# Original Article

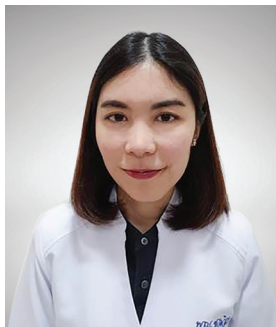# Validity of Vision Screener among Workers in a Private Hospital in the Northern Part of Thailand

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## Abstract

**OBJECTIVES:** To assess whether results obtained by Titmus V4 occupational landolt model are valid compared to the results obtained by traditional vision tests.

**MATERIAL AND METHODS:** Specific tests were performed by Titmus for distance and near visual acuity, stereoacuity and color perception while traditional vision tests were performed by using 20-feet and 14-inch number snellen charts for visual acuity, Stereofly wirt dot for stereoacuity and Ishihara 38-plates for color perception. The results obtained through Titmus and those obtained through traditional vision tests were compared. Descriptive statistics, sensitivity, specificity and kappa statistics were calculated for data analysis.

**RESULT:** Visual performance of 220 participants mean aged 34 ± 8.6 years was obtained. Sensitivity of Titmus for distance visual acuity, near visual acuity, color perception and stereoacuity were 95.8%, 90.9%, 100% and 64.3% respectively. Specificity of Titmus for distance visual acuity, near visual acuity, color perception and stereoacuity were 64.8%, 61.7%, 100% and 68.2% respectively. Agreements of Titmus ranged from 63.2% (Near VA Both eyes) to 100% (color perception.)

**CONCLUSION:** Titmus proved to be a valid test for color vision deficiency. Titmus can also be used as an occupational vision screener for the assessment of distance and near visual acuity, but with poor diagnostic criteria. According to Titmus's moderate sensitivity and specificity, Titmus is not suggested to be used for stereoacuity test. It is recommended that further clinical investigation to be undertaken for a more accurate diagnosis of the extent of abnormal visual performance among those whose tests are positive for Titmus.

**Keywords:** occupational vision test, occupational health, titmus V4 occupational landolt model, sensitivity, specificity

Many occupations require people to have sufficient visual performance to be able to work effectively and safely. Some jobs require high levels of visual function, such as operation of heavy moving machinery. Truck drivers must have normal color perception in order to perceive colored signals correctly, and so as electricians. Some specific tasks, such as working in a confined space, have standards regulated by law.[1,2] These requirements are known as occupational vision standards.

The important law that provides requirements, guidelines, and standards with which employers must comply is the Ministerial Regulation on the Prescribing of Criteria and Method of Conducting Health Checkup of Employees and Forwarding the Results of Health Checkup to Labour Inspector B.E. 2547 (2004),[2] Labour Protection Act B.E. 2541 (1998), administered by Thai Department of Labour. Furthermore, there are laws that offer standards for special tasks which require visual performance tests such as Ministerial Regulation on the Prescribing of Standard for Administration and Management of Occupational Safety, Health and Work Environment in Confined Space B.E. 2547 (2004)[3], administered by Thai Department of Labour. Furthermore, the Ministry of Public Health Announcement Regarding to the Principle, Procedure and Condition when issued the Medical Certificate to Demonstrate Readiness of the Seafarer on Board B.E. 2559 (2016)[4], Maritime Labour Act B.E. 2558 (2015), administered by Thai Ministry of Public Health.

Occupational visual performance, which includes distance and near visual acuity, color perception and visual field, is a non-invasive screening test.[5] In Thailand, a vision screener is a recommended tool to rapidly perform visual screenings. Vision screeners are simple and easy to use, and have low maintenance costs and thus are considered as a useful tool for prevention services.

Titmus is one of the most widely used vision screeners.[5,6] Six vision tests are available to screen for:
1. Far (20 feet) and near (14 inches) visual acuity
2. Muscle balance (horizontal and vertical phoria)
3. Depth perception (stereoacuity)
4. Color perception
5. Visual field
6. Binocular vision.

A previous study had shown the validity of Titmus in normal-vision young adults.[7] Although, there is no study about the validity of Titmus among workers in Thailand yet. The current study is an attempt to study the validity of Titmus among workers in Thailand.

