《論　文》

The Analytical Methods in Physical Activity Information

TOSHIHIRO ISHIDA

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[Abstract]
In the Sports and Health Science fields, Information plays an important part in the physical activity. Hence, there are many analytical methods of this area. For example, statistical and measurement technologies belong to this area. On the other hands, OR (Operations Research) methods are also powerful tool.

We previously mentioned these problems in some papers. (1) (2)

In this paper, we also use Statistical and OR methods in the physical activity problems.

1. Fundamental theory of t test in Statistical Analysis.

We first show the next data (3) Ten dancer are given a jump-and-reach test. Then they take part in 10 weeks on dance activity that involve leap and jump 3 days per week. Data are as follows (cm unit).

We examine that there are difference between pretest and posttest. In other words, there exists the progress between pretest and posttest. Hence, we judge this question by using statistical method. Especially, the T test analysis is very powerful tool.

So we first mention about the characteristic of T distribution and T test theory.

Let X be random variable and followed normal distribution $N(\mu, \sigma^2)$ and further we define next formula. where, μ is population mean and σ is population variance.

$$t = \frac{(\bar{x}-\mu)\sqrt{n-1}}{s}$$

t will be followed degree of freedom $\phi = n-1$ t distribution. The probability density function

Table 1-1 jump and reach test data

Subject	1	2	3	4	5	6	7	8	9	10
Pretest	12	15	13	20	21	19	14	17	16	18
Posttest	16	21	15	22	21	23	16	18	22	23

of t distribution is as follows.

$$f(t) = c\,(1+\frac{t^2}{n-1})^{-\frac{n}{2}}$$

$$c = \Gamma(\frac{n}{2}) \Big/ \Gamma(\frac{n-1}{2})$$

Therefore, we define next T test(one side test) procedure.

H_0 : μ = pretest average (same as before)

H_1 : μ > pretest average

(progressive compare to pretest)

Where H_0 means Null Hypothesis and H_1 means Alternative Hypothesis.

Hence, we analyze above Table 1-1 data using the computer program. As before we use VBA(Visual Basic for Applications) language on Excel. VBA language do not operate itself. So we programmed on Excel (Table 1-2).

Now we can calculate the t value defined above.

$$t = \frac{(\bar{x}-\mu)\sqrt{n-1}}{s} = \frac{(19.7-16.5)3}{2.968} = 3.234$$

Now we judge the difference between pretest and posttest by using t test procedure. In other words, T testing method mentioned above must be applied.

$t = 3.234 > t_{10-1}(0.05) = 1.83$.

Therefore, it is progressive protest comparing to pretest as a whole. In other words, we can judge in the statistical approach.

2. Fundamental theory of χ^2 test in statistical approach

We analyze the next statistical approach. We are sometimes interested in evaluating the difference between actual chance and what would be expected on the basis of chance. For example, in baseball game, defensive team would be expected 3 batters in each inning. In this case, chi square test provides a statistical test significance of the discrepancy between the observed and the expected results.

So, we mention the overview of chi square test procedure.

Let X be the random variable and be followed

Table 1-2 Working Table of Table 1-1 using VBA program

Subject	1	2	3	4	5	6	7	8	9	10	Ave.	S.D
Pretest	12	15	13	20	21	19	14	17	16	18	16.5	
Posttest	16	21	15	22	21	23	16	18	22	23	19.7	2.9682

Ave=Average, S.D=Standard Deviation

```
Sub jumt()
Worksheets(1).Select
Goukei1 = 0
Goukei2 = 0
Goukei3 = 0
For J = 2 To 11
Goukei1 = Goukei1 + Cells(2, J)
Goukei2 = Goukei2 + Cells(3, J)
Goukei3 = Goukei3 + Cells(3, J) ^ 2
Next J
Cells(2, 12) = Goukei1 / 10
Cells(3, 12) = Goukei2 / 10
Cells(3, 13) = Sqr(Goukei3 / 10 - Cells(3, 12) ^ 2)
End Sub
```

to standard normal distribution N(0, 1). In this case, we define next expression.

$$\chi^2 = X_1^2 + X_2^2 + \cdots + X_n^2$$

χ^2 be followed degree of freedom ϕ = n chi square distribution.

This probability density function is as follows.

$$f(\chi^2) = \frac{(\chi^2)^{\frac{n}{2}-1} e^{-\frac{\chi^2}{2}}}{2^{\frac{n}{2}}\Gamma(\frac{n}{2})}$$

Where, Γ is gamma function.

Therefore, we define next chi square test procedure.

case	1	2	3	⋯	k	Total
Observed value	f_1	f_2	f_3	⋯	f_k	
Expected value	F_1	F_2	F_3	⋯	F_k	

$$\chi^2 = \sum_{i=1}^{k} \frac{(f_i - F_i)^2}{F_i}$$

We first define above formula and do the next null hypothesis.

$$H_0 : f_i = F_i \ (i = 1, 2, \cdots, k)$$

If

$$\chi^2 > \chi_\phi^2(\varepsilon)$$

H_0 is rejected.

Where, degree of freedom ϕ =k − 1.

3. Case study of chi square test

Now let's show case study of chi square test in baseball game in Japan.

