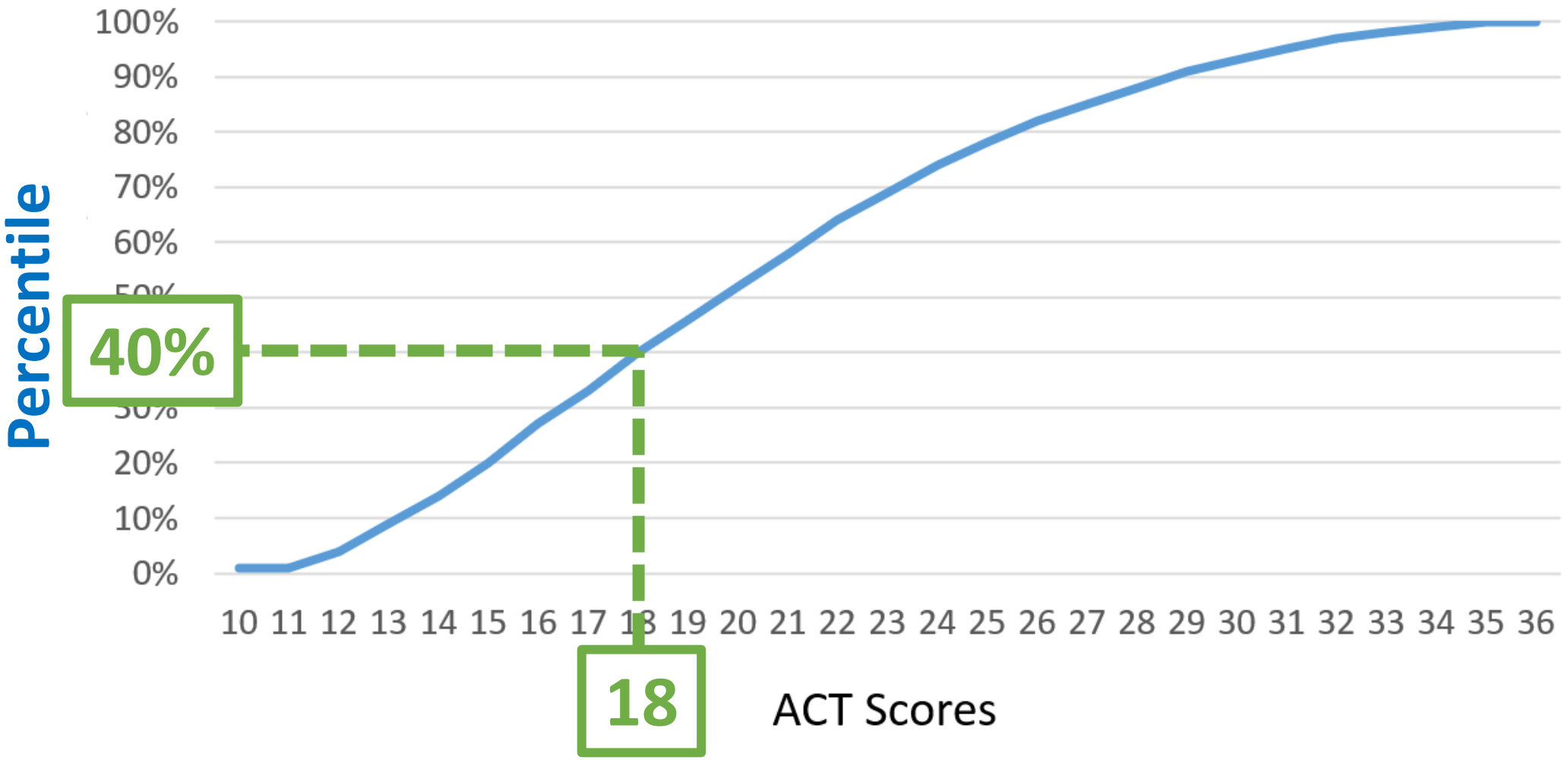
Cumulative Relative Frequency Charts

Is 18 a good ACT score?



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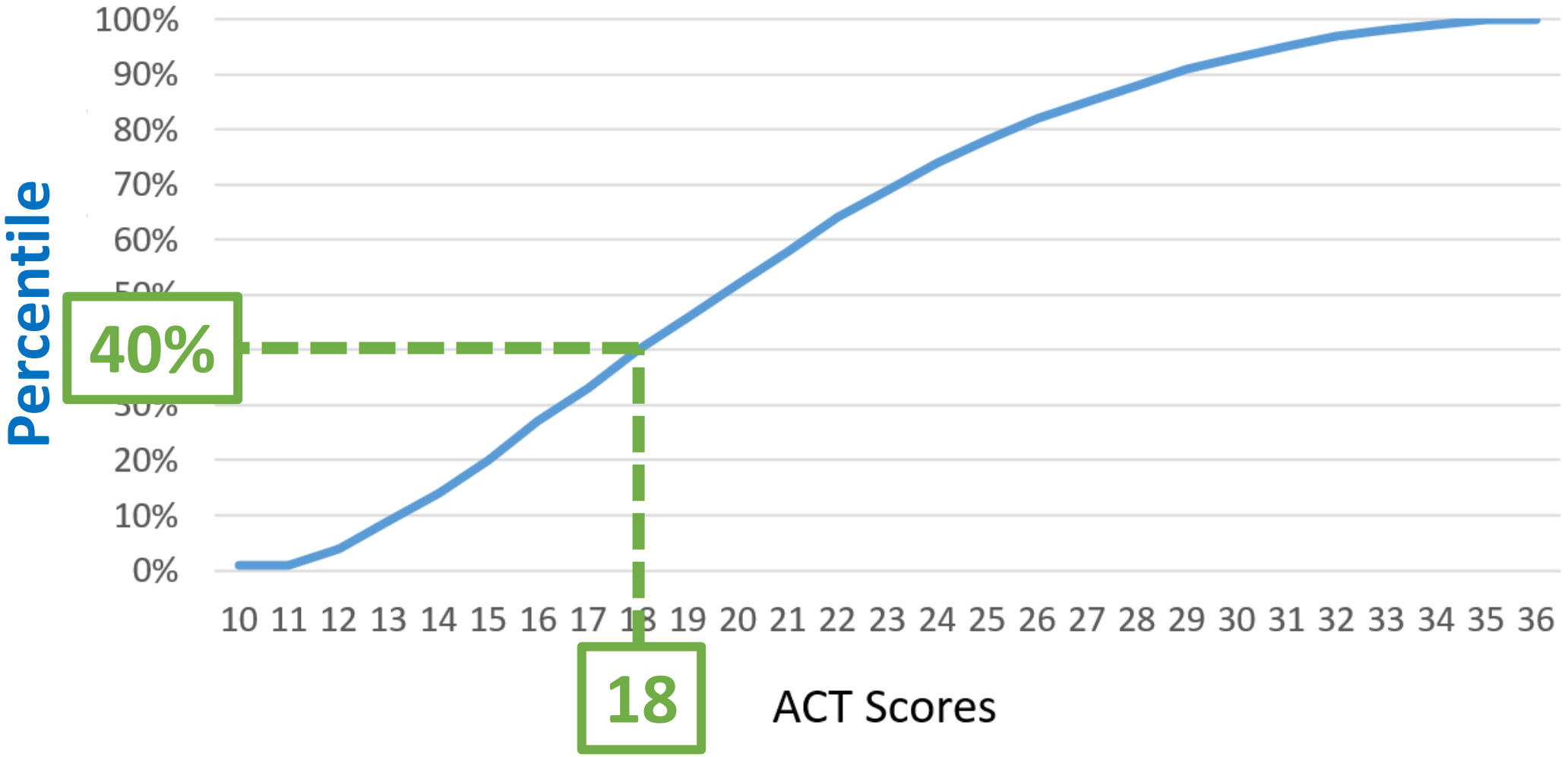
Cumulative Relative Frequency Charts

Is 18 a good ACT score? → 40th percentile



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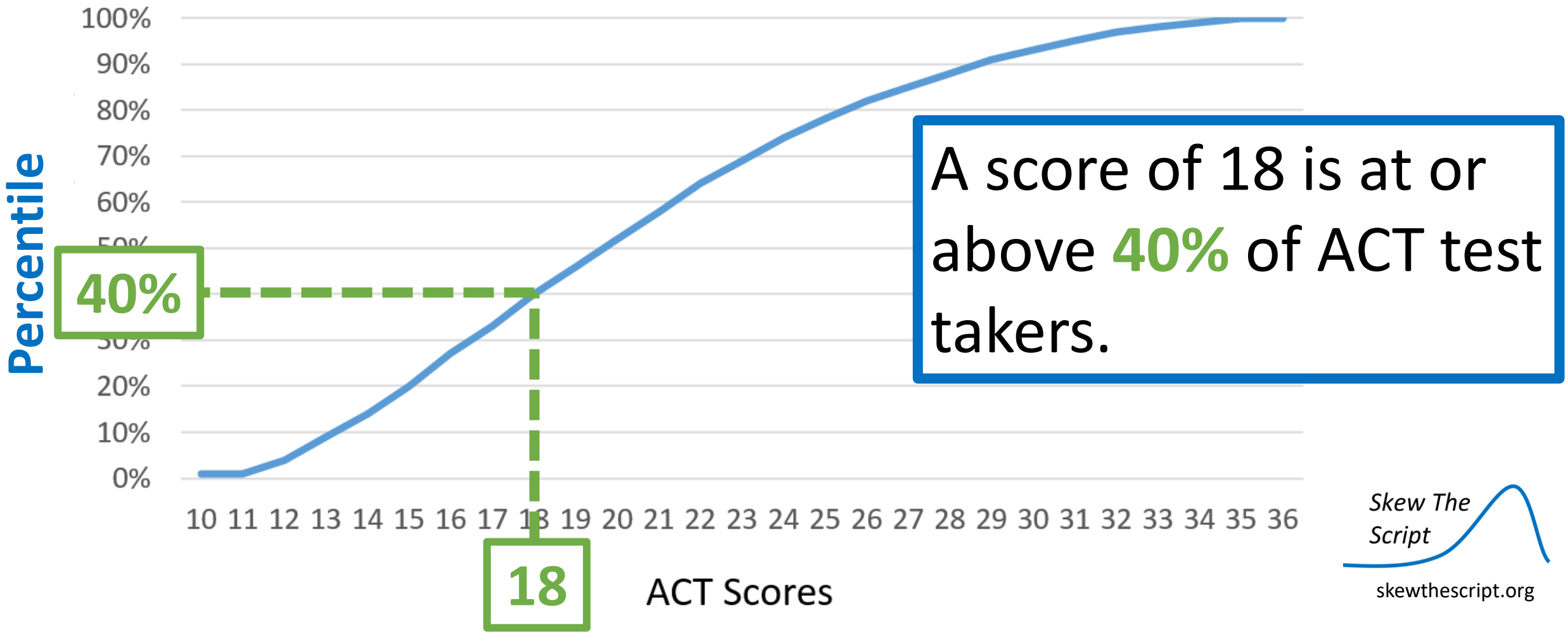
Cumulative Relative Frequency Charts

Is 18 a good ACT score? → 40th percentile



A score of 18 is at or above 40% of ACT test takers.

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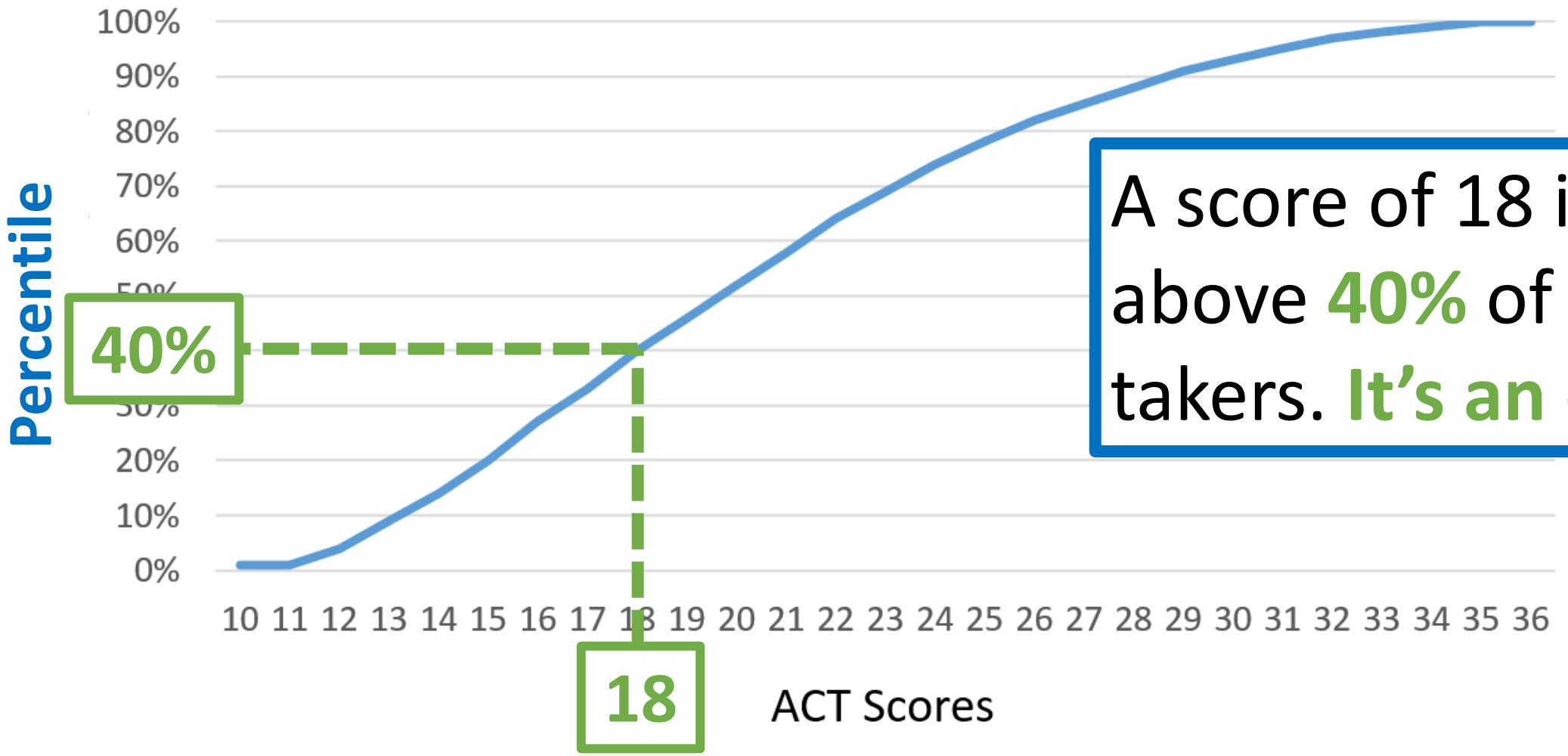
Cumulative Relative Frequency Charts

