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**MULTIPLE CHOICE**

1. A researcher conducted a study to see if there are differences in mean prostate-specific antigen (PSA) levels between men aged >50 years ($\mu_1$) and men aged ④50 years ($\mu_2$). The researcher hypothesizes that there will be a difference in mean PSA between the two groups. We are assuming that PSA levels have a symmetric distribution. The 95% confidence interval for the difference in mean PSA between age groups was (0.2, 6.0). What can you conclude from this confidence interval?
   a. We are 95% confident that the estimated mean PSA level for men aged ④50 years is 0.2 and for men aged >50 years is 6.0.
   b. We are 95% confident that mean PSA levels between the two groups are the same.
   c. We are 95% confident that the mean PSA levels between the two groups are different.
   d. We do not have enough information to form a conclusion.

   ANS: C
   Because our confidence interval does not include 0, we have sufficient evidence to conclude that there are differences in mean PSA levels between men aged >50 years and men aged ④50 years.

   PTS: 1

2. When are the mean and median the same?
   a. If the distribution is normally distributed.
   b. If the distributions are not symmetric.
   c. The mean and median can never be the same.
   d. The sample size must be small.

   ANS: A
   The mean and the median can be the same if the distribution is normally distributed. The median, by definition, is the middle value, so it will always be the middle of the distribution. If the distribution is normal, both the mean and median will be in the center.

   PTS: 1

3. A researcher is preparing a grant that will focus on comparing mother's history of drug abuse (history vs. no history) and infant birth weight. The grant proposal requires a sample size calculation for testing the difference between the two groups. In order to calculate the sample size, the researcher needs the following three items:
   a. Power, type 1 error rate, and effect size.
   b. Confidence interval and power.
   c. *p*-value, power, and effect size.
   d. Sample size is not needed.

   ANS: A
   When performing a sample size calculation, it is important to have the power, type 1 error, and the effect size.

   PTS: 1

4. An investigator is considering a study for assessing the change in viral loads among those individuals who are on drug treatments versus those who are not. Two sample sizes were proposed (300 and 600). If the investigator chooses the larger sample size, what will happen to the precision (width) of the interval estimate?
   a. Width remains the same because sample size is not related to the width of the interval.
   b. Width gets smaller because a larger sample reduces the margin of error.

c. Width gets larger because with a larger sample there is more variability.
d. None of the above.

ANS: B
The relationship between an interval estimate and the sample size is that when the sample size gets larger, the estimate becomes more precise, which means the interval gets smaller.

PTS: 1

5. Suppose that the overall *F*-test obtained from performing a one-way ANOVA resulted in a *p*-value that was not statistically significant. Which of the following CANNOT be true?
a. The variability within the groups is very large compared to between-group variability.
b. The variability between the groups is very large compared to within-group variability.
c. The ratio of the between and within variability was not sufficiently large.
d. The *F*-statistic was not larger than the critical value obtained from the *F*-distribution.

ANS: B
When there is a large amount of variability between the groups compared to that of within the groups, the ratio (*F*-statistic) will be large.

