**There is sufficient evidence to conclude that the Lymphocytes mean size and TumorCells mean size are not equal.**

**Explanation:**

An unpaired t-test also known as an independent t-test, is a statistical procedure that compares the means of two independent or unrelated groups to determine if there is a significant difference between the two group means.

**Null Hypothesis, H0: μ1 - μ2 = 0**

**Alternative Hypothesis, H1: μ1 - μ2 ≠ 0**; (claim), it's a two-tailed test for it contain the symbol "≠" for "decreased".

where: μ1 & μ2 = population mean size of Lymphocytes and TumorCells, respectively

The null hypothesis only do contain the symbols = , ≥ , ≤. And the alternative hypothesis only do contain the symbols ≠ , > , <.

We assume the data are normally distributed and since the population standard deviations σ are not known, we use the test statistic t.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **S.N.** | **Lymphocytes Sizes** | | | **S.N.** | **TumorCells Sizes** | | |
| **x1** | **x1 - x̄1** | **(x1 - x̄1)2** | **x2** | **x2 - x̄2** | **(x2 - x̄2)2** |
| 1 | 9 | 2.05 | 4.20 | 1 | 12.6 | -5.32 | 28.30 |
| 2 | 6.3 | -0.65 | 0.42 | 2 | 16.7 | -1.22 | 1.49 |
| 3 | 8.6 | 1.65 | 2.72 | 3 | 20 | 2.08 | 4.33 |
| 4 | 7.4 | 0.45 | 0.20 | 4 | 17.7 | -0.22 | 0.05 |
| 5 | 8.8 | 1.85 | 3.42 | 5 | 16.3 | -1.62 | 2.62 |
| 6 | 9.4 | 2.45 | 6.00 | 6 | 14.6 | -3.32 | 11.02 |
| 7 | 5.7 | -1.25 | 1.56 | 7 | 15.9 | -2.02 | 4.08 |
| 8 | 7 | 0.05 | 0.00 | 8 | 17.8 | -0.12 | 0.01 |
| 9 | 8.7 | 1.75 | 3.06 | 9 | 15.1 | -2.82 | 7.95 |
| 10 | 5.2 | -1.75 | 3.06 | 10 | 17.7 | -0.22 | 0.05 |
| 11 | 4.7 | -2.25 | 5.06 | 11 | 16.2 | -1.72 | 2.96 |
| 12 | 5 | -1.95 | 3.80 | 12 | 15.8 | -2.12 | 4.49 |
| 13 | 6.8 | -0.15 | 0.02 | 13 | 13.9 | -4.02 | 16.16 |
| 14 | 4.9 | -2.05 | 4.20 | 14 | 16.9 | -1.02 | 1.04 |
| 15 | 7.1 | 0.15 | 0.02 | 15 | 18.1 | 0.18 | 0.03 |
| 16 | 4.8 | -2.15 | 4.62 | 16 | 23.9 | 5.98 | 35.76 |
| 17 | 3.5 | -3.45 | 11.90 | 17 | 16 | -1.92 | 3.69 |
| 18 | 7.1 | 0.15 | 0.02 | 18 | 22.1 | 4.18 | 17.47 |
| 19 | 7.4 | 0.45 | 0.20 | 19 | 16.4 | -1.52 | 2.31 |
| 20 | 5.3 | -1.65 | 2.72 | 20 | 24.3 | 6.38 | 40.70 |
| 21 | 8.9 | 1.95 | 3.80 | 21 | 23.3 | 5.38 | 28.94 |
| 22 | 7.8 | 0.85 | 0.72 | 22 | 17.9 | -0.02 | 0.00 |
| 23 | 5.7 | -1.25 | 1.56 | 23 | 13.9 | -4.02 | 16.16 |
| 24 | 6.4 | -0.55 | 0.30 | 24 | 22.8 | 4.88 | 23.81 |
| 25 | 4.7 | -2.25 | 5.06 | 25 | 11.2 | -6.72 | 45.16 |
| 26 | 4.9 | -2.05 | 4.20 | 26 | 17.1 | -0.82 | 0.67 |
| 27 | 10.4 | 3.45 | 11.90 | 27 | 13.4 | -4.52 | 20.43 |
| 28 | 7.6 | 0.65 | 0.42 | 28 | 18.3 | 0.38 | 0.14 |
| 29 | 7.1 | 0.15 | 0.02 | 29 | 19.4 | 1.48 | 2.19 |
| 30 | 8.4 | 1.45 | 2.10 | 30 | 19.5 | 1.58 | 2.50 |
| 31 | 8.4 | 1.45 | 2.10 | 31 | 20 | 2.08 | 4.33 |
| 32 | 8 | 1.05 | 1.10 | 32 | 19.1 | 1.18 | 1.39 |
| 33 | 6.2 | -0.75 | 0.56 | 33 | 22.8 | 4.88 | 23.81 |
| 34 | 6.3 | -0.65 | 0.42 | 34 | 19.6 | 1.68 | 2.82 |
| 35 | 6.4 | -0.55 | 0.30 | 35 | 18.6 | 0.68 | 0.46 |
| 36 | 5.9 | -1.05 | 1.10 | 36 | 21 | 3.08 | 9.49 |
| 37 | 8 | 1.05 | 1.10 | 37 | 16.6 | -1.32 | 1.74 |
| 38 | 7.1 | 0.15 | 0.02 | 38 | 13 | -4.92 | 24.21 |
| 39 | 8.8 | 1.85 | 3.42 | 39 | 18.4 | 0.48 | 0.23 |
| 40 | 8.3 | 1.35 | 1.82 | 40 | 16.4 | -1.52 | 2.31 |
| **Total, ∑ =** | **278** |  | **99.32** | 41 | 19.1 | 1.18 | 1.39 |
|  | | | | 42 | 18.9 | 0.98 | 0.96 |
| 43 | 17.9 | -0.02 | 0.00 |
| 44 | 18.2 | 0.28 | 0.08 |
| 45 | 16.1 | -1.82 | 3.31 |
| 46 | 19.4 | 1.48 | 2.19 |
| 47 | 18.7 | 0.78 | 0.61 |
| 48 | 15.2 | -2.72 | 7.40 |
| 49 | 20.7 | 2.78 | 7.73 |
| 50 | 21.5 | 3.58 | 12.82 |
| **Total, ∑ =** | **896** |  | **431.82** |