Is 18 a good ACT score? → 40th percentile



A score of 18 is at or above **40%** of ACT test takers. **It's an ok score.**

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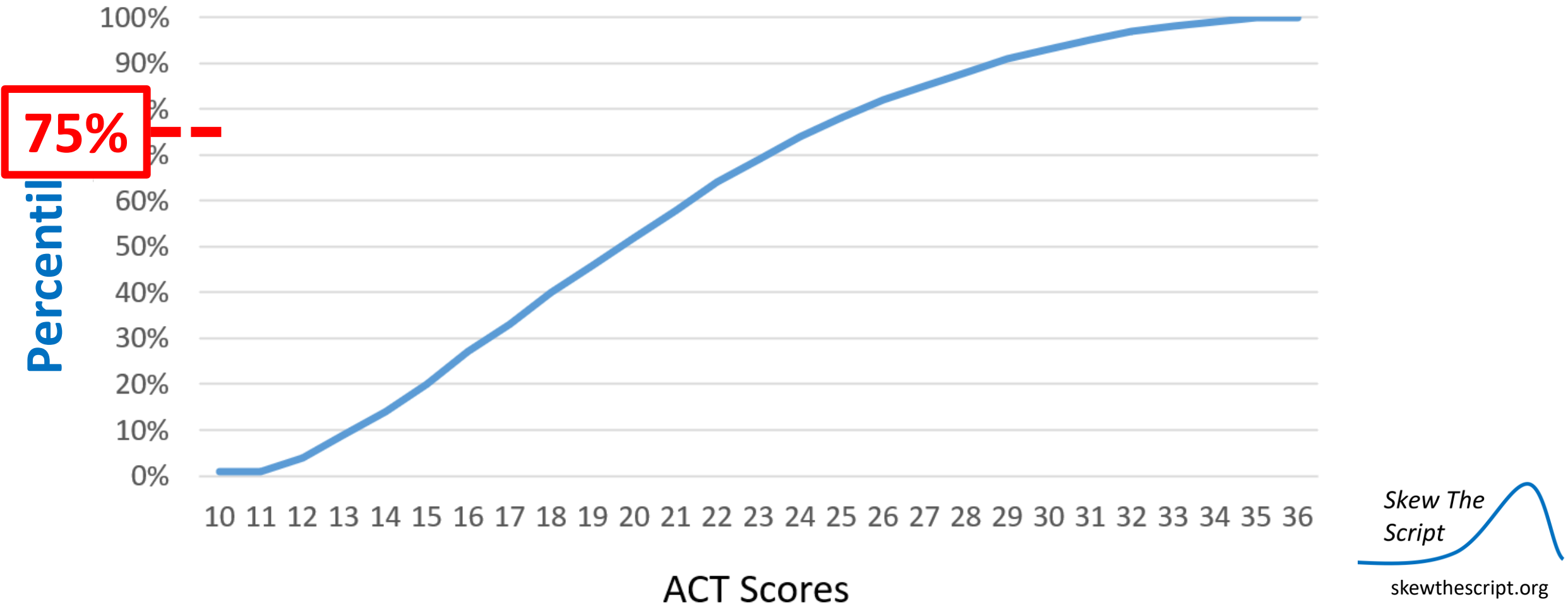
Cumulative Relative Frequency Charts

To be in the top quartile, what score do you need?



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Cumulative Relative Frequency Charts

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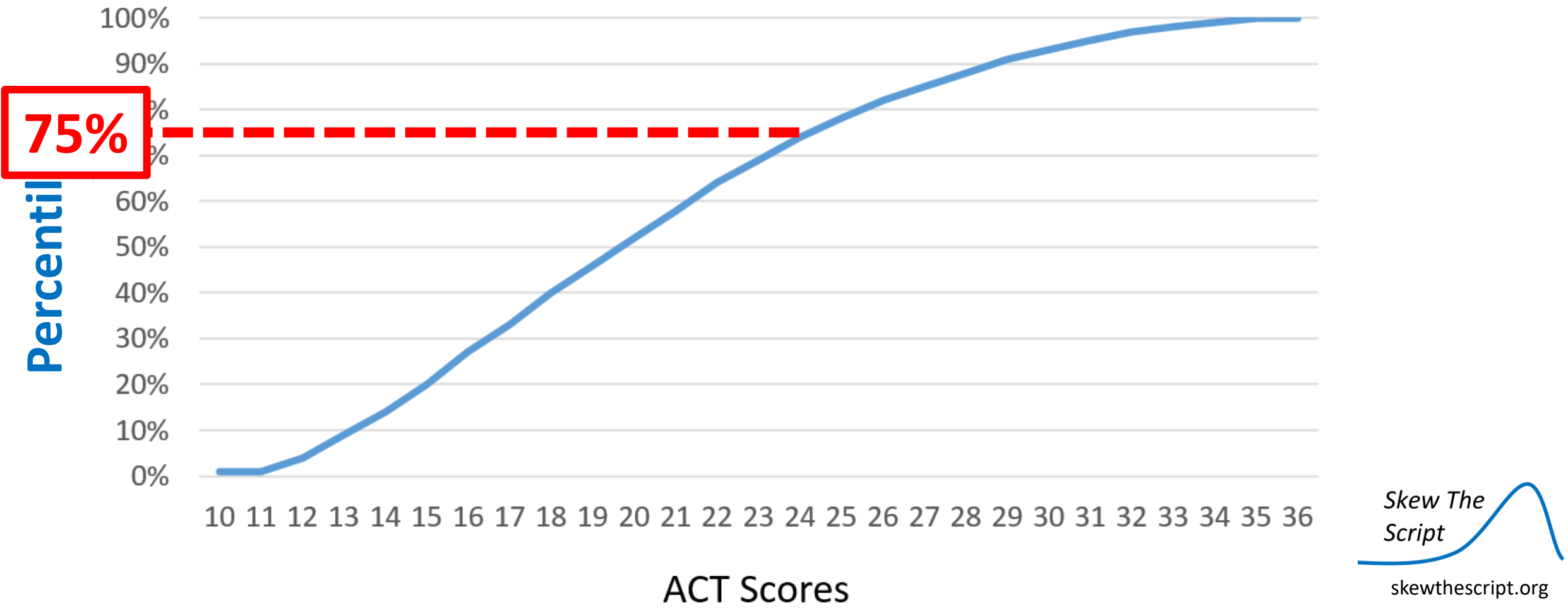

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Cumulative Relative Frequency Charts

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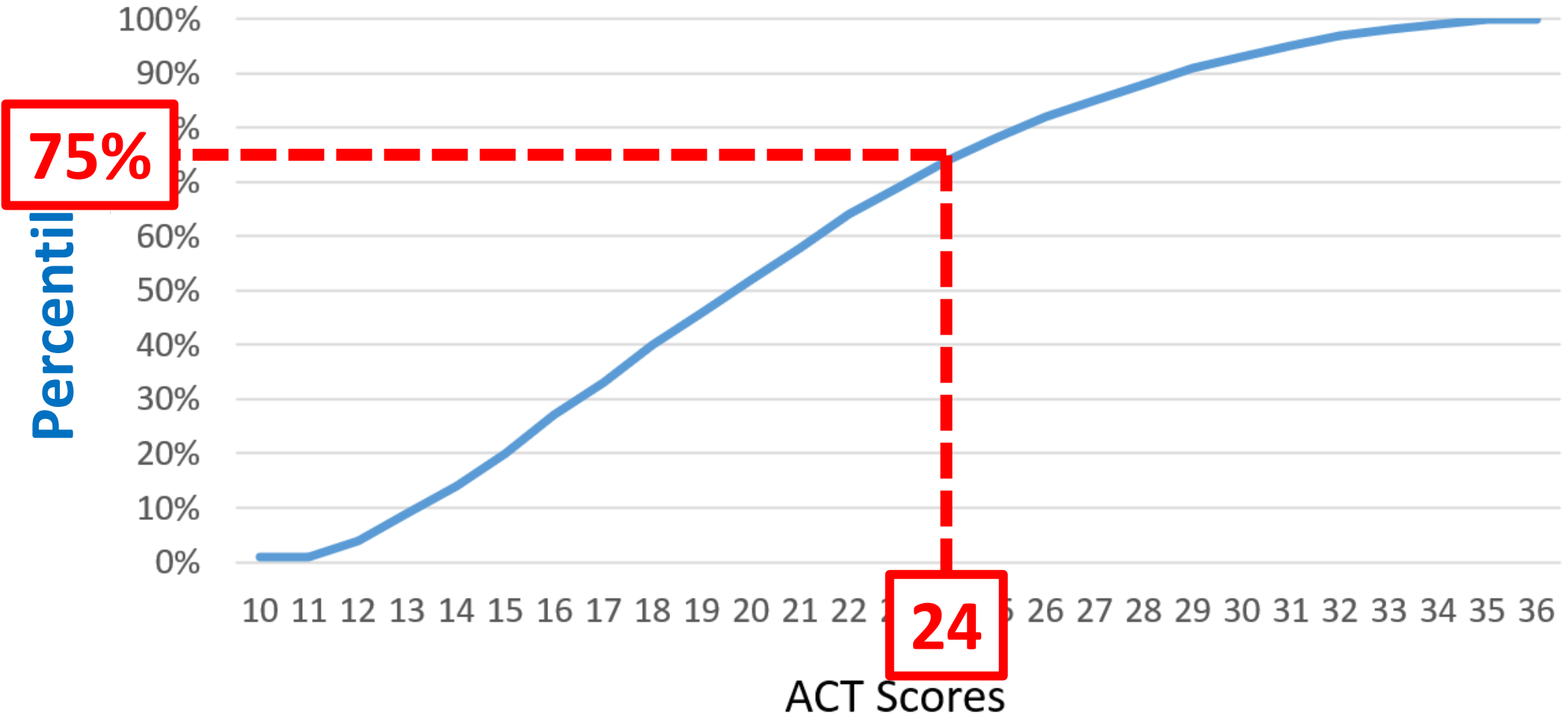

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Cumulative Relative Frequency Charts

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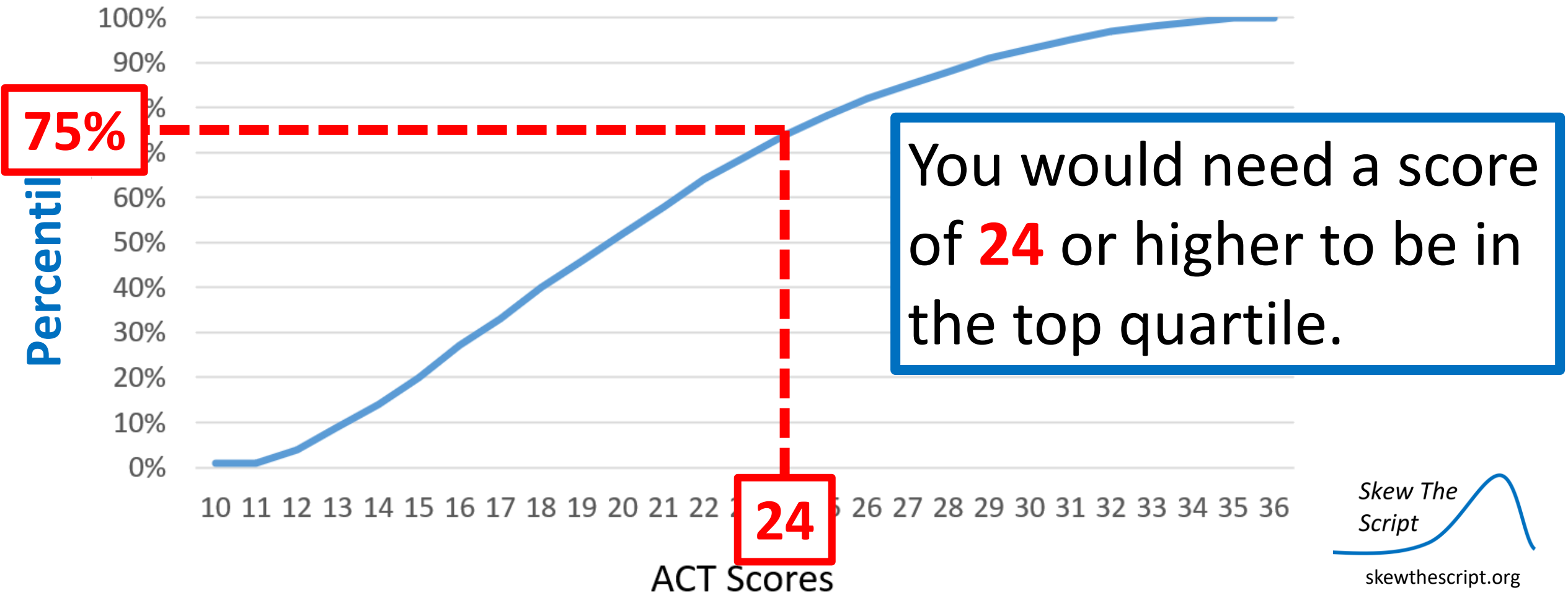

You would need a score of **24** or higher to be in the top quartile.

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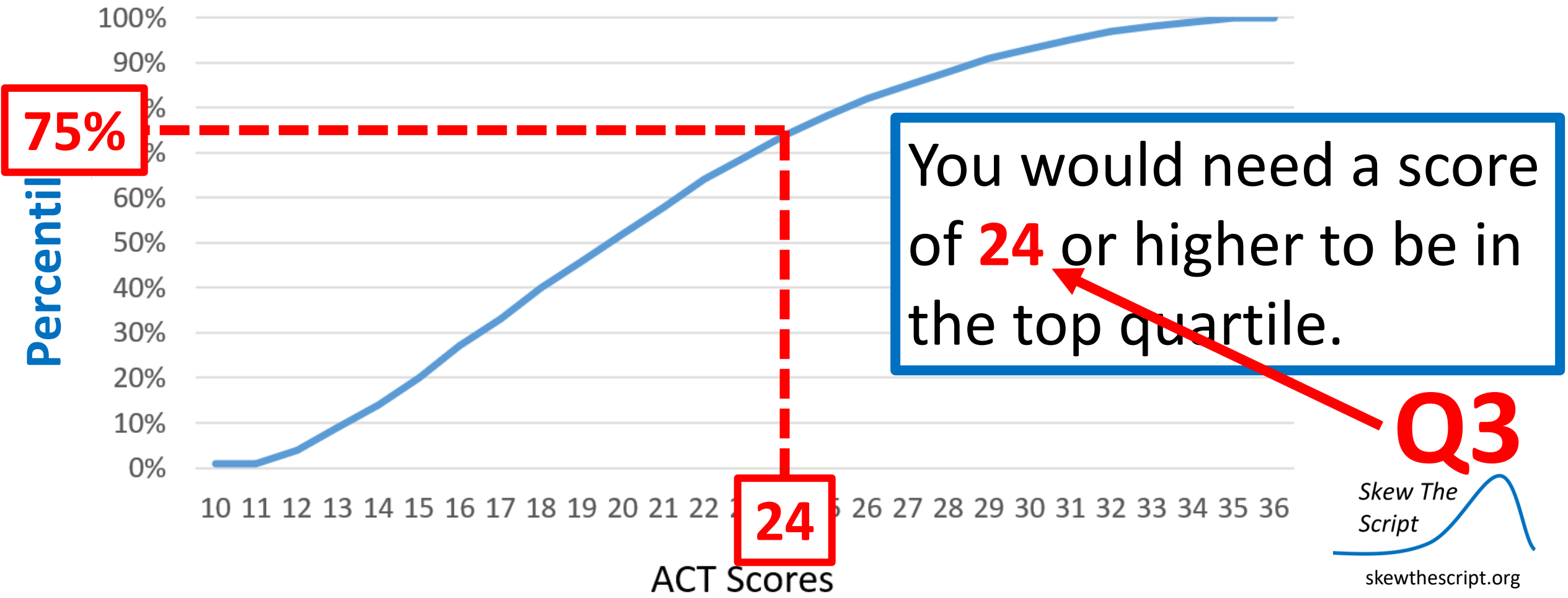
Cumulative Relative Frequency Charts

To be in the top quartile, what score do you need?