### Materials and Methods

This study was conducted in workers from Bangkok Hospital Phitsanulok who enrolled in the study, inclusion criteria being a healthcare worker, 18-60 years old (working age)[8], and absence of undergoing treatment for an ocular pathology[5] or monocular vision[9]. All participants were tested by occupational health doctors and nurses at the health promotion and occupational center, Bangkok Hospital Phitsanulok. Participants were asked to perform the tests with their actual vision while they were working (with or without correction e.g. glasses, contact lens) without further correction. Written informed consent was obtained and the study was approved by the Institutional Review Board (IRB) with COA number 2019-05 dated 24th January 2019.

220 subjects, was an estimate of the proportion of workers with refractive errors.

This was calculated from the population proportion of percentage of refractive errors in adults[11] and number of workers who attended the annual health examination in 2018. The subjects were sorted by hospital number (HN) in order from lowest to highest. The first number is generated by computer, followed next by every other number.

A comparison was made between results obtained through the Titmus and traditional vision tests. The visual performance was measured and the results were divided into 4 categories for comparison as follows:
1. Distance Visual Acuity (Both eyes and each eye)
2. Near Visual Acuity (Both eyes and each eye)
3. Stereoacuity
4. Color perception. (Figure 2)



**Figure 1:** Titmus vision screener [6]

**Sample size was calculated as follows:**

$$ n = \frac{N Z_{\frac{\alpha}{2}}^{2}\, p(1 - p)}{e^2\,(N - 1) + Z_{\frac{\alpha}{2}}^{2}\, p(1 - p)} $$

Population Proportion – Sample Size equation[10]

Zα/2 = the critical value of the normal distribution at α/2 (for a confidence level of 95%, α is 0.05 and the critical value 1.96)
e = 0.05
p = proportion of adult with refractive errors = 0.4[11]
q = 1-p = 0.6
N = 494 workers who attended annual health examination in 2018

**Visual acuities (VA):** Visual acuity refers to sharpness and clarity of vision. Distance visual acuity (dVA) results reported by Titmus were compared with 20-feet snellen chart with number optotypes. Near visual acuity (nVA) results reported by Titmus were compared with 14-inch snellen chart with number optotypes. When partial lines of letters in snellen chart were viewed and reported, the interpolation was then used to convert the result into decimal acuity for each letter reported correctly, e.g., 20/20-1 .975.[12] This was done in order to facilitate a more exact correlation between snellen chart decimal acuity and that obtained by the Titmus. Any VA higher than 20/20 was reported as 20/20. The VA was identified with both eyes (BE), right eye (RE) and left eye (LE).

**Stereoacuity (SA):** Stereofly is defined as sterofly wirt dot stereopsis test. SA results obtained by Titmus and stereofly were compared (both using the stereotest-circles). All results were reported by seconds of arc to facilitate an easy comparison between the two different methods of measurement. Even though the Titmus can measure stereoacuity up to 20 seconds of arc[6], any value greater than 40 seconds of arc stereoacuity was recorded as 40 seconds of arc, because it is the highest stereoacuity the stereofly is capable of measuring.[13]

**Color perception (CP):** Titmus and the Ishihara color perception both consisted of a series of color plates containing a circle of dots that appear randomly in color and size and were used to diagnose red-green color deficiencies. The color perception checks for a problem in recognizing colors but does not classify type or degree of severity. For Titmus, the participants were asked to read eight digits in the six circles (the circles were selected from Ishihara's color perception). A gross measure of "pass" for Titmus is recorded if five or more from eight digits in the six circles were identified.[6] For this study, the measure of "pass" was eight from eight digits, the participants must answer all correctly otherwise it was recorded as "fail." Then participants were asked to read the first twenty-one plates of Ishihara's test for color deficiency: 38 plates edition. The measure of "pass" was seventeen or more from twenty-one plates answered correctly.

Data were recorded and analyzed using the SPSS version 23. A pass/fail score for this study was based on a visual job standard which was a minimum standard for use with those whose work involved machines (Job group 4: Operators). The visual requirement was at or just within arm's reach.[12] Sensitivity and specificity were analyzed to compare the accuracy of Titmus results with the traditional vision test's results. Kappa statistics was used as the measure for inter-rater agreement between eye screening tools. The percentage of reliability were classified in 6 levels, which are none (0-4%), minimal (4-15%), weak (15-35%), moderate (35-63%), strong (64-81%), and almost perfect (82-100%).