PTS: 1

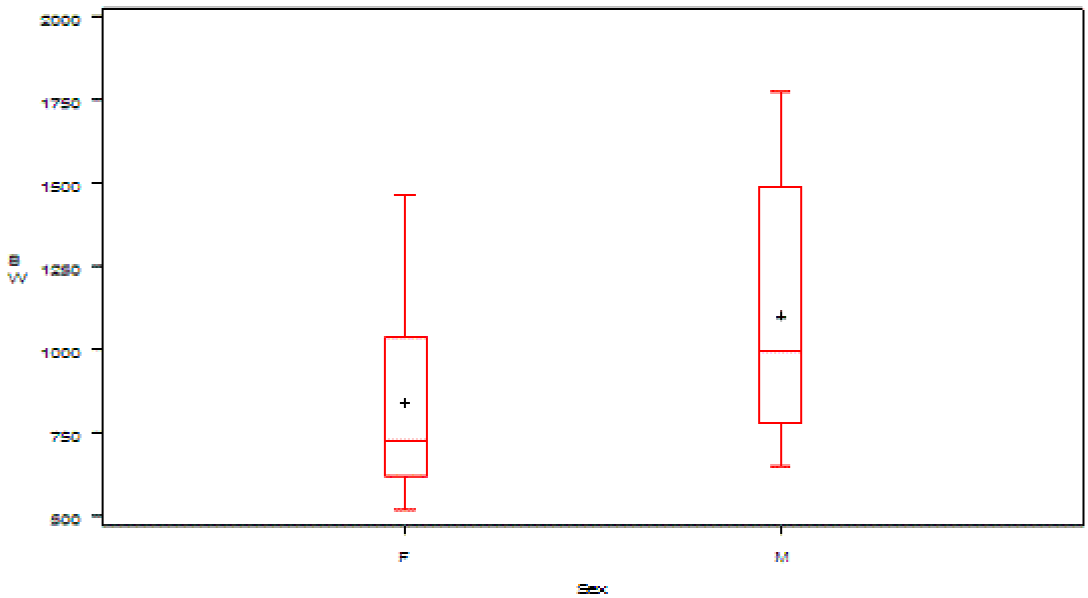
**SHORT ANSWER**

1. You are given a large data set that includes patients from six major hospitals. You are interested in estrogen levels among the women in the data set. You find that most of the measurements are similar, but a few are rather large. If you plotted a histogram, what shape would it take on? How would the mean and median compare?

ANS:
If a histogram was plotted, the histogram would be skewed with a long right tail because of the few values that were quite larger than the rest of the measurements. The mean would be pulled toward the tails and would be larger than the median.

PTS: 1

2. You are interested in whether the infants in your unit differ in birth weight by sex (male and female). You present your results in a box plot provided below:




What information can you obtain from this plot?

ANS:
The median birth weight for females appears to be approximately 725 g. The median birth weight for the males appears to be close to 1000 g. Although, the researcher has not conducted a formal test, it does appear that males have a higher average birth weight than females. It should also be noted that males have a bigger range of values.

PTS: 1

3. You have measured the blood lead levels (μg/dL) of a random sample of 30 children living in an urban area. A 90% confidence interval for the mean blood lead levels for the children is computed to be (10.1, 35.8). Provide a valid interpretation of this interval.

ANS:
When random samples are taken many times, then approximately 90% of the resulting confidence intervals would cover the true mean blood lead level for the children living in this urban area. We are 90% confident that this interval (10.1, 35.8) covers the true mean blood lead level. Therefore, this interval estimate provides a set of plausible values for the true parameter, the true mean blood level for children in this area. According to the Center for Disease Control and Prevention (CDC), a blood lead level of 10 μg/dL or above is problematic.

PTS: 1

4. The size of an infant's thyroid can predict the health of that infant. A journal article has been submitted describing a study where the researchers wanted to see if there were differences in thyroid volume size between infants born prematurely and those born full term. You have been asked to review the journal article and find the statement, "Thyroid volume was found to be skewed, so we employed a nonparametric test to investigate the following hypothesis: $H_0$: $\mu_1 - \mu_2 = 0$ vs. $H_1$: $\mu_1 - \mu_2$ 🕒 0; the mean differences between the two groups are not different versus they are different." Critique the statement.

ANS:

I agree with the researcher because thyroid volume is skewed (no symmetric distribution) and a nonparametric test should be employed. What is not correct in his statement is the hypothesis statement. With skewed data, means are not appropriate. The hypotheses should refer to differences in thyroid volume distribution for the two groups and not the mean differences.

PTS: 1

5. A group of individuals were selected to participate in a diet program. Waist circumferences were collected before and after the program. The question of interest was whether there was a mean change in circumference due to the diet program. A mean change of 2 inches is considered clinically meaningful.
   a. The researcher found a mean change of 2.2 inches and wants to conclude that the diet works. Can the researcher make this conclusion? Why or why not?
   b. Suppose a 95% confidence interval for the mean change was calculated (–1.75, 3.00). Explain to the researcher what this means.

   ANS:
   a. No, the researcher has only found a mean change for this sample. In order to generalize the conclusions of this sample, the researcher would need to show that this mean change was actually a statistically significant change and not due to chance, the researcher will need to employ confidence intervals or hypothesis testing (inference).
   b. The confidence interval ranges from –1.75 to 3.00. The interval contains zero. This means that 0 is a possible value for the true mean change in waist circumference. Hence, it is not possible to conclude that there will be a change in waist circumference.

   PTS: 1

6. A group of researchers conducted a study to see if intravenous drug users (IDUs) have lower CD4+ cell counts at initiation of antiretroviral therapy compared to non-IDUs. CD4+ cell counts are known to have skewed distributions. Provide the appropriate statistical test along with the corresponding null and research hypotheses for investigating differences in CD4+ cell counts between the two groups.

   ANS:
   A nonparametric test will be the appropriate test since the data are skewed. The Wilcoxon or Mann-Whitney test would be appropriate.
   $H_0$: Distributions of CD4+ cell counts for IDUs and non-IDUs are the same.
   $H_1$: The distributions are not equal.

   PTS: 1

7. A study was conducted to investigate biomarker levels associated with cartilage damage in a population of healthy athletes.
   a. You suggest that a histogram be created. Explain to your colleagues what information a histogram provides and why it would be helpful.
   b. As an additional aim of the study, the primary investigator would like to compare biomarker levels based on severity of injuries experienced (none, moderate, severe). Explain to your colleagues what information box-and-whisker plots provide and why they would be helpful.