You would need a score of **24** or higher to be in the top quartile.

Q3

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Topics

1. Percentiles
2. Cumulative Relative Frequency
3. **Standardized Scores (Z-Scores)**

Z-Scores (Standardized Score)

Z-Scores: measures how many **standard deviations** a data point is **above/below** the mean.

Z-Scores (Standardized Score)

Z-Scores: measures how many **standard deviations** a data point is **above/below** the mean.

$$z = \frac{data\ point - mean}{standard\ deviation}$$

$$z = \frac{x_i - \mu}{\sigma}$$

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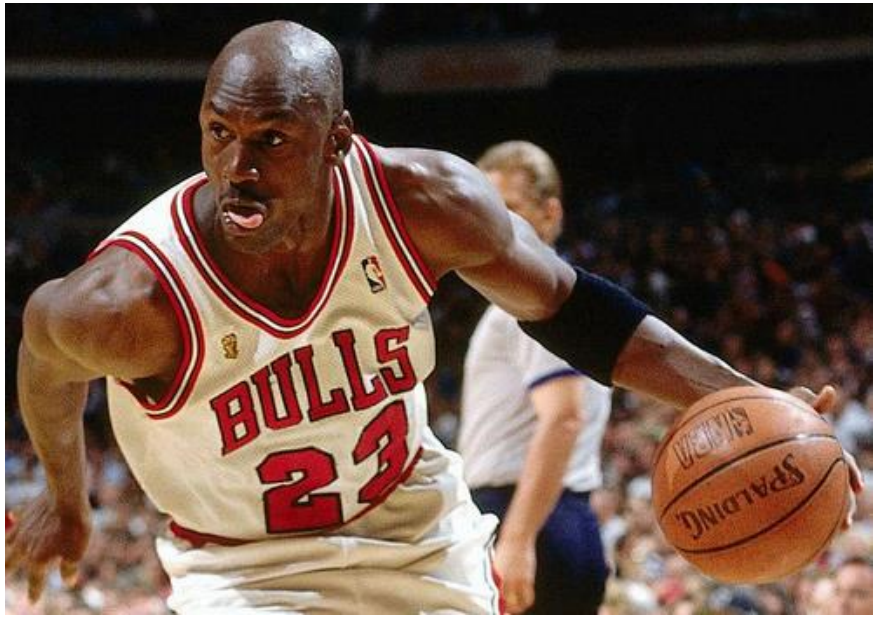
Who is the best **scorer**?

Paul Vathis, AP Images

Wilt - 1960's



Jordan - 1990's

LeBron - 2010's

All NBA stats used in this lesson were made possible by the data compiled in this NBA Kaggle database: kaggle.com/drgilermo/nba-players-stats

Skew The Script

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Who is the best **scorer**?

Wilt - 60's

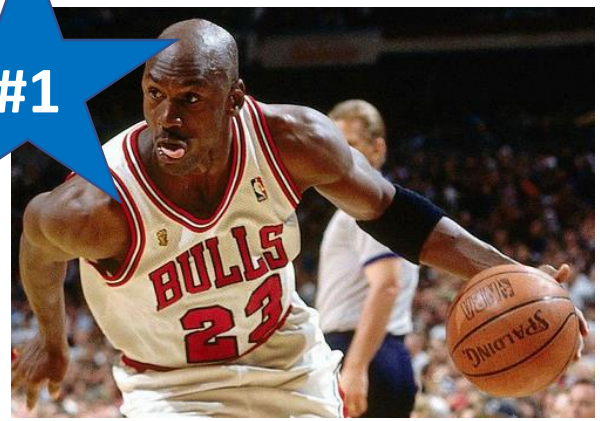
#1

Paul Vathis, AP Images

30.1 PPG

Jordan - 90's

#1



30.1 PPG

LeBron - 2010's

#3

27.1 PPG

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Note: All NBA data in this lesson is from 2020 and prior.

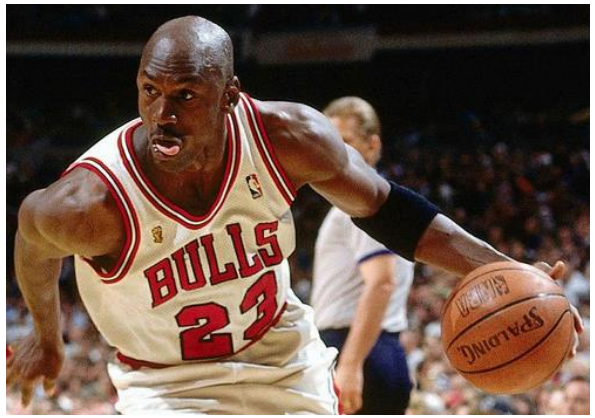
Who is the best relative to their time?

Wilt - 60's

Paul Vathis, AP Images

30.1 PPG

Jordan - 90's



30.1 PPG

LeBron - 2010's

27.1 PPG

Skew The Script

skewthescript.org

Note: All NBA data in this lesson is from 2020 and prior

Who is the best relative to their time?

Wilt - 60's

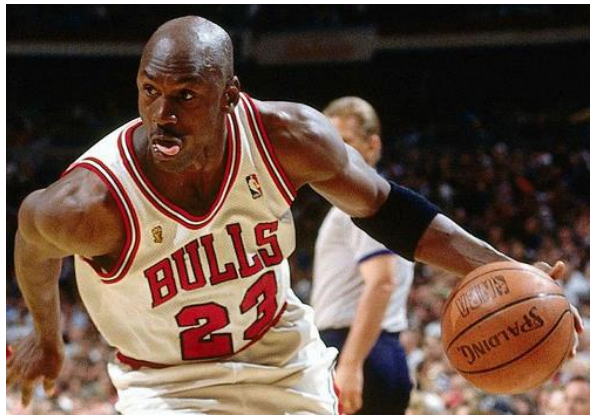
Paul Vathis, AP Images

30.1 PPG

60's NBA:

$\mu = 10.8$ ppg

Jordan - 90's



30.1 PPG

90's NBA:

$\mu = 8.7$ ppg

LeBron - 2010's

27.1 PPG

2010's NBA:

$\mu = 8.4$ ppg

Skew The Script

skewthescript.org

Note: All NBA data in this lesson is from 2020 and prior

Who is the best relative to their time?

Wilt - 60's

Paul Vathis, AP Images

30.1 PPG

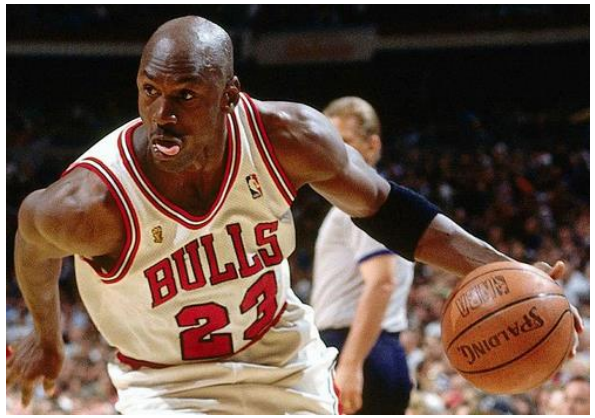
60's NBA:

$\mu = 10.8$ ppg

30.1 – 10.8 =

Diff: **19.3**

Jordan - 90's



30.1 PPG

90's NBA:

$\mu = 8.7$ ppg

30.1 – 8.7 =

21.4

LeBron - 2010's

27.1 PPG

2010's NBA:

$\mu = 8.4$ ppg

27.1 – 8.4 =

18.7

Skew The Script

skewthescript.org

Who is the best relative to their time?

Wilt - 60's

#2

Paul Vathis, AP Images

30.1 PPG

60's NBA:

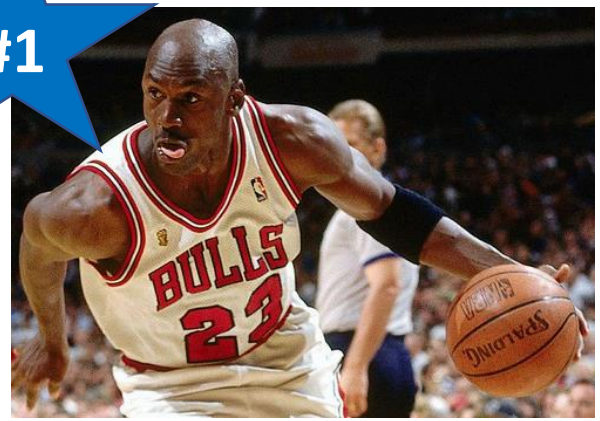
$\mu = 10.8$ ppg

30.1 – 10.8 =

Diff: **19.3**

Jordan - 90's

#1



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LeBron - 2010's

#3

27.1 PPG

2010's NBA:

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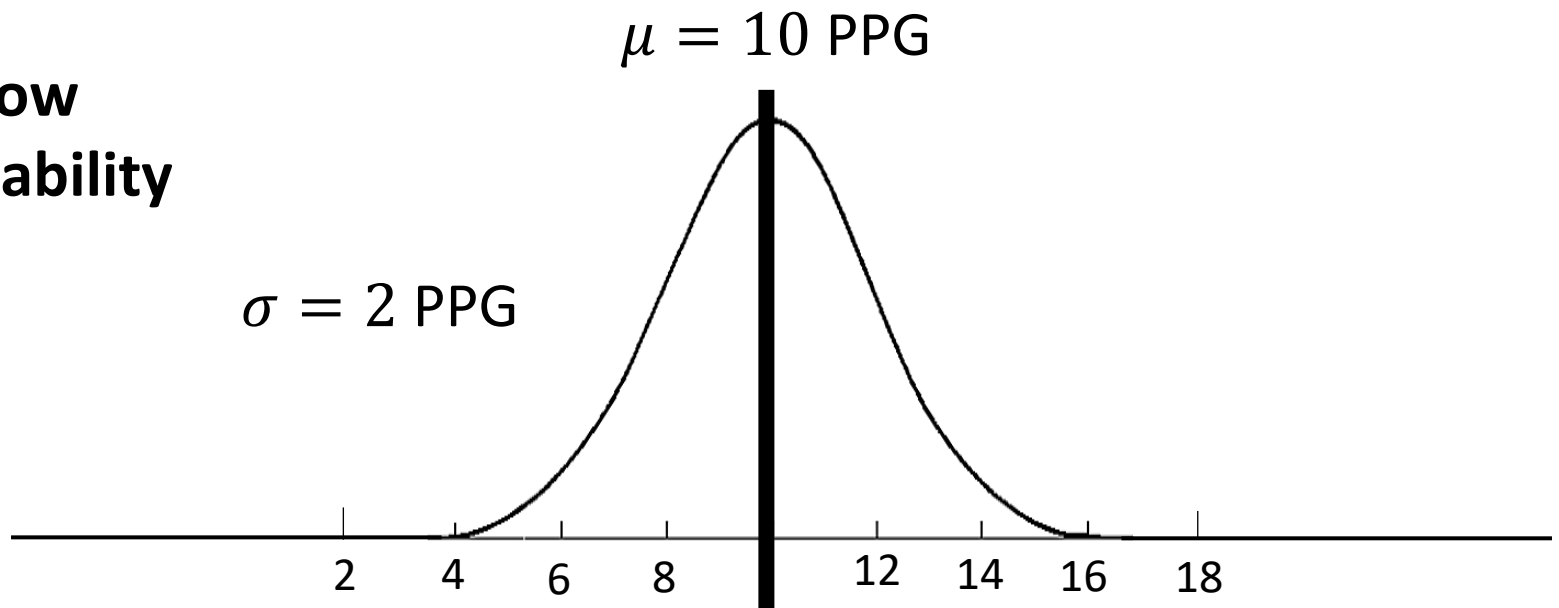
18.7

Skew The Script

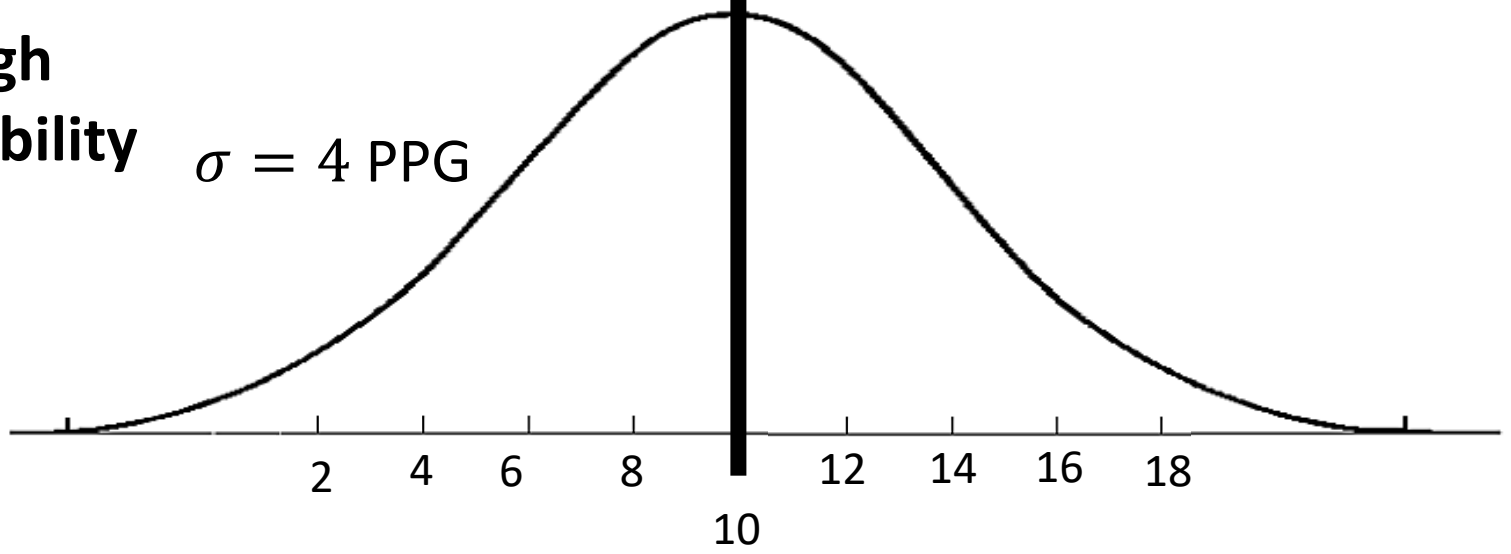
skewthescript.org

What about variability?