The data are the game 4 of Japan Series. The game matched Chunichi dragons against Nippon Ham Fighters. The Dragongs won 4-2 to take 3-1 lead in the Series. The scores are as follows.

Fighters 000 110 000 − 2

Dragons 200 010 10X − 4

The Newspaper Japan Times said that "Dragons on brink of title" and also said "Chunichi can clinch the title at home in front of its long suffering fans who have waited 53 years for the franchise's second Japan Series title".

Now we show the result of game 4 as table 3-1.

Table 3-1 The members of Dragons and Fighters

The member of players of Dragons

second	Araki	【1】 hit	hit	sacrifice	fly
short	Ibata	deadball	ground	walk	【7】 walk
left · third	Morino	sacrifice	【3】 ground	hit	two-base-hit
first	T.Woods	error	strikeout	ground	strikeout
pitcher	Iwase				
third · first	Nakamura	walk	ground	fly	hit
right	Ri	ground	【4】 strikeout	【6】 fly	strikeout
center	Hirata	strikeout	strikeout		
pitcher	Suzuki				
batter	Arai			walk	
pitcher	Hirai				
pitcher	Okamoto				
batter	Inoue				【8】 fly
left	Ueda				
catcher	Tanisige	【2】 ground	fly	fly	fly
pitcher	Ogasawara	strikeout			
center	Fujii		【5】 walk	walk	ground

The member of players of Fighters

center	Morimoto	【1】 error	【3】 fly	strikeout
second	Tanaka	sacrifice	ground	【5】 strikeout
right	Inaba	ground	two-base-hit	strikeout
first	Seguignol	walk	walk	two-base-hit
run · third.	Iiyama			
batter	Takahashi			
third · first	Koyano	strikeout	fly	walk
left	Kudou	【2】 ground	【4】 hit	hit
pitcher	Takeda			
short	Kaneko	hit	two-base-hit	walk
catcher	Tsuruoka	fly	strikeout	fly
batter	Tsuboi			
catcher	Nakajima			
pitcher	Yoshikawa	strikeout	ground	【6】 strikeout
pitcher	Oshimoto			
left	Kawashima			
bat · left	Konda			
center	Morimoto	【6】 ground		ground
second	Tanaka	strikeout		【9】 strikeout
right	Inaba	【7】 ground		strikeout
first	Seguignol	walk		
run · third	Iiyama			
batter	Takahashi			ground
third · first	Koyano	fly		
left	Kudou	walk		
pitcher	Takeda			
short	Kaneko	ground		
catcher	Tsuruoka			
batter	Tsuboi	【8】 hit		
catcher	Nakajima			
pitcher	Yoshikawa			
pitcher	Oshimoto			
left	Kawashima			
bat · left	Konda	strikeout		

Now we show the chi square test using Table 3-1 data. In the baseball game, as for the offensive team, the most favorable inning should end 3 batters. For example, if 10 batters are there in a inning there are gotten some scores in the inning. So we can measure distance between 3 and how many batters in a inning. For example, member of Fighters in table 3-1, as for the 1 inning batters are 5. Therefore the distance equals 2(5-3). We can also measure the whole inning this distance by use of chi square test.

The chi square test is showed in table 3-2 using VBA program.

Table 3-2 Chi Square Test and VBA program

Fighters

Inning	1	2	3	4	5	6	7	8	9
f_i	5	4	5	5	7	3	5	3	3
F_i	3	3	3	3	3	3	3	3	3
f_i-F_i	2	1	2	2	4	0	2	0	0
$(f_i-F_i)^2$	4	1	4	4	16	0	4	0	0
$(f_i-F_i)^2/F_i$	1.333	0.333	1.333	1.333	5.333	0	1.333	0	0
								Chi	11

Dragons

Inning	1	2	3	4	5	6	7	8	9
f_i	7	4	3	3	6	5	5	3	0
F_i	3	3	3	3	3	3	3	3	3
f_i-F_i	4	1	0	0	3	2	2	0	-3
$(f_i-F_i)^2$	16	1	0	0	9	4	4	0	9
$(f_i-F_i)^2/F_i$	5.333	0.333	0	0	3	1.333	1.333	0	3
								Chi	14.33

```
Sub ChiTest()
Call Keisan(3)
Call Keisan(12)
End Sub
Sub Keisan(K)
Worksheets(1).Select
S = 0
For J = 2 To 10
 Cells(K + 2, J) = Cells(K, J) - Cells(K + 1, J)
 Cells(K + 3, J) = Cells(K + 2, J) ^ 2
 Cells(K + 4, J) = Cells(K + 3, J) / Cells(K + 1, J)
 S = S + Cells(K + 4, J)
Next J
 Cells(K + 5, J - 1) = S
Exit Sub
End Sub
```

In table 3-2, the value of χ^2 of Dragons(14.33) greater than that of Fighters(11). As mentioned above, Dragons won 4-2.

4. Conclusion

We analyzed the physical activity data by use of statistical methods.

Especially we use the t-distribution and chi square distribution. And also we construct the computer program. The used programming language is VBA language. That language is usually called Macro. That language can moved on the Microsoft Office. So we construct it on the Excel.

Next paper we will also analyze these physical activity data using statistical methods and OR methods.

References

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