   ANS:
   a. A histogram will be helpful in determining the actual distribution of the biomarker levels. You can determine whether data have a symmetric distribution or not. Also, from a histogram, you are able to get center and spread of the data as well as shape.

b. Box-and-whisker plots are helpful when you want to compare groups. Here, box-and-whisker plots would be appropriate because we will be able to compare the biomarker levels by the three severities of injuries. From the box-and-whisker plots, we are able to get the median, minimum, and maximum values, and also the first and the third quartile.

PTS: 1

8. You have conducted a study where you were interested in the amount of menthol cigarette consumption (cigarettes per day) among black females. Your results suggested that the average number of menthol cigarettes consumed per day was 3.0. The national average number of menthol cigarettes smoked per day for females was 2.5. Assuming normality, you conducted a one-sample *t*-test to test $H_0$: $\mu = 2.5$ versus $\mu > 2.5$. You get a *p*-value of 0.08. Interpret the results.

ANS:
A *p*-value of 0.08 is small. Although not smaller than 0.05, it is smaller than 0.1. Many times, investigators will talk about a trend when the *p*-value is small but not smaller than 0.05. For example, an investigator might say that while these results were not significant at 0.05 level, the small *p*-value suggests that there might be a trend toward higher menthol use in black females.

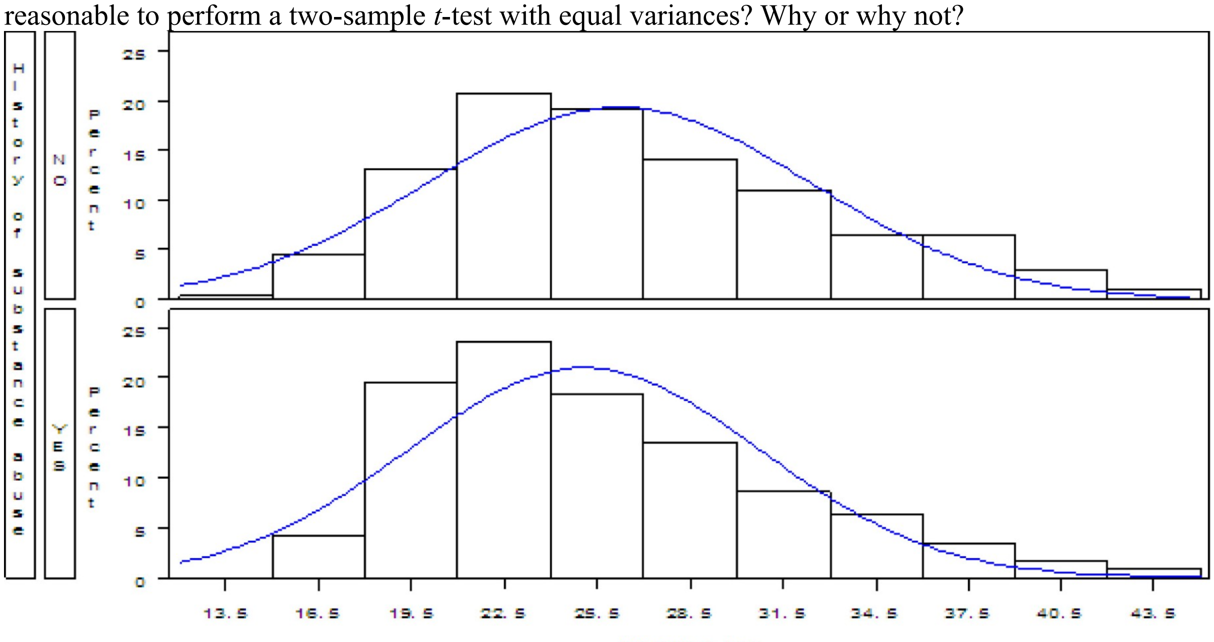
PTS: 1

9. You have decided to conduct a study where you are interested in observing mean differences in blood lead levels (μg/dL) in individuals who drink well water versus those who drink tap water. A previous study reported an effect size of 0.10, and you use this in planning your study. This effect size is considered small, what impact will a small effect size have on sample size planning? Explain.

ANS:
If the researcher wants to observe small effect sizes, then the sample size will need to be large in order to have sufficient power.

PTS: 1

10. An investigator wants to compare the mean ages between mothers who have and do not have a history of substance abuse. Histograms for the two groups are given below. Based on these figures, would it be reasonable to perform a two-sample *t*-test with equal variances? Why or why not?