A: Low Variability



B: High Variability



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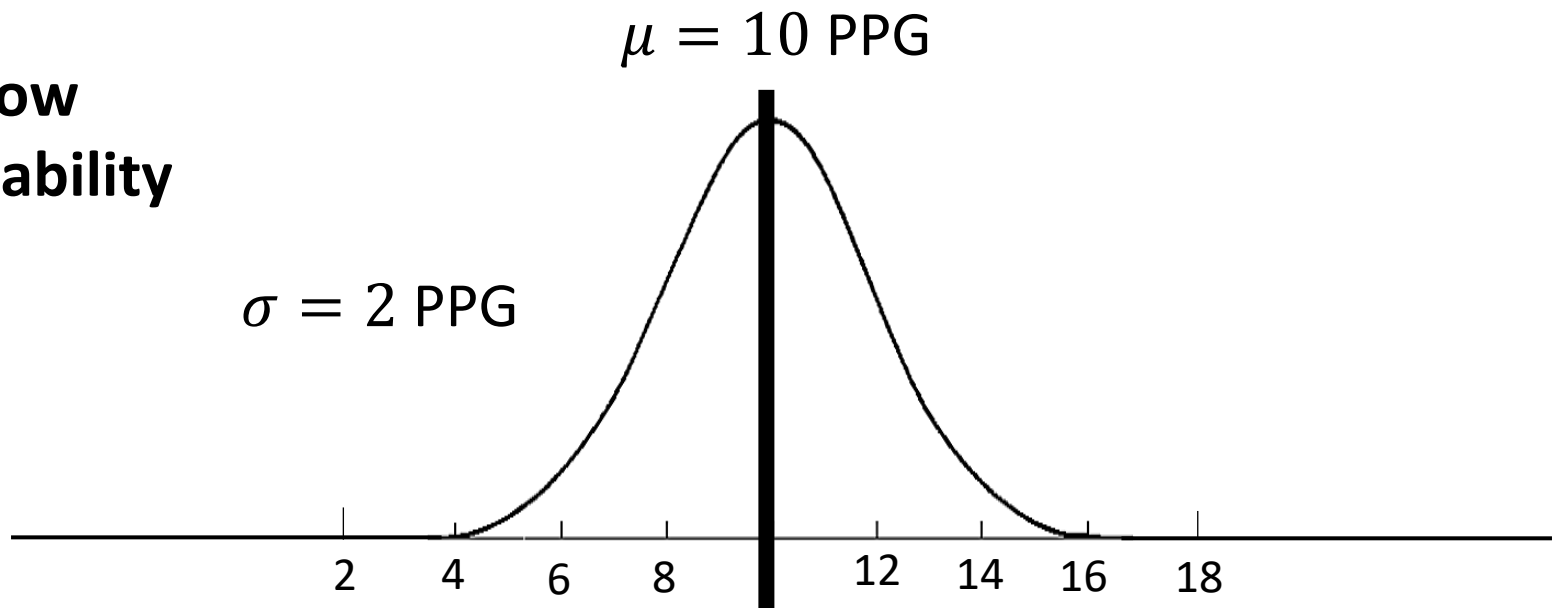

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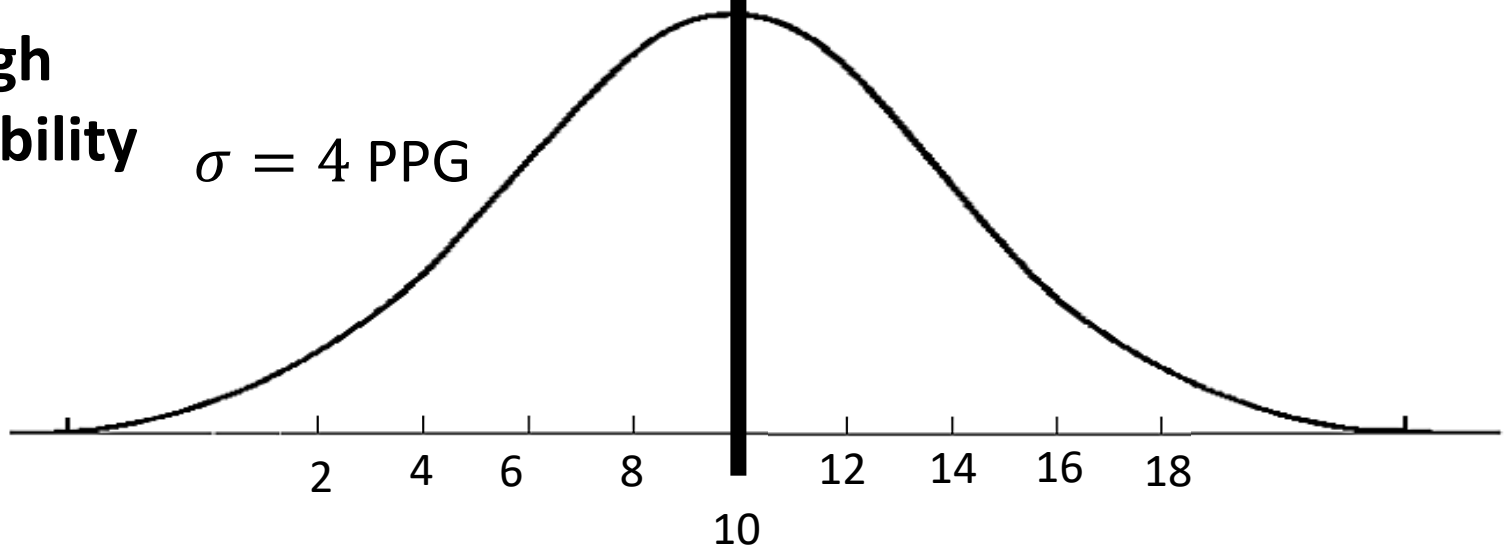

Skew The Script

skewthescript.org

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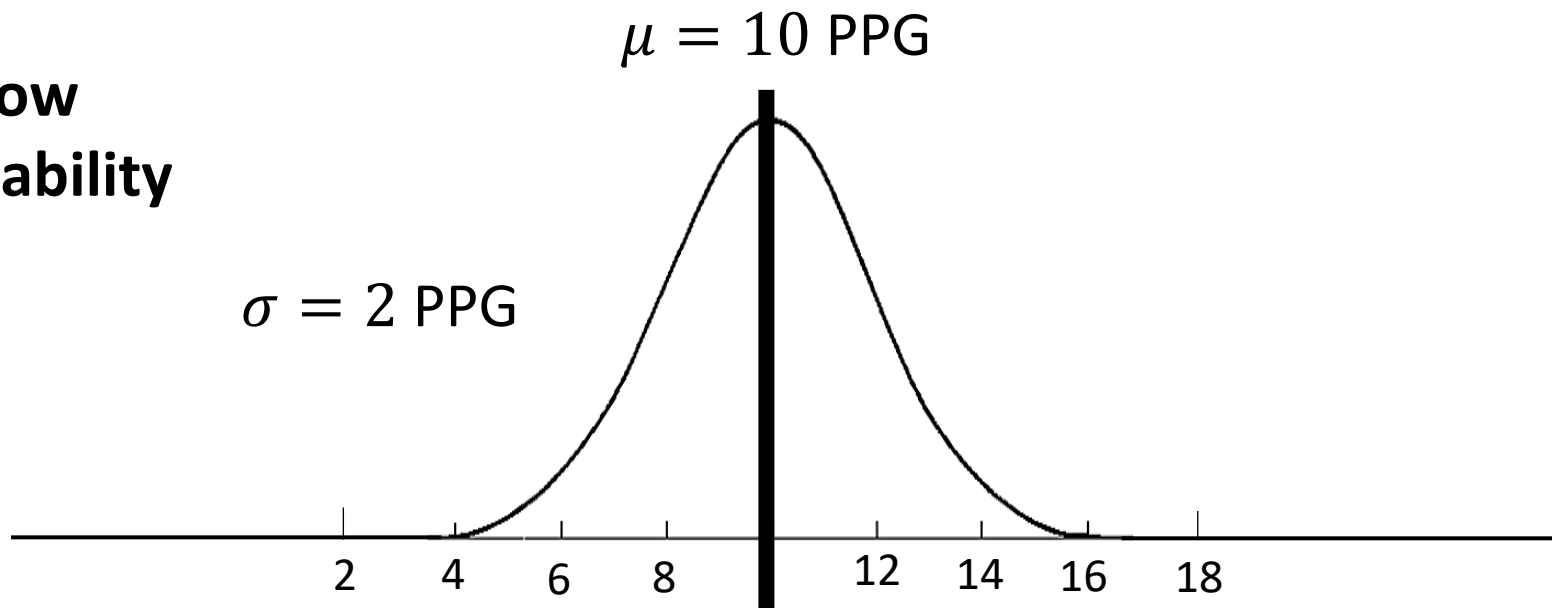

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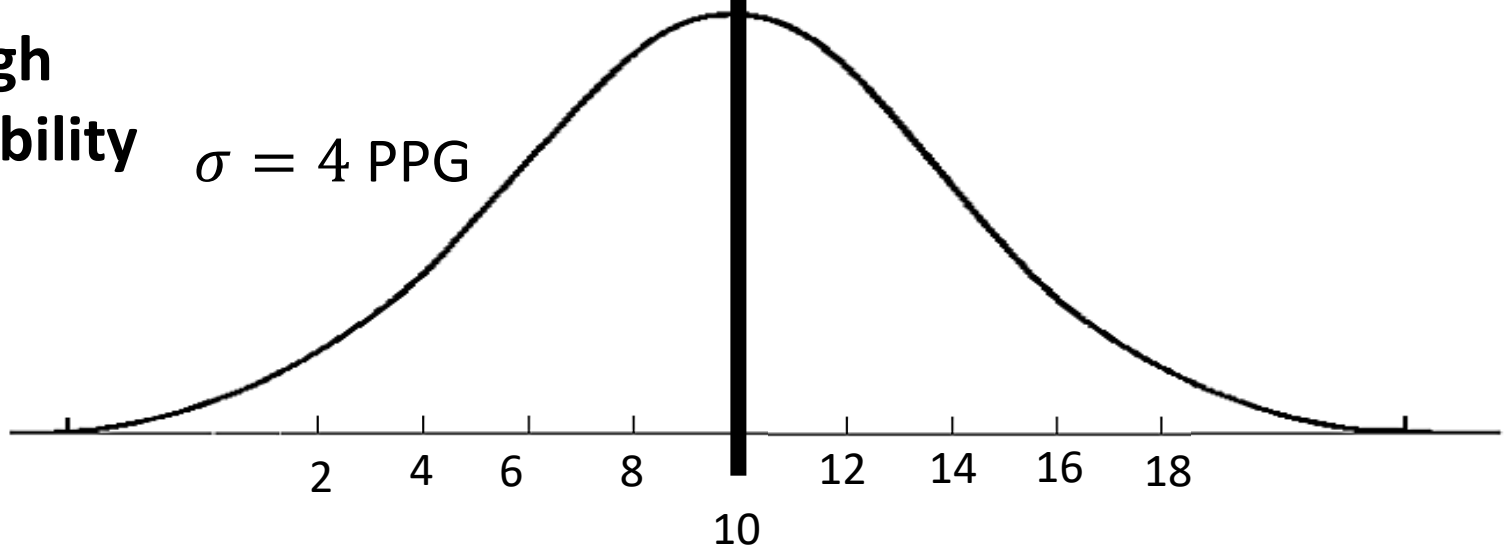

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skewthescript.org

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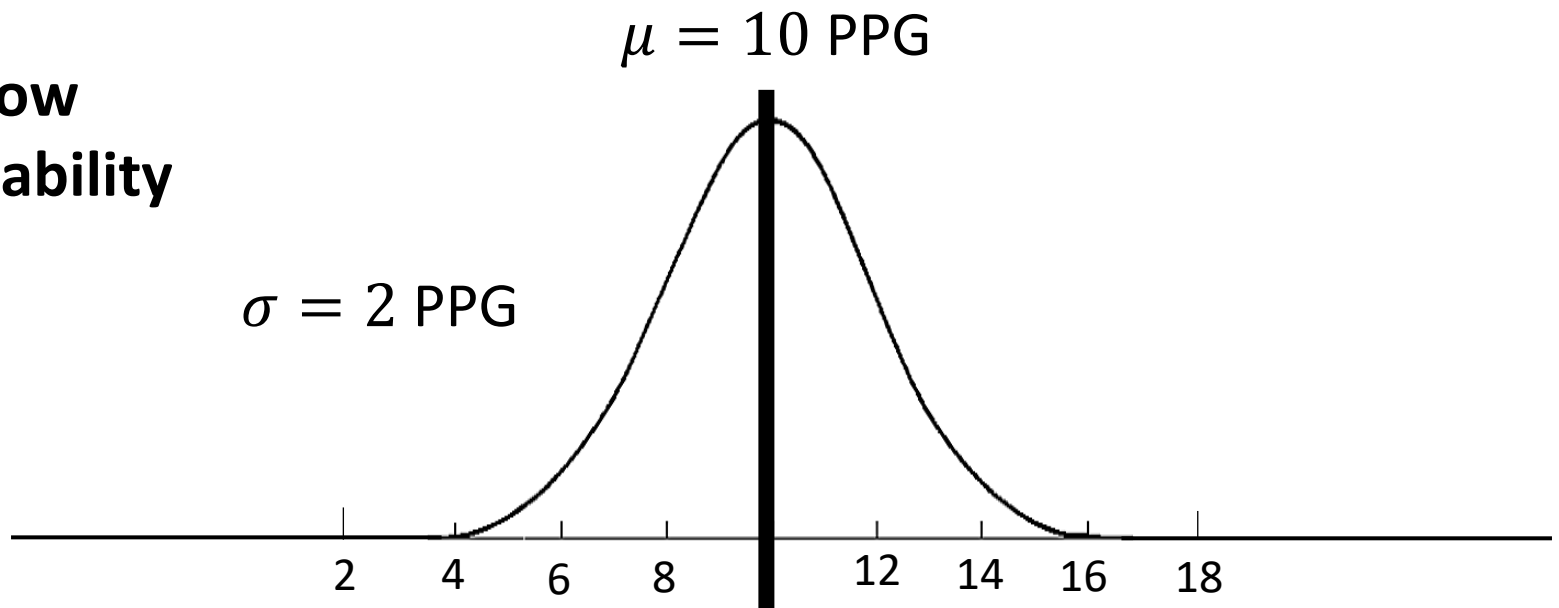