### Results

A total of 220 workers participated, 177 (80.5%) females and 43 (19.5%) males. Participants were between 21 and 60 years old (mean age 34 ± 8.6 years) shown in Table 2. Participants had visual acuity ranges from 1.00 decimal acuity to 0.10 decimal acuity and stereoacuity ranges from 40 arc sec to 400 arc sec. The mean VA and SA measure using various tools are given in Table 3. Mean decimal acuity of both distance VA and near VA using snellen chart were higher than that of Titmus. Mean SA reported by stereofly was 1.5 times better than Titmus.

Sensitivity in this study was defined as the ability of the screening test to detect all individuals who had worse sight than occupational vision standard. Specificity was defined as the ability to detect all individuals who met occupational vision standard or better. The sensitivities of Titmus were 95.8%, 90.9% and 100% for distance VA, near VA and color perception respectively. Sensitivity of Titmus for stereoacuity was only 64.3 %. Specificities were similar for distance VA, near VA and stereoacuity (64.8%, 61.7% and 68.2% respectively). Only for color perception, specificity of Titmus was 100%. (Table 4.) Agreement of Titmus with standard tests ranged from 63% (Near VA both eyes) to 100% (color perception). (Table 4.)
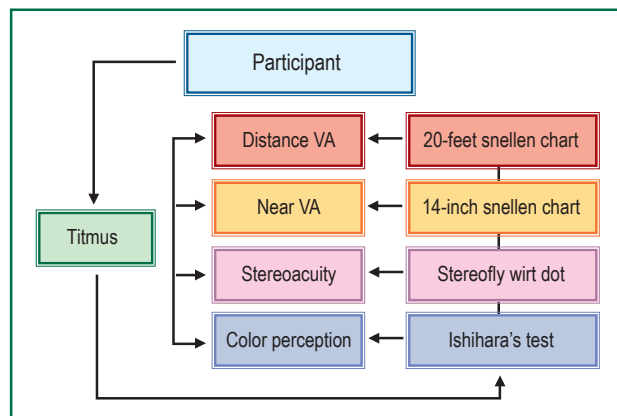


**Figure 2:** A comparison was made between results obtained through the Titmus and traditional vision tests

**Table 1:** Fail criteria of visual job standards for this study[14]

| Vision test | Fail criteria |
|---|---|
| Distance VA | Decimal acuity |
| Both eyes | < 0.8 (20/25) |
| Left eye & Right eye | < 0.66 (20/30) |
| Near VA | Decimal acuity |
| Both eyes | < 0.8 (20/25) |
| Left eye & Right eye | < 0.66 (20/30) |
| Stereoacuity | > 50 arch sec |
| Color perception | Color deficiency |

**Table 2:** Demographics of participants (n = 220)

| Demographic | n (%) |
|---|---|
| Gender | |
| Male | 43 (19.5) |
| Female | 177 (80.5) |
| Age (years); mean ± SD | 34 ± 8.6 |
| 20-30 | 100 (45.5) |
| 31-40 | 69 (31.4) |
| 41-50 | 39 (17.7) |
| 51-60 | 12 (5.5) |
| Glasses | |
| No | 132 (60.0) |
| Yes | 88 (40.0) |

**Table 3:** Mean visual acuity and stereoacuity of each tool.

| Detail | Mean ± SD |
|---|---|
| Distance VA BE (Decimal acuity) | |
| 20-feet Snellen | 0.93 ± 0.17 |
| Titmus | 0.73 ± 0.24 |
| Near VA BE (Decimal acuity) | |
| 14-inch Snellen | 0.97 ± 0.08 |
| Titmus | 0.75 ± 0.20 |
| Stereoacuity (arc sec) | |
| Stereofly wirt dot | 50.95 ± 46.87 |
| Titmus | 78.18 ± 87.64 |