**Lymphocytes:** sample size, n1 = 40

sample mean, x̄1 = ∑x1 / n1 = 278 / 40 = 6.95

sample variance, s12 = ∑(x1 - x̄1)2 / (n1 - 1) = 99.32 / (40 - 1) = 2.55

**TumorCells:** sample size, n2 = 50

sample mean, x̄2 = ∑x2 / n2 = 896 / 50 = 17.92

sample variance, s22 = ∑(x1 - x̄2)2 / (n2 - 1) = 431.82 / (50 - 1) = 8.81

**1.**Assume that the variances of the two groups are equal.

Unpaired Two Sample t test, assuming equal variances, t = (x̄1 - x̄2) / sp√(1/n1 + 1/n2)

pooled standard deviation, sp = √{[(n1 - 1)s12 + (n2 - 1)s22] / (n1 + n2 - 2)}

sp = √{[(40 - 1)\*2.55 + (50 - 1)\*8.81] / (40 + 50 - 2)} = 2.46

**Test statistic t =** (6.95 - 17.92) / 2.46\*√(1/40 + 1/50) = **-21.02**

degrees of freedom, df =  n1 + n2 - 2 = 40 + 50 - 2 = 88

If the calculated test statistic < -t critical value, we reject the null hypothesis. Otherwise, we fail to reject the null hypothesis.

From the t-table, kindly see the attached photos below, with df = 88, assumed significance level, α = 0.05 and it's a two-tailed test, the t critical values = + 1.987

**Reject H0 if t > 1.987   or   Reject H0 if t < -1.987**

Since the test statistic of -21.02 < -1.987 t critical value, we **reject the null hypothesis**.

**There is sufficient evidence to conclude that the Lymphocytes mean size and TumorCells mean size are not equal.**

**2.**Assume that the variances of the two groups are unequal.

**Unpaired Two Sample t test, assuming unequal variances,**t = (x̄1 - x̄2) /√(s12/n1 + s22/n2)

**Test statistic** **t =** (6.95 - 17.92) /√(2.55/40 + 8.81/50) = **-22.39**

degrees of freedom, df = [s12/n1 + s22/n2]2 / [(s12/n1)2/(n1 - 1) + (s22/n2)2/(n2 - 1)]

df = [2.55/40 + 8.81/50]2 / [(2.55/40)2/39 + (8.81/50)2/49] = 78.04 say 78

From the t-table, kindly see the attached photos below, with df = 78, assumed significance level, α = 0.05 and it's a two-tailed test, the t critical values = + 1.991

**Reject H0 if t > 1.991   or   Reject H0 if t < -1.991**

Since the test statistic of -22.39 < -1.991 t critical value, we **reject the null hypothesis**.

**There is sufficient evidence to conclude that the Lymphocytes mean size and TumorCells mean size are not equal.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Total, ∑ =** | **896** |  | **431.82** |