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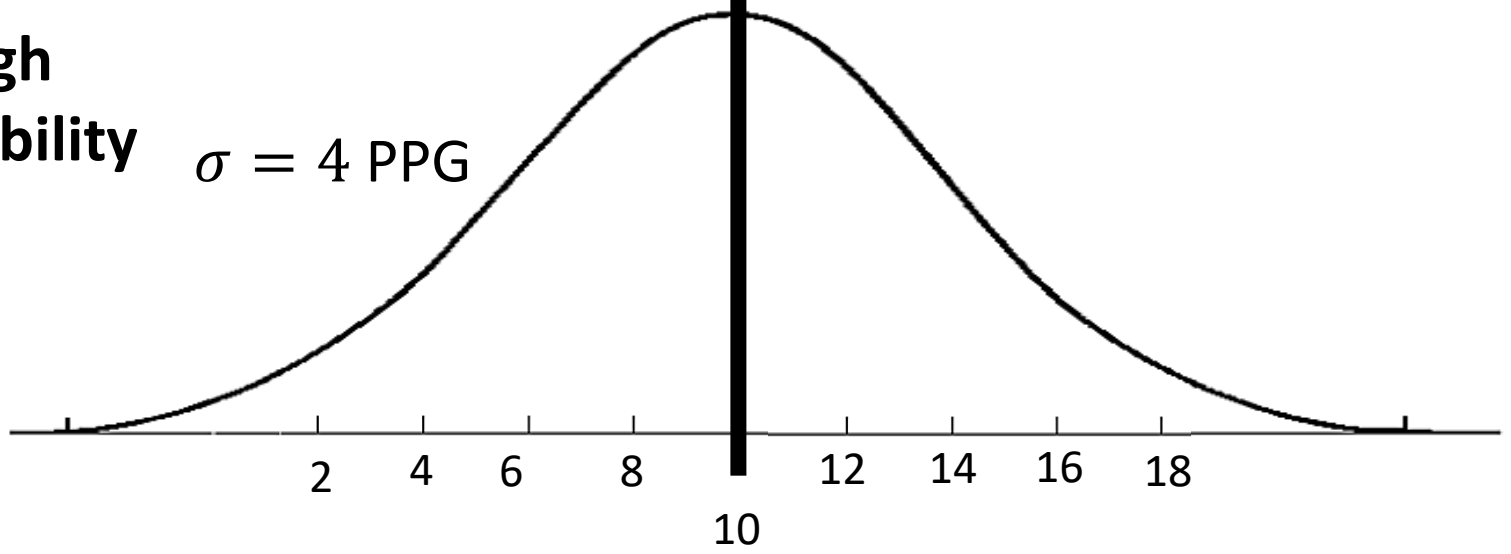

Skew The Script

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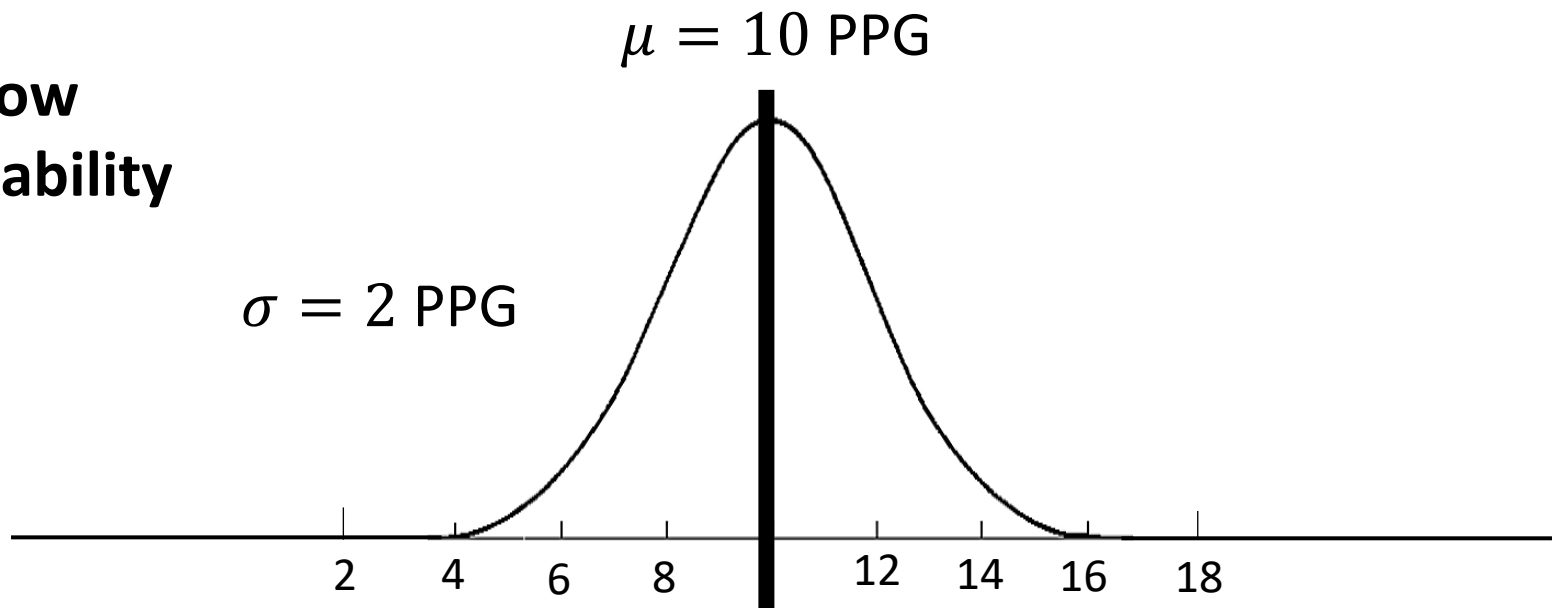

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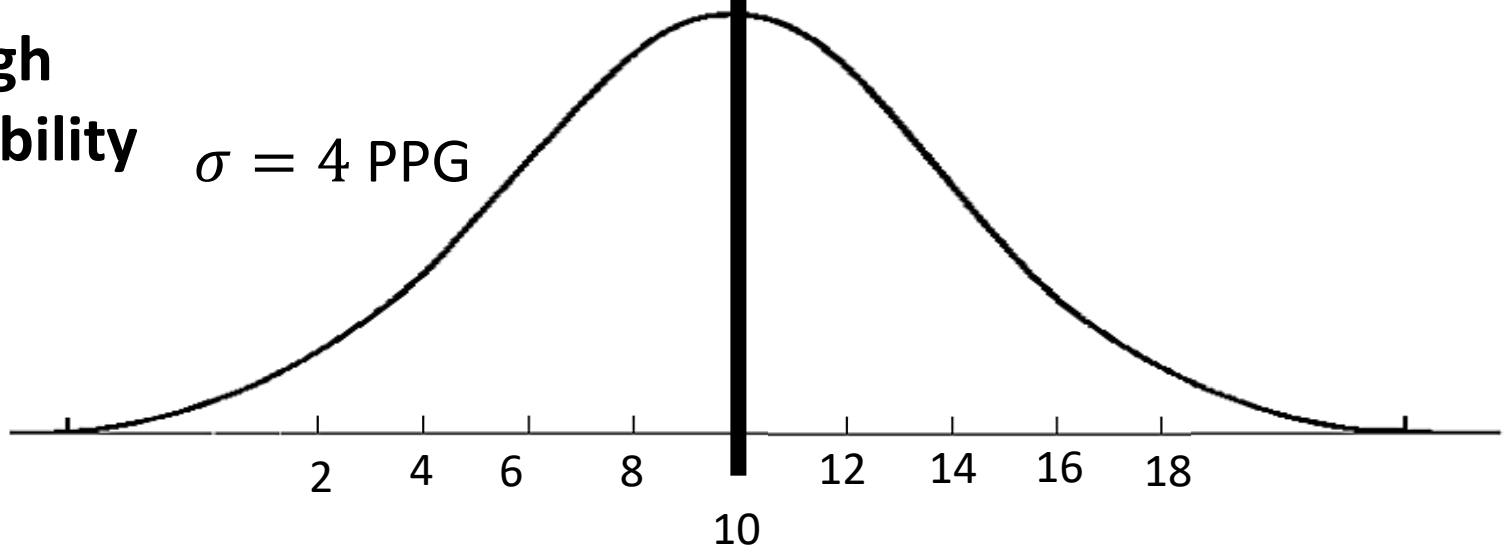

14 PPG

Skew The Script

skewthescript.org

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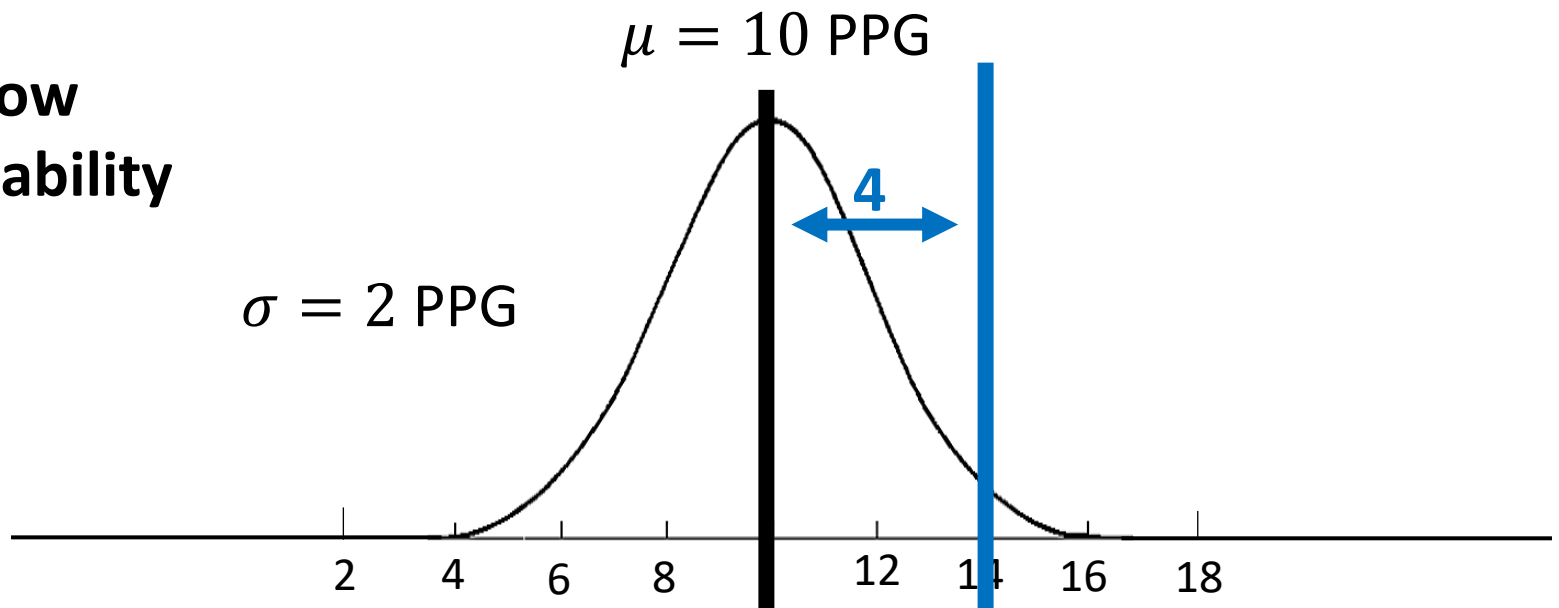
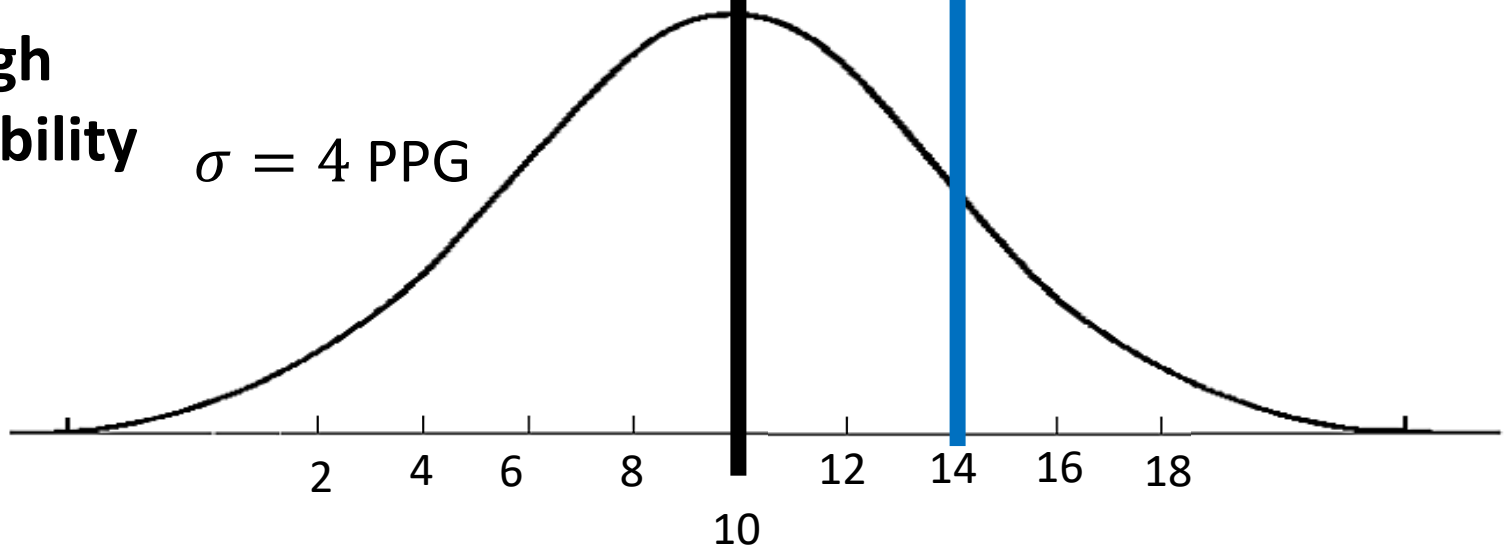