ANS:
Based on the figure, it would be reasonable to conduct a two-sample *t*-test with equal variances. Looking at the distribution of the two groups, the tails and spreads of both histograms look similar. So it would be reasonable to assume the variances are equal and conduct the *t*-test.

PTS: 1

11. The investigator has two options for designing a study. One option is a single-group design where the subjects are measured before and after the intervention. Another option is a two-group design where one group receives the intervention and the other does not. Compare and contrast these two designs. Provide an example for when each would be appropriate.

ANS:
With both designs, you are able to compare the intervention and the control groups. When the between-subject variability is considerable, it may be better to conduct the single-group design.

PTS: 1

12. An investigator has conducted a study where it is hypothesized that exposing premature babies to small amounts of caffeine within 24 hours of birth will decrease their length of hospital stay. The sample size for the study was 80. The mean length of stay for the infants given caffeine was 40 (SD=12) days. The literature reports that premature infants given noncaffeine stimulants within 24 hours had a mean length of stay of 46 (SD=13) days.
a. Does caffeine do a better job at reducing the length of stay? Support your answer with statistical evidence.
b. After additional investigation, the investigator realizes that the distribution of length of stay is skewed. How does that impact the findings in (a)? What advice would you give the investigator for answering the question of whether caffeine does a better job at reducing the length of stay?

ANS:
a. Caffeine does a better job at reducing the length of stay. Using a one-sample *t*-test, the *t*-value is –2.14, with 79 degrees of freedom ($p = 0.0177$). This means that we have sufficient evidence to reject the null hypothesis that the two means are equal.
b. A comparison of means is not appropriate. Because the length of stay is skewed, it would be best to conduct a nonparametric test to perform a one-sample test of medians.

PTS: 1

13. An investigator collected HbA1c levels on a sample of 10 patients who are suspected to be at risk for diabetes. The values for the 10 patients are 2, 2, 2, 4, 4, 6, 7, 7, 9, and 9. The mean level was 5.2 with a standard deviation of 2.78. The median was 5 with an interquartile range of 2 and 7. The investigator adds two more patients with values 1 and 12. Explain what will happen to the center and spread of this distribution.

ANS:
The spread and mean will increase because of the value 12. The median will not be affected by the additions.

PTS: 1

14. An investigator wants to compare mean HbA1c levels among three groups.

a. Suppose that the three groups being compared involve a control and two experimental therapies. The purpose of the study is exploratory to see if the therapies impact HbA1c. The investigator uses the Bonferroni adjustment to reduce the chance of making a type 1 error. Is this appropriate? What are the implications of making the adjustment?

b. Suppose that the study is an observational one and is the first investigation of differences in HbA1c for these three groups. The purpose of the study is exploratory to see if a clinical trial investigating these three groups is warranted. Without adjusting for multiple comparisons, the investigator finds that there is a difference between groups 1 and 2, but after adjusting for multiple comparisons, the *p*-value is no longer significant. Advise the investigator.

c. Suppose that the study is a confirmatory clinical trial to investigate the impact of a no-treatment control, an active control, and a treatment on HbA1c. When making comparisons among the three groups, the investigator decides to implement an adjustment to protect against making a type 1 error. Is this appropriate? What are the implications of making the adjustment?

ANS:

a. Performing a Bonferroni adjustment would reduce the chance of making a type 1 error, but since the purpose of the study is exploratory, a multiple comparison adjustment may not be necessary. There are only three groups and a Bonferroni adjustment may inflate the type 2 error (a more serious error in this case).

b. If the investigator is only interested in understanding the differences between groups 1 and 2, I would advise the investigator to only focus on those two groups. If the investigator just focuses on groups 1 and 2, then a multiple comparison adjustment will not need to be made.

c. A multiple comparison adjustment may be appropriate. In confirmatory trials, type 1 errors tend to be more serious than type 2 errors. For this reason, adjustment for multiple comparisons would be justified.

PTS: 1

15. An investigator conducted an ANOVA where he was interested in group (three) differences in mean blood pressure levels. The results are given in the table below

| Analysis of Variance | | | | | |
|---|---|---|---|---|---|
| Source | DF | Sums of Squares | Mean Square | *F*-value | |
| Model | 2 | 8.167 | 4.08 | 0.29 | 0.7546 |
| Error | 9 | 126.5 | 14.05 | | |
| Total | 11 | 134.67 | | | |

What can the investigator conclude?

ANS:
There are no group differences in mean blood pressure levels. The variability within groups (mean square error) is larger than the variability between groups (mean square model). Our *p*-value (0.7546) suggests that we do not have enough evidence to reject the null hypothesis. Since there does not appear to be any differences between the groups, the investigator should not go on and try to investigate differences between specific groups.

PTS: 1