**Table 4:** Validity of Titmus

| Gold standard | Test (Titmus) | | Sensitivity | Specificity | Agreement |
|---|---|---|---|---|---|
| | Fail | Pass | % (95% CI) | % (95% CI) | |
| Distance VA (20- feet snellen) | | | | | |
| Both eyes | | | | | |
| Fail | 23 | 1 | 95.8 (78.9-99.9) | 64.8 (57.7-71.5) | 68.2% |
| Pass | 69 | 127 | | | |
| Right eye | | | | | |
| Fail | 39 | 1 | 97.5(86.8-99.9) | 65.6 (58.1-72.5) | 71.4% |
| Pass | 62 | 118 | | | |
| Left eye | | | | | |
| Fail | 39 | 2 | 95.1 (83.5-99.4) | 66.5 (59.1-73.3) | 71.8% |
| Pass | 60 | 119 | | | |
| Near VA (14-inch snellen) | | | | | |
| Both eyes | | | | | |
| Fail | 10 | 1 | 90.9 (58.7-99.8) | 61.7(54.8-68.3) | 63.2% |
| Pass | 80 | 129 | | | |
| Right eye | | | | | |
| Fail | 10 | 0 | 100 (69.2-100.0) | 64.8 (57.9-71.2) | 66.4% |
| Pass | 74 | 136 | | | |
| Left eye | | | | | |
| Fail | 8 | 1 | 88.9 (51.8-99.7) | 72.4 (65.8-78.3) | 73.1% |
| Pass | 58 | 152 | | | |
| Color perception (Ishihara's Test) | | | | | |
| Fail | 3 | 0 | 100 (29.2-100.0) | 100 (98.3-100.0) | 100.0% |
| Pass | 0 | 217 | | | |
| Stereoacuity (Stereofly) | | | | | |
| Fail | 18 | 10 | 64.3 (44.1-81.4) | 68.2 (61.1-74.7) | 67.7% |
| Pass | 61 | 131 | | | |

## Discussion

Occupational vision screening aims to identify visual ability that is out of the reference range for a safe and effective level of productivity. There are several tests including distance and near visual acuity (VA), color perception and stereoacuity. Titmus is one of the most commonly used occupational vision screeners in Thailand.

The current study shows that distance and near VA results obtained from Titmus were lower when compared with standard measurements. Apparently, the assessment of VA depends on the optotype used for measurement. Our results corresponded with several studies that vision was generally poorer with landolt C (used by Titmus) compared to snellen chart. Still, the differences were small.[15-17] We also noted that participants found it difficult to give answers for landolt C (used by Titmus). Related to a study among Thai population, Chaikitmongkol et al.[17] agreed that the landolt C chart involved a longer test duration compared to number chart in both normal and abnormal VA groups (1.7 times longer than with number chart in healthy eyes). It might be because the snellen charts with number optotypes are widely used in Thailand.

For stereoacuity, even though stereotest-circles test had proven for good repeatability,[18,19] our findings show that traditional stereofly obtained better stereoacuity than Titmus. These might be an effect of different circle size and viewing distance.[20]

The results demonstrate high sensitivity of Titmus for distance VA, near VA and color perception. These results are relevant to a previous study by Horberry TJ et al.,[21] which found that Titmus had overall 82.1% sensitivity and 62.5% specificity. However, sensitivity of Titmus for stereoacuity was only 64.3%, it appears that Titmus is not a proper tool for stereoacuity screening.

The moderate level of specificity of Titmus for stereoacuity (68.2%) distance VA (64.8%) and near VA (61.7%) may lead to over referrals for an ophthalmologist.

Our results corroborate with various studies that there are no significant differences in color perception between Titmus and traditional Ishihara's Test.[7,21] Correlation to Van Staden D et al.,[22] this study proved that Titmus was a valid tool for color blindness screening (100% sensitivity, 100% specificity).

This study has some advantages of using health care workers who are familiar with visual capacity and are likely to comply with testing protocols. Disproportion of male to female should not substantially affect test results as the study does not try to

identify prevalence of color deficiency. However, the facts that some subjects had inadequate correction of the visual acuity might result in some information biases. Age and job a ssignments should not play significant confounding roles.

Limitations of the study were the inability to determine validity of horizontal phoria, vertical phoria and visual field due to limitation of equipment. Future efforts should focus more on assessing the effectiveness of Titmus vision screener by comparing the results to occupational vision standards (e.g., drivers must able to read car plate and road signs).

## Conclusions

Titmus V4 occupational landolt model is a valid occupational visual screener for color perception, distance and near visual acuity (sensitivity 100%, 95.8%, 90.9% respectively). For the stereoacuity, Titmus is not recommended to be used due to its moderate sensitivity and specificity (64.3% and 68.2% respectively). We suggest that further clinical evaluation should

be performed among those whose test is positive for Titmus for more accuracy of the magnitude of abnormal visual performance.

## Conflicts of interest

The authors declare that there was no conflict of interest.

## Acknowledgments

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