B: High Variability

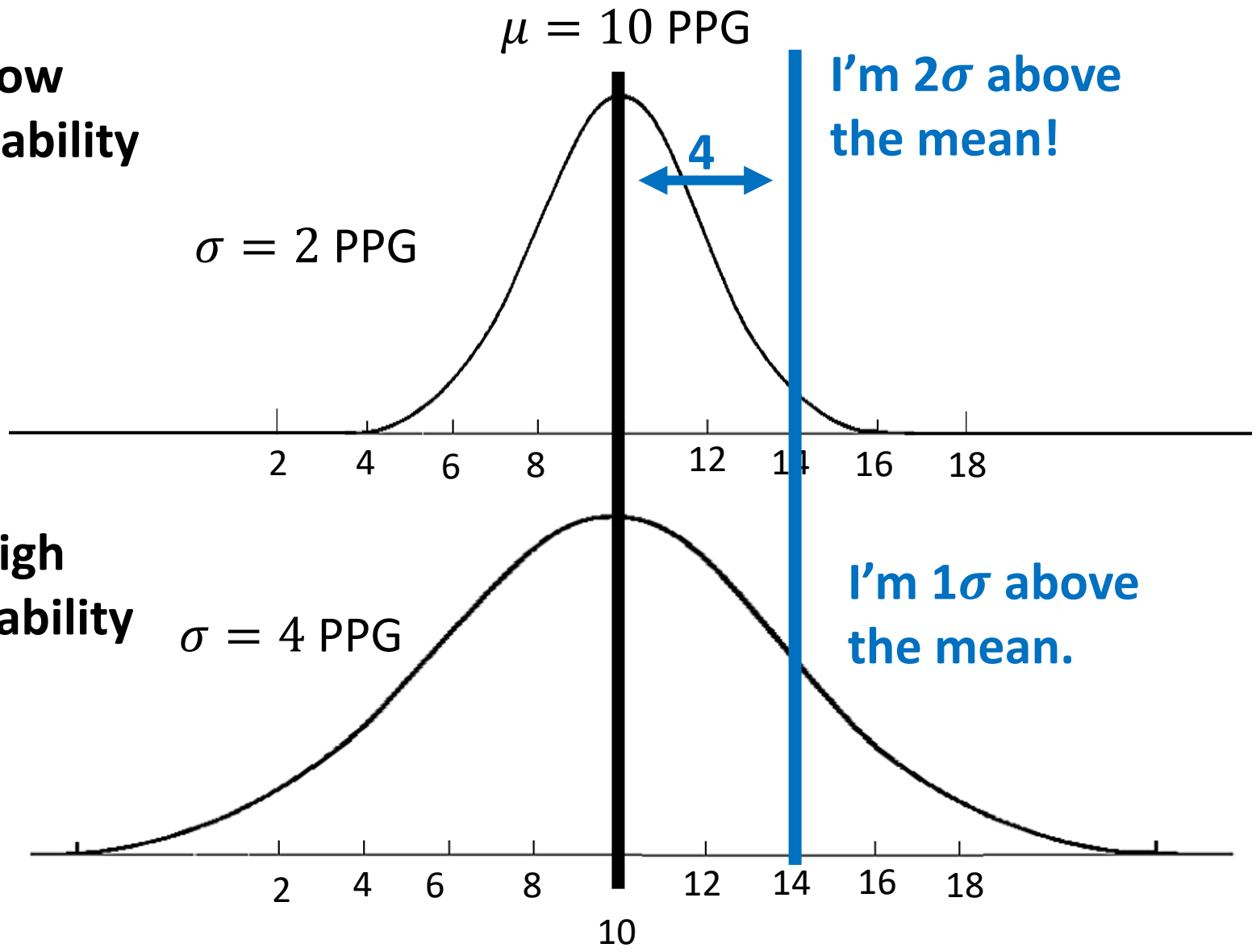


14 PPG

Skew The Script

skewthescript.org

What about variability?



14 PPG

Skew The Script

skewthescript.org

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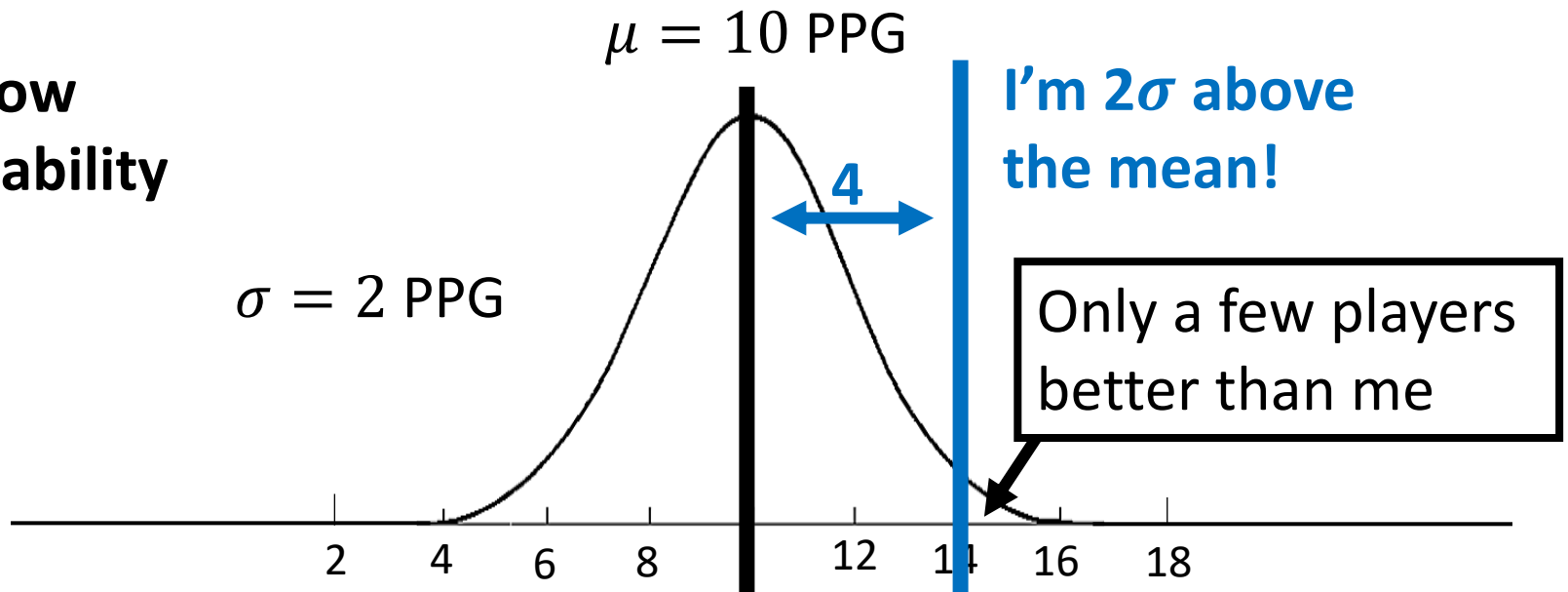
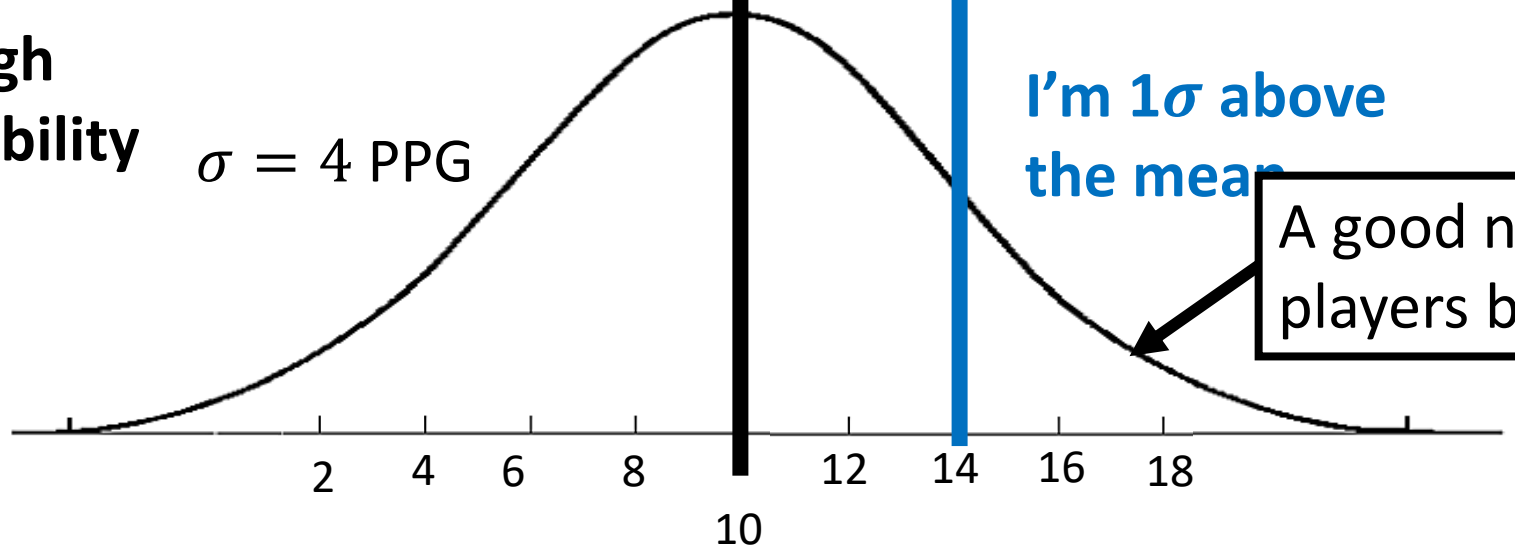


B: High Variability



4 PPG

Skew The Script

skewthescript.org

Standardization

A point's location in the distribution depends on **both** distance from the **center** and the distribution's **spread or variation**.

Standardized: Who Was Best?

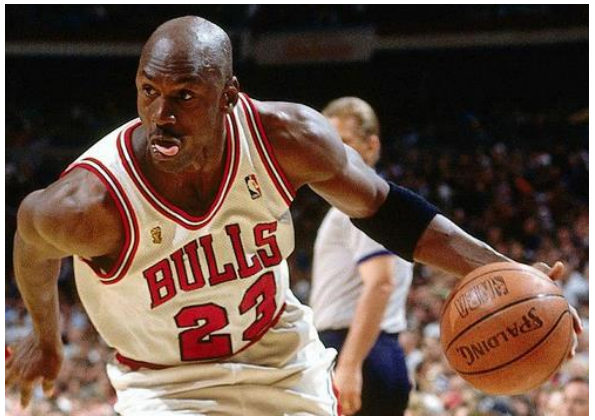
Wilt - 60's

Paul Vathis, AP Images

30.1 – 10.8 =

Diff: **19.3** ppg

Jordan - 90's



30.1 – 8.7 =

21.4 ppg

LeBron - 2010's

27.1 – 8.4 =

18.7 ppg

Skew The Script

skewthescript.org

Standardized: Who Was Best?

Wilt - 60's

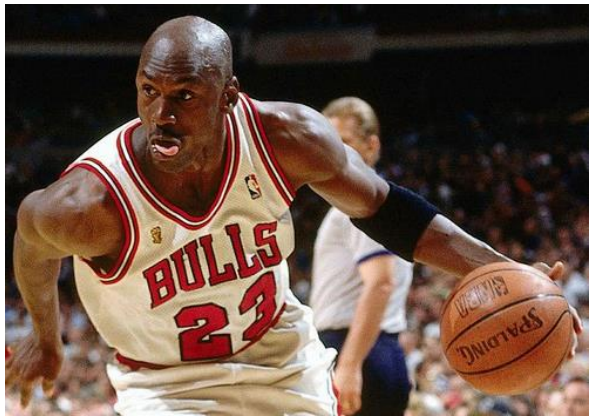
Paul Vathis, AP Images

30.1 – 10.8 =

Diff: **19.3** ppg

(σ) **7.0** ppg

Jordan - 90's



30.1 – 8.7 =

21.4 ppg

5.9 ppg

LeBron - 2010's

27.1 – 8.4 =

18.7 ppg

5.5 ppg

Skew The Script

skewthescript.org

Standardized: Who Was Best?

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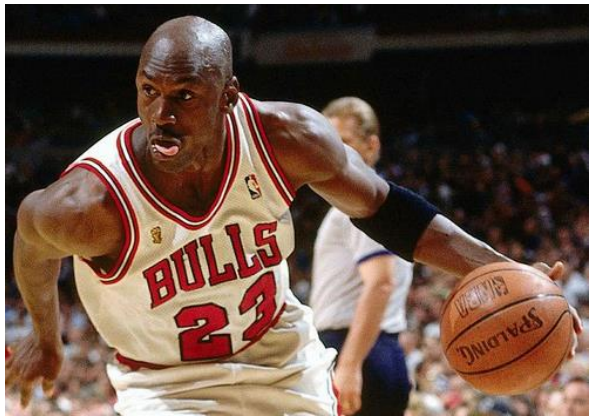


30.1 – 8.7 =

21.4 ppg

5.9 ppg

LeBron - 2010's

27.1 – 8.4 =

18.7 ppg

5.5 ppg

(Z)

Z-score: The number of standard deviations away from the mean

Skew The Script

skewthescript.org

Standardized: Who Was Best?

Wilt - 60's

Paul Vathis, AP Images

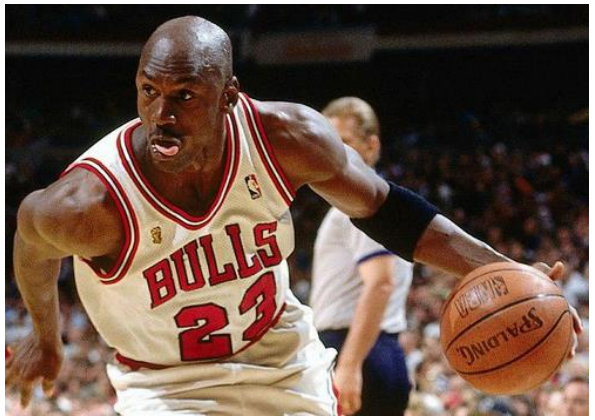
30.1 – 10.8 =

Diff: **19.3** ppg

÷

(σ) **7.0** ppg

Jordan - 90's



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21.4 ppg

÷

5.9 ppg

LeBron - 2010's

27.1 – 8.4 =

18.7 ppg

÷

5.5 ppg

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Z-score: The number of standard deviations away from the mean

Skew The Script

skewthescript.org

Standardized: Who Was Best?

Wilt - 60's

Paul Vathis, AP Images

30.1 – 10.8 =

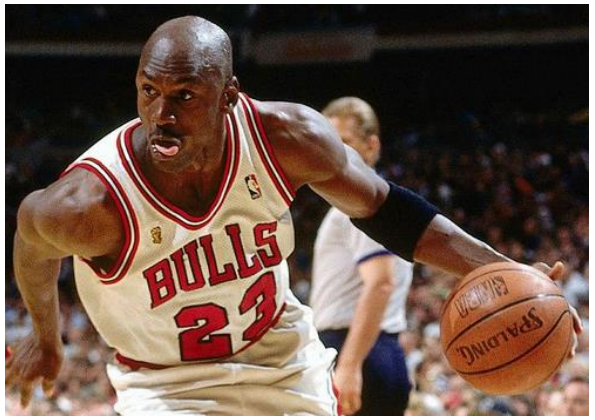
Diff: **19.3** ppg

÷

(σ) **7.0** ppg

(Z) **2.8**

Jordan - 90's



30.1 – 8.7 =

21.4 ppg

÷

5.9 ppg

3.6

LeBron - 2010's

27.1 – 8.4 =

18.7 ppg

÷

5.5 ppg

3.4

Z-score: The number of standard deviations away from the mean

Skew The Script

skewthescript.org

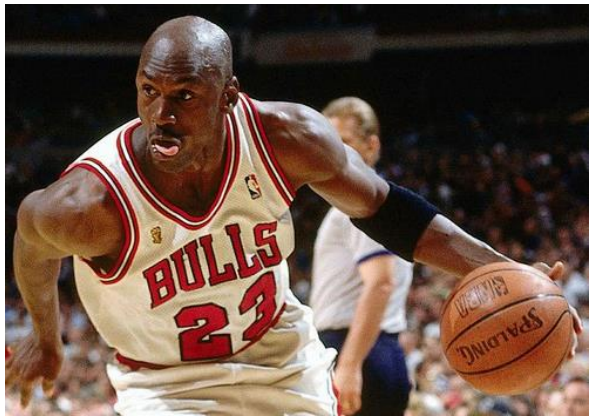
Standardized: Who Was Best?

Wilt - 60's

Paul Vathis, AP Images

$$\frac{30.1 - 10.8}{7.0}$$

Jordan - 90's



$$\frac{30.1 - 8.7}{5.9}$$

LeBron - 2010's

$$\frac{27.1 - 8.4}{5.5}$$

$$\frac{\text{Data} - \text{Mean}}{\text{Standard Dev}}$$

(Z) $= 2.8$ $= 3.6$ $= 3.4$

Skew The Script

skewthescript.org

G.O.A.T

Wilt - 60's

#3

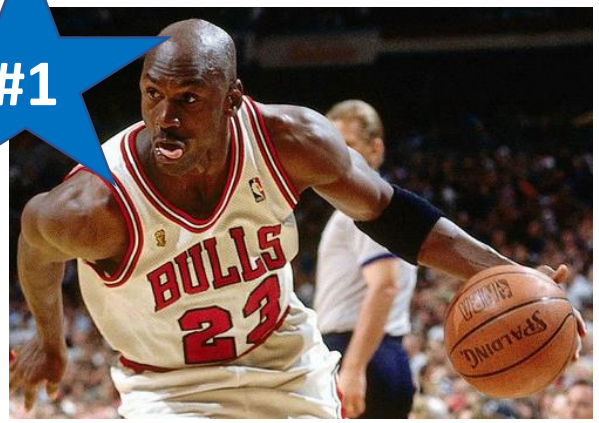
Paul Vathis, AP Images

$$\frac{30.1 - 10.8}{7.0}$$

$$(Z) = 2.8$$

Jordan - 90's

#1



$$\frac{30.1 - 8.7}{5.9}$$

$$= 3.6$$

LeBron - 2010's

#2

$$\frac{27.1 - 8.4}{5.5}$$

$$= 3.4$$

$$\frac{\text{Data} - \text{Mean}}{\text{Standard Dev}}$$

Skew The Script

skewthescript.org

G.O.A.T

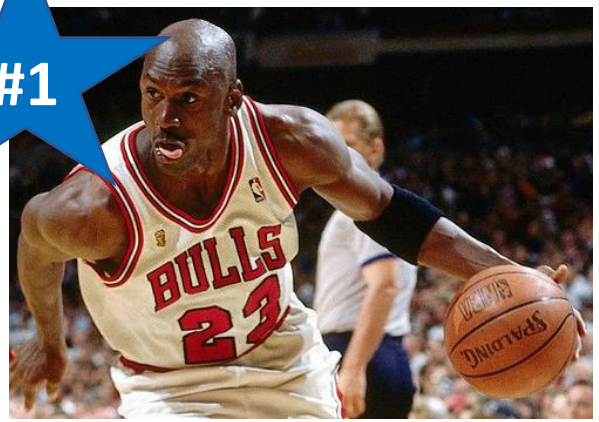
Wilt - 60's

#3

Paul Vathis, AP Images

Jordan - 90's

#1



LeBron - 2010's

#2

$$\frac{\text{Data} - \text{Mean}}{\text{Standard Dev}}$$

$$\frac{30.1 - 10.8}{7.0}$$

$$\frac{30.1 - 8.7}{5.9}$$

$$\frac{27.1 - 8.4}{5.5}$$

$$(Z) = 2.8$$

$$= 3.6$$

$$= 3.4$$

MJ's PPG was **3.6** standard deviations **above** the mean for his era, making him the most **unusually high** scorer.

Skew The Script

skewthescript.org

What about a not-so-great player?

Photo: opencourt-basketball.com

Adam Morrison, pictured where he spent most of his time with the Lakers: on the bench.

2009 Season:
played 44 minutes **total**

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2,999 min

2,960 min

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skewthescript.org

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While with the Lakers, he averaged **2.2 PPG**. (League: $\mu = 8.4$, $\sigma = 5.5$)

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$$z = \frac{data\ point - mean}{standard\ deviation}$$

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$$z = \frac{\mathbf{2.2} - 8.4}{5.5}$$

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skewthescript.org

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$$z = \frac{\mathbf{2.2} - 8.4}{5.5} = \mathbf{-1.1}$$

Skew The Script

skewthescript.org

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Photo: opencourt-basketball.com

Adam Morrison

While with the Lakers, he averaged **2.2 PPG**. (League: μ = 8.4, σ = 5.5)

$$z = \frac{data\ point - mean}{standard\ deviation}$$

Adam Morrison's scoring rate was 1.1 standard deviations **below** the league **average** in his era.

$$z = \frac{\mathbf{2.2} - 8.4}{5.5} = \mathbf{-1.1}$$

Skew The Script

skewthescript.org

Positive/Negative Z-Scores

Photo: opencourt-basketball.com

2.2 PPG

$$z = -1.1$$

27.1 PPG

$$z = 3.4$$

Skew The Script

skewthescript.org

Positive/Negative Z-Scores

Photo: opencourt-basketball.com

2.2 PPG

27.1 PPG

$$z = -1.1$$

$$z = 3.4$$

$$z = \frac{data\ point - mean}{standard\ deviation}$$

data > mean → **positive**

data < mean → **negative**

Skew The Script

skewthescript.org

Positive/Negative Z-Scores

Photo: opencourt-basketball.com

2.2 PPG

$$z = -1.1$$

27.1 PPG

$$z = 3.4$$

Positive Z-Score: The number of standard devs **above** the mean.

Negative Z-Score: The number of standard devs **below** the mean.

$$z = \frac{data\ point - mean}{standard\ deviation}$$

data > mean → **positive**

data < mean → **negative**

Skew The Script

skewthescript.org

It’s all about the bling.

Pau Gasol

Kobe Bryant

It’s all about the bling.

Pau Gasol

Kobe Bryant

2009

Skew The Script

skewthescript.org

It’s all about the bling.

Pau Gasol

Kobe Bryant

2009

2010

Skew The Script

skewthescript.org

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Pau Gasol

Kobe Bryant

Photo: opencourt-basketball.com

Adam Morrison

2009

2010

Skew The Script

skewthescript.org

It’s all about the bling.

has more championship rings than…

Photo: opencourt-basketball.com

Adam Morrison

2009

2010

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2010

Allen Iverson

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Adam Morrison

Allen Iverson

Russell Westbrook

2009

2010

Skew The Script

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Adam Morrison

Allen Iverson

Russell Westbrook

Steve Nash

2009

2010

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It’s all about the bling.

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Photo: opencourt-basketball.com

2.2 PPG

Adam Morrison

2009

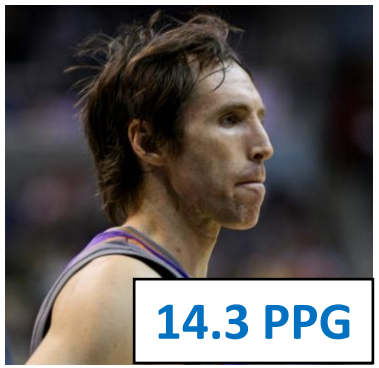
2010

26.7 PPG

Allen Iverson

23.2 PPG

Russell Westbrook



14.3 PPG

Steve Nash

25.1 PPG

Harden

Skew The Script

skewthescript.org

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Photo: opencourt-basketball.com

2.2 PPG

Adam Morrison

2009

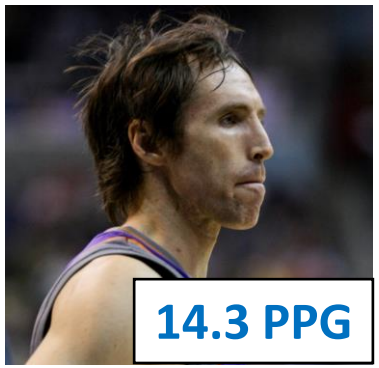
2010

26.7 PPG

Allen Iverson

23.2 PPG

Russell Westbrook



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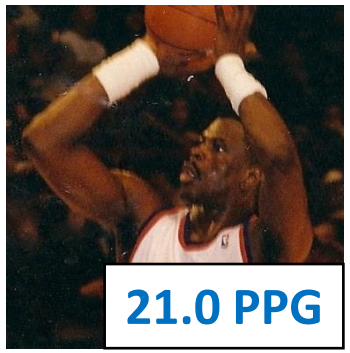
25.1 PPG

Harden



21.0 PPG

Ewing

Skew The Script

skewthescript.org

It’s all about the bling.

has more championship rings than…

Photo: opencourt-basketball.com

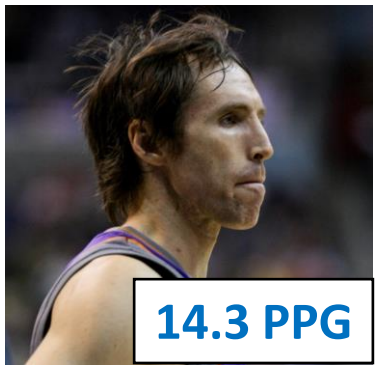
Adam Morrison

2009

2010

Allen Iverson

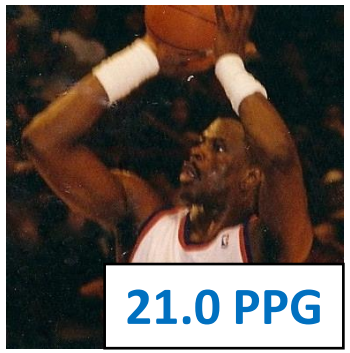
Russell Westbrook



Steve Nash

Harden

Ewing



Chris Paul

It’s all about the bling.

has more championship rings than…

Photo: opencourt-basketball.com

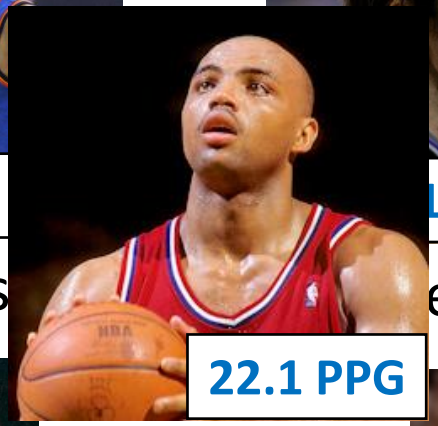
Adam Morrison

2009 **2010**

Allen Iverson

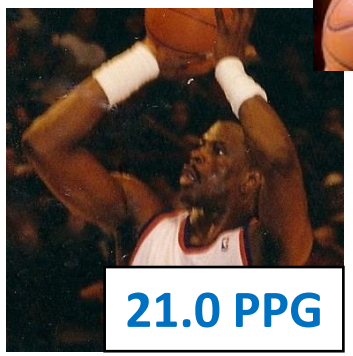
Russell Wes

e Nash



Barkley

Harden



Ewing

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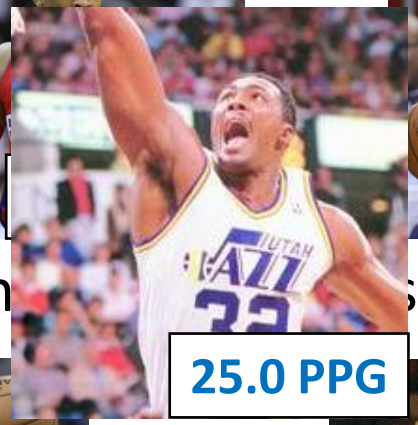
Photo: opencourt-basketball.com

Adam Morrison

2009

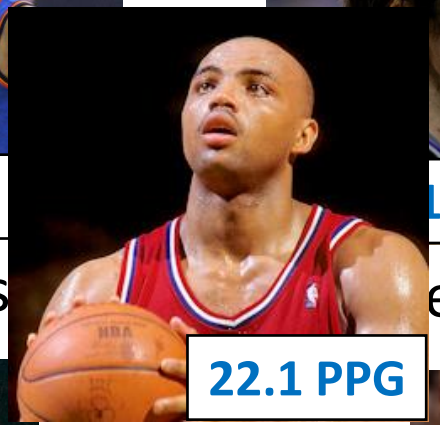
2010

Allen

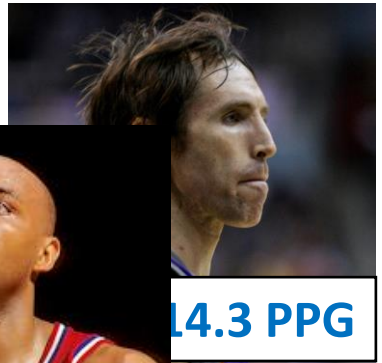


Malone

ssell Wes

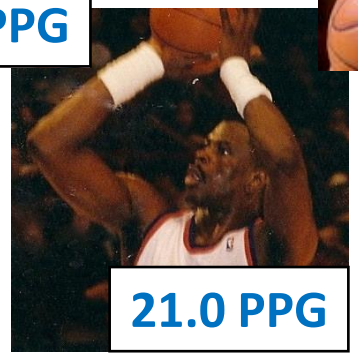


Barkley



e Nash

Harden



Ewing

Chris Paul

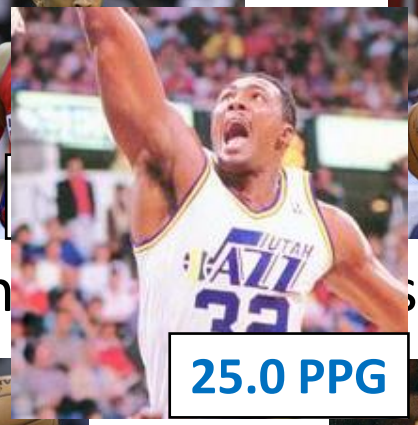
It’s all about the bling.

has more championship rings than…

Photo: opencourt-basketball.com

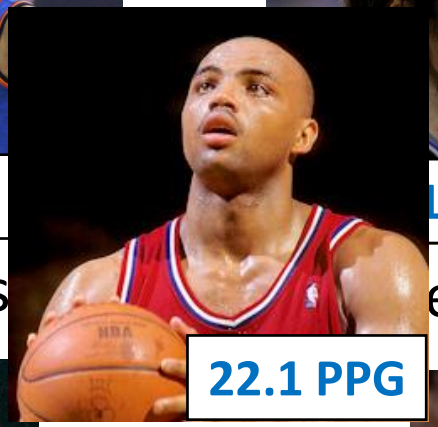
Adam Morrison

Allen



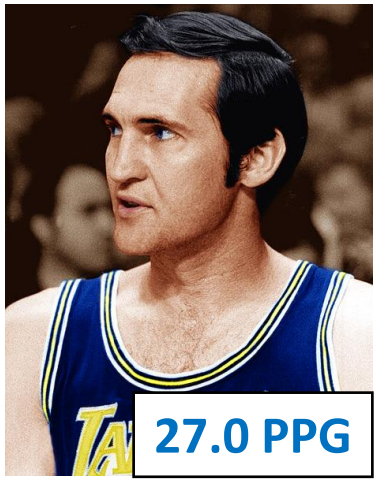
Malone

ssell Wes



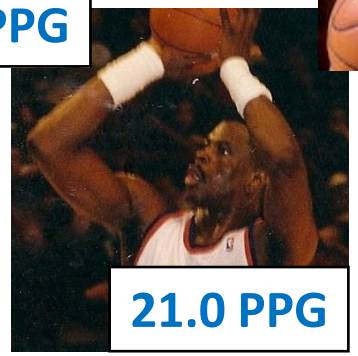
Barkley

e Nash



Jerry West

Harden



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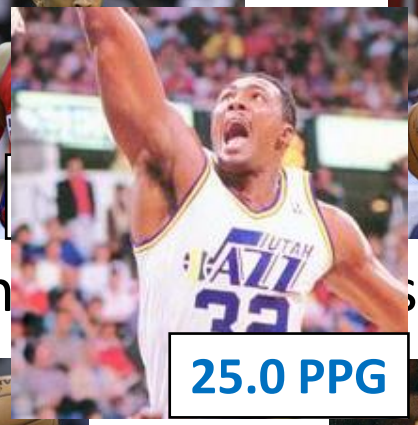
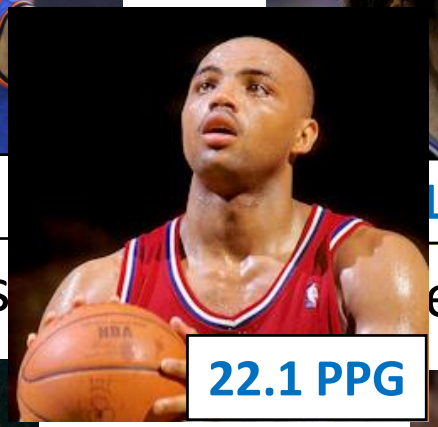


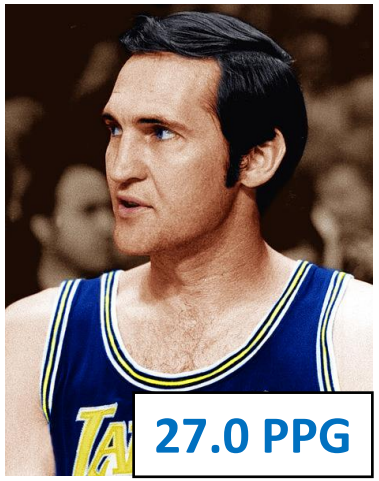
Malone

ssell Wes



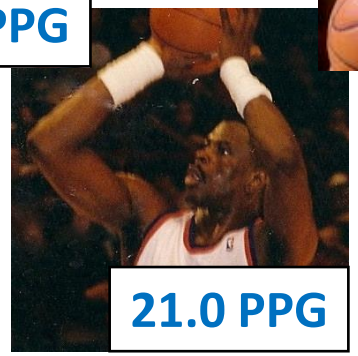
Barkley

e Nash



Jerry West

Harden



Ewing

Chris Paul

It’s all about the bling.

has more championship rings than…

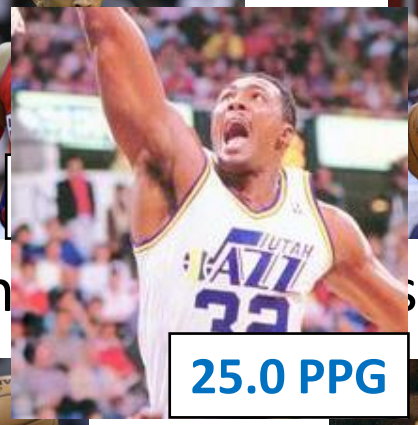
COMBINED

Photo: opencourt-basketball.com

Adam Morrison

+

Allen



+

ssell Wes

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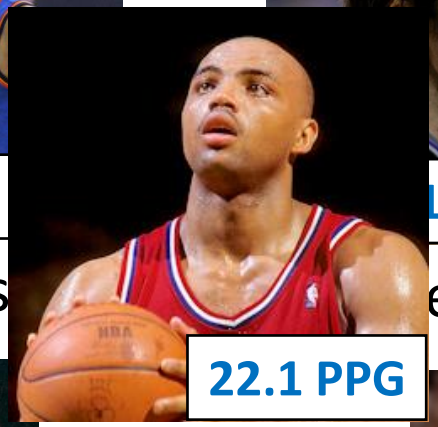
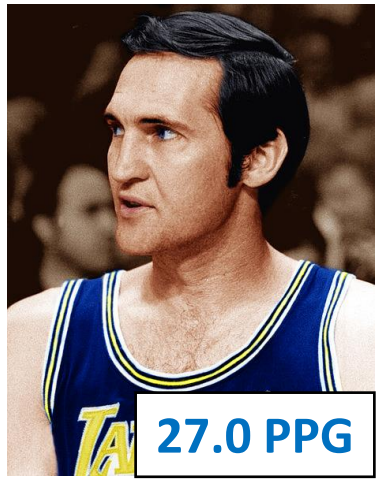


e Nash

+



Jerry West

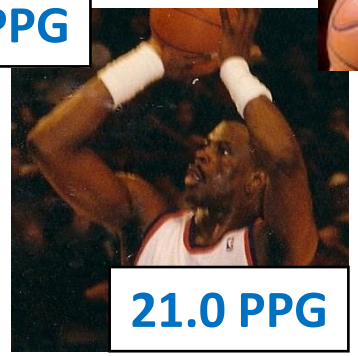
+

Harden

Malone

+

Ewing



Barkley

+

Chris Paul

It’s all about the bling.

G.O.A.T?

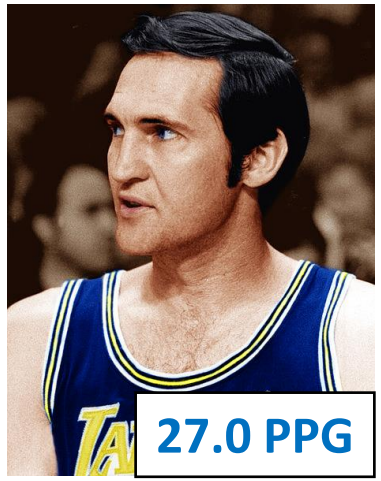
has more championship rings than…

COMBINED

Photo: opencourt-basketball.com

2.2 PPG

Adam Morrison

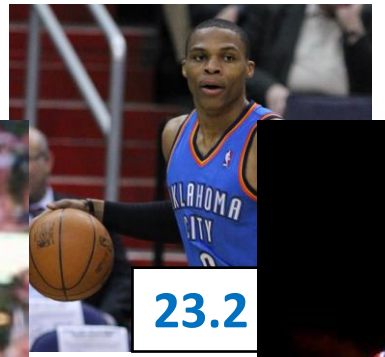


27.0 PPG

Jerry West

+

+



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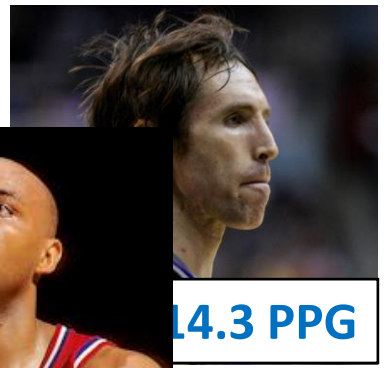
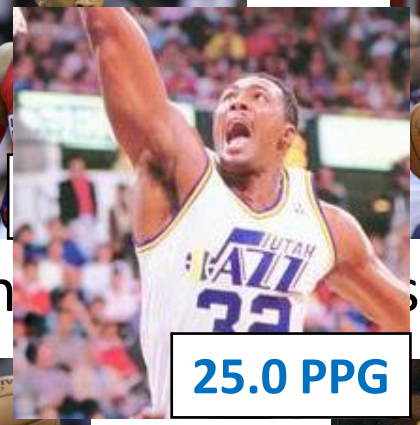


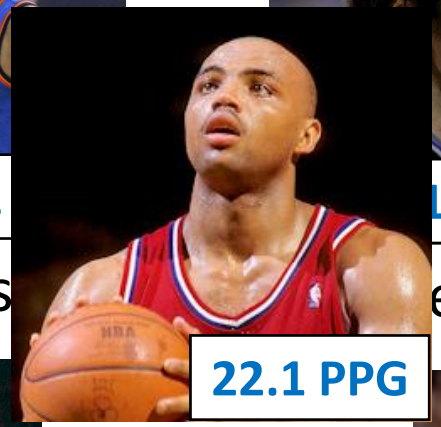


25.0 PPG

Allen

23.2

ssell Wes



22.1 PPG

14.3 PPG

e Nash

+

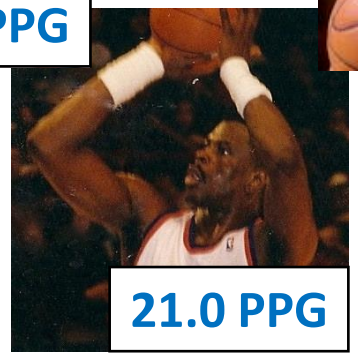
25.1 PPG

Harden

Malone

+

Ewing



21.0 PPG

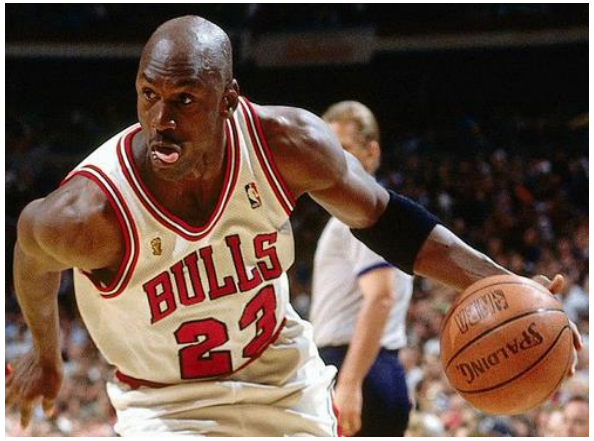
Barkley

+

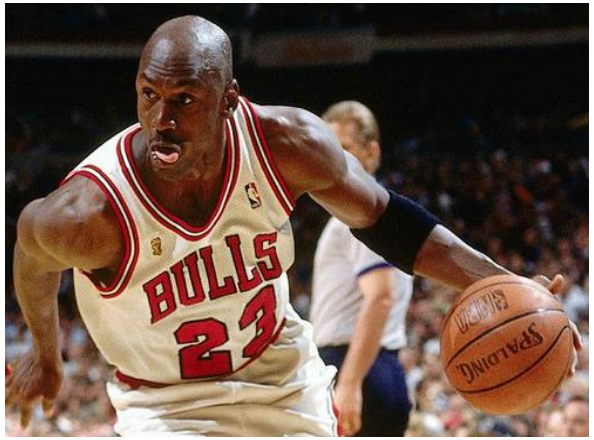
Chris Paul

18.5 PPG

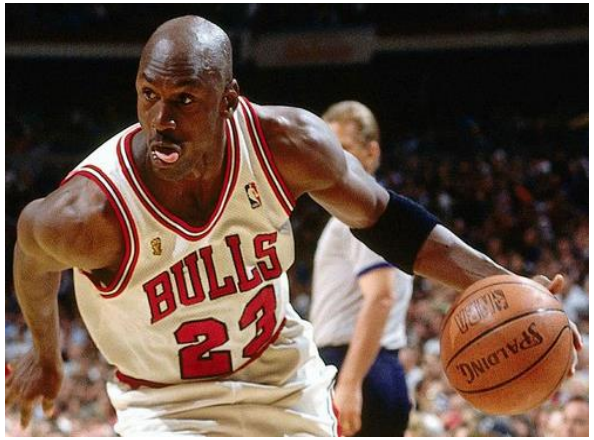
Lesson 2.1
Discussion

Wilt	Jordan	LeBron	
			
Paul Vathis, AP Images			
2.8	**3.6**	**3.4**	**(Z)**

- Jordan scored the most (relatively)

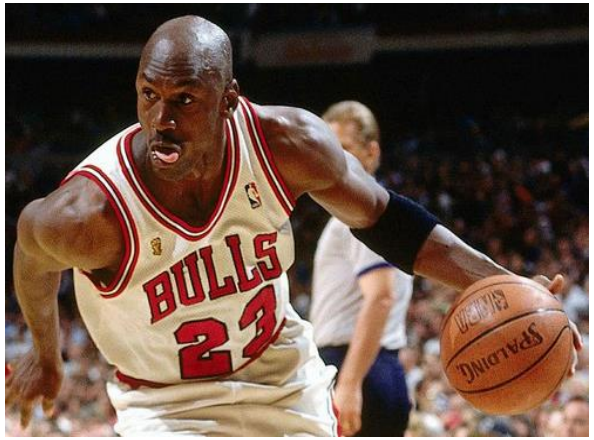
Wilt	Jordan	LeBron	
			
Paul Vathis, AP Images			
2.8	**3.6**	**3.4**	**(Z)**

- Jordan scored the most (relatively)
- Is it because he shot the most?

Wilt	Jordan	LeBron	
 Paul Vathis, AP Images			
22.5	**22.9**	**19.6**	Shots per game

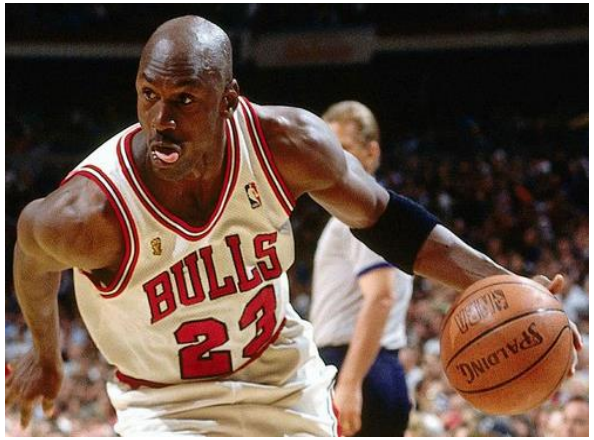
Skew The Script

skewthescript.org

Wilt	Jordan	LeBron	
 Paul Vathis, AP Images			
22.5	**22.9**	**19.6**	Shots per game
54.0%	**49.7%**	**50.4%**	% shots made

Skew The Script

skewthescript.org

Wilt	Jordan	LeBron	
			
22.5	**22.9**	**19.6**	Shots per game
54.0%	**49.7%**	**50.4%**	% shots made

????

Discussion: Is Jordan still the G.O.A.T at scoring? What other stats may be helpful in determining who was the best?

Skew The Script

skewthescript.org

Lesson 2.1